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Authors
Ulloa, Jesus G
Kirkpatrick, Vincent E
Wilson, Samuel E
et al.

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Stent Salvage of Arteriovenous Fistulas and Grafts

Jesus G. Ulloa, MD[1,2], Vincent E. Kirkpatrick, MD[1,2], Samuel E. Wilson, MD[1,2], and Russell A. Williams, MD[1,2]

Abstract

Objectives: This study analyzes our experience using stents to salvage dysfunctional hemodialysis access sites at a single institution. **Methods:** We examined the outcomes of 42 consecutive patients who had covered (36 patients) or bare-metal (9 patients) stent intervention for hemodialysis access salvage. **Results:** Of our 42 male patients, 11 had stent salvage of an arteriovenous fistula, which yielded postintervention primary and secondary 6-month patencies of 27% and 55%, respectively. For 31 patients with arteriovenous grafts, the postintervention primary and secondary 6-month patencies were 26% and 29%, respectively. Patency rates were superior for stents placed in patent access sites, in fistulas compared to grafts, and when stents were placed in forearm sites although only the latter achieved statistical significance. **Conclusions:** Stents can extend patency for the thrombosed or failing arteriovenous access, but results are poor once thrombosis has occurred. Stent placement appears to be more effective in fistulas compared to grafts.

Keywords

hemodialysis, arteriovenous fistula, arteriovenous graft, stent, covered stent, pseudoaneurysm

Introduction

The 2012 Annual Report of the United States Renal Data System estimated an incidence of 116 946 new patients with end-stage renal disease and 393 992 already on hemodialysis in the United States for the year 2010. An estimated 82% of patients with end-stage renal disease initiate hemodialysis through a central venous catheter,[1] and bridging catheters are required when vascular access sites fail. Complications of hemodialysis through a central venous catheter include catheter-related infection, catheter thrombosis or malfunction, and central venous stenosis, which increase morbidity and mortality.[2] Consequently, maintenance of existing vascular access sites (arteriovenous fistulas or grafts) is an imperative for hemodialysis.

Common causes of access failure are venous outflow stenosis, thrombosis, and formation of pseudoaneurysms or aneurysms. Given that there are limited lifetime access sites, the preservation of existing sites through novel means is of high priority. Endoluminal stents have been used to treat central venous stenosis, arteriovenous access stenosis, large pseudoaneurysms, and to control unstable hematomas after venous rupture.[3]

This study analyzes our experience with stents to salvage vascular access sites in a group of patients at a single institution.

Patients and Methods

Using the electronic operating room log and electronic medical record system, we identified a consecutive series of 44 patients who underwent creation of an arteriovenous fistula or arteriovenous graft that subsequently underwent placement of a bare-metal or polytetrafluoroethylene (PTFE)-covered stent. Of the 44 patients we treated, 2 were excluded as they moved away soon after their procedure and were lost to follow-up. Of the remaining 42 patients, 11 had an arteriovenous fistula that underwent stenting, and 31 patients had 1 or more arteriovenous grafts that underwent stenting. Four patients had stent salvage of 2 different grafts at separate anatomic sites for a total of 35 grafts that underwent stent placement.

The indications for stent placement were failing access sites with impaired flow, completely thrombosed access sites, and pseudoaneurysms or aneurysms that were enlarging, accumulating thrombus, or causing significant thinning of the skin over the access site. At our institution, stents are placed when there is elastic recoil or residual stenosis after percutaneous transluminal angioplasty. There is no strict threshold of percentage of residual stenosis that is used to determine the need for stent

[1]Veterans Administration Long Beach Healthcare System, Department of Surgery, Long Beach, CA, USA
[2]University of California, Irvine School of Medicine, Department of Surgery, Orange, CA, USA

Corresponding Author:
Vincent E. Kirkpatrick, VA Long Beach Healthcare System, Building 8 Room 326, 5901 E 7th St, Long Beach, CA, USA.
Email: kirkpatrickv@uthscsa.edu

placement, which is at the discretion of the vascular surgeon performing the procedure. No stents were placed prophylactically based on abnormal findings on ultrasound surveillance of functional arteriovenous accesses, as we do not perform routine ultrasound surveillance of functional arteriovenous access sites at our institution. The patients had hemodialysis at several centers, but all interventions were at 1 urban hospital in the Veterans Affairs Health System.

