TJVS Turkish Journal of Vascular Surgery

Turk J Vasc Surg. 2026;35(3):237-46
DOI: 10.9739/tjvs.2026.05.032

Available online at www.turkishjournalofvascularsurgery.org

Original Article

Upper-arm PTFE arteriovenous grafts in hemodialysis: Patency, predictors, and angioplasty salvage

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Received: June 06, 2026 Accepted: July 16, 2026 Published online: October 20, 2026

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Abstract

Aim: Arteriovenous grafts (AVGs) are an essential dialysis access option for patients unsuitable for autogenous fistula creation. We evaluated patency, predictors of patency loss, infection outcomes, and balloon angioplasty salvage of upper-arm polytetrafluoroethylene (PTFE) AVGs in a high-risk hemodialysis cohort.

Material and Methods: This retrospective single-center cohort study (January 2018 – December 2023) included 124 patients undergoing upper-arm straight PTFE AVG placement (brachial artery – axillary vein). The mean age was 59.1 ± 9.3 years; 74.2% had diabetes and 83.1% hypertension. Patency was estimated by Kaplan – Meier analysis and predictors of primary patency loss by multivariable Cox regression. Twenty-nine patients underwent balloon angioplasty after surgical embolectomy for post-anastomotic venous stenosis with thrombosis. Median follow-up was 11 months (IQR 7 – 16).

Results: Primary patency was 58% at 6 months and 46% at 12 months; secondary patency was 71% and 58%. On Cox regression, peripheral vascular disease (HR 2.05, p = 0.004) and diabetes (HR 1.75, p = 0.023) independently predicted patency loss. Infection occurred in 12 patients (9.7%); three required explantation, with no bacteremia or sepsis. Balloon angioplasty achieved technical success in 21/29 (72.4%). Mean reintervention rate was 1.6 procedures per year.

Conclusion: Upper-arm PTFE AVGs provide acceptable patency and manageable infection rates in high-risk hemodialysis patients. Timely angioplasty salvage extends secondary patency, supporting the continued role of AVGs when paired with structured surveillance and proactive endovascular management.

Keywords: Arteriovenous graft; balloon angioplasty; graft infection; graft patency; thrombosis

INTRODUCTION

Vascular access represents the functional cornerstone of maintenance hemodialysis, and its failure is a leading cause of morbidity, hospitalization, and reduced quality of life in patients with end-stage renal disease (ESRD). The 2019 Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guidelines advocate an individualized approach to vascular access selection, centered on the ESRD Life Plan concept, which tailors access type to patient anatomy, comorbidity burden, and life expectancy [1]. Within this framework, the autogenous arteriovenous fistula (AVF) remains the preferred access modality due to superior long-term durability, lower infection rates, and reduced overall reintervention burden [2].

Nevertheless, a clinically significant proportion of patients presenting for access creation are not suitable candidates for primary AVF formation. Advanced age, diffuse arterial

CITATION
Jalalzai I, Kilic Y, Usta H, Sonmez E, Aykut MC, Erkut B, et al. Upper-arm PTFE arteriovenous grafts in hemodialysis: Patency, predictors, and angioplasty salvage. Turk J Vasc Surg. 2026;35(3):237-46.

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calcification secondary to long-standing diabetes mellitus, peripheral arterial disease, obesity, prior venous damage from repeated phlebotomy, and central venous stenosis from prior catheter use all contribute to rendering native fistula creation unfeasible or unlikely to mature [3]. For this population, the prosthetic arteriovenous graft (AVG), most commonly fabricated from polytetrafluoroethylene (PTFE), provides a reliable and guideline-supported alternative. Its uniform geometry permits consistent cannulation approximately two weeks after placement, and its anatomical predictability facilitates repeated endovascular reintervention at the venous anastomosis, the principal site of dysfunction [4]. The homogeneous configuration also reduces anatomical heterogeneity, which is a methodological advantage when comparing outcomes across institutional cohorts.

The primary pathophysiological process underlying AVG failure is venous neointimal hyperplasia (NIH), characterized by fibromuscular thickening of the subintimal layer at the graft – native vein anastomosis, driven by hemodynamic shear stress, compliance mismatch, surgical trauma, graft material bioincompatibility, and repetitive cannulation injury [4,5]. Progressive luminal narrowing leads to stenosis, reduced access flow, and ultimately thrombosis. Approximately 50% of AVGs require at least one intervention within six months of initiating hemodialysis [6], and venous anastomotic stenosis accounts for 45% to 85% of all lesions causing AVG dysfunction [5].

