Primary patency rate with paclitaxel-coated balloon angioplasty versus covered stenting of failed arteriovenous grafts: a retrospective comparative study

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Aim
To compare the technical success, primary patency of thrombosed prosthetic vascular access grafts of the upper limb after thrombectomy and to deal with the stenosis at the venous anastomotic site either with percutaneous angioplasty with a paclitaxel-coated balloon or with stenting using a covered stent.
Patients and methods
We reviewed the data of 47 patients with thrombosed prosthetic vascular access polytetrafleuroethylene grafts of the upper limb, who met our inclusion criteria, from January 2014 till January 2021. The patients underwent thrombectomy and intraoperative angiography. The patients were stratified into two groups according to how we dealt with the venous anastomotic site. In group A, we used a paclitaxel-coated balloon, whereas in group B, we used a covered stent.
Results
The success rate was 100% (*n*=26), 100% (*n*=21) in both groups, in either the technical aspect or the clinical one (having dialysis from the access). There was no statistically significant difference between both groups regarding descriptive data. Moreover, there was no statistically significant difference between both groups regarding the time since creation of the access (*P*=0.9159). The primary patency rates of the procedure for group A at 3, 6, 12, 18, and 24 months were 88.46, 73.08, 61.54, 53.85, and 42.31%, respectively, whereas in group B, they were 90.48, 80.95, 66.67, 57.14, and 52.38%, respectively.
Conclusion
The use of covered stent has a higher patency rate than using paclitaxel-coated percutaneous angioplasty balloon catheters for treating venous site anastomotic stenosis, especially in the mid-term follow-up periods, but still these results are statistically insignificant, may be owing to the small number of the study sample.

Keywords:
covered stent, graft thrombectomy, paclitaxel-coated percutaneous angioplasty balloon, venous anastomosis stenosis

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Introduction

Patency of the dialysis access represents a challenge since the prevalence of end-stage renal disease is rising. Failure of the dialysis access represents 'the Achilles' heel' of hemodialysis in patients with end-stage renal disease [1]. Usually, we start by creating an autogenous access and then we revert to a synthetic one, although the synthetic access has the advantage of early cannulation (within 2 weeks), but usually the synthetic graft fails within 18 months from implantation owing to intimal hyperplasia [2]. Neointimal hyperplasia at the site of venous anastomosis leads to thrombosis of the synthetic access. Usually, the access can be salvaged without interrupting the dialysis schedule of the patient [3].

Neointimal hyperplasia is much more prone to occur after vascular interventions; the presentation of such lesions may occur from a few weeks to 2 years [4]. Neointimal hyperplasia results in a dense fibrotic stenotic lesion; dealing with this lesion with balloon angioplasty does not remove this lesion but only creates deep fractures in this dense tissue, increasing the cross-sectional diameter [5], and for this to happen, high-pressure balloons should be used [6].

Currently, neointimal hyperplasia starts as an acute inflammatory response. Because of the incomplete functional recovery of the repopulated endothelial cells and the phenotypic switch of smooth muscle cells, the acute inflammation often does not completely resolve, leaving behind a chronic inflammation in the intimal tissue. Inflammatory cells, particularly macrophages

and T cells, are found in established intimal lesions [7]. Systemic use of drug therapy using several compounds was investigated but was poorly tolerated, had narrow therapeutic ranges, and had diminished efficacy when administered systemically [8,9]. These outcomes have led to the concept of local drug administration; which leads to delivery of 400–1000 times drug concentration to vascular tissue than that with systemic [10–13]. Stent grafts have been used to treat stenotic lesions in the venous anastomotic sites and have shown 6-month primary patency rates of 36–100% [14–16].

