Case Report

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Novel technique for arteriovenous fistula stenosis using a nitinol-caged balloon: a case report

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Introduction and Importance: End-stage renal disease patients rely heavily on arteriovenous fistulas (AVFs) for hemodialysis access, but vascular access-related complications such as stenosis frequently compromise long-term patency. Percutaneous transluminal angioplasty (PTA) remains the primary intervention, yet resistant lesions pose significant clinical challenges.
Case Presentation: This case report describes the use off-label of a nitinol-caged balloon (NCB) for treating refractory AVF stenosis that remains unresponsive to standard high-pressure angioplasty. An 85-year-old patient with a juxta-anastomotic stenosis underwent initial balloon dilation with conventional and drug-eluting balloons, which failed to achieve sustained patency. Subsequently, the NCB was employed, providing uniform and controlled expansion while minimizing vascular trauma. The procedure successfully resolved the stenosis, with the patient maintaining long-term fistula patency at 1-year follow-up and no complications.
Clinical Discussion: The patency of an AVF is vital for dialysis patients, but stenosis and occlusion are common complications often caused by neointimal hyperplasia. Standard balloon angioplasty is the first-line treatment; however, resistant cases may benefit from high-pressure or ultra-high-pressure balloons. The NCB device has shown promise for refractory stenosis.
Conclusion: These findings suggest that the NCB may offer a promising alternative for managing resistant AVF stenosis, potentially reducing restenosis rates and preserving vascular access. Further studies are warranted to validate its efficacy and safety in larger patient cohorts.

Keywords: arteriovenous fistula, AVF stenosis, dialysis, PTA, renal failure

Introduction

Worldwide, approximately 2 million people undergo dialysis for end-stage renal disease. Autologous arteriovenous fistula (AVF) is the preferred vascular access for hemodialysis due to its superior patency rates and lower risk of infection compared to arteriovenous grafts and central venous catheters[1,2]. A common approach to treating AVF stenosis is to perform a secondary procedure to restore the fistula[3,4]. Advances in medicine have led to the widespread use of percutaneous transluminal angioplasty (PTA) as the primary treatment for AVF stenosis[5]. High-pressure PTA is considered the first-line intervention[6]. However, some studies indicate that PTA is associated with a high rate of restenosis, primarily due to neointimal hyperplasia, which is the main pathophysiological mechanism underlying vascular restenosis after PTA[7]. Juxta-anastomotic lesions, in particular, are uniquely resistant to angioplasty due to a combination of factors, including pronounced fibrosis, elevated wall shear stress at the anastomosis, and repeated puncture trauma in this segment, which collectively promote aggressive vascular remodeling and limit vessel compliance[8]. This resistance contributes to the high rates of restenosis observed in this critical region and challenges long-term patency[9]. Recently, innovative devices such as the nitinol-caged balloon (NCB) have shown promising results. Approved for balloon dilation of lesions in peripheral vascular segments, including the iliac, femoral, popliteal, infra-popliteal, and renal arteries, this device has also been used, based on our experience, to treat AVF lesions due to its unique design. The NCB offers predictable, uniform, and atraumatic expansion, minimizing issues such as dog-boning and overinflation, thereby reducing

HIGHLIGHTS

- End-stage renal disease patients rely heavily on AVF for hemodialysis access.
- Vascular access complications such as stenosis compromise long-term patency.
- PTA is the primary intervention; resistant lesions are clinical challenges.
- The NCB device has shown promise for refractory stenosis.

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the risk of dissections and decreasing the need for bailout stenting[10]. In this report, we present a novel application of the NCB to successfully treat refractory AVF stenosis that previously resisted high-pressure dilation with standard peripheral angioplasty balloons. This intervention resulted in long-term patency with minimal complications.

This work has been written in accordance with the SCARE criteria[11].