Percutaneous transluminal angioplasty (PTA) using plain balloon angioplasty, combined with embolectomy when thrombus is present, is the established first-line treatment strategy for stenotic and thrombosed AVGs [7,8]. Published six-month primary patency rates following balloon angioplasty in AVGs range from 27 to 63% across cohort studies [7–9], reflecting the impact of comorbidity burden, lesion location, and institutional experience. Lilly et al. identified prior access failure, diabetes, and peripheral vascular disease as independent predictors of AVG patency loss after radiologic intervention [9], factors prevalent in the majority of patients in the present cohort. For lesions demonstrating early or recurrent restenosis, stent graft placement at the venous anastomosis has demonstrated superior patency to plain angioplasty in randomized trials and is now considered an early escalation option [10].

Turkey carries a growing burden of ESRD driven in part by the high national prevalence of type 2 diabetes mellitus and hypertension. Single-center AVG outcome data from Turkish tertiary referral centers remain limited in the published literature.

Despite the widespread use of prosthetic grafts in access-exhausted dialysis patients, contemporary outcome data from high-burden diabetic populations and from Turkish tertiary centers remain scarce, and predictors of graft failure in such cohorts are incompletely defined. We therefore aimed (i) to determine primary and secondary patency of uniformly configured upper-arm straight PTFE AVGs; (ii) to identify independent predictors of primary patency loss; (iii) to quantify infection outcomes; and (iv) to evaluate the technical success and durability of balloon angioplasty salvage after embolectomy. We hypothesized that, despite the high comorbidity burden, structured surveillance with timely endovascular salvage would yield patency and infection outcomes comparable to published benchmarks for this access type.

The contribution of the present study is threefold. First, it reports outcomes for a uniformly configured upper-arm straight brachio-axillary PTFE cohort, eliminating the anatomical heterogeneity that confounds many mixed forearm/upper-arm graft series. Second, it evaluates a consistent salvage protocol combining surgical embolectomy with same-session balloon angioplasty. Third, it adds to the limited dedicated AVG patency, predictor, and infection data available from Turkish tertiary referral centers serving an unusually comorbid, diabetes-predominant, access-exhausted population.

MATERIAL AND METHODS

Study Design and Ethics

This was a retrospective, observational, single-center cohort study conducted at the Department of Cardiovascular Surgery, Atatürk University Research Hospital, Erzurum, Türkiye, between January 2018 and December 2023. The study is reported in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement, and vascular-access patency outcomes are defined and reported following the Society of Interventional Radiology standardized reporting guidelines [11].

This study was approved by the Atatürk University Faculty of Medicine Ethics Committee (Approval No: B.30.2.ATA.0.01.00/167; Date: 02/04/2026) and was conducted in accordance with the Declaration of Helsinki and its subsequent amendments. Owing to the retrospective design, the requirement for written informed consent was waived by the ethics committee; all patient data were anonymized prior to analysis.

Patient Selection, Inclusion and Exclusion Criteria

Access selection followed an autogenous-first algorithm in accordance with the 2019 KDOQI ESRD Life-Plan principle [1]. After failure or exclusion of distal and proximal radiocephalic and brachiocephalic fistulas, every patient was specifically assessed for two-stage basilic vein transposition (superficialization) on preoperative duplex vein mapping. When the basilic vein was of adequate caliber and quality, superficialization was performed; seven such patients underwent basilic vein superficialization during the study period and, having received an autogenous access, were not included in the present AVG cohort. A prosthetic

AVG was offered only to patients in whom all autogenous options, including basilic superficialization, were unsuitable or had failed.

Inclusion criteria were all consecutive patients who underwent primary upper-arm straight PTFE AVG placement during the study period and who had a minimum follow-up of four months. Exclusion criteria were follow-up shorter than four months and prior ipsilateral graft placement at the same anatomical site. Consecutive, non-probability sampling was used: every eligible patient treated during the study period was included, without selection or matching. No a priori sample-size calculation was undertaken; the resulting sample of 124 patients represents a convenience census of the eligible population rather than a powered sample. A total of 124 patients fulfilled the inclusion criteria. Patient demographics, comorbidity profiles, prior access history, dialysis vintage, procedural data, and all follow-up records were extracted from institutional electronic medical records and dedicated access surveillance logs. Of the 124 patients, 78 (62.9%) had at least one prior failed AVF and 96 (77.4%) were catheter-dependent at the time of graft placement. Mean dialysis vintage prior to AVG creation was 18.4 ± 11.2 months, reflecting a population in whom graft placement followed exhaustion of native access options.

Preoperative Assessment

All candidates underwent preoperative assessment of arterial inflow (clinical examination, segmental pressures, and duplex; digital subtraction angiography when indicated) and, in patients with prior central catheterization or clinical signs of central venous obstruction, central venous imaging. Significant uncorrectable inflow peripheral arterial disease or central venous occlusion was regarded as a contraindication to ipsilateral graft placement because of the risk of access-related hand ischemia and symptomatic venous hypertension. In patients with a correctable subclavian or central venous stenosis/occlusion, percutaneous transluminal angioplasty of the central lesion was performed first; when a durable central outflow was re-established, an autogenous fistula was attempted in preference to a graft, and a tunneled central venous catheter was reserved for cases in which the fistula failed to mature.