Patients and methods

We retrospectively reviewed 47 patients (from January 2014 till January 2021) with occluded arteriovenous synthetic graft (A straight synthetic brachio-axillary arteriovenous graft) who underwent thrombectomy of the graft complemented by intraoperative angiography. Those patients were divided into two groups according to how we dealt with the venous anastomotic site. We included patients with arteriovenous grafts who received adequate dialysis from it after creation. We excluded patients with previous graft thrombectomy, those who have had signs of venous hypertension, patients with lost brachial artery pulsations, and patients having signs of graft infection. This research was performed at the Department of General Surgery, Ain Shams University Hospitals. Ethical Committee approval and written informed consent were obtained from all participants.

Preprocedural workup

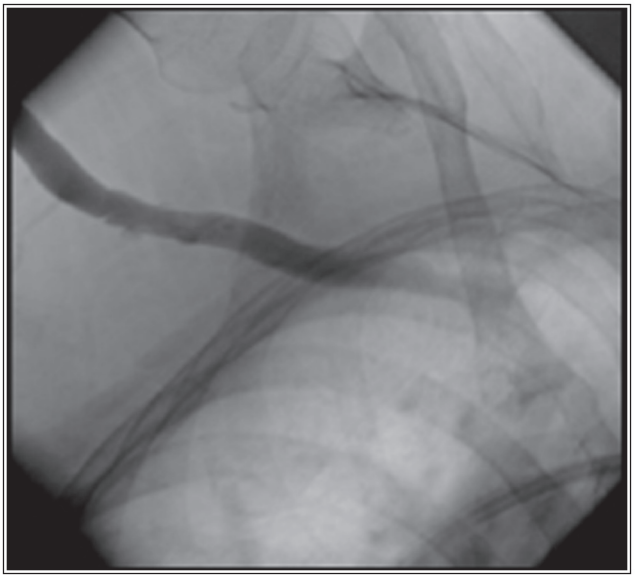
Patients were subjected to history taking, keeping in mind the last session the patient has had his dialysis through the graft; clinical examination was done to exclude patients having signs of graft infection; and Duplex ultrasound was done to detect the presence of arterial insufficiency.

Procedure

In either group, the procedure was done under local infiltration anesthesia. A skin incision was made at the site of the polytetrafleuroethylene (PTFE) graft in the mid arm while the patient was in the supine position. Dissection and exposure of an adequate length of the graft (sufficient for application of vascular clamps) was done, and then two vascular clamps were applied proximal and distal to the proposed incision site. A transverse incision was made in the graft. A 5-F Fogarty's catheter was introduced toward the venous side for thrombectomy, and then a 4-F catheter toward the arterial side for thrombectomy under fluoroscopic imaging.

After ensuring adequate thrombectomy, the incision in the graft was sutured with 5/0 polypropylene, and before tying up the sutures, an 8-F sheath is introduced in between the suture line. Diagnostic angiogram was done from the graft to view the anastomotic site, axillary vein up to the superior vena cava, as shown in Fig. 1. A 0.035 J-shaped hydrophilic guide wire was manipulated to cross the lesion, and high-pressure percutaneous angioplasty (PTA) balloon catheters were used to predilate the anastomotic site.

Figure 1



Angiography of the axillary and subclavian veins up to superior vena cava.

For group A, a paclitaxel-coated PTA balloon catheter was applied, whereas in group B, we applied a stent graft of 8 mm in diameter with different lengths according to the lesion length. Completion angiography was done for evaluation of angioplasty results. Then, the skin incision was closed.

Patients were allowed to have dialysis from this access immediately.

The procedure was followed up every 3, 6, 12, 18, and 24 months by clinical examination (thrill over the graft, and efficient dialysis sessions), and duplex ultrasound was done to detect the presence of restenosis at the venous anastomotic site.

Definitions

Technical success was considered when there was a thrill over the graft, and clinical success was defined as the success to have a complete dialysis session from the graft after procedure. Primary patency was defined as the interval from the time of this surgical intervention until loss of graft function or the need for an intervention to maintain graft patency.

