Acute ischemia secondary to popliteal artery stent fracture and embolization

Annalise M. Panthofer, BS,[a] Jeniann A. Yi, MD,[b] Andy C. Chiou, MD, MPH,[c] *and* Jon S. Matsumura, MD,[a] *Madison, WI; Aurora, CO, and Peoria, IL*

ABSTRACT

Femoropopliteal disease comprises more than one half of lesions in peripheral vascular disease. The treatment modalities for stenosis or occlusion of this anatomic region include femoropopliteal bypass and percutaneous transluminal angioplasty with or without stenting. Our patient developed acute leg ischemia 3 years after stenting, secondary to stent fracture, with distal embolization of stent fragments. Using mechanical thromboembolectomy and superficial femoral artery to below-the-knee popliteal in situ saphenous vein bypass, we were able to restore perfusion to the limb and retrieve fragments of the fractured stent. (J Vasc Surg Cases Innov Tech 2023;9:101143.)

Keywords: Arterial occlusive diseases; Chronic limb-threatening ischemia; Intermittent claudication; Peripheral arterial disease; Self-expandable metallic stents; Venous stent; Venous thrombosis

The prevalence of percutaneous transluminal angioplasty (PTA) and stent placement in the coronary anatomy and the iliac system have paved the way for other applications within the peripheral vascular system, including the abdominal aorta, renal arteries, carotid arteries, and arteries of the lower extremities. Limited long-term data are available regarding PTA and stenting of the lower extremities, primarily the femoropopliteal segment, although evidence has shown that stenting has acceptable short- and mid-term patency in select patients.[1-4] Compared with other vascular anatomic regions, femoropopliteal disease is often more complex, with longer and more diffuse atherosclerotic lesions that tend to be multilevel. Surgical bypass has traditionally been used as treatment for these complicated lesions; however, endovascular therapies, including PTA and stenting, have emerged as alternative treatments. Careful evaluation of the indications, morbidity, and long-term results is underway, and a wide variety of complications, including stent fractures, has been reported.[5-10] We report the case of a popliteal stent fracture with distal fragment embolization that required emergent surgical bypass. The patient provided written informed consent for the report of his case details and imaging studies.

CASE REPORT

A 45-year-old man was emergently transferred to our unit after presenting with sudden-onset of severe right leg pain, a cold foot, and calf muscle weakness. Three years prior, the patient underwent angiography for intermittent claudication, which revealed a short-segment above-the-knee right popliteal artery stenosis. This stenosis was treated with PTA, which was thought to be suboptimal, and a self-expanding Wallstent (Boston Scientific) was placed (Fig 1).

The initial evaluation revealed nonpalpable pedal pulses and absent Doppler signals distal to and at the popliteal fossa. Myopathic changes, including pain with muscle weakness, were pronounced, and emergent diagnostic angiography, fasciotomy, and surgical reconstruction were performed. On intraoperative diagnostic angiography, the superficial femoral artery was occluded, with reconstitution of flow visualized at the below-the-knee (BK) popliteal artery (Fig 2). A fractured stent was identified in the above-the-knee popliteal artery (Fig 3).

Operation. Through a medial approach, the right popliteal artery was explored, and an acute thrombus was identified. A Fogarty embolectomy catheter (Edwards Lifesciences LLC) was used and taken to 35 cm to confirm

From the Division of Vascular Surgery, Department of Surgery, University of Wisconsin School of Medicine and Public Health, Madison[a]; the Division of Vascular Surgery, Department of Surgery, University of Colorado Anschutz Medical Campus, Aurora[b]; and the Peoria Vein Center, Peoria.[c]

Author conflict of interest: A.M.P. is supported by the University of Wisconsin Institute for Clinical and Translational Research-Shapiro Yearlong Research Fellowship. J.A.Y. is a consultant for Silk Road Medical. J.S.M. receives institutional grant support from Abbott, W.L. Gore & Associates, Cook Medical Inc, Endologix, and Medtronic. A.C.C. has no conflicts of interest.

