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Three-Year Outcome of Endovascular Treatment of Superficial Femoral Artery Occlusion

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# Three-Year Outcome of Endovascular Treatment of Superficial Femoral Artery Occlusion

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**Hypothesis:** Patency after primary percutaneous transluminal angioplasty (PTA) and stenting of superficial femoral artery (SFA) occlusions is better than historical experience with PTA alone.

**Design:** Consecutive case series of primary PTA with stenting, and follow-up with duplex imaging every 6 months (mean  $\pm$  SD follow-up, 32  $\pm$  15 months).

**Setting:** Veterans Affairs medical center.

**Patients and Methods:** Patients were 57 previously untreated men with 71 limbs having chronic atherosclerotic SFA occlusion with supragenicular reconstitution and patent tibial runoff. Critical ischemia (Society for Vascular Surgery [SVS] category, 4-6) was present in 7 (10%), the remainder had intermittent claudication only (SVS, 1-3).

**Interventions:** Guidewire recanalization followed by PTA, Wallstent deployment, and adjunctive thrombolysis as necessary; 19 limbs (27%) required thrombolysis to manage periprocedural thrombosis.

**Main Outcome Measures:** Cumulative patency, limb salvage, and complications.

**Results:** Length (mean  $\pm$  SD) of occlusion was 14.4  $\pm$  9.9 cm. Length of stented artery was 24.3  $\pm$  11.1 cm. Ankle brachial index increased from 0.59  $\pm$  0.14 to 0.86  $\pm$  0.16

( $P < .001$ ) after stenting. One- and 3-year patencies were as follows: primary, 54.6%  $\pm$  6.3% and 29.9%  $\pm$  6.6%; assisted primary, 72.3%  $\pm$  5.6% and 59.0%  $\pm$  6.8%; and secondary, 81.6%  $\pm$  4.8% and 68.3%  $\pm$  6.5%. Three-year secondary patency when periprocedural thrombolysis was required was 35.7%  $\pm$  12.5% compared with 70.6%  $\pm$  7.4% for limbs not requiring periprocedural thrombolysis ( $P = .02$ ); the differences in occlusion length and severity of ischemia were not significant between these 2 groups. Limbs undergoing adjunctive PTA during angiography 6 to 12 months after initial stenting had 63.0%  $\pm$  13.3% patency at 3 years compared with 100% patency in limbs not requiring PTA at 6 to 12 months angiography ( $P = .046$ ). Periprocedural mortality and morbidity were 2.8% and 15.5%, respectively. Three of the 7 limbs with critical ischemia underwent amputation during follow-up compared with 2 (3%) of 64 limbs with functional ischemia ( $\chi^2$  test,  $P < .006$ ). A mean of 1.8 endovascular interventions per limb were performed.

**Conclusions:** Percutaneous transluminal angioplasty and stenting yielded higher patency rates than historical controls undergoing PTA alone. When periprocedural thrombolysis is required, subsequent patency appears to be significantly worse. Poor results after PTA and stenting of limbs with critical ischemia and the need for additional endovascular therapy limit the technique's utility.

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**I**N RECENT years increasing numbers of patients with stenosis and occlusion of the femoropopliteal segment of the arterial tree have been treated with percutaneous transluminal angioplasty (PTA) or PTA with stenting. In previously reported series, many subjects underwent stenting for management of suboptimal PTA results or after failure of previous interventions.<sup>1-3</sup> Although the long-term results of stenting the superficial femoral artery (SFA) may not be better than PTA alone,<sup>4</sup> previous outcomes may have reflected an unfavorable bias, given the large

proportion of cases in which stents were used after previous endovascular failures. This article summarizes the consecutive experience of a radiology-surgery team at 1 institution with a consistent treatment strategy using stenting. Each subject had a chronic femoropopliteal occlusion and had never undergone previous infrainguinal therapy. A similar technique of mechanical guidewire recanalization, PTA, and stenting was applied to each case. We have examined patency rates, limb salvage outcomes, and complications and account for the total number of interventions required to implement this novel strategy.