All procedures were performed by a vascular surgeon in an operating room with fluoroscopy. Endoluminal wire access was achieved at a suitable location along the access site through a small incision. Mechanical thrombectomy was performed as necessary by Fogarty catheter or by fragmentation and aspiration using the Trerotola device (Arrow International, Pennsylvania). No pharmacological thrombolysis was used in this study. Stenoses were dilated by transluminal balloon angioplasty followed by placement of a stent. Of the 46 stents placed, 36 (78%) were PTFE-covered stent grafts, 9 (20%) were uncovered bare-metal stents, and 1 was indeterminate from incomplete documentation. The brands of the stents were 16 of the 46 Fluency Plus Stent Graft (Bard Peripheral Vascular, Tempe, Arizona), 16 of the 46 VIABAHN endoprosthesis (W.L. Gore & Associates, Flagstaff, Arizona), 9 of the 46 SMART Vascular Stent System (Cordis, New Jersey), 2 of the 46 FLAIR stent graft (Bard Peripheral Vascular, Tempe, Arizona), and in 3 patients, the brand was not documented in the medical record. Dimensions of stents placed were most commonly 6 to 8 mm by 4 to 8 cm, with a range of 5 to 10 mm by 2 to 15 cm.

Patient age, ethnicity, cause of end-stage renal disease, years on hemodialysis, lifetime access types (fistula, graft, or central venous catheter), anatomic access location, and common comorbidities were recorded.

Our patency definitions given subsequently are consistent with the current Society of Vascular Surgery guidelines.[4] Patency end points are reported both in days and as percentages at 1 month, 6 months, and 1 year after stent placement. Postintervention primary patency begins at the time of stent placement and ends at the time of intervention, thrombosis, or abandonment of the access site. Postintervention secondary patency ends at the time of access abandonment or surgical revision.

Statistical analysis was performed using a microcomputer program (Prism; GraphPad Software, La Jolla, California). Patency data survival curves were compared by log-rank analysis. This retrospective study was approved by the institutional review board.

Results

Of the 42 patients who underwent stent salvage of their hemodialysis access sites, all were male with a mean age of 63 years. African Americans accounted for 23 (55%) of the patients, Caucasians 14 (33%), Hispanics 3 (7%), and Asians and Native Americans both 1 (2%). Comorbidities and etiology of end-stage renal disease are listed in Table 1. Lifetime vascular access sites were calculated as 1.3 arteriovenous fistulas, 2.6 arteriovenous grafts, and 3.7 central venous catheters per patient. Follow-up was complete for all patients from the time of stent intervention until access site abandonment.

Table 1. Characteristics of Patients That Underwent Stent Salvage of Vascular Access.

Demographics	
Male sex	42 (100%)
Age began hemodialysis, years	63 ± 12
Years on hemodialysis	4.9 ± 3.3
Lifetime arteriovenous fistula	1.3 ± 1
Lifetime arteriovenous graft	2.6 ± 1.9
Lifetime central venous catheter	3.7 ± 3.0
Ethnicity	
African American	23 (55%)
Caucasian	14 (33%)
Hispanic	3 (7%)
Asian	1 (2%)
Native American	1 (2%)
Diagnosed cause of end-stage renal disease	
Hypertension	13 (31%)
Diabetes	17 (40%)
Other	12 (29%)
Comorbidities	
Congestive heart failure	6 (14%)
Atrial fibrillation	6 (14%)
Hyperlipidemia	15 (36%)
Hepatitis C	5 (12%)
Gout	6 (14%)
Obstructive sleep apnea	7 (17%)
Coronary artery disease	19 (45%)
Cerebral vascular accident	7 (17%)
Hypertension	37 (88%)
Diabetes	28 (67%)

Figure 1 describes the prevalent anatomic locations of the arteriovenous grafts and fistulas placed during the study period among the 42 patients reviewed. Of the 11 arteriovenous fistulas, 6 (55%) were between the brachial artery and the cephalic vein, 4 (36%) were between the radial artery and the cephalic vein, and 1 (9%) was brachiobasilic. With regard to the arteriovenous grafts, 15 (43%) were between the brachial artery and the axillary vein. The other 20 (57%) were primarily looped in the forearm, straight radial to cephalic, and only 1 (3%) femoral to saphenous graft in the groin.

