CASE REPORT

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Endovascular salvage of an immature radiocephalic arteriovenous fistula: a case report

Danang Himawan Limanto[1,2*], Thomas Jatiman[1,2], Juliana[3,4]

[1]Senior Attendant of the Department of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[2]Senior Attendant of the Department of Thoracic, Cardiac, and Vascular Surgery, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
[3]Resident of Department of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia
[4]Resident of the Department of Thoracic, Cardiac, and Vascular Surgery, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia

*Corresponding Author:
Danang Himawan Limanto; Senior Attendant of the Department of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia;
danang.himawan@fk.unair.ac.id

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ABSTRACT

Background: Autogenous arteriovenous fistulas (AVFs) are the preferred vascular access for hemodialysis, offering superior patency and lower complication rates compared to grafts or catheters. However, non-maturation occurs in 20–40% of cases, often due to juxta-anastomotic stenosis or accessory venous runoff, leading to prolonged catheter dependence and increased morbidity. Endovascular salvage strategies such as balloon-assisted maturation (BAM) and coil embolization achieve technical success rates exceeding 90% and are now central to access preservation.

Case Presentation: We report a 66-year-old male with stage V chronic kidney disease on regular hemodialysis who developed an immature left radiocephalic AVF four months post-creation, complicated by ipsilateral hand edema. Duplex ultrasonography revealed draining vein diameters of 0.42–0.54 cm and flow volumes of 130–150 mL/min. Venography confirmed juxta-anastomotic stenosis with competitive runoff into the distal cephalic vein. The patient underwent endovascular salvage consisting of coil embolization of the cephalic runoff and balloon angioplasty of the draining vein using sequential 4.0 and 6.0 mm balloons. Post-procedural venography demonstrated elimination of distal runoff and restoration of antebrachial flow. Clinically, hand edema regressed, and AVF patency was preserved.

Conclusion: Combined coil embolization and angioplasty can successfully salvage immature AVFs with venous stenosis and accessory runoff. This case underscores the importance of structured duplex surveillance, early identification of failing maturation, and timely endovascular intervention to preserve autogenous vascular access.

Keywords: Arteriovenous Fistula, Hemodialysis Access, Balloon-Assisted Maturation, Coil Embolization, Vascular Access Salvage.
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INTRODUCTION

Hemodialysis remains the predominant renal replacement therapy for patients with end-stage kidney disease, and the establishment of reliable vascular access is fundamental for treatment success. Autogenous arteriovenous fistulas (AVFs) are universally recommended as the preferred access by both KDOQI and European Society for Vascular Surgery (ESVS) guidelines due to their superior long-term patency and lower morbidity compared with prosthetic grafts or central venous catheters.[1,2] Despite these advantages, AVF non-maturation affects approximately 25-33% of newly created fistulas, with failure rates even higher among elderly patients and those with diabetes or peripheral vascular disease.[3,4] The clinical and economic burden of non-maturation is substantial, as patients with immature fistulas remain dependent on central venous catheters, which carry increased risks of bacteremia, thrombosis, and central venous stenosis, all of which are associated with poorer survival outcomes.[1,5]

The maturation of an AVF is a complex biological process requiring adequate arterial inflow, a patent anastomosis, and sufficient venous wall remodeling in response to increased shear stress. Failure of maturation is commonly caused by juxta-anastomotic stenosis (JAS), inadequate venous caliber, or the presence of accessory venous runoff.[3,6] Duplex ultrasonography has become the cornerstone for surveillance of newly created fistulas, with the pragmatic "rule of 6s"—a draining vein diameter ≥ 6 mm, depth ≤ 6 mm, and flow ≥ 600 mL/min—serving as the threshold for successful cannulation readiness.[7]

Advances in endovascular techniques have expanded the armamentarium for AVF salvage. Balloon-assisted maturation (BAM) has been shown to achieve technical success rates of up to 97% and clinical success rates approaching 90%, according to recent systematic reviews and meta-analyses.[6] Furthermore, staged long-segment angioplasty has been reported to enhance venous remodeling and improve functional outcomes, with increases in mean vessel diameter from approximately 4 mm to 6 mm and flow augmentation above 700 mL/min.[5] Similarly, the management of accessory venous runoff through surgical ligation or selective coil embolization has been

shown to redirect blood flow and promote maturation, with recent studies reporting significant improvements in flow and maturation rates.[5]

In alignment with the 2019 KDOQI guidelines and their 2022 implementation review, which emphasize the importance of individualized strategies to maximize preservation of autogenous access, we present a case of an immature radiocephalic AVF complicated by venous hypertension and hand edema, successfully salvaged with combined coil embolization and balloon angioplasty.