## SUBJECTS AND METHODS

From January 1994 through September 1998, 57 men with 71 chronic occlusions of the SFA (14 subjects had staged therapy of bilateral lesions) were treated according to an institutional review board–approved research protocol by a single team of radiologists and surgeons. Eligible subjects had not previously undergone infrainguinal arterial surgery or endovascular intervention and had complete occlusion of the SFA ending 5 cm or more above the bony femorotibial articulation on radiographs. At least 1 tibial vessel providing patent runoff in continuity with the reconstituted popliteal segment had to be present. In general, subjects had to have 3 months of stable claudication symptoms and not have limb-threatening ischemia. Infrainguinal bypass was not routinely offered to most of the subjects enrolled, except for a minority with incapacitating symptoms. The few cases where critically ischemic limbs were treated with stents were either patients with such severe comorbidities that endovascular therapy was elected instead of bypass or, in one instance, a patient who refused to undergo bypass but would accept endovascular therapy. Our methods of recanalization, angioplasty, and stenting have previously been described in detail.<sup>5,6</sup> Subintimal passage of the guidewire was frequently used,<sup>7</sup> and PTA was performed as necessary to aid in dissection and penetration of the point of obstruction. Predilation before deployment of Wallstents (Boston Scientific, Boston, Mass) was routine and noncompliant 5- to 7-mm diameter angioplasty balloons were used to maximally dilate the stents after deployment. Multiple Wallstents were deployed in an overlapping fashion; infrequently Palmaz stents<sup>8</sup> were required to manage small areas of residual stenosis or intimal flap. The length of the artery that was stented generally exceeded the length occluded, as neighboring stenoses were liberally dilated and stented as necessary for stenosis of 30% or more diameter reduction. Heparin sodium, 5000 U, was given intravenously prior to stent deployment. When necessary, intra-arterial urokinase was infused to manage thrombus developing at the conclusion of stent deployment and dilation.<sup>9</sup> With the first 55 limbs treated in our series, postprocedural thrombosis was inhibited with heparin infusion beginning 4 hours after removal of the arterial sheath and maintained until a therapeutic effect of warfarin sodium

(Coumadin) was achieved (international normalized ratio, 1.5-2.0). After hospital discharge, warfarin therapy was maintained for the first 30 days; thereafter, coagulation was inhibited with aspirin (325 mg/d) alone. The last 16 limbs treated in the series received only aspirin, unless other indications for anticoagulation were present (eg, atrial fibrillation).

After hospital discharge, subjects returned at 30 days and every 6 months for duplex ultrasound evaluation of stent patency and determination of ankle brachial index (ABI) (or ankle-to-arm systolic blood pressure ratio). The mean  $\pm$  SD follow-up is  $32 \pm 15$  months, and only 1 patient has been lost to follow-up. The majority of primarily patent subjects consented to undergo contrast angiography of the treated limb between 6 and 12 months after revascularization to assess the development of intimal hyperplasia. When restenosis of 50% or more from intimal hyperplasia was identified at this follow-up, it was routinely treated with PTA. After the first follow-up, subsequent angiography was reserved for either 75% diameter reduction demonstrated by duplex ultrasound<sup>10</sup> within the stented SFA or for worsening clinical status. At the discretion of the treating physicians, known stent occlusion was observed without further attempts to restore blood flow.

*Primary patency* is defined as the time a stent remains open without any adjunctive interventions after the conclusion of initial treatment. When urokinase infusion was started immediately after initial recanalization and stenting and was successful, the revascularized SFA was deemed primarily patent until subsequent occlusion occurred. *Assisted primary patency* includes the additional time a previously primarily patent stent remains open after an intervention (eg, balloon angioplasty) to treat restenosis in the stented or adjacent arterial segments. *Secondary patency* refers to continued patency after successful endovascular management of thrombosis within the stent and adjacent segments. Only data derived from either duplex ultrasound or angiographic imaging demonstrating stent patency were used to construct Kaplan-Meier survival curves. Initial failures were incorporated into the survival curves in accordance with recommended standards.<sup>11</sup> Statistical analyses using  $\chi^2$  and *t* tests and log-rank methods to determine probabilities were performed with the assistance of a microcomputer program (Prism; GraphPad Software, Inc, San Diego, Calif).

## RESULTS

All 57 patients were men with a mean age of  $65.4 \pm 4.7$  years, and most had moderate to severe claudication (Society for Vascular Surgery [SVS] category: 1, 2, or 3<sup>11</sup>), but in 7 cases (10%), critical limb ischemia was present (**Table 1**). The average ABI at study entry was  $0.59 \pm 0.14$ , and increased to  $0.86 \pm 0.16$  after stenting ( $P < .001$ ). The average occlusion length was  $14.4 \pm 9.9$  cm (range, 1.5-35.0 cm). An average of  $2.9 \pm 1.09$  stents were deployed per limb, generally using 6- or 7-mm diameter Wallstents of varying lengths, with the mean length of stented artery being  $24.3 \pm 11.1$  cm. Recanalization and stent deployment were achieved in all limbs, but immediate rethrombosis was encountered in 19 cases (27%) requiring urokinase administration at the time of initial stenting. Four of these cases could not have patency maintained

and were considered initial failures (1 was a previously undiagnosed thrombosed popliteal aneurysm).