Results

This study reviewed patients with chronic renal failure who presented with thrombosed AV grafts (PTFE) of dialysis. We reviewed 47 patients from January 2014 till January 2021 who met our criteria. We divided the patients into two groups according to how we dealt with the venous anastomotic site. In group A (we used drug-coated balloons, as shown in Fig. 2), 26 patients were included, whereas in group B (we used a stent graft, as shown in Fig. 3), 21 patients were included.

Table 1 shows the descriptive data of the studied groups, and there was no statistically significant difference between both groups.

The access for the patients in group A was created since 8.808 ± 3.305 months, whereas in group B was since 8.905 ± 2.860 months. There was no statistical difference between both groups (*P*=0.9159).

We included in our study patients with no symptoms or signs of venous hypertension. Upon intraoperative angiography, none of the patients in our study groups has had central venous stenosis or occlusion.

Technical success was achieved in 100% of cases, and patients underwent a dialysis session from the arteriovenous graft the same day of the surgical intervention or a day after.

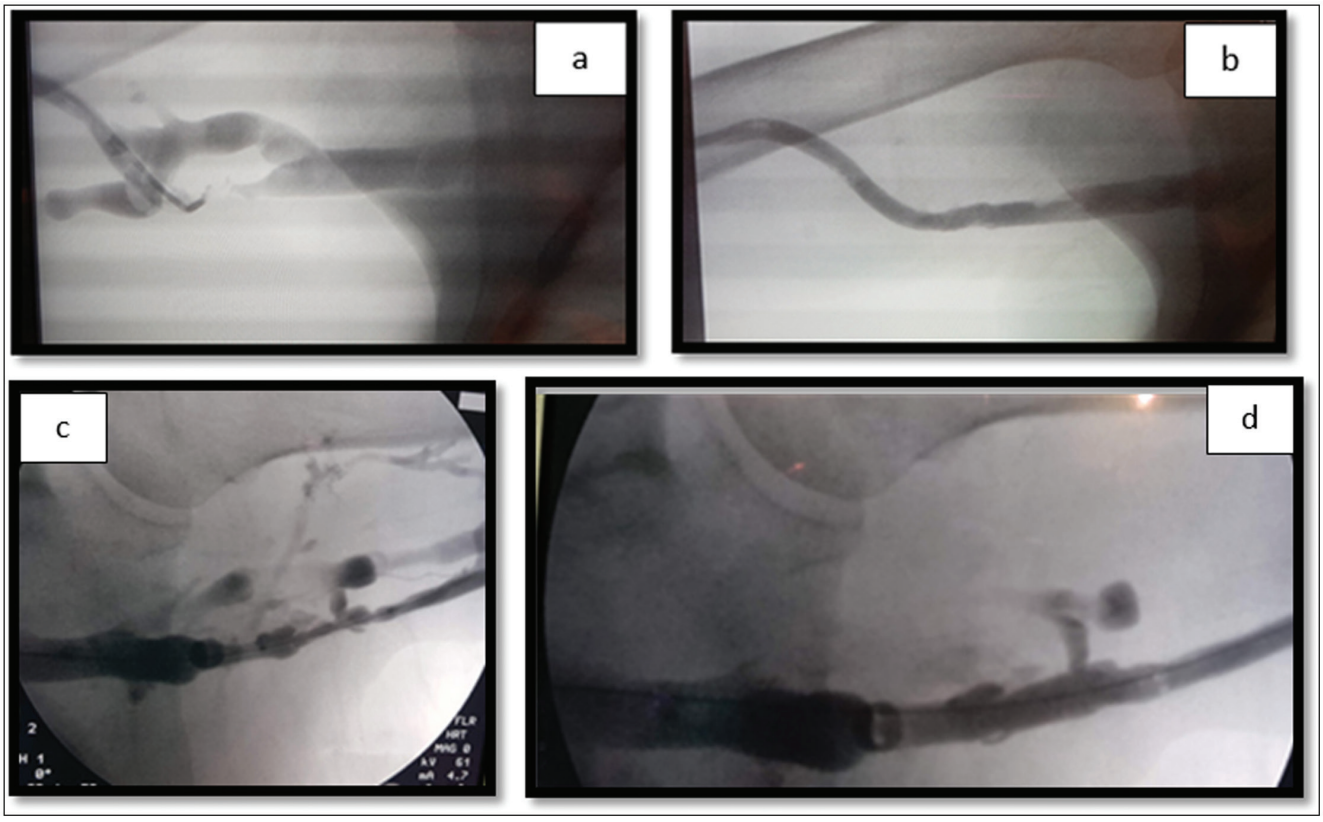
All of these patients were followed up for 3, 6, 12, 18, and 24 months. The definition of a failing prosthetic access was described in Guideline 6 of the National Kidney Foundation's 2006 Clinical Practice Guidelines for Vascular Access [17], considering the graft was patent if it had a thrill over it and the patient was having efficient dialysis from this AV graft together with duplex ultrasound follow-up to detect a stenosis of more than 30% of the luminal diameter.