Correspondence: Annalise M. Panthofer, BS, Division of Vascular Surgery, Department of Surgery, University of Wisconsin School of Medicine and Public Health, 600 Highland Ave, H4/735, Madison, WI 53792 (e-mail: panthofer@surgery.wisc.edu).

The editors and reviewers of this article have no relevant financial relationships to disclose per the Journal policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

2468-4287

https://doi.org/10.1016/j.jvscit.2023.101143

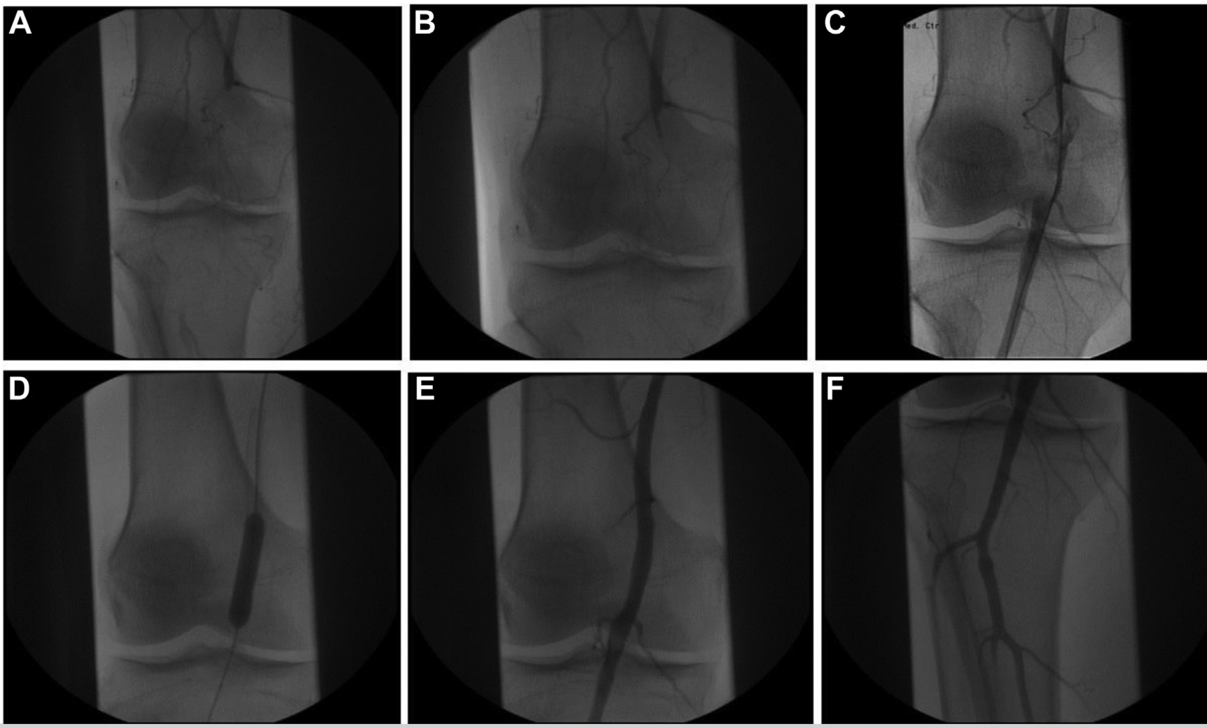

Fig 1. Views of preimplant angiogram revealing a short-segment above-the-knee right popliteal artery stenosis (**A,B**), prompting treatment with percutaneous transluminal angioplasty (**C,D**) with a self-expanding Wallstent (**E,F**) 3 years before the acute presentation described in the present report.