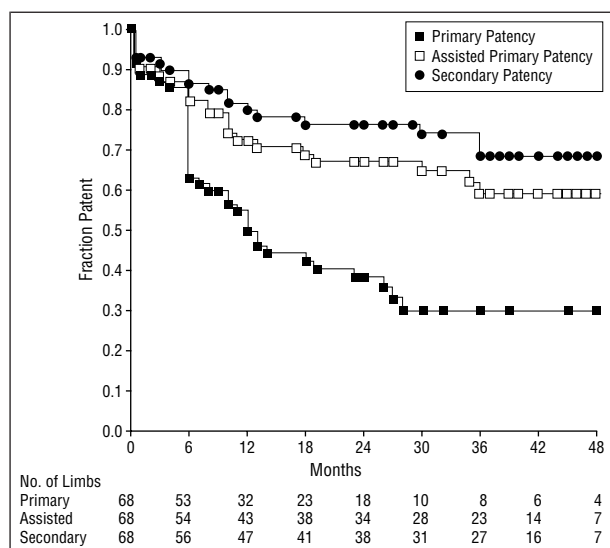
Primary patency at 6 months was  $85.6\% \pm 4.2\%$ , with 1-, 2-, and 3-year cumulative patencies of  $54.6\% \pm 6.3\%$ ,  $38.1\% \pm 6.5\%$ , and  $29.9\% \pm 6.6\%$ , respectively (**Figure 1**). Assisted primary patency was  $82.2\% \pm 4.7\%$  at 6 months, and  $72.3\% \pm 5.6\%$ ,  $66.8\% \pm 6.0\%$ , and  $59.0\% \pm 6.8\%$  at 1, 2, and 3 years, respectively. Secondary patency was  $86.7\% \pm 4.1\%$  at 6 months, and  $81.6\% \pm 4.8\%$ ,  $76.2\% \pm 5.4\%$ , and  $68.3\% \pm 6.5\%$  at 1, 2, and 3 years, respectively. We performed univariate analysis to examine several factors that may affect patency. Length of occlusion did not appear to significantly affect assisted primary patency (**Figure 2**). Although 3-year patency for occlusions greater than 20 cm long was moderately reduced compared with short ( $<10$  cm) and medium length (10-20 cm) occlusions, there were no significant differences be-

**Table 1. Patient Demographics**

Characteristic	No. (%)
Diabetes*	19 (33)
Race*	
Black	20 (35)
White	36 (63)
Current smokers*	22 (39)
Ischemia category†	
1	4 (6)
2	39 (55)
3	21 (30)
4	1 (1)
5	4 (6)
6	2 (3)

\*n = 57 patients.

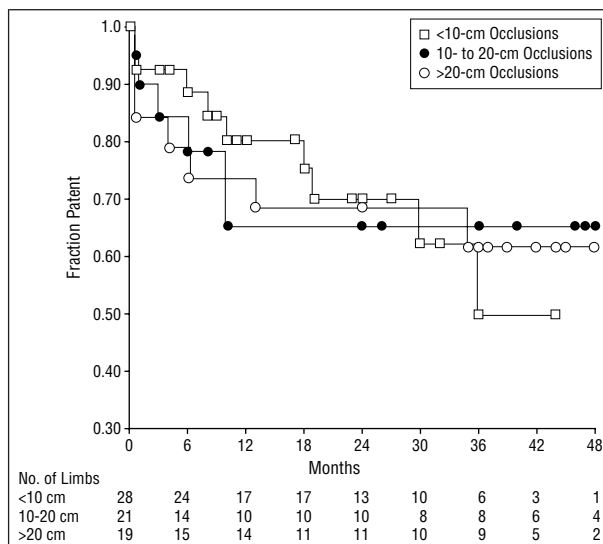
†n = 71 limbs.



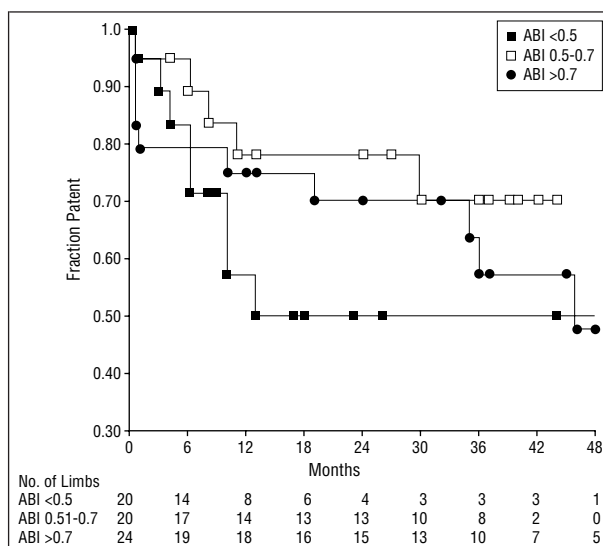
**Figure 1.** Cumulative primary, assisted primary, and secondary patency for all limbs. Numbers of patients at risk at the start of each interval are shown at the bottom.

tween the survival curves. At the end of the first year, decreased assisted primary patency was observed in patients whose initial ABI was less than 0.5 compared with those with higher ABIs at study entry (**Figure 3**), and the difference in patency at 1 year between those with ABIs less than 0.5 compared with those with ABI greater than 0.7 was significantly different ( $\chi^2$  test,  $P = .04$ ). After the first year, the differences in patency decreased, and the overall survival curves were not significantly different by log-rank analysis. When the difference between preprocedural and postprocedural ABI ( $\Delta$ ABI) was greater than 0.3, assisted primary patency was moderately more than that observed in limbs where  $\Delta$ ABI was less than 0.3, but the difference was not statistically significant (**Figure 4**).