Group A

During the follow-up period of 3 months, three (11.54%) patients presented with thrombosed access that needed another intervention to reestablish the patency of the access. However, at 6 months, a patient (3.84%) has had inefficient dialysis sessions owing to increased dynamic venous pressure measured during the dialysis sessions and a follow-up duplex showed a 50% stenosis at the venous anastomotic site, and another three (11.54%) patients presented with graft thrombosis. All of these patients needed another intervention to restore graft patency.

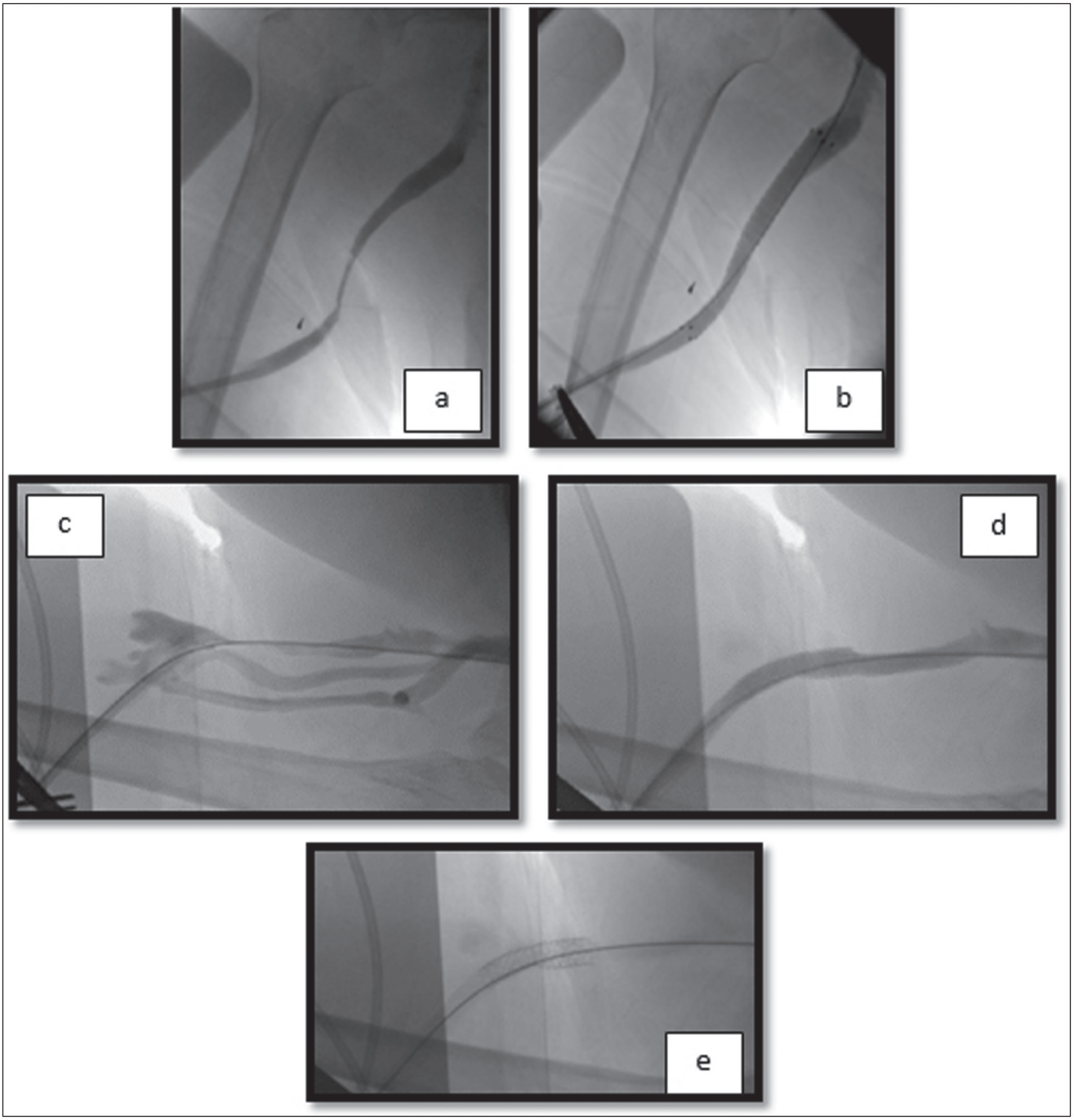
During the follow-up period of 12 months, another three (11.54%) presented with graft thrombosis