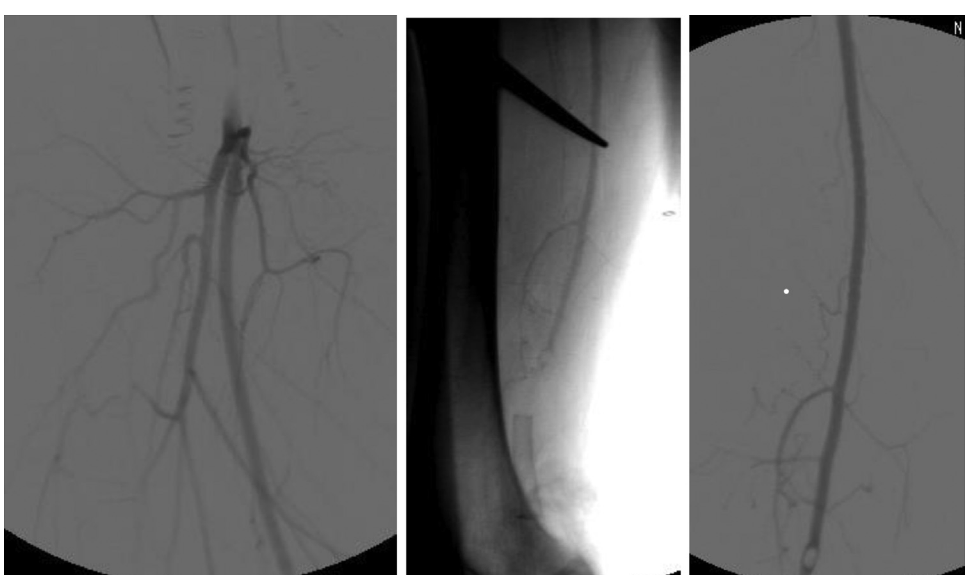

Fig 2. Intraoperative diagnostic angiography was performed in response to acute limb ischemia and revealed visualization of the superficial femoral artery reconstitution of flow with poor runoff at the below-the-knee (BK) popliteal artery.

outflow patency and perform embolectomy. A right superficial femoral artery to BK popliteal artery in situ saphenous vein bypass was performed (Fig 4). Doppler signals to the ankle were still absent. The patient underwent a repeated and more aggressive catheter thromboembolectomy (ie, with more balloon insufflation and greater wall contact) through the hood of the vein bypass, resulting in removal of more thrombus and

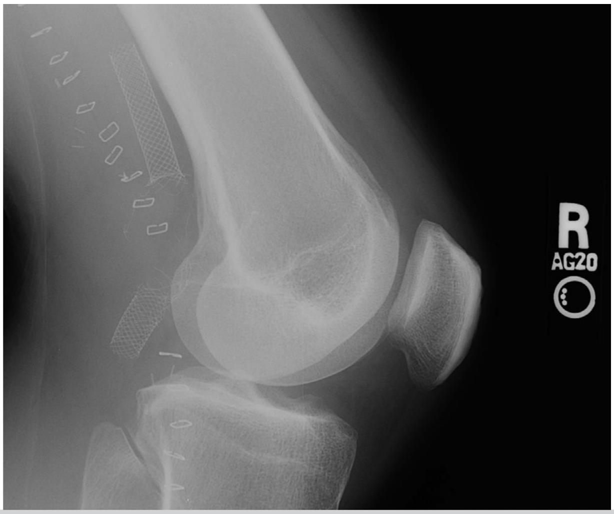

Fig 3. A fractured stent visualized in the above-the-knee popliteal artery.

Fig 4. A right superficial femoral artery to below-the-knee popliteal in situ saphenous vein bypass was performed.

some fragments of the Wallstent that had embolized distally (Fig 5). Tissue plasminogen activator 4 mg was infused through the BK popliteal artery during a 45-minute period. Subsequently, Doppler signals were present in the posterior tibial artery, and the foot appeared clinically viable. Final completion angiography revealed a single-vessel runoff to the posterior tibial artery. A four-compartment fasciotomy of the right calf was also performed, in anticipation of compartment syndrome. The patient tolerated the procedure well without any subsequent complications or operations and was discharged on the fourth postoperative day with a 10-week course of warfarin.