CASE PRESENTATION

A 66-year-old male with stage V chronic kidney disease on regular hemodialysis presented with a left radiocephalic arteriovenous fistula (AVF) created four months earlier that remained unused due to failure to mature, and he reported progressive swelling of the ipsilateral wrist and hand. The patient had a history of temporary vascular access, including a femoral catheter that was later replaced with a right internal jugular catheter, which remained his primary access for hemodialysis.

On admission, the physical examination revealed pallor and edema of the left hand. The AVF thrill was palpable but weaker proximally, and duplex ultrasonography demonstrated an anastomotic diameter of 0.42–0.54 cm, draining vein diameters

Figure 1. Ultrasound evaluation of the AVF

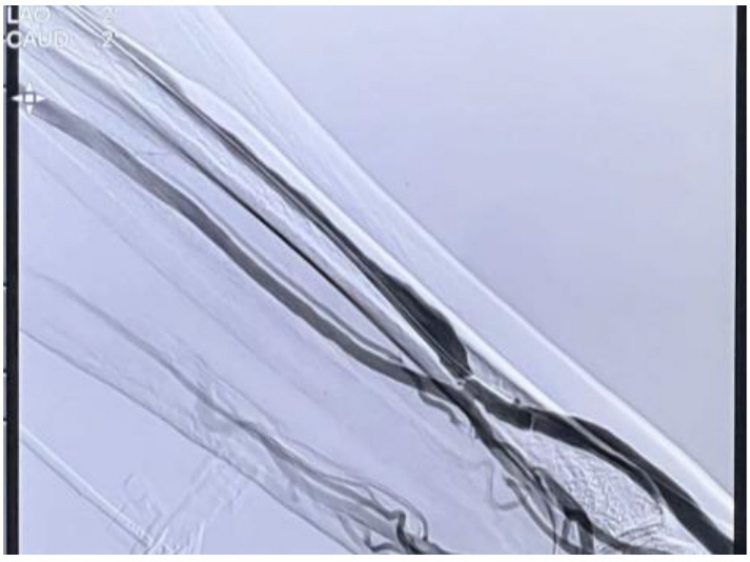

Figure 2. Intra-operative Venography shows stenosis in the juxta-anastomosis

Figure 3. Intraoperative fluoroscopy image showing coil embolization of the distal cephalic branch

Figure 4. Balloon angioplasty of the juxta-anastomotic draining vein using 4.0 mm and 6.0 mm balloons.

Figure 5. Post-balloon angioplasty venography showing improved flow through the draining vein.

of 0.43 cm (antebrachii) and 0.54 cm (manus), and a flow volume of only 130–150 mL/min, findings consistent with immaturity (**Figure 1**). Preoperative venography confirmed juxta-anastomotic stenosis and significant runoff into the cephalic vein toward the manus with collateral formation (**Figure 2**).

The patient underwent endovascular salvage under local anesthesia. Intraoperatively, juxta-anastomotic stenosis was confirmed, and coil embolization was performed on the distal cephalic vein runoff, followed by balloon angioplasty of the antebrachial draining vein using sequential 4.0 × 60 mm and 6.0 × 60 mm balloons. Completion venography demonstrated marked improvement of stenosis, complete occlusion of the distal runoff with the coil in situ, and restoration of antebrachial outflow (**Figure 3**, **Figure 4**). Postoperatively, the patient remained hemodynamically stable, with minimal pain and no bleeding or hematoma at the access site. Ultrasound demonstrated patent draining vein flow and absent flow at the coiled distal cephalic branch. The patient was discharged in stable condition with plans for reassessment of fistula maturation after several weeks.

The patient was re-evaluated two weeks after balloon-assisted maturation and coil embolization during a scheduled follow-up visit. He reported no complaints, and the most recent hemodialysis session had been performed uneventfully via the right internal jugular catheter. Local examination of the left radiocephalic AVF revealed a palpable thrill and audible bruit extending to the proximal antebrachial segment, with a well-healed surgical site.