The need to use urokinase during the initial endovascular treatment episode significantly correlated with worse patency for assisted primary patency (**Figure 5**). The 3-year patency in subjects requiring urokinase was  $35.7\% \pm 12.5\%$  compared with  $70.6\% \pm 7.4\%$  in those not undergoing thrombolysis (log-rank test,  $P = .02$ ). A similar relation between initial urokinase use and decreased

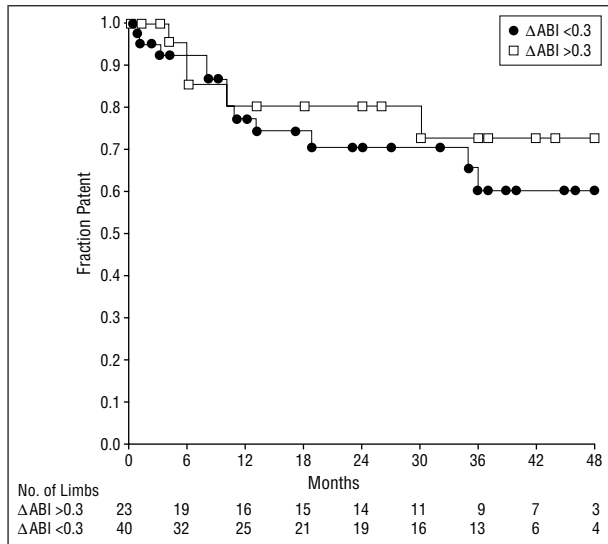


**Figure 2.** Relation between length of occlusion treated and subsequent assisted primary patency. Superficial femoral artery occlusions were divided into 3 groups. The differences between groups were not significant ( $P > .05$ ).

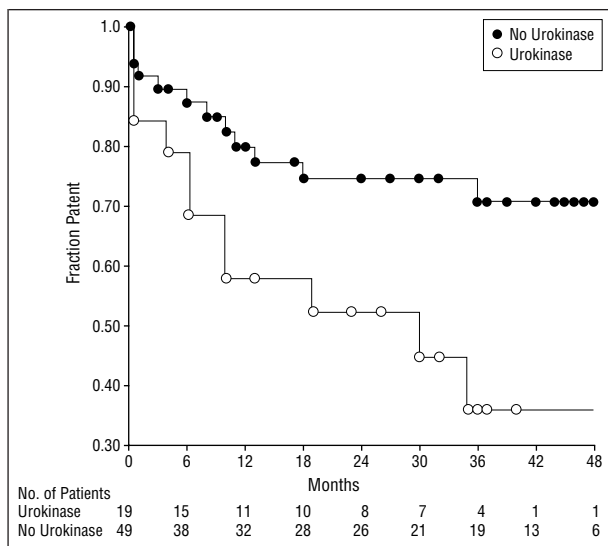


**Figure 3.** Relation between preprocedural ankle brachial index (ABI) and subsequent assisted primary patency. Differences between curves were not significant by log-rank analysis ( $P > .05$ ).

patency was found when primary or secondary patency survival curves were analyzed (data not shown). We examined these 2 groups of patients to determine whether there was a significant difference in occlusion length, current use of tobacco, ABI parameters, or severity of ischemia that could explain the difference in observed patency. Four (21%) of the group requiring urokinase infusion were active tobacco smokers compared with 15 (38%) subjects not requiring thrombolysis. Average occlusion length was  $13.2 \pm 1.4$  cm for the group not requiring thrombolysis compared with  $17.2 \pm 2.3$  cm in the urokinase group ( $P = .13$ ). The urokinase group had a mean preprocedural ABI of  $0.57 \pm 0.03$ , rising  $0.27 \pm 0.02$  after stenting, similar to the no urokinase group whose preprocedural ABI was  $0.56 \pm 0.03$ , rising  $0.26 \pm 0.02$  after stenting—these differences were nonsignificant ( $P > .88$ ). Four (21%) of 19 of the urokinase group had