Case presentation

An 85-year-old male patient was diagnosed with stage 5 chronic kidney disease. His medical history includes hypertension, interstitial lung disease, chronic cerebrovascular disease, and type 2 diabetes mellitus. He has been undergoing dialysis via an external CVC for 2 months. In March 2024, an autologous brachiocephalic AVF was created in the left forearm in our hospital for dialysis access. After 2 months, the patient was readmitted due to decreased flow volume during dialysis of the left forearm AVF and absence of thrill. Preoperative ultrasonography revealed a significant juxta-anastomotic stenosis measuring 3 mm in diameter and 4 cm in length, characterized by the absence of arterialized flow in the efferent vein. No thrombosis or calcification was observed. After the discussion, our team decided to perform an angioplasty on the left forearm AVF. Informed consent was obtained before the procedure. After local anesthesia with lidocaine, left trans-radial access with a 5-Fr vascular introducer sheath was secured. After systemic heparinization with 2500 IU, an angiogram of the fistula was performed, revealing a tight stenosis of the vein immediately beyond the anastomosis (Fig. 1). The lesion was crossed with a 0.014 guidewire. Predilatation was performed using plain old balloon angioplsty (POBA) (3 × 120 mm) inflated at nominal pressure for 2 min (Fig. 2). During the next step, angioplasty was performed using a drug eluting balloon (DEB) 6 × 60 mm PTA balloon, inflated to 8 atm for 3 min (Fig. 3). The control angiogram showed residual perianastomotic stenosis of 50% (Fig. 4). Given this situation, the safest approach to minimize the risk of endothelial rupture, dissection or postoperative neointimal hyperplasia was to use a NCB (Chocolate 6 × 80 mm PTA balloon – Medtronic, Minneapolis, Minnesota) (Fig. 5). The balloon was progressively inflated at nominal pressure for at least 3 min, resulting in a crack in the fibrotic segment. Final angiogram showed the resolution of the stenosis, improved flow in the efferent vein, and the reappearance of a thrill over the AVF (Fig. 6). The vascular sheaths were removed, and hemostasis was achieved by manual compression. The patient was discharged 2 days after with successful dialysis

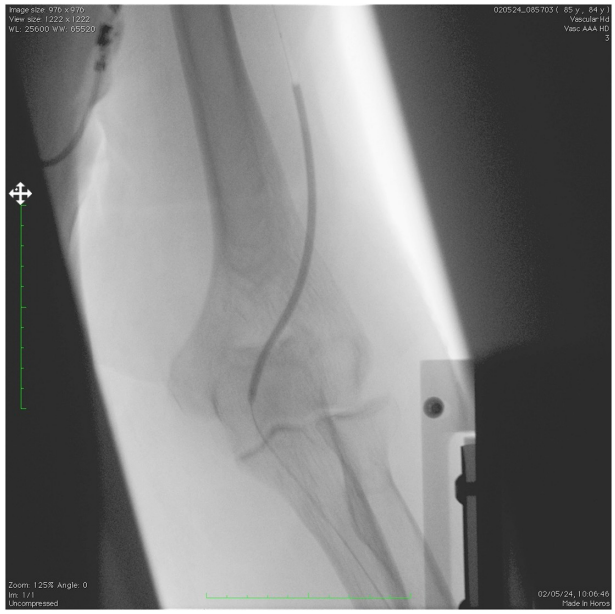

Figure 2. Predilatation with plain old balloon angioplsty.

Figure 1. Digital subtraction angiography showing stenosis at the origin of the efferent vein.

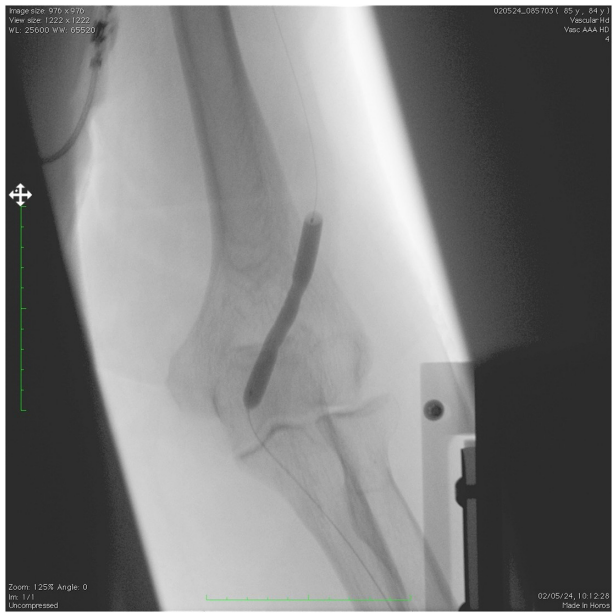

Figure 3. PTA with DEB.