Postoperative course. At 10 weeks postoperatively, duplex ultrasound showed a widely patent bypass graft. Pulses were palpable in the graft and posterior tibial artery. The patient was ambulating without any difficulties.

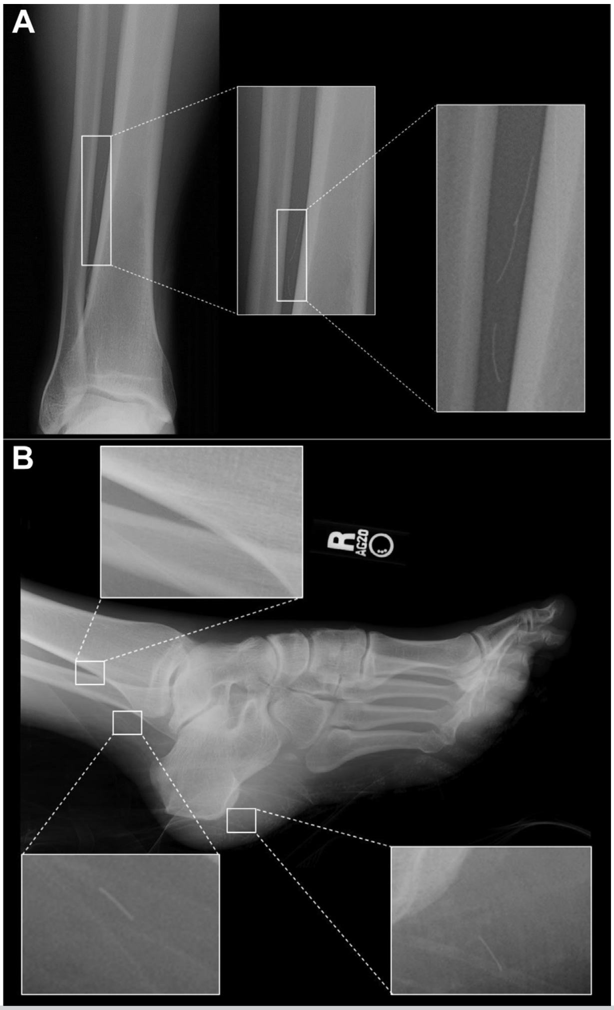

Fig 5. Distally embolized fragments of the Wallstent in the peroneal artery (**A**) and its distal branches (**B**).

His warfarin was discontinued, and he resumed his prior regimen of aspirin. At 2 years postoperatively, primary patency of the bypass graft was maintained.

DISCUSSION

Dotter and Judgkins first predicted the possible benefits of intravascular stenting in combination with PTA in 1964 (Dotter CT, Judkins MP. Transluminal treatment of arteriosclerotic obstruction. *Circulation*. 1964;30(5):654-670. doi:10.1161/01.cir.30.5.654). Five years later, Dotter[11] reported his experience with implanting coil-spring tube grafts in canine popliteal arteries. Not until 14 years later did the principle begin to see application in the clinical setting. The last three decades have seen abundant growth and extensive clinical trials exploring many different models in search of the ideal stent. Although the short- and mid-term results have been promising with the use of these stents, long-term outcomes are less explored.

The reported patency rates vary. Wallstents in the iliac and femoral arteries have reported primary patency rates of 61% at 1 year and 49% at 2 years.[8] Nitinol stents have a primary patency rate of 85% at 1 year.[12] Others have reported first-year patency of stents in the femoropopliteal system of 49% to 81%.[13-15] The long-term patency rates for femoropopliteal stenting and PTA currently do not demonstrate equivalence or equipoise with the 5-year surgical bypass patency rates.[16-18] Recently, the BEST-CLI (best endovascular vs best surgical therapy in patients with critical limb ischemia) trial reported superior outcomes for bypass in patients with an adequate saphenous vein.[19] Two primary reasons for the decreased patency with PTA and stenting include early thrombosis and intimal hyperplasia.[14] Additionally, lesions >10 cm are associated with lower patency rates, reported to be 20% to 69% in the first year.[20,21] Conversely, larger arterial diameters are associated with higher patency rates.[13,20]