Table 2 shows the sites of stent placement as well as the rates for subsequent interventions after stenting. Venous stenosis was the most common indication for stenting of arteriovenous grafts, and in 30 (97%) of the 31 patients, the location of the stenosis was at the graft–vein anastomosis. Only 1 (3%) arteriovenous graft underwent stenting of a lesion in the central venous outflow. By contrast, of the 7 arteriovenous fistulas that underwent stenting for venous stenosis, 4 (57%) were for stenosis in the access site and 3 (43%) were for more proximal venous stenosis, which includes 2 (29%) in the central, thoracic venous outflow.

Table 3 shows the primary and secondary postintervention patency data for arteriovenous fistulas and arteriovenous grafts

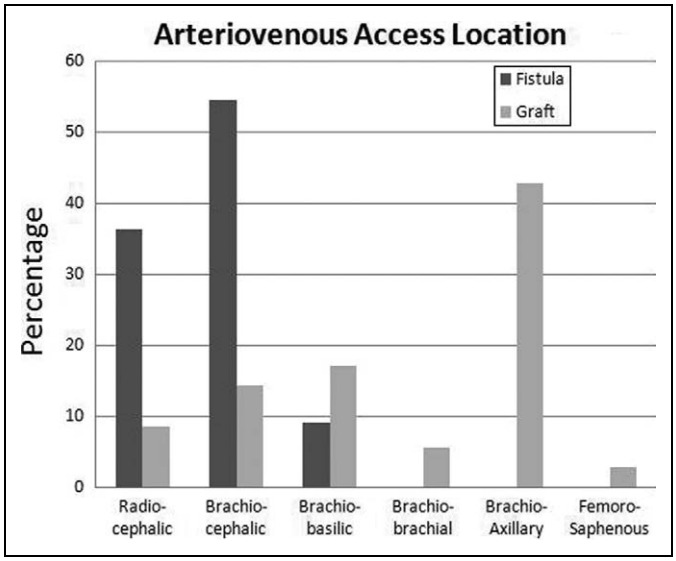

Figure 1. Arteriovenous access site location.

Table 2. Location and Indication for Stent and Additional Interventions.

	Fistula (11)	Graft (35)
Intervention location/indication		
Venous stenosis	27% (3)	89% (31)
Arterial stenosis	0% (0)	3% (1)
Intra-access stenosis	36% (4)	6% (2)
Problematic pseudoaneurysm/aneurysm	36% (4)	3% (1)
Endovascular interventions after stenting to maintain secondary patency		
Percent requiring reintervention	45% (5)	23% (8)
Additional stent	27% (3)	20% (7)
Angioplasty	27% (3)	9% (3)

separated by whether the access site was completely occluded by thrombosis at the time of stent placement or whether the access was patent with impaired flow. Six of 11 (54%) arteriovenous fistulas and 25 (71%) of 35 arteriovenous grafts were thrombosed at the time of stent placement, or 31 (67%) of 46 of the total arteriovenous access sites. Postintervention secondary patency rates were higher for both arteriovenous fistulas and arteriovenous grafts when the access site was still patent at the time of stent placement compared to patients in which thrombosis of the access had occurred. Postintervention primary patency was also improved in patients in which the arteriovenous graft was still patent; however, the inverse was observed for the postintervention primary patency of arteriovenous fistulas.