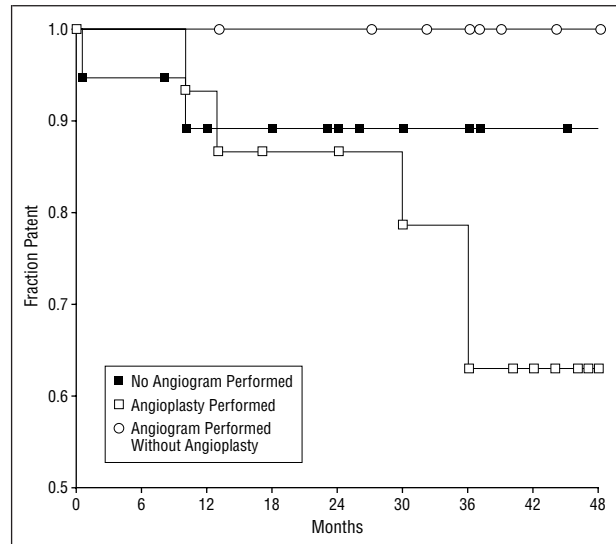
**Figure 4.** Relation between change in ankle brachial index ( $\Delta$ ABI) and assisted primary patency.  $P > .05$ .



**Figure 5.** Relation between need to use urokinase during initial endovascular therapy and subsequent assisted primary patency.  $P = .02$ .

SVS ischemia scores of 4 or higher compared with 3 (6%) of 52 in the no urokinase group, but the difference in proportions was not significant ( $\chi^2$  test,  $P = .14$ ). The mean SVS score for the no urokinase group was  $2.50 \pm 0.90$  and for the urokinase group,  $2.79 \pm 1.32$  (Mann-Whitney test,  $P = .68$ ).

We looked at the impact of angioplasty performed at routine angiographic follow-up on secondary patency (**Figure 6**). Excluded from this analysis are cases where endovascular or surgical intervention was required before elective angiography could be performed, early failures managed with observation, and cases where death, insufficient duration, or noncompliance prevented angiography. A total of 28 primarily patent limbs underwent elective angiographic evaluation between 6 to 12 months. There were 19 primarily patent limbs not restudied in the first year due to patient preference. The patency in 3 groups was analyzed: (1) those who had elec-



**Figure 6.** Relation between elective angiography between 6 and 12 months and subsequent secondary patency. Each limb in this analysis had primary patency through 6 months and was either studied or not because the patient refused. The difference between patency for limbs having percutaneous transluminal angioplasty compared with those studied where percutaneous transluminal angioplasty was not required was significant ( $P = .046$ ).

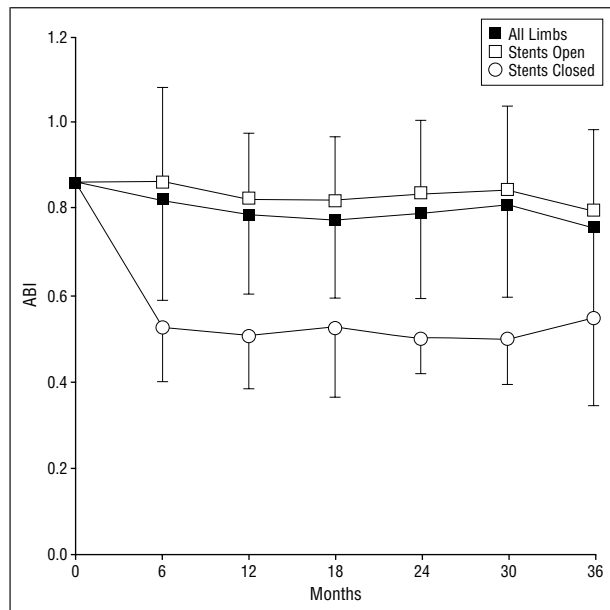
tive angiography but no associated PTA (12 limbs), (2) those who had PTA performed within the previously stented arterial segment (16 limbs), and (3) those who did not undergo elective angiography within the first year (19 limbs). There was 100% cumulative secondary patency at 3 years in limbs undergoing angiography that had insufficient intimal hyperplasia or restenosis to warrant PTA. In contrast, when PTA was performed at elective follow-up, secondary patency at 3 years was  $63.0\% \pm 13.3\%$ ; subjects who did not undergo angiography had a 3-year secondary patency of  $89.2\% \pm 7.2\%$ . The difference in patency for limbs not requiring PTA at elective follow-up angiography compared with limbs needing PTA was significant (log-rank test,  $P = .046$ ), but the patency differences between each of these 2 groups and those who did not undergo angiography were not significant. If restenosis severe enough to warrant PTA is encountered at 6 to 12 months, subsequent patency appears to be significantly worse than when PTA is not required. Although we believe that PTA can reduce the impact of intimal hyperplasia developing within stents, our data do not directly support this contention.