Increasingly, fractures have emerged as a significant risk factor for late stent failure in the peripheral arteries, with reports of stent fractures in the biliary tract, dialysis grafts, esophagus, coronary arteries, subclavian arteries, abdominal aorta, and, even, veins. The clinical effects of this event vary from catastrophic to inconsequential.[22] Although fractures in the iliac, femoral, and popliteal arteries have been reported, reports are limited of acute limb ischemia due to embolization of stent fragments, especially in the femoropopliteal region. Other clinical sequelae of stent fracture can include pseudoaneurysm, infection, vessel rupture, arterial dissection, compartment syndrome, and amputation.

Given the potentially severe and life-threatening consequences of stent fracture, its etiology has been explored in several studies. The rigidity of densely calcified arteries has been associated with stent fracture, with one study of carotid stents reporting that the presence of calcification resulted in a 7.7 times greater odds of a fractured stent.[23] Metal-on-metal stress created by overlapping stents and their associated rigidity is another proposed mechanism for stent fracture.[24] Biomechanical forces, including flexion, torsion, pulsion, compression, and elongation, play a fundamental role in the development of stent fracture,[12] especially in the highly dynamic and mobile femoropopliteal region. Diaz et al[25] explored the use of dynamic angiography to assess the stress in the popliteal artery. They concluded that evaluating patients' popliteal artery dynamics in flexion, in conjunction with using the most durable stent (ie, self-expandable stents for their crush reversibility), might help prevent stent fracture by identifying the most appropriate site for stent implantation. The rate of stent fracture and its associated complications could, thus, be mitigated by (1) designing stents to better respond to the dynamic mechanics of the femoropopliteal region and (2) identifying the optimal implantation site to minimize mechanical stressors.

CONCLUSIONS

Stenting is a common treatment option for patients with femoropopliteal disease. As advances in materials, engineering, and manufacturing technology progress, improvements are expected in the durability of stents and their long-term results. Although rare, stent fracture can be a dangerous complication, and clinicians should be aware of the potential for distal fragment embolization. Future stent development must consider the lower extremity mechanics and their interaction with implanted stents to improve the durability of endovascular treatment, particularly of the highly dynamic femoropopliteal segment.