Figure 2



Multiple cases of pre (a, c) and post (b, d) dilatation using a drug-coated balloon in group A.

Figure 3



Multiple cases of pre (a, c) and post (b, d, e) angioplasty and covered stenting.

and underwent thrombectomy. At 18 months, two (7.69%) more patients showed restenosis of the venous anastomotic site and an intervention was done. At 24 months of follow-up, two (7.69%) patients presented with graft thrombosis, whereas one (3.84%) showed restenosis by duplex ultrasound.

Group B

During the follow-up of 3 months, two (9.52%) patients, and at 6 months, two (9.52%) more presented with thrombosis of the access. Moreover, at 12 months, three (14.28%) patients presented with thrombosis of the access. At 18 months, one (4.76%) patient presented with in-stent stenosis by duplex ultrasound and one (4.76%) presented with graft thrombosis. At 24 months, only one (4.76%) presented with in-stent stenosis that was in need for intervention.

Overall, four (15.38%) patients presented with restenosis in group A versus two (9.52%) in group B. It was found that there was no statistically significant difference (P=1.000) between both groups regarding the cause for reintervention, whether thrombosis of the graft or a significant stenosis detected by duplex

Table 1 Description of the studied patients

	Group A (*N*=26) [*n* (%)]	Group B (*N*=21) [*n* (%)]	*P* value
Age	52.85±8.34	49.90±8.86	0.2471
Sex			
Male	14 (53.85)	12 (57.14)	1.0000
Female	12 (46.15)	9 (42.86)	
Side of the AV graft			
Right	9 (34.6)	10 (47.6)	0.3896
Left	17 (65.4)	11 (52.4)	
Diabetes mellitus			
Yes	18 (69.23)	14 (66.67)	1.0000
No	8 (30.77)	7 (33.33)	
Hypertension			
Yes	19 (73.08)	16 (76.19)	1.0000
No	7 (26.92)	5 (23.81)	

Table 2 Primary patency rates at 3, 6, 12, 18, and 24 months

	Group A [*n* (%)]	Group B [*n* (%)]	*P* value
3 months	23 (88.46)	19 (90.48)	1.0000 Fisher's exact
6 months	19 (73.08)	17 (80.96)	0.7310 Fisher's exact
12 months	16 (61.54)	14 (66.67)	0.7681 Fisher's exact
18 months	14 (53.85)	12 (57.14)	1.0000 Fisher's exact
24 months	11 (42.31)	11 (52.38)	0.5643 Fisher's exact

ultrasound. The primary patency of the prosthetic graft after thrombectomy and dealing with the outflow problem using interventional techniques are shown in Table 2.