Figure 4. Digital subtraction angiography showing residual stenosis.

sessions via his AVF and no reported postoperative complications, such as thrombosis, heart failure, pseudoaneurysm, infection, or hemodialysis access-induced distal ischemia syndrome. At the 1-year follow-up, the fistula remained patent with normal function, without hemodynamically significant restenosis or significant increase in neointimal thickness, and there were no dialysis-related complications.

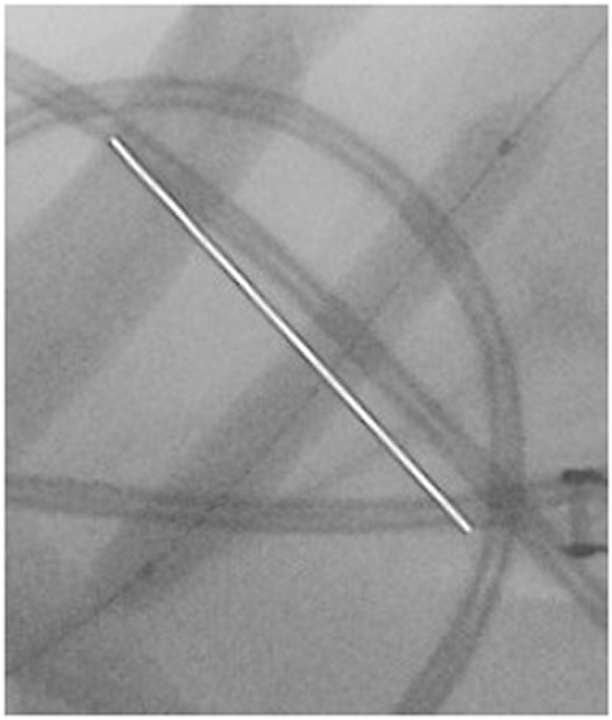

Figure 5. Nitinol-constrained balloon PTA.

Figure 6. Final digital subtraction angiography showing resolution of the stenosis.

Discussion

As the duration of AVF use increases, the incidence of vascular access-related complications, such as AVF stenosis and occlusion, also rises significantly. Common issues include failure to mature, stenosis development, and thrombosis, all of which are frequent problems associated with arteriovenous access[11,12]. Several studies have shown that AVF patency rates are generally around 60–65% at 1 year post-operation, with a 2-year patency rate ranging from 38 to 56%[13,14]. The patency of AVFs is crucial for survival and quality of life in the dialysis population. Maintaining AVF patency is essential for patient survival and quality of life. Primary failure often results from juxta-anastomotic stenosis, the most common site of narrowing or occlusion[7,15–17]. The anastomosis of an AVF can become stenotic due to various factors, with neointimal hyperplasia being the most common[18]. The wall stress in this region promotes vascular remodeling, which can also occur in areas subjected to multiple punctures[19]. PTA remains the recommended first-line treatment for AVF stenosis according to updated Kidney Disease Outcomes Quality Initiative guidelines[20]. Techniques include standard or high-pressure balloons, drug-coated balloons such as paclitaxel, cutting balloons, stenting, and surgery[10,21,22]. According to these guidelines, technical success is defined as achieving a residual stenosis of ≤30%, while clinical success refers to the restoration of adequate access function without the need for additional intervention. Common PTA techniques include standard or high-pressure balloons, DEB, cutting balloons, as well as adjunctive therapies such as stenting or surgical revision when necessary. Outcome reporting should differentiate between target-lesion primary patency, the freedom from restenosis or reintervention at the treated site and access-circuit patency, which reflects the overall functionality of the entire vascular access[20,23]. High- and ultra-high-pressure PTA achieve technical success rates of 90–95%, outperforming standard balloons (70–80%)[24,25]. Precise control of inflation