REFERENCES

1. Montero-Baker M, Ziomek GJ, Leon L, et al. Analysis of endovascular therapy for femoropopliteal disease with the Supera stent. J Vasc Surg 2016;64:1002-8.
2. Saxon RR, Chervu A, Jones PA, et al. Heparin-bonded, expanded Polytetrafluoroethylene-lined stent graft in the treatment of femoropopliteal artery disease: 1-year results of the VIPER (Viabahn Endoprosthesis with Heparin Bioactive Surface in the treatment of superficial femoral artery Obstructive disease) trial. J Vasc Interv Radiol 2013;24:165-73.
3. Mwipatayi BP, Hockings A, Hofmann M, Garbowski M, Sieunarine K. Balloon angioplasty compared with stenting for treatment of femoropopliteal occlusive disease: a meta-analysis. J Vasc Surg 2008;47:461-9.
4. Rocha-Singh KJ, Bosiers M, Schultz G, Jaff MR, Mehta M, Matsumura JS. A single stent strategy in patients with lifestyle limiting claudication: 3-year results from the durability II trial. Catheter Cardiovasc Interv 2015;86:164-70.
5. Becker GJ. Intravascular stents. General principles and status of lower-extremity arterial applications. Circulation 1991;83:I122-36.
6. Becker GJ, Palmaz JC, Rees CR, et al. Angioplasty-induced dissections in human iliac arteries: management with palmaz balloon-expandable intraluminal stents. Radiology 1990;176:31-8.
7. Palmaz JC, Garcia OJ, Schatz RA, et al. Placement of balloon-expandable intraluminal stents in iliac arteries: first 171 procedures. Radiology 1990;174:969-75.
8. Martin EC, Katzen BT, Benenati JF, et al. Multicenter trial of the wallstent in the iliac and femoral arteries. J Vasc Interv Radiol 1995;6:843-9.
9. Babal E, Gülbaran M, Gürmen T, Öztürk S. Fracture of popliteal artery stents. Circ J 2003;67:643-5.
10. Carpenter JP, Anderson WN, Brewster DC, et al. Multicenter pivotal trial results of the Lifepath System for endovascular aortic aneurysm repair. J Vasc Surg 2004;39:34-42.
11. Dotter CT. Transluminally-placed Coilspring Endarterial tube grafts. Invest Radiol 1969;4:329-32.
12. Allie DE, Hebert CJ, Walker CM. Nitinol stent fractures in the SFA. Endovasc Today 2004;7:22-34.
13. Henry M, Amor M, Ethevenot G, Henry I, Amicabile C, Beron R, et al. Palmaz stent placement in iliac and femoropopliteal arteries: primary and secondary patency in 310 patients with 2-4-year follow-up. Radiology 1995;197:167-74.
14. Do-dai-Do, Triller J, Walpoth BH, Stirnemann P, Mahler F. A comparison study of self-expandable stents vs balloon angioplasty alone in femoropopliteal artery occlusions. Cardiovasc Intervent Radiol 1992;15:306-12.
15. Sapoval MR, Long AL, Raynaud AC, Beyssen BM, Fiessinger JN, Gaux JC. Femoropopliteal stent placement: long-term results. Radiology 1992;184:833-9.
16. Johnston KW, Rae M, Hogg-Johnston SA, Colapinto RF, Walker PM, Baird RJ, et al. 5-year results of a Prospective study of percutaneous transluminal angioplasty. Ann Surg 1987;206:403-13.
17. Adar R, Critchfield GC, Eddy DM. A confidence profile analysis of the results of femoropopliteal percutaneous transluminal angioplasty in the treatment of lower-extremity ischemia. J Vasc Surg 1989;10:0057-67.
18. Matsi PJ, Manninen HI. Impact of different patency criteria on long-term results of femoropopliteal angioplasty: analysis of 106 consecutive patients with claudication. J Vasc Interv Radiol 1995;6:159-63.
19. Farber A, Menard MT, Conte MS, Kaufman JA, Powell RJ, Choudhry NK, et al. Surgery or endovascular therapy for chronic limb-threatening ischemia. N Engl J Med 2022;387:2305-16.
20. Capek P, McLean GK, Berkowitz HD. Femoropopliteal angioplasty. Factors influencing long-term success. Circulation 1991;83:I70-80.
21. Murray JG, Apthorp LA, Wilkins RA. Long-segment (> or = 10 cm) femoropopliteal angioplasty: improved technical success and long-term patency. Radiology 1995;195:158-62.
22. Weinberg I, Beckman JA, Matsumura JS, Rosenfield K, Ansel GM, Chaturvedi S, et al. Carotid stent fractures are not associated with adverse events: results from the ACT-1 multicenter randomized trial (carotid angioplasty and stenting versus endarterectomy in asymptomatic subjects who are at standard risk for carotid endarterectomy with significant extracranial carotid stenotic disease). Circulation 2018;137:49-56.
23. Ling AJ, Mwipatayi P, Gandhi T, Sieunarine K. Stenting for carotid artery stenosis: fractures, proposed etiology and the need for surveillance. J Vasc Surg 2008;47:1220-6.
24. Lossef SV, Lutz RJ, Mundorf J, Barth KH. Comparison of mechanical deformation properties of metallic stents with use of stress-strain analysis. J Vasc Interv Radiol 1994;5:341-9.
25. Diaz J, Villegas M, Tamashiro G, Micelli M, Enterrios D, Balestrini A, et al. Flexions of the popliteal artery: dynamic angiography712. J Invasive Cardiol 2004;16:712-5.

Submitted Dec 27, 2022; accepted Feb 14, 2023.