In spite of the difference between the patency rates between both groups, the difference was not statistically significant.

Discussion

Arteriovenous graft failure is mostly caused by a thrombotic event, which is mainly due to an outflow problem caused by neointimal hyperplasia. Many methods have been used to prolong the functionality of the graft, including antiplatelet or antithrombotic and routine follow-up [18].

Surgical patch angioplasty was used to treat patients having short focal stenosis at the venous anastomotic site. Trinh *et al.* [19] concluded that using stents in failed arteriovenous access extended the postinterventional patency over patch angioplasty, though the results were statistically not significant. Moreover, Allam *et al.* [20] concluded that there was no statistical difference between patch angioplasty and plain balloon angioplasty in patients with thrombosed vascular access who were treated with thrombectomy and either of the procedures.

Then, balloon angioplasty became the standard method of treatment because of the more convenient and fast the procedure was, but its average primary patency rate at 6 months was 21% [21]. Then stents and covered stents have been used to prolong the function of the prosthetic access. A study by Beathard [22] showed that the use of a self-expandable stent was not superior over percutaneous balloon angioplasty alone. However, with the advancement of the stent technology, different results have emerged. This appeared in the meta-analysis by Fu *et al.* [23], who concluded that stenting has a primary patency rate higher than balloon angioplasty. Shemesh *et al.* [24] concluded that the use of a covered stent in recurrent cephalic arch stenosis improved the long-term patency compared with bare metal stents. The use of covered stents seems to be beneficial in preventing restenosis by isolating the lesion from the arteriovenous circulation. The covered stent configuration seems to prevent the in-stent growth of neointimal tissue together with prevention of elastic recoil after PTA [14].

The hypothesis behind using paclitaxel-coated PTA balloon catheters was that the most common failure mode of prosthetic grafts for dialysis is intimal hyperplasia at the venous anastomosis [4], so using it will give us better patency rates.

In the study by Kohler *et al.* [25], over a sheep model, they used a bioabsorbable vascular wrap paclitaxel-eluting mesh, and the mesh was placed around the distal end of the graft and venous anastomosis. At 8 weeks after implantation, the grafts and veins were harvested for histologic examination. After histologic processing, neointimal area was significantly reduced in the paclitaxel mesh groups.

In a prospective, multicenter trial, randomly assigning 190 patients who were undergoing hemodialysis and who had a venous anastomotic stenosis, they underwent balloon angioplasty alone or balloon angioplasty plus placement of a stent graft. The

6-month patency rate of the treatment area was significantly greater in the stent-graft group than in the balloon-angioplasty group (51 vs. 23%, $P<0.001$) [14]. Chan *et al.* [26] showed a primary treatment area patency rate of 85 ± 16% at 2 and 6 months using ultralow-porosity expanded polytetrafluoroethylene covered stent in the treatment of venous stenosis. Another study showed a primary patency of 0, 18, and 65% at 12 months and 0, 18, and 37% at 24 months in the PTA, stent, and covered stenting groups, respectively ($P<0.0001$) [27].

Liao *et al.* [28] concluded that the usage of drug-coated balloons significantly improve the 6-month patency rate over conventional balloons.

Another meta-analysis on the use of drug-coated balloons in arteriovenous access found a significant improvement of primary patency with no increase in mortality rate on short-term and mid-term follow-up [29].

The main purpose for the intervention in our study was to find a method that provides the patient with a higher patency rate to decrease the rate of reintervention. To our knowledge, there was no study comparing the use of a drug-coated balloon to the use of a covered stent in treating a failing prosthetic access owing to an outflow venous problem. Our study showed superiority of the covered stent, but this was not a significant result.