Table 4 shows a statistical analysis of the data comparing the median postintervention primary and secondary patency rates in days between covered and uncovered stents, larger caliber (8-10 mm) versus smaller caliber (5-6 mm) stents, stents placed for pseudoaneurysm exclusion versus vessel stenosis, stents in forearm access sites versus upper arm sites, and stents

Table 3. Postintervention Patency.

	1 month	6 month	1 year
Postintervention primary patency			
Fistulas (11)	82%	27%	18%
Thrombosed (6)	83%	50%	33%
Patent (5)	80%	0%	0%
Grafts (35)	60%	26%	14%
Thrombosed (25)	44%	16%	16%
Patent (10)	100%	50%	10%
Total	65%	26%	15%
Postintervention secondary patency			
Fistulas (11)	82%	55%	36%
Thrombosed (6)	83%	50%	33%
Patent (5)	80%	60%	40%
Grafts (35)	60%	29%	17%
Thrombosed (25)	44%	20%	16%
Patent (10)	100%	50%	20%
Total	65%	35%	22%

placed in fistulas versus grafts. Stents placed in arteriovenous access sites in the forearm had significantly longer postintervention primary and secondary patency compared to stents placed in arteriovenous access sites in the upper arm ($P = .03$, $P = .02$, respectively). The other comparisons did not achieve statistical significance.

Discussion

Arteriovenous fistulas and arteriovenous grafts have proven indispensible tools for prolonging the life expectancy of patients with end-stage renal disease and the opportunity for kidney transplant, yet they are vulnerable to progressive dysfunction by pseudoaneurysm formation and stenosis leading to thrombosis and failure. Although pseudoaneurysm formation appears to be due to weakening of the wall of the access site from repeated needle puncture, the mechanism behind the progressive stenosis of arteriovenous grafts and arteriovenous fistulas, neointimal hyperplasia, is poorly understood.

Some investigators describe neointimal hyperplasia as a process involving oxidative stress, inflammation, and endothelial dysfunction characterized by the presence of α smooth muscle actin positive cells.[5] Early experience with covered stents found restenosis of the covered stent to be almost universal and associated with migration of smooth muscle cells.[6]

There is some evidence that covered stents may decrease the incidence of intragraft stenosis dependent upon the porosity of the material.[7] A recent study on restenosis and neointimal area comparing different porosities of PTFE covered stents to bare-metal stents in porcine arterial injury models found that medium to high porosity material could limit restenosis as compared to bare-metal stents.[8] One proposed benefit of stents is an increase in laminar in-line flow and reduced turbulence and shear stress that may contribute to venous outflow stenosis.[9,10]

Before the development of stents and endoluminal technology, failing arteriovenous access sites were salvaged

Table 4. Postintervention Patency Statistical Analysis.

	Postintervention Primary Patency, Median ± SD, days	Log-Rank *P* Value	Postintervention Secondary Patency, Median ± SD, days	Log-Rank *P* Value
Uncovered stent (9/46)	62 ± 109		62 ± 108	
Covered stent (36/46)	52 ± 285	0.53	70 ± 287	0.22
8-10 mm stent (12/46)	47 ± 148		47 ± 153	
5-6 mm stent (12/46)	63 ± 188	0.67	104 ± 201	0.42
Pseudoaneurysm (5/46)	56 ± 49		59 ± 301	
Stenosis (41/46)	55 ± 321	0.19	68 ± 322	0.63
Thrombosed (31/46)	31 ± 332		31 ± 332	
Patent (15/46)	123 ± 258	0.27	188 ± 285	0.20
Forearm (10/46)	77 ± 513		292 ± 492	
Upper arm (35/46)	43 ± 195	0.03	55 ± 222	0.02
Fistula (11/46)	59 ± 445		193 ± 438	
Graft (35/46)	45 ± 252	0.28	45 ± 255	0.08

surgically, which involved an incision across the stenosed area and repair with an oval prosthetic patch or excision of the stenotic portion and interposition of a segment of synthetic graft. The introduction of percutaneous transluminal angioplasty offered a less invasive alternative although early comparisons showed superiority of open surgical repair.[11] Increased operator experience and new technology led to improved patency rates, and percutaneous transluminal angioplasty became commonly used for venous anastomotic lesions.[12]