pressure is crucial to avoid elastic recoil or vessel injury, both of which contribute to restenosis[26]. However, about 20% of stenoses prove resistant to standard PTA due to fibrosis, necessitating alternative approaches. Repeat PTA or bare-metal stenting often yields limited long-term success. In recent years, DEBs, particularly those coated with paclitaxel, have shown superiority over plain old POBA in maintaining AVF patency, as demonstrated by randomized controlled trials such as the IN.PACT AV study, which reported significantly improved target lesion primary patency at 6 months[27]. DEBs reduce neointimal hyperplasia by delivering antiproliferative agents locally, thus addressing one of the main mechanisms of restenosis. Cutting and scoring balloons represent another strategy for resistant lesions, providing controlled plaque modification through microblades or scoring elements that facilitate vessel dilation while minimizing trauma and reducing elastic recoil[28,29]. These devices have shown promise in resistant or fibrocalcific lesions but may increase the risk of vessel injury and require careful technique. Compared to cutting/scoring balloons and DEBs, the NCB offers a unique mechanical advantage by uniformly distributing radial forces and minimizing "dog-boning" and vessel trauma through its constraining nitinol cage. While the NCB does not deliver pharmacologic therapy, its ability to achieve controlled expansion may complement or serve as an alternative to existing modalities, especially in lesions refractory to conventional PTA. Although the benefits of the NCB are well documented in peripheral arterial interventions, high-quality comparative data evaluating NCBs against other specialized balloons in the AVF setting remain limited, highlighting the need for further research[30,31]. The need to post-dilate resistant stenoses, those unresponsive to initial PTA, to reduce the risk of lesions requiring stenting or surgical repair has led us to consider a tool already widely used in peripheral vessel preparation: the NCB. This device features a nitinol constraining structure that allows uniform and controlled inflation and rapid deflation. The retaining structure creates "balloon pillows" and grooves designed to limit balloon elongation during angioplasty and reduce radial stress on vessel walls, thereby minimizing vessel damage[24]. Given its proven effectiveness in peripheral arterial interventions, we hypothesized that the NCB could be a valuable option for treating AVF restenosis or refractory stenosis, as it provides uniform expansion and nearly eliminates "dog-boning" phenomena. Although the NCB has proven effective in managing restenosis in peripheral arterial disease, evidence supporting its use for refractory stenosis in AVF patients is limited, and its application in this context remains off-label. Several recent studies have explored the use of the NCB in the treatment of stenoses of AVFs. Additionally, using the NCB as a first-line device in tight "hourglass" stenoses may be more cost-effective than sequentially employing multiple peripheral balloons, reducing procedure time and resource use. In this case report, we successfully performed AVF PTA using an NCB to treat resistant stenosis after standard balloon angioplasty failed, achieving long-term patency. This approach reduces the number of balloons required, saves time and resources, and should be considered a viable treatment alternative.

Conclusions

In conclusion, the NCB achieved both technical and clinical success in treating refractory stenosis of AVF at the juxta-anastomotic site of fistulas. Its structure reduces trauma to the endothelium of the vascular wall, lowering the risk of dissection or neointimal hyperplasia, and was associated with no adverse events and long-term patency. This approach is an effective method to preserve limited vascular resources. It could become a future tool for PTA in dialysis fistulas, providing a viable alternative for managing challenging lesions. Further studies involving larger patient populations are necessary to optimize this interventional technique and improve outcomes for patients with refractory AVF stenosis. Randomized controlled trials are needed to establish its comparative effectiveness and to define its role within current treatment algorithms.

Ethical approval

All procedures followed were in accordance with the ethical standards of the Institutional Committee on Human Experimentation and with the Helsinki Declaration. According to the internal review board, the retrospective and anonymized nature of the study did not require medical ethical committee approval.