Conclusion

Creating a prosthetic vascular access may be a necessary step for patients having regular hemodialysis sessions for long periods of time. The maintenance of such access may need multiple interventions, which are costly and interrupt the patients' schedule of dialysis. So, we compared the use of a paclitaxel-coated balloons versus covered stent to achieve a better primary patency rate. We found that covered stents have better primary patency rates, but those results were statistically insignificant. Larger randomized studies may be needed to prove these results with longer follow-up time periods.

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Nil.

Conflicts of interest

No conflict of interest.

References

1 Kjellstrand CM. The Achilles' heel of the hemodialysis patient. Arch Intern Med 1978; 138:1063–1064.

2 Pisoni RL, Young EW, Dykstra DM, Greenwood RN, Hecking E, Gillespie B *et al.* Vascular access use in Europe and the United States: results from the DOPPS. Kidney Int 2002; 61:305–316.

3 Abularrage CJ, Sidawy AN, Weiswasser JM, White PW, Arora S. Medical factors affecting patency of arteriovenous access. Semin Vasc Surg 2004; 17:25–31.

4 Lee T, Roy-Chaudhury P. Advances and new frontiers in the pathophysiology of venous neointimal hyperplasia and dialysis access stenosis. Adv Chronic Kidney Dis 2009; 16:329–338.

5 Becker GJ, Katzen BT, Dake MD. Noncoronary angioplasty. Radiology 1989; 170:921–940.

6 Vesely TM, Pilgram TK. Angioplasty balloon inflation pressures during treatment of hemodialysis graft-related stenoses. J Vasc Interv Radiol 2006; 17:623–628.

7 Jiang Z, Tao M, Omalley KA, Wang D, Ozaki CK, Berceli SA. Established neointimal hyperplasia in vein grafts expands via TGF-β mediated progressive fibrosis. Am J Physiol Heart Circ Physiol 2009; 297: 200–207.

8 Hamon M, Lecluse E, Monassier JP, Grollier G, Potier JC. Pharmacological approaches to the prevention of restenosis after coronary angioplasty. Drugs Aging 1998; 13:291–301.

9 Sharma S, Christopoulos C, Kukreja N, Gorog DA. Local drug delivery for percutaneous coronary intervention. Pharmacol Ther 2011; 129:260–266.

10 Fram DB, Mitchel JF, Azrin MA, Chow MS, Waters DD, McKay RG. Local delivery of heparin to balloon angioplasty sites with a new angiotherapy catheter: pharmacokinetics and effect on platelet deposition in the porcine model. Cathet Cardiovasc Diagn 1997; 41:275–286.

11 Gradus-Pizlo I, Wilensky RL, March KL, Fineberg N, Michaels M, Sandusky GE, Hathaway DR. Local delivery of biodegradable microparticles containing colchicine or a colchicine analogue: effects on restenosis and implications for catheter-based drug delivery. J Am Coll Cardiol 1995; 26:1549–1557.

12 Herdeg C, Oberhoff M, Baumbach A, Blattner A, Axel DI, Schroder S, Heinle H, Karsch KR. Local paclitaxel delivery for the prevention of restenosis: biological effects and efficacy in vivo. J Am Coll Cardiol 2000; 35:1969–1976.

13 Muller DW, Topol EJ, Abrams GD, Gallagher KP, Ellis SG. Intramural methotrexate therapy for the prevention of neointimal thickening after balloon angioplasty. J Am Coll Cardiol 1992; 20:460–466.

14 Haskal ZJ, Trerotola S, Dolmatch B, Schuman E, Altman S, Mietling S *et al.* Stent graft versus balloon angioplasty for failing dialysis-access grafts. N Engl J Med 2010; 362:494–503.