Surgical Technique

All patients received standard-wall PTFE grafts configured as upper-arm straight conduits from the brachial artery to the axillary vein. This uniform configuration was applied throughout the study period, reducing anatomical heterogeneity across the cohort. All procedures were performed by attending cardiovascular surgeons under either regional anesthesia (83 patients, 66.9%) or general anesthesia (41 patients, 33.1%), the choice being guided by patient comorbidity and anesthetic assessment. Perioperative antibiotic prophylaxis consisted of intravenous ampicillin – sulbactam (1.5 g) administered at induction to all patients without a documented penicillin allergy; penicillin-allergic patients received intravenous teicoplanin as an alternative. Graft maturation was assessed clinically at the first postoperative visit, and cannulation was permitted approximately 14 days after placement following confirmation of adequate thrill and structural integrity on clinical and duplex ultrasound assessment.

Access Surveillance

Access dysfunction was identified through a structured combined surveillance strategy. At each outpatient hemodialysis session, clinical assessment was performed including evaluation of thrill quality, pulsatility, and audible bruit. Dialysis flow parameters were monitored routinely; patients with documented access blood flow below 600 mL/min, rising venous pressures, or persistent cannulation difficulty were referred for duplex ultrasonography [1]. Those demonstrating a hemodynamically significant stenosis of greater than 50% luminal narrowing with a matching clinical indicator on subsequent fistulography were referred for intervention [7].

Balloon Angioplasty Salvage Technique

Twenty-nine patients presenting with AVG thrombosis attributable to post-anastomotic venous stenosis underwent surgical embolectomy as the primary step, followed by percutaneous transluminal balloon angioplasty in the same operative setting. Vascular access was obtained percutaneously under fluoroscopic guidance. Initial fistulography characterized lesion location, length, and severity. The mean lesion length was 2.6 ± 1.2 cm, and the mean diameter stenosis was 74 ± 11%. High-pressure non-compliant balloons of 6 – 8 mm diameter—sized approximately 1 mm in excess of the adjacent normal vein—were inflated to 12 – 20 atm. Each lesion was treated with sustained inflations of 60 – 120 seconds, repeated until waist effacement (mean 2.1 inflations per lesion). Technical success was defined as restoration of antegrade graft flow with less than 30% residual stenosis confirmed on completion angiography. Anastomotic extravasation was managed with prolonged balloon tamponade. After salvage, all patients underwent duplex ultrasonography within two weeks and were thereafter monitored at every dialysis session with monthly access-flow measurement.

Endpoints and Patency Definitions

The primary endpoints were primary and secondary patency at 6 and 12 months, estimated by Kaplan – Meier analysis. Secondary endpoints were independent predictors of primary patency loss, overall infection rate stratified by type and management, technical success and durability of balloon angioplasty salvage, anastomotic complication rate, new graft creation rate following failed salvage, and the mean reintervention rate per graft-year.

Patency definitions were adopted in accordance with the standardized reporting guidelines for hemodialysis vascular access interventions [11]. Primary patency was defined as the interval from AVG creation to the first thrombotic event, significant stenosis requiring reintervention, or permanent abandonment without prior salvage. Assisted primary patency, defined as access survival without thrombosis but with intervening reinterventions to maintain patency, could not be reliably reconstructed from the retrospective dataset because records did not consistently distinguish pre-emptive from post-thrombotic interventions, and is acknowledged as a limitation. Secondary patency was defined as the interval from AVG creation to permanent abandonment, inclusive of all intervening surgical and endovascular reinterventions. The reintervention rate was calculated as the total number of access-related reinterventions (endovascular and surgical combined) divided by the total graft follow-up time expressed in access-years.