The hemodynamic effect of endovascular therapy was examined by assessing trends in ABI. Average ABI was maintained for all limbs throughout the follow-up close to the immediate postprocedural level (**Figure 7**). At all intervals, limbs with patent stents had significantly higher mean ABIs than those observed in limbs with SFA reocclusion ( $t$  test,  $P < .05$ ).

**Figure 8** depicts the typical angiograms seen with PTA and stenting of occluded femoropopliteal segments. The artery remains patent 44 months after initial treatment.

Periprocedural complications are summarized in **Table 2**. There were 2 deaths in the first 30 days, both related to endovascular therapy. The first was the result of bleeding into the retroperitoneum starting 48 hours





**Figure 7.** Relation between stent patency and ankle brachial index (ABI). Mean ABI and SDs are depicted for all limbs, limbs with patent stents, and limbs with closed stents. The y intercept represents the mean postprocedural ABI. The difference in ABI for limbs with patent or closed stents was significant at all intervals ( $\chi^2$  test,  $P < .05$ ).



**Figure 8.** A, Chronic distal superficial femoral artery obstruction prior to percutaneous transluminal angioplasty and stent deployment; B, after endovascular therapy.

after all sheaths had been removed. The patient was taking heparin and had received warfarin. Despite emergent groin exploration to repair a bleeding femoral puncture and evacuation of hematoma, he succumbed to multiorgan system failure. The second death occurred a week after stenting and appeared to result from cholesterol microembolism inducing severe acute renal failure. There were 3 other emergent operations precipitated by stenting complications: (1) exploration of the groin, repair of a bleeding femoral puncture, and evacuation of scrotal and retroperitoneal hematoma; (2) iliofemoropopliteal balloon thrombectomy; and (3) ilio-

**Table 2. Periprocedural Complications**

Deaths
Multiorgan failure after retroperitoneal hemorrhage
Renal failure from microcholesterol emboli
Major or operative
Repair artery, evacuate scrotal and retroperitoneal hematoma
Repair artery, evacuate hematoma
Femoral thrombectomy with fasciotomies
Femoral thrombectomy
Hypotension from bleeding requiring transfusion
Minor
Tibial embolus treated with urokinase
Tibial embolus, not treated
Transient hypertension, not treated
Transient hypertension, not treated
Leg swelling treated conservatively
Popliteal arteriovenous fistula, not treated

**Table 3. Amputations and Surgical Revascularizations During Follow-up\***

Limb No.	Stent Patency, mo	Limb Fate	Revascularization
6	6	Intact	Femoropopliteal bypass
10	47†	Syme amputation	None
18	4	BKA	Femoropopliteal bypass
19	36	Intact	Femorotibial bypass
21	<1	AKA	None
24	30	Intact	Femoropopliteal bypass
41	6	Intact	Femorofemoral and femoropopliteal bypass
40	10	Intact	Femoropopliteal bypass
55	23	AKA	None
56	8	Intact	Femoropopliteal bypass
63	6	BKA	None

\*BKA indicates below-knee amputation; AKA, above-knee amputation.  
†Remains patent.

femoropopliteal balloon thrombectomy with fasciotomies. In both the last 2 cases, operation was undertaken after intra-arterial thrombolysis failed to relieve new limb-threatening ischemia, and in both, limb function was preserved without tissue loss. Another complication was the development of transient hypotension from bleeding immediately after stent deployment, which required transfusion. There were 6 complications judged as minor, for an overall procedural mortality of 2.8% and complication rate of 15.5%.

Five patients (7%) required major amputation and 6 (8%) required infrainguinal bypass during follow-up (**Table 3**). Two of the amputations occurred (limb numbers 10 and 55) in patients with critical ischemia despite successful endovascular therapy—in both cases, amputation was required for advanced tissue loss, and in both, the SFAs were patent at last follow-up. In limb numbers 21 and 63, amputation was performed after stent failure in patients deemed unsuitable for bypass because of prohibitive medical risk. In limb number 21, critical ischemia was present prior to endovascular therapy. The stent occluded immediately after deployment, and, despite urokinase administration, patency could not be

**Table 4. Results of Endovascular Therapy of Femoropopliteal Occlusions\***

Year	Authors	n	Stent	Mean Occlusion Length, cm	Patients With Critical Ischemia, %	% Totally Occluded	% Patent at 1 y		% Patent at 2 y	
							Primary	Secondary	Primary	Secondary
1991	Zollikofer et al <sup>12</sup>	12	W	13.5	23	100	...	55	...	...
1992	Sapoval et al <sup>2</sup>	18	W	6.6	14	100	49	69	49	55
1995	Henry et al <sup>13</sup>	41	P	4	7	100	58	92	43	86
1997	Strecker et al <sup>14</sup>	47	S	8.2	...	100	47	...	33	...
1997	Damaraju et al <sup>15</sup>	41	W	...	23	Most	49	...	41	...
1997	Gray et al <sup>1</sup>	58	W + P	15	53	90	22	...	...	...
	Present study	71	W + P	14.5	10	100	55	82	38	76
1994	Matsi et al <sup>16</sup>	69	PTA only	5.5	0	...	40	...	...	...
1994	London et al <sup>7</sup>	200	PTA only	11	11	100	56	...	46	...
1994	Gordon et al <sup>17</sup>	40	PTA only	18	0	100	29	...	...	...
1995	Murray et al <sup>18</sup>	26	PTA only	22	23	100	86	...	52	...