15 Kim YC, Tandberg DJ, Rosenberg MD, Miller MJ, Suhocki PV, Smith TP. Outcomes of prosthetic hemodialysis grafts after deployment of bare metal versus covered stents at the venous anastomosis. Cardiovasc Intervent Radiol 2012; 35:832–838.

16 Yamamoto Y, Nakamura J, Nakayama Y, Hino H, Kobayashi H, Sugiura T. Relationship between the outcomes of stent placement and the properties of arteriovenous graft outflow vein stenotic lesions. J Vasc Access 2012; 13:426–431.

17 National Kidney Foundation. NKF-KDOQI clinical practice guidelines for vascular access. Am J Kidney Dis 2006; 48:S176–S275.

18 Mousa AY, Patterson W, Abu-Halimah S, Hass SM, Alhalbouni S, Sadek BT *et al.* Patency in arteriovenous grafts in hemodialysis patients. Vasc Endovascular Surg 2013; 47:438–443.

19 Trinh KN, Wilson SE, Gordon IL, Williams RA. Postintervention patency: a comparison of stenting versus patch angioplasty for dysfunctional hemodialysis access sites. Ann Vasc Surg 2016; 33:120–125.

20 Allam AK, Desouki AAH, Mohammed AE. Comparative outcome of patch angioplasty versus balloon angioplasty after surgical thrombectomy of thrombosedarteriovenous hemodialysis graft: 18-month results. Egypt J Surg 2020; 39:60–72.

21 Dariushnia SR, Walker TG, Silberzweig JE, Annamalai G, Krishnamurthy V, Mitchell JW *et al.* Society of Interventional Radiology Standards of Practice Committee. Quality improvement guidelines for percutaneous image-guided management of the thrombosed or dysfunctional dialysis circuit. J Vasc Interv Radiol 2016; 27:1518–1530.

22 Beathard GA. Gianturco self-expanding stent in the treatment of stenosis in dialysis access grafts. Kidney Int 1993; 43:872–877.

23 Fu N, Joachim E, Yevzlin AS, Shin JI, Astor BC, Chan MR. A meta-analysis of stent placement vs. angioplasty for dialysis vascular access stenosis. Semin Dial 2015; 28:311–317.

24 Shemesh D, Goldin I, Zaghal I, Berlowitz D, Raveh D, Olsha O. Angioplasty with stent graft versus bare stent for recurrent cephalic arch stenosis in autogenous arteriovenous access for hemodialysis: a prospective randomized clinical trial. J Vasc Surg 2008; 48:1524–1531.

25 Kohler TR, Toleikis PM, Gravett DM, Avelar RL. Inhibition of neointimal hyperplasia in a sheep model of dialysis access failure with the bioabsorbable vascular wrap paclitaxel-eluting mesh. J Vasc Surg 2007; 45:1029–1037.

26 Chan MG, Miller FJ, Valji K, Bansal A, Kuo MD. Evaluating patency rates of an ultralow-porosity expanded polytetrafluoroethylene covered stent in the treatment of venous stenosis in arteriovenous dialysis circuits. J Vasc Interv Radiol 2014; 25:183–189.

27 Kavan J, Kudlicka J, Malik J, Chytilova E, Lambert L, Slavikova M, Matras P, Burgetova A. Treatment of failing arterio-venous dialysis graft by angioplasty, stent, and stent graft: Two-years analysis of patency rates and cost-effectiveness. Exp Ther Med 2019; 18:4144–4150.

28 Liao MT, Lee CP, Lin TT, Jong CB, Chen TY, Lin L *et al.* A randomized controlled trial of drug-coated balloon angioplasty in venous anastomotic stenosis of dialysis arteriovenous grafts. J Vasc Surg 2020; 71: 1994–2003.

29 Chen X, Liu Y, Wang J, Zhao J, Singh N, Zhang WW. A systematic review and meta-analysis of the risk of death and patency after application of paclitaxel-coated balloons in the hemodialysis access. J Vasc Surg 2020; 72:2186–2196.