Consent

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contributions

Conceptualization, R.F., E.D., and D.M.; methodology, E.D. and F.P.; software, R.F.; validation, D.M., E.D., and F.P.; formal analysis, R.F. and E.D.; investigation, R.F.; resources, R.F. and E.D.; data curation, E.F.; writing – original draft preparation, R.F.; writing – review and editing, E.D. and E.R.; visualization, D.M. and F.P.; supervision, F.P.; project administration, D.M. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest disclosure

The authors declare no conflict of interest.

Guarantor

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Data availability statement

The data presented in this study are available on request from the corresponding author.

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References

[1] Gou WJ, Zhou FW, Providencia R, *et al*. Association of Mineralocorticoid Receptor Antagonists With the Mortality and Cardiovascular Effects in Dialysis Patients: A Meta-analysis. Front Pharmacol 2022;13:823530.
[2] National Kidney Foundation. Lok CE, Huber TS, Lee T, *et al*. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis 2020;75:S1–S164.
[3] Mirabella D, Dinoto E, Rodriquenz E, *et al*. Improved Ultrasound-Guided Balloon-Assisted Maturation Angioplasty Using Drug-Eluting Balloons in the First Autogenous Arteriovenous Fistula Procedure: Early Experience. Biomedicines 2024;12:1005.
[4] Khan T, Bhat M, Shah OA, *et al*. Percutaneous Transluminal Angioplasty of Dysfunctional Hemodialysis Vascular Access: Can Careful Selection of Patients Improve the Outcomes? Indian J Nephrol 2022;32:233–39.
[5] Maccarrone R, Zanoli L, Pace L, *et al*. The new frontier in endovascular treatment of arteriovenous fistula stenosis: the role of ultrasound-guided percutaneous transluminal angioplasty. G Ital Nefrol 2019;36:2019–vol2.
[6] Aktas A, Bozkurt A, Aktas B, *et al*. Percutaneous transluminal balloon angioplasty in stenosis of native hemodialysis arteriovenous fistulas: technical success and analysis of factors affecting postprocedural fistula patency. Diagn Interv Radiol 2015;21:160–66.
[7] Ormiston W, Dyer-Hartnett S, Fernando R, *et al*. An update on vessel preparation in lower limb arterial intervention. CVIR Endovasc 2020;3:86.
[8] Brathwaite S, Kernodle AB, Massarweh NN, *et al*. Review of maintenance and surveillance of dialysis access. Semin Vasc Surg 2024;37:387–93.
[9] Huang C, Yao G, Hu R, *et al*. Outcome and Risk Factors of Restenosis Post Percutaneous Transluminal Angioplasty at Juxta-Anastomotic of Wrist Autogenous Radial-Cephalic Arteriovenous Fistulas: A Retrospective Cohort Study. Ann Vasc Surg 2023;93:234–42.
[10] Trinh KN, Wilson SE, Gordon IL, *et al*. Postintervention Patency: A Comparison of Stenting versus Patch Angioplasty for Dysfunctional Hemodialysis Access Sites. Ann Vasc Surg 2016;33:120–25.
[11] Kerwan A, Al-Jabir A, Mathew G, *et al*. Revised Surgical CAse REport (SCARE) guideline: An update for the age of Artificial Intelligence. Prem J Sci 2025;10:100079.
[12] Canadian Society of Nephrology Vascular Access Work Group. MacRae JM, Dipchand C, Oliver M, *et al*. Arteriovenous Access Failure, Stenosis, and Thrombosis. Can J Kidney Health Dis 2016;3:20543 58116669126.
[13] Roy-Chaudhury P, Kelly BS, Melhem M, *et al*. Vascular access in hemodialysis: issues, management, and emerging concepts. Cardiol Clin 2005;23:249–73.
[14] Chang HH, Chang YK, Lu CW, *et al*. Statins Improve Long Term Patency of Arteriovenous Fistula for Hemodialysis. Sci Rep 2016;6:22197.