A prospective, multicenter, and randomized controlled trial demonstrated noninferiority of covered stents in conjunction with percutaneous transluminal angioplasty when compared to angioplasty alone among 190 patients that underwent treatment.[13] Covered stents were placed exclusively in arteriovenous graft venous stenoses that were patent and had not yet thrombosed. The reported 6-month patency was 38% in the stent group compared to 20% for percutaneous transluminal angioplasty alone. By comparison, in the 10 patients from our series who had a patent but dysfunctional arteriovenous graft that underwent stenting, the postintervention primary patency at 6 months was 50%. The superiority of our results may be related to the fact that all of our patients were male, while 64% were women in the study of Haskal et al. Women have smaller vessel diameters and higher rates of primary fistula failure than men,[14] and thus they may have worse outcomes after stent placement compared to men.

Dolmatch et al published a series of 106 patients who underwent stent placement for arteriovenous access sites in which percutaneous transluminal angioplasty had failed, there was a rupture during percutaneous transluminal angioplasty or there was a pseudoaneurysm present.[15] Postintervention primary and secondary patency at 6 months was 47% and 79%, respectively. In addition, they found that a larger diameter stent, stent placement in an arteriovenous fistula, and avoidance of stent placement across the arm joint were 3 factors associated with improved patency duration. Although our 6-month postintervention primary and secondary patency of 26% and 35%, respectively, are lower than that found with Dolmatch et al, in their series only 22.6% of the arteriovenous access sites that received a stent were thrombosed compared to 67% of the access sites in our series. Thrombosis has been shown to decrease the secondary patency of arteriovenous grafts compared to angioplasty performed on a patent access.[16] In addition, there were more pseudoaneurysms that underwent stent placement in our series (11% compared to 4%), and the 6-month postintervention primary and secondary patency of pseudoaneurysms in our series was 0. Like Dolmatch, we also found superior patency of stents placed in arteriovenous fistulas compared to arteriovenous grafts, although this did not achieve statistical significance.

One unique finding in our series was that stents placed in arteriovenous access sites in the forearm had superior postintervention primary and secondary patency rates compared to those placed in sites in the upper arm. This seems counterintuitive since veins become larger more proximally and maturation rates are superior for arteriovenous fistula created in the upper arm compared to the forearm due to larger vein caliber.[17] Moreover, in the series of 106 patients of Dolmatch et al described earlier, there was no difference in 6-month postintervention patency between stents placed in forearm arteriovenous access sites versus upper arm sites.[15] Further studies are needed to clarify this issue.

It is important to note that many of our patients required additional interventions after their stenting procedure to maintain access patency as shown in Table 2. Similarly, the above-mentioned randomized trial of Haskal et al comparing percutaneous transluminal angioplasty versus stenting recorded 32% and 16% incidence of reintervention at 6 months in the respective cohorts.[13] Considering that the net cost of covered stent placement may be as high as US$47,665 per procedure,[18] further studies are needed to evaluate these additional therapies from a cost-benefit perspective.

A potential limitation of our data is that all of our patients are male, as there are few female patients at our veterans hospital. As mentioned earlier, women have smaller veins and higher rates of fistula failure compared to men,[14] so our data may not be relevant to female patients.

Another limitation of our study is the lack of control group of patients treated with percutaneous transluminal angioplasty

alone. We felt this comparison had been examined effectively in the randomized controlled trial of Haskal et al mentioned earlier, so we did not make this the focus of the current study. In addition, comparison with a control group in a retrospective study like ours introduces significant selection bias.

Conclusion

In summary, although stents can extend the patency of arteriovenous access sites results are poor once thrombosis has occurred, which underlines the need for monitoring to detect the failing access and allow intervention before thrombosis. Fistulas appear to have superior postintervention secondary patency compared to grafts after stenting regardless of the presence of thrombosis, although this did not achieve statistical significance. Although the full role of stents is still to be determined, clearly they have evolved into another option for the hemodialysis-dependent patient.

Declaration of Conflicting Interests

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