\*PTA indicates percutaneous transluminal angioplasty; W, Wallstent; P, Palmaz; S, Strecker; and ellipses, data not available.

maintained. Subsequent bypass was not performed because of the patient's comorbidities and operative risk. This was the only instance where initial failure of stenting led to subsequent amputation. Amputation of limb number 63 was necessitated 9 months after revascularization and 3 months after the SFA reoccluded and was unsuccessfully treated with intra-arterial thrombolysis. The fifth amputation (limb 18) involved a stent that closed at 4 months, followed by an unsuccessful femoropopliteal bypass. The remaining 6 operative arterial reconstructions had successful limb salvage outcomes. Overall there were 3 amputations in the 7 patients who had critical ischemia prior to stenting compared with 2 amputations in the 64 claudicants enrolled ( $\chi^2$  test,  $P < .006$ ).

Supplemental contrast fluoroscopy procedures were used in this series to follow-up patients and maintain patency. As noted earlier, 19 subjects refused elective angiography between 6 and 12 months. Forty-eight limbs received an angiography at least once during follow-up, with a total of 71 diagnostic angiograms performed after initial therapy. In this series, 31 (44%) of 71 limbs required supplemental procedures: PTA was required at least once in 31 limbs, stents in 4 limbs, and thrombolysis in 8 limbs, with 56 total adjunctive procedures being performed. Counting each initial revascularization as 1 intervention and not counting diagnostic angiography as an intervention, a total of 127 therapeutic interventions were performed on 71 limbs to induce and maintain patency, representing an average of 1.8 procedures per limb enrolled in the study.

#### COMMENT

We report on a group of consecutive patients, treated with the same endovascular therapy, with similar atherosclerotic disease, as none had undergone previous treatment. The primary and secondary patency rates achieved at 1 and 2 years in our series are comparable to those reported in other series of PTA or PTA with stenting of chronic femoropopliteal occlusions (**Table 4**), particularly those reported by Henry et al,<sup>13</sup> whose study subjects were similar in their proportion of functional and critical ischemia. Preprocedural ischemia has been shown to be an important prognostic factor for patency after sur-

gical revascularization, where bypass patency negatively correlates with the severity of ischemia,<sup>19,20</sup> and has also been shown to influence the results of endovascular therapy.<sup>21</sup> The relation between the patencies and demographics of various series summarized in Table 4 also suggest that severity of ischemia (represented by proportions of subjects with critical ischemia) negatively correlates with patency after endovascular therapy. The exclusion of previously treated limbs in our series may have favorably influenced patency results compared with results of previous studies, as subjects who have already failed endovascular therapy would be more likely to have unfavorable characteristics influencing patency, such as tobacco dependency,<sup>22</sup> than those never treated.

Several investigators have noted a negative correlation between occlusion length and patency<sup>14,21,23</sup>; this was a strong relation in our previous study of PTA for chronic femoropopliteal occlusion.<sup>17</sup> The absence of such a correlation in the present study possibly is related to some feature of our endovascular method, which better opposes the biological influence that lesion length usually exerts. Such a methodological factor could be aggressive stenting of neighboring stenoses or the frequent performance of additional PTA after the initial endovascular episode. Possibly, using stenting as initial therapy for chronic occlusion favorably influenced the results. Given the differences in ischemia severity, indications for stenting, lesion lengths, and technical details of this investigation compared with earlier ones, it is difficult to ascribe the lack of a significant relation between patency and lesion length to any specific factor. The absence of a significant relation between length and patency may simply reflect small numbers in each length subgroup, such that the usual correlation was obscured (type II error). Similarly, low subgroup numbers may have weakened the power of the analysis to show a significant relation between patency and ABI parameters.

The association between initial urokinase use and subsequent worsened patency was unexpected. Cigarette consumption, ABI parameters, and mean occlusion length differences between the 2 groups (those requiring and not requiring initial thrombolysis) do not appear to explain the patency difference; the severity of presenting ischemia was more severe in the thromboly-

sis group, but this difference also failed to be significant. The need for lytic therapy may be a surrogate marker for other factors that induce worse patency, such as unappreciated residual dissection or stenosis. Further studies with multivariate analysis may clarify the issue.