[15] Stolic RV, Trajkovic GZ, Kostic MM, *et al*. Factors affecting the patency of arteriovenous fistulas for hemodialysis: Single center experience. Hemodial Int 2018;22:328–34.
[16] Pirozzi N, Garcia-Medina J, Hanoy M. Stenosis complicating vascular access for hemodialysis: indications for treatment. J Vasc Access 2014;15:76–82.
[17] Rajan DK, Bunston S, Misra S, *et al*. Dysfunctional autogenous hemodialysis fistulas: outcomes after angioplasty–are there clinical predictors of patency? Radiology 2004;232:508–15.
[18] Brahmbhatt A, Remuzzi A, Franzoni M, *et al*. The molecular mechanisms of hemodialysis vascular access failure. Kidney Int 2016;89:303–16.
[19] Zhang D, Kong D, Ma L, *et al*. Using a plastic cannula prevents arteriovenous fistula failure in early cannulation. Ren Fail 2025;47:2458192.
[20] Wu CC, Lin MC, Pu SY, *et al*. Comparison of cutting balloon versus high-pressure balloon angioplasty for resistant venous stenoses of native hemodialysis fistulas. J Vasc Interv Radiol 2008;19:877–83.
[21] DePietro DM, Trerotola SO. Choosing the right treatment for the right lesion, part I: a narrative review of the role of plain balloon angioplasty in dialysis access maintenance. Cardiovasc Diagn Ther 2023;13:212–32.
[22] Pecoraro F, Dinoto E, Pakeliani D, *et al*. Efficacy and one-year outcomes of Luminor® paclitaxel-coated drug-eluting balloon in the treatment of popliteal artery atherosclerosis lesions. Ann Vasc Surg 2021;76:370–77.
[23] Lookstein RA, Haruguchi H, Ouriel K, *et al*. IN.PACT AV Access Investigators. Drug-Coated Balloons for Dysfunctional Dialysis Arteriovenous Fistulas. N Engl J Med 2020;383:733–42.
[24] Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis 2006;48:S176–247.
[25] Trerotola SO, Kwak A, Clark TW, *et al*. Prospective study of balloon inflation pressures and other technical aspects of hemodialysis access angioplasty. J Vasc Interv Radiol 2005;16:1613–18.
[26] Shirai S, Mori S, Yamaguchi K, *et al*. Impact of Chocolate percutaneous transluminal angioplasty balloon on vessel preparation in drug-coated balloon angioplasty for femoropopliteal lesion. CVIR Endovasc 2022;5:46.
[27] Kambayashi Y, Yao A, and Yokochi A. Effectiveness of second drug-coated balloon angioplasty for arteriovenous fistulas following initial treatment failure with first-generation DCBs. J Vasc Access 2025;27:183–89.
[28] Lookstein R, Haruguchi H, Suemitsu K, *et al*. IN.PACT AV Access Investigators. IN.PACT AV Access Randomized Trial of Drug-Coated Balloons for Dysfunctional Arteriovenous Fistulae: Clinical Outcomes through 36 Months. J Vasc Interv Radiol 2023;34:2093–2102.e7.
[29] Ross JR. Restoring arteriovenous access: Pilot study using a scoring balloon in 50 patients. J Vasc Access 2021;22:623–28.
[30] Pang S, Chang T, Chang M, *et al*. Efficacy of cutting balloon angioplasty versus high-pressure balloon angioplasty for the treatment of arteriovenous fistula stenoses in patients undergoing hemodialysis: Systematic review and meta-analysis. PLoS One 2024;19:e0296191.
[31] Spiliopoulos S, Karamitros A, Reppas L, *et al*. Novel balloon technologies to minimize dissection of peripheral angioplasty. Expert Rev Med Devices 2019;16:581–88.
[32] Ansel GM, Brodmann M, Rocha-Singh KJ, *et al*. IN.PACT Global Study Investigators. Five-Year Safety and Effectiveness of Paclitaxel Drug-Coated Balloons Alone or With Provisional Bare Metal Stenting for Real-World Femoropopliteal Lesions: IN.PACT Global Study Subgroup Analysis. Circ Cardiovasc Interv 2024;17:e013084.