Statistical Analysis

All analyses were performed using IBM SPSS Statistics version 29.0 (IBM Corp., Armonk, NY, USA). As a retrospective observational cohort study without comparison groups, no randomization was performed and blinding was not applicable; outcomes were ascertained from objective electronic medical records, imaging reports, and access-surveillance logs to minimize ascertainment bias. Normality of continuous variables was assessed visually using histograms and analytically using the Shapiro – Wilk test prior to the selection of parametric or non-parametric tests. Normally distributed continuous variables are presented as mean ± standard deviation and non-normally distributed variables as median (interquartile range). Categorical variables are expressed as frequencies and proportions with 95% confidence intervals calculated using the Wilson score method. Kaplan – Meier survival analysis was used to estimate primary and secondary patency, with censoring applied at the time of renal transplantation, death from non-access causes, or loss to follow-up; the log-rank test was used for univariable comparisons. Post-salvage primary and secondary patency in the balloon angioplasty subgroup were also estimated using Kaplan – Meier analysis, with the date of technically successful salvage defined as time zero and censoring applied at renal transplantation, death from non-access causes, or loss to follow-up. A multivariable Cox proportional-hazards model was constructed to identify independent predictors of primary patency loss, entering six prespecified covariates simultaneously: age, diabetes mellitus, peripheral vascular disease, active smoking, prior failed AVF, and catheter dependence at the time of graft placement. These covariates were selected a priori based on their established clinical relevance to AVG patency and with consideration of the number of observed primary patency-loss events, thereby limiting model complexity and reducing the risk of overfitting. Age was analyzed per 10-year increase, and the proportional-hazards assumption was assessed using log-minus-log survival plots. The association between infection and diabetic status (categorical) was assessed using the chi-square test, or Fisher's exact test where any expected cell count was fewer than five; the association between infection and age (continuous) was assessed using the independent-samples t-test or the Mann – Whitney U test according to distribution. A two-tailed p-value of less than 0.05 was considered statistically significant.

RESULTS

One hundred and twenty-four patients underwent PTFE AVG placement and met inclusion criteria. The mean age was 59.1 ± 9.3 years (range: 31 – 81); 71 (57.3%) were male. The comorbidity burden was substantial: 92 patients (74.2%) had diabetes mellitus, 103 (83.1%) had hypertension, 42 (33.9%) had ischemic heart disease, 72 (58.1%) had hyperlipidemia, 35 (28.2%) had peripheral vascular disease, 15 (12.1%) had a prior stroke, and 58 (46.8%) were active smokers. Mean dialysis vintage was 18.4 ± 11.2 months; 78 patients (62.9%) had at least one prior failed AVF and 96 (77.4%) were catheter dependent at the time of graft placement. All grafts were upper-arm straight PTFE conduits (brachial to axillary). Mean cannulation time was 14.2 ± 3.8 days. Among patients who experienced thrombosis or required intervention, the mean time to first event was 5 months. Mean follow-up was 12 months and median follow-up was 11 months (IQR 7 – 16; range 4 – 22). Detailed characteristics are presented in Table 1.

Kaplan – Meier analysis demonstrated a primary patency of 58% (95% CI: 49.1 – 66.9%) at 6 months and 46% (95% CI: 34.8 – 53.2%) at 12 months. Secondary patency was 71% (95% CI: 62.5 – 79.5%) at 6 months and 58% (95% CI: 48.7 – 67.3%) at 12 months. Secondary patency exceeded primary patency at both time points, confirming that endovascular and surgical reinterventions extended access function beyond primary failure. At 6 months, 101 patients had available follow-up data; 7 had undergone renal transplantation and 16 were censored for loss to follow-up. At 12 months, 72 patients had available follow-up data, with 6 additional transplant-related censorings. Kaplan – Meier numbers at risk are displayed beneath each survival curve in Figure 1 and Figure 2. The number at risk declined over time, and the reduced risk set at later intervals should be considered when interpreting the 12-month patency estimates.

Nine deaths occurred during follow-up: 6 (66.7%) cardiovascular and 3 (33.3%) ESRD related; no death was access related. Mean reintervention rate was 1.6 procedures per year, within the 2019 KDOQI threshold of fewer than three interventions per year [1]. Kaplan – Meier curves with 95% confidence intervals and numbers at risk are shown in Figure 1 and Figure 2. Patency and follow-up data are summarized in Table 2.

Table 1. Baseline patient and procedural characteristics (n = 124)

Variable	Value (n = 124)
Demographic characteristics	
Age, mean ± SD (years)	59.1 ± 9.3
Age range (years)	31 – 81
Sex: male, n (%)	71 (57.3%)
Sex: female, n (%)	53 (42.7%)
Dialysis vintage before AVG, mean ± SD (months)	18.4 ± 11.2
Prior failed AVF, n (%)	78 (62.9%)
Prior central venous catheter dependence, n (%)	96 (77.4%)
Comorbidities	
Diabetes mellitus, n (%)	92 (74.2%)
Hypertension, n (%)	103 (83.1%)
Ischemic heart disease, n (%)	42 (33.9%)
Hyperlipidemia, n (%)	72 (58.1%)
Peripheral vascular disease, n (%)	35 (28.2%)
Stroke, n (%)	15 (12.1%)
Active smokers, n (%)	58 (46.8%)
Procedural characteristics	
Graft material	Standard-wall ePTFE
Graft configuration	Upper-arm straight (brachial – axillary)
Anesthesia: regional / general, n (%)	83 (66.9%) / 41 (33.1%)
Cannulation time, mean ± SD (days)	14.2 ± 3.8
Time to first event among those with thrombosis/intervention, mean (months)	5.0
Follow-up, median (IQR; range) (months)	11 (7 – 16; 4 – 22)

Abbreviations: AVF, autogenous arteriovenous fistula; IQR, interquartile range; PTFE, polytetrafluoroethylene; SD, standard deviation.