At the time this study commenced, it was not clear what form of periprocedural anticoagulation therapy would offer an optimal balance between the risks of early stent thrombosis and anticoagulant-associated bleeding. We chose to use an aggressive periprocedural anticoagulation regimen (early resumption of heparin, aspirin, and warfarin therapy initiated within 24-48 hours), because we were concerned that otherwise, early stent thrombosis that could be avoided might obscure the long-term results. The occurrence late in the study of a fatal retroperitoneal hemorrhage led us to change our strategy, and we adopted aspirin alone for subsequent anticoagulation. Since changing to aspirin alone, we have not seen an increased frequency of early stent thrombosis.

Supragenicular bypass with prosthetic grafts had a 3-year primary patency of 60% in a recent prospective, multicenter, randomized trial in which no operative deaths were noted in 244 cases.<sup>24</sup> Primary patency in this surgical series is similar to the assisted primary patency at 3 years (59%) achieved in this endovascular series. Comparisons of endovascular and conventional surgical therapy should consider initial costs, procedural morbidities, and the need for supplemental procedures. Infragenicular bypass has different associated common complications (eg, seromas, wound necrosis, graft sepsis<sup>25</sup>) than do endovascular methods (eg, tibial emboli and puncture site bleeding<sup>26</sup>). The morbidity noted in this study is fairly representative of other endovascular series, many of which have comparable 30-day mortalities and major complication rates.<sup>13,14,21,23</sup> It is not clear whether endovascular therapy is safer or more economical than conventional bypass, as the large number of supplemental procedures required by endovascular methods are both costly and renew the exposure of patients to procedural complications. A less invasive initial strategy that requires many adjunctive procedures may, in the long run, be worse than a riskier and more invasive initial procedure with better primary patency. Predictably, controversy regarding the merits of endovascular therapy vs bypass will develop, much like that regarding prosthetic vs autologous vein conduits for femoropopliteal bypass—prosthetic conduits have poorer long-term patency and require more adjunctive procedures but entail shorter incisions and operations.

It should be appreciated that many of the patients treated in this trial would not normally have femoropopliteal bypass surgery offered as therapy. Our practice is to avoid infrainguinal reconstructions for claudication alone, unless the patient is truly incapacitated, and femoropopliteal bypass is only rarely performed for functional ischemia at our institutions. The results of stenting critically ischemic limbs suggest that with increasingly severe ischemia, worse patency is to be expected. It may be that the best results with stenting femoropopliteal occlusions are achieved with patients who need the intervention the least. We believe that bypass with autologous vein should still be considered the best inter-

vention for critical ischemia, with endovascular therapy reserved for the patient with prohibitive operative risks. Should SFA occlusion in claudicatory patients be treated with endovascular therapy outside the context of clinical studies? Given the good results achieved with medication and exercise,<sup>27-29</sup> and the risks and costs of endovascular revascularization, we believe that most claudicatory patients should not be managed with current endovascular methods.

The patencies observed in this study do suggest, however, that better results, more comparable to those achieved with bypass, may eventually be achievable with devices such as coated stents<sup>30-35</sup> or possibly with the addition of adjunctive brachytherapy.<sup>36,37</sup> Ultimately, as endovascular devices and methods improve and mature, good prospective trials comparing conservative, endovascular, and surgical therapies will be needed to understand the optimal roles of each in the management of femoropopliteal atherosclerosis.

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### ARCHIVES OF INTERNAL MEDICINE

#### Hormone Replacement Therapy and Peripheral Arterial Disease: The Rotterdam Study

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**Background:** As the number of elderly women increases in Western society, peripheral arterial disease (PAD) is likely to become an increasing problem. Hormone replacement therapy, suggested to protect against coronary atherosclerosis, might also inhibit the development of PAD.

**Methods:** The association between hormone replacement therapy and the presence of PAD was studied in a population-based study consisting of 2196 naturally menopausal women aged 55 to 80 years living in a suburban area of Rotterdam, the Netherlands. Peripheral arterial disease was defined as an ankle/arm systolic blood pressure index (ratio of the systolic blood pressure at the ankle to the systolic blood pressure at the arm) lower than 0.9.

**Results:** Hormone replacement therapy for 1 year or longer was associated with a 52% decreased risk of PAD (odds ratio, 0.48 [95% confidence interval, 0.24-0.85]), while no association was found for therapy duration shorter than 1 year (odds ratio, 0.97 [95% confidence interval, 0.58-1.63]) after adjustment for age, smoking, and socioeconomic status. Additional adjustment for body mass index, age at menopause, total cholesterol and high-density lipoprotein cholesterol, alcohol intake, and frequency of visits to health care facilities did not change the results.

**Conclusion:** The findings of this population-based study suggest that hormone replacement therapy given for a year or more is associated with a decreased risk of PAD among postmenopausal women. (2000;160:2498-2502)

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