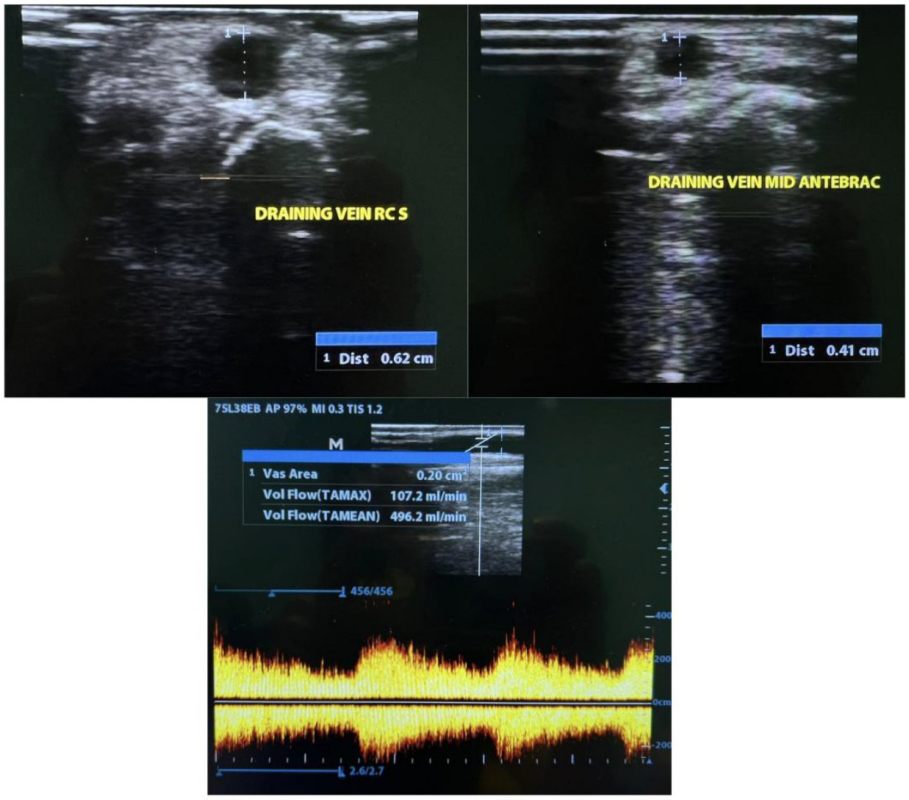

Figure 6. Postoperative duplex ultrasonography of the left radiocephalic AVF

Duplex ultrasonography demonstrated significant improvement, with the draining vein diameter measuring 6.2 mm distally and 4.1 mm at the mid-antebrachial level, and a markedly increased flow volume of 496.2 mL/min (**Figure 6**). These findings indicated early successful maturation of the access. The patient was advised to continue observation and return for a repeat ultrasound in one week, with instructions to perform hand-grip exercises to promote further venous remodeling. In the interim, hemodialysis was maintained via the right jugular catheter. Current medications included oral nifedipine 30 mg daily and furosemide 40 mg daily.

DISCUSSION

Non-maturation of arteriovenous fistulas remains a prevalent problem, affecting up to 40% of newly created fistulas, particularly in elderly patients and those with comorbid vascular disease such as hypertension and diabetes mellitus.[3,4] Among forearm radiocephalic fistulas, early failure may occur in nearly one-third of cases, with juxta-anastomotic stenosis and accessory venous runoff identified as the most frequent causes.[4,7] The consequences of non-maturation are clinically significant, as prolonged dependence on central venous catheters is associated with an increased risk of bloodstream infection, thrombosis, and central venous stenosis, all of which contribute to excess morbidity and mortality in patients on long-term hemodialysis.[1,5]

According to the 'rule of 6s,' a draining vein diameter ≥6 mm, depth ≤6 mm, and flow ≥600 mL/min are required for functional cannulation.[7] In our case, duplex ultrasonography demonstrated flow volumes of only 130–150 mL/min, well below this threshold. Salvage was nevertheless attempted because both duplex and venographic findings confirmed a correctable juxta-anastomotic stenosis and a dominant accessory runoff, conditions that could be technically addressed. Thus, the decision to intervene was based on anatomical correctability rather than absolute flow values, aligning with contemporary guidelines that support early salvage attempts to prevent abandonment of autogenous access.[1,2]