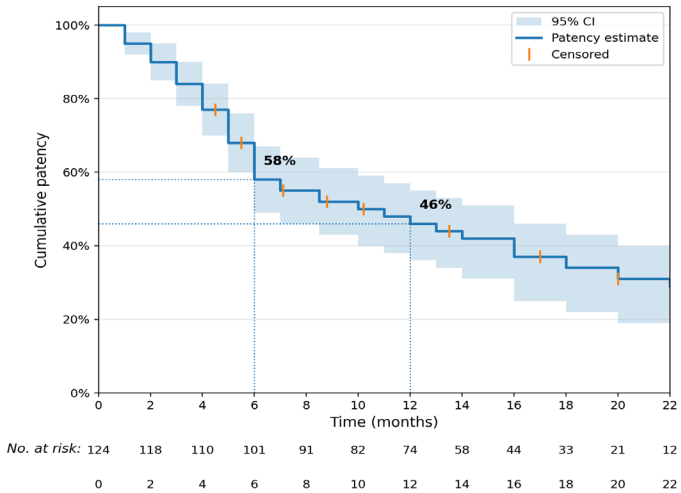


Figure 1. Kaplan – Meier estimate of primary patency with 95% confidence interval (shaded band) and censoring marks. Numbers at risk are displayed beneath the curve. Primary patency was 58% (95% CI 49.1 – 66.9%) at 6 months and 46% (95% CI 34.8 – 53.2%) at 12 months. Abbreviations: CI, confidence interval.

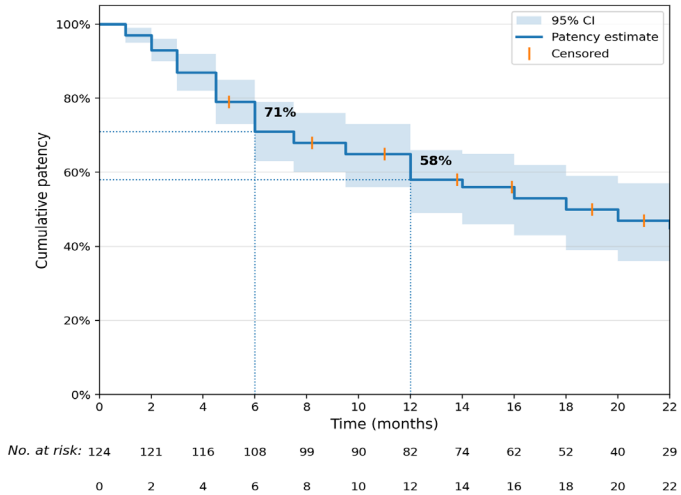


Figure 2. Kaplan – Meier estimate of secondary patency with 95% confidence interval (shaded band) and censoring marks. Numbers at risk are displayed beneath the curve. Secondary patency was 71% (95% CI 62.5 – 79.5%) at 6 months and 58% (95% CI 48.7 – 67.3%) at 12 months. Abbreviations: CI, confidence interval.

Table 2. Kaplan – Meier patency, follow-up, censoring, and mortality

Patency outcome	6-mo (%)	95% CI	12-mo (%)	95% CI
Primary patency	58	49.1 – 66.9	46	34.8 – 53.2
Assisted primary patency	NC	—	NC	—
Secondary patency	71	62.5 – 79.5	58	48.7 – 67.3
Follow-up and censoring				
Patients with available follow-up data at 6 months, n		101		
Renal transplantation, censored by 6 months, n		7		
Lost to follow-up by 6 months, n		16		
Patients with available follow-up data at 12 months, n		72		
Renal transplantation, additional censoring by 12 months, n		6		
Mortality				
Total deaths during follow-up, n		9		
Cardiovascular cause, n (%)		6 (66.7%)		
ESRD-related, non-access cause, n (%)		3 (33.3%)		
Access-related death, n		0		
Mean reintervention rate, procedures per graft-year		1.6		

"Available follow-up data" refers to patients with clinical outcome information available at the specified time point and should not be interpreted as the Kaplan – Meier number at risk. In Kaplan – Meier analysis, grafts were censored at the date of renal transplantation, death from non-access causes, or loss to follow-up. Deaths are reported separately as total events during follow-up because interval-specific death censoring is not shown in this summary table. Assisted primary patency was not calculable from the retrospective dataset and is acknowledged as a limitation. Abbreviations: CI: confidence interval, NC: not calculable;

On multivariable Cox regression (Table 3), peripheral vascular disease and diabetes mellitus were independent predictors of primary patency loss. Peripheral vascular disease showed the strongest association, with approximately a twofold higher hazard of primary patency loss (HR 2.05, 95% CI 1.25 – 3.36; p = 0.004). Diabetes mellitus was also independently associated with patency loss (HR 1.75, 95% CI 1.08 – 2.84; p = 0.023). Prior failed AVF showed a borderline association with primary patency loss (HR 1.52, 95% CI 0.98 – 2.36; p = 0.061). Age, active smoking, and catheter dependence at placement were not independently associated with primary patency loss. Visual inspection of the log-minus-log survival plots showed no meaningful departure from proportionality; therefore, the proportional-hazards assumption was considered satisfied for all covariates.

Table 3. Multivariable Cox regression for predictors of primary patency loss

Variable	HR	95% CI	p-value
Age (per 10-year increase)	1.15	0.91 – 1.45	0.24
Diabetes mellitus	1.75	1.08 – 2.84	**0.023**
Peripheral vascular disease	2.05	1.25 – 3.36	**0.004**
Active smoking	1.34	0.86 – 2.09	0.19
Prior failed AVF	1.52	0.98 – 2.36	0.061
Catheter dependence at placement	1.24	0.77 – 1.99	0.37

Bold p-values are statistically significant. Abbreviations: AVF, arteriovenous fistula; CI, confidence interval; HR, hazard ratio.

Graft-related infection was observed in 12 patients (9.7%; 95% CI: 5.6 – 16.4%). Seven patients (58.3% of infections) developed superficial wound infections, all resolving with antibiotic therapy. Five patients (41.7%) developed true graft infections; two resolved with antibiotics and three required surgical graft explantation. No patient developed bacteremia or sepsis. Infection was not significantly associated with patient age (p = 0.68) or diabetic status (p = 0.42); however, with only 12 infection events, these analyses were underpowered and the absence of statistical significance should not be interpreted as evidence of no association. Outcomes are detailed in Table 4.

Table 4. Infection outcomes (n = 124)

Incidence	
Overall infection rate, n (%; 95% CI)	12 (9.7%; 5.6 – 16.4)
Superficial wound infection, n (% of infections)	7 (58.3%)
Graft infection, n (% of infections)	5 (41.7%)
Bacteremia or sepsis, n	0
Management	
Antibiotic therapy alone, n	9
Surgical graft explantation, n	3
Statistical associations	
Infection vs diabetes mellitus (chi-square/Fisher)	p = 0.42
Infection vs age (t-test/Mann – Whitney U)	p = 0.68

Infection analyses were exploratory and underpowered (12 events); non-significant results should not be interpreted as evidence of no association. Abbreviations: CI, confidence interval.

Balloon Angioplasty Salvage Subgroup

Twenty-nine patients underwent balloon angioplasty following surgical embolectomy for AVG thrombosis with post-anastomotic venous stenosis. Venous anastomotic stenosis was present in 22 patients (75.9%); 7 (24.1%) demonstrated combined anastomotic and intragraft disease. Balloon diameters of 6 – 8 mm were used at 12 – 20 atmospheres. Technical success was achieved in 21 of 29 patients (72.4%; 95% CI: 54.3 – 85.3%). Anastomotic extravasation occurred in 2 patients (6.9%; 95% CI: 1.9 – 22.0%), both managed with balloon tamponade without surgical conversion. Among the 21 technically successful procedures, Kaplan – Meier-estimated post-salvage primary patency was 62% at 3 months and 43% at 6 months. Recurrent thrombosis occurred in 9 of 21 grafts (42.9%) at a median of 3.4 months after salvage, and Kaplan – Meier-estimated post-salvage secondary patency, including repeat reinterventions, was 71% at 6 months. All 8 patients with failed salvage received temporary central venous catheter insertion; 7 (24.1%) subsequently underwent new graft creation at 4 – 6 weeks. Subgroup data are presented in Table 5.