In this patient, two key mechanisms contributed to the immaturity of the access. First, angiography confirmed the presence of juxta-anastomotic stenosis, restricting antegrade flow into the draining vein. Second, a distal cephalic branch acted as a competing outflow, siphoning blood away from the antebrachial segment and producing venous hypertension manifested by ipsilateral hand edema. These findings illustrate the multifactorial nature of AVF failure and the need for tailored interventions that address both stenotic and accessory runoff lesions.[4,7]

We acknowledge that the follow-up period was limited to two weeks, during which functional cannulation of the fistula had not yet been attempted. Long-term outcomes such as sustained patency, dialysis adequacy, and complication rates remain to be determined. However, duplex surveillance at two weeks showed marked improvement in vein diameter and flow (496.2 mL/min), suggesting favorable remodeling. Continued monitoring will be necessary, and ultimate success should be defined by functional use for dialysis.

Endovascular therapy has become the principal strategy for salvaging non-maturing fistulas. Balloon-assisted maturation (BAM) has demonstrated high technical success, with a recent 2023 meta-analysis reporting a rate of 97% and clinical success of 90% across more than 1,400 patients.[6] Staged or long-segment angioplasty further enhances venous remodeling, with documented increases in vessel diameter from approximately 4 mm to 6 mm and flow augmentation exceeding 700 mL/min.[8] These results have established angioplasty as the preferred approach to overcome venous stenosis in immature accesses.

Equally important is the management of accessory venous branches. Competitive runoff can prevent adequate dilation of the target vein, leading to persistent immaturity. Traditionally managed through surgical ligation, these branches can also be effectively treated with endovascular embolization. Accessory venous branches can be managed either surgically by ligation or endovascularly by embolization. We opted for coil embolization in this case because it is minimally invasive, allows simultaneous treatment during angioplasty, and avoids surgical dissection in an edematous field. While surgical ligation is cost-effective and widely available, it carries risks of wound complications, delayed healing, and the need for anesthesia. Conversely, coil embolization provides immediate flow redirection, lower peri-procedural morbidity, and can be performed in the same session as BAM. Cost considerations remain relevant, but the increasing availability of embolization materials makes this option more feasible in tertiary centers. Recent reports, including a 2025 pilot study, demonstrated maturation in most cases after accessory vein ligation, with average flow increases of 44%.[5] Coil embolization, as performed in this case, is minimally invasive, can be executed in conjunction with angioplasty, and effectively redirects flow toward the desired outflow while simultaneously alleviating the clinical consequences of venous hypertension.[5]

Current guidelines, particularly the 2019 KDOQI update with the 2022 implementation review, emphasize that immature fistulas should not be prematurely abandoned. Instead, timely salvage interventions are recommended to preserve autogenous access whenever feasible.[1] The combined approach used in this case—coil embolization of a distal cephalic branch and balloon angioplasty of the draining vein—was in full concordance with guideline recommendations and resulted in restoration of physiologic flow dynamics, regression of hand edema, and preservation of access patency.

This case highlights that a structured surveillance program using duplex ultrasonography, coupled with early endovascular intervention, can effectively address both stenosis and accessory runoff. For vascular surgeons, such proactive management underscores the principle that most immature fistulas can be salvaged if promptly evaluated and treated, thereby reducing catheter dependence, lowering complication rates, and optimizing the lifespan of autogenous access.[1,5]

CONCLUSION

This case demonstrates that immature radio-cephalic arteriovenous fistulas complicated by juxta-anastomotic stenosis

and accessory runoff can be effectively salvaged through a combined endovascular approach of coil embolization and balloon angioplasty. Structured duplex ultrasonography enabled the timely detection of dysfunction, while intervention restored adequate venous diameter and flow to support maturation. Early recognition and prompt salvage are critical to reducing catheter dependence, preserving autogenous access, and improving long-term outcomes in patients requiring chronic hemodialysis.

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CONFLICT OF INTEREST

The authors declare no conflict of interest related to the conduct of this study, the interpretation of its findings, or the preparation of the manuscript.

ETHICAL CLEARANCE

Written informed consent was obtained from the patient for publication of this case and accompanying images. Ethical clearance was waived for this single-patient report in accordance with institutional policy.

AUTHOR CONTRIBUTION

DHL conceptualized and supervised the study, performed the procedure, and critically revised the manuscript. TJ contributed to clinical management, intraoperative data acquisition, and imaging interpretation. Juliana assisted in data collection, literature review, and manuscript drafting. All authors reviewed the final version of the manuscript and approved it for submission.

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