Table 5. Balloon angioplasty salvage subgroup outcomes (n = 29)

Indication and approach	
Indication	Post-anastomotic venous stenosis with thrombosis
Approach	Balloon angioplasty after surgical embolectomy
Lesion location	
Venous anastomotic stenosis, n (%)	22 (75.9%)
Combined anastomotic + intragraft disease, n (%)	7 (24.1%)
Procedural parameters	
Lesion length, mean ± SD (cm)	2.6 ± 1.2
Diameter stenosis, mean ± SD (%)	74 ± 11
Balloon diameter range (mm)	6 – 8
Inflation pressure range (atm)	12 – 20
Inflations per lesion, mean	2.1
Outcomes	
Technical success, n (%; 95% CI)	21 (72.4%; 54.3 – 85.3)
Anastomotic extravasation, n (%; 95% CI)	2 (6.9%; 1.9 – 22.0)
Post-salvage primary patency at 3 months (%)	62
Post-salvage primary patency at 6 months (%)	43
Recurrent thrombosis, n (%); median time	9 (42.9%); 3.4 months
Post-salvage secondary patency at 6 months (%)	71
Temporary catheter after failed salvage, n	8
New graft creation at 4 – 6 weeks, n (%)	7 (24.1%)

Abbreviations: CI, confidence interval; SD, standard deviation.

DISCUSSION

This retrospective single-center study reports patency, predictors, infection, and endovascular salvage outcomes of uniformly configured upper-arm straight PTFE AVGs in a comorbid hemodialysis population. The principal findings are a 6-month primary patency of 58%, a 12-month secondary patency of 58%, the identification of peripheral vascular disease and diabetes as independent predictors of patency loss, a 9.7% overall infection rate without systemic septic complications, and a 72.4% technical success rate for balloon angioplasty salvage. The mean reintervention rate of 1.6 procedures per year is well within the accepted KDOQI threshold [1]. These results are broadly consistent with published benchmarks for this access type in similarly comorbid populations.

The primary patency rates observed in this study fall within ranges reported across major cohort series of AVGs undergoing balloon angioplasty. Beathard, in a prospective cohort of 536

AVGs, reported six-month primary patency of 61% and twelve-month patency of 38% [8]. Kanterman et al. demonstrated six-month primary patency of 63% and twelve-month patency of 41%, with secondary patency of 50% and 25% at corresponding time points [12]. Ratnam et al., in their systematic review of plain balloon angioplasty, reported a six- to twelve-month primary patency range of 27 to 61% and 10 to 41% for AVGs across multiple cohort studies [7]. Our results are consistent with this range and reflect the adverse influence of a heavily comorbid, access-exhausted cohort.

The multivariable analysis identified peripheral vascular disease and diabetes mellitus as the principal independent predictors of primary patency loss. These findings are clinically plausible because peripheral vascular disease reflects impaired arterial inflow and systemic atherosclerotic burden, while diabetes contributes to endothelial dysfunction, vascular calcification, and accelerated neointimal hyperplasia. Prior failed AVF showed a borderline association, suggesting that previous access failure may serve as a marker of limited vascular reserve or more complex access history. Active smoking was associated with a numerically higher hazard of primary patency loss but did not reach statistical significance; smoking cessation should nevertheless remain part of comprehensive access care.

Secondary patency of 71% at 6 months and 58% at 12 months exceeded primary patency at both time points, as expected by definition, confirming that reinterventions effectively extended access function. Kanterman et al. reported secondary patency of 50% at 6 months and 25% at 12 months in their forearm graft series [12]; the comparatively higher secondary patency seen in our upper-arm straight configuration may reflect the larger caliber of the axillary venous outflow, which accommodates repeated angioplasty with a lower risk of access abandonment than smaller forearm targets.

The mean time from AVG creation to first thrombotic event of 5 months reflects the early failure pattern characteristic of PTFE grafts driven by rapid NIH at the venous anastomosis. Maya et al. demonstrated that venous anastomotic stenosis develops more rapidly and with greater severity in grafts than in native fistulas, consistent with the macrophage-mediated peri-graft tissue response to PTFE material [13]. This early failure pattern is compounded by the 74.2% prevalence of diabetes in our cohort, as hyperglycemia promotes endothelial dysfunction and smooth muscle cell proliferation, accelerating NIH progression [5].

The clinical importance of AVGs in contemporary dialysis practice stems from the epidemiology of the patients they serve. In our cohort, 62.9% had a prior failed AVF and 77.4% were catheter dependent at the time of graft placement. For these access-exhausted patients, the AVG represents the most appropriate available permanent access option rather than a second-best compromise. Richardson et al. noted that in elderly patients in whom AVF maturation failure rates are high, the net benefit of attempting AVF creation over direct AVG placement is less clear than population-level guidelines imply [3]. Vesely and Siegel observed that AVGs are reliably amenable to repeated endovascular treatment at the venous anastomosis, a site both anatomically predictable and technically accessible [14].

The 72.4% technical success rate for balloon angioplasty following embolectomy in our salvage subgroup represents a realistic outcome for combined thrombotic and stenotic AVG disease. Tan et al. reported 100% technical success in 15 AVGs treated for predominantly stenotic lesions without preceding thrombosis [15], where the absence of thrombus burden and anastomotic fibrosis facilitates complete effacement. Vignesh et al. reported 88.8% success in a mixed cohort [16]. These comparisons must be interpreted cautiously, because the cited series differ in access type and lesion composition: Vignesh et al. studied predominantly autogenous fistulas, and Ratnam et al. pooled mixed cohorts across lesion types, so differences in conduit, anastomotic anatomy, and thrombus burden limit direct comparison with our uniformly prosthetic, post-thrombotic cohort. The use of 6 to 8 mm balloons at 12 to 20 atmospheres is consistent with standard high-pressure technique; DePietro and Trerotola note that 9 to 13% of venous anastomotic stenoses require pressures above 20 atmospheres for complete effacement, suggesting ultra-high-pressure balloon escalation may have improved outcomes in a subset of resistant lesions [5]. Importantly, technical success did not equate to durability: Kaplan – Meier-estimated post-salvage primary patency decreased to 43% at 6 months, with recurrent thrombosis occurring in 42.9% of grafts, underscoring that angioplasty after embolectomy is a flow-restoring rather than a definitive procedure and that close post-salvage surveillance is essential.

The anastomotic extravasation rate of 6.9% is consistent with published complication rates of 2% to 16% for balloon angioplasty at the venous anastomosis [16]. Both cases resolved with balloon tamponade, avoiding surgical conversion. For patients with recurrent early anastomotic restenosis, the FLAIR randomized controlled trial demonstrated a six-month target lesion patency of 51% for covered stent-grafts versus only 23% for plain angioplasty [10], supporting early stent-graft escalation as a key component of the access management pathway for this subgroup.

The 9.7% overall infection rate is within the accepted complication profile for PTFE AVGs in a diabetic dialysis population. The predominance of superficial wound infections (58.3%), all resolving with antibiotics, reflects effective early detection in a closely monitored program. Three of five graft infections required explantation, consistent with the principle that established PTFE graft infection is unlikely to resolve with

antibiotics alone. The absence of bacteremia or sepsis suggests that infection was identified and managed prior to systemic dissemination in all cases. With only 12 infection events among 124 patients, however, the study had limited power to detect modest associations between infection and either diabetes or age; the non-significant results are exploratory and hypothesis-generating only, and adequately powered prospective studies with prespecified infection endpoints are required to characterize these relationships.

Limitations

This study has several limitations. First, the retrospective single-center design introduces selection bias and limits generalizability, and no a priori sample-size calculation was performed. Second, assisted primary patency could not be calculated because the retrospective records did not consistently distinguish pre-emptive interventions performed for stenosis without thrombosis from those performed after thrombosis, limiting comparison with studies reporting primary, assisted primary, and secondary patency together. Third, although Kaplan – Meier methodology permits estimation beyond the median follow-up, the declining number of grafts at risk at later intervals widens the confidence intervals and reduces the precision of the 12-month estimates, which should be interpreted with corresponding caution. Fourth, detailed periprocedural data including fluoroscopy time and contrast volume were not systematically available. Fifth, the exact time from graft placement to infection was not captured, preventing analysis of early versus late infection patterns. Finally, the absence of a comparative AVF arm within our institution prevents direct head-to-head comparison of access types in our own patient population.

CONCLUSION

This retrospective single-center study demonstrates that upper-arm straight PTFE AVGs provide acceptable patency and manageable infection rates in a high-risk hemodialysis population characterized by diabetes, hypertension, prior failed AVFs, and catheter dependence. Primary patency of 58% at 6 months and 46% at 12 months, and secondary patency of 71% and 58% at corresponding time points, are consistent with published benchmarks, and secondary patency exceeding primary patency confirms that structured reintervention effectively extended access function. Peripheral vascular disease and diabetes mellitus were independent predictors of primary patency loss, highlighting targets for preoperative risk stratification. Balloon angioplasty following embolectomy achieved technical success in 72.4% of thrombosed accesses, although durability was limited and frequently required repeat intervention. The 9.7% infection rate without systemic septic complications reflects effective surveillance and management, and a mean reintervention rate of 1.6 procedures per year is within accepted KDOQI thresholds. These findings support the valuable role of AVGs as a necessary dialysis access option in patients unsuitable for fistula creation, provided that structured surveillance, timely endovascular salvage, and a clear escalation pathway to surgical revision or stent-graft placement are embedded within the clinical management framework.

Ethics Committee Approval: This study was approved by the Atatürk University Faculty of Medicine Ethics Committee (Approval No: B.30.2.ATA.0.01.00/167; Date: 02/04/2026) and was conducted in accordance with the Declaration of Helsinki and its subsequent amendments.

Patient Consent for Publication: Owing to the retrospective design, the requirement for written informed consent was waived by the ethics committee; all patient data were anonymized prior to analysis.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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