Revision of Aneurysmal Arteriovenous Access with Immediate Use Graft Is Safe and Avoids Prolonged Use of Tunneled Hemodialysis Catheters

Outcomes of aneurysmal arteriovenous fistula revision

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ABSTRACT

Introduction: Aneurysmal AVF can pose a difficult treatment dilemma for the vascular surgeon. Prolonged tunneled dialysis catheters (TDC) in patients requiring long-term dialysis are associated with significantly increased mortality compared to arteriovenous fistulas (AVF). We aimed to elucidate the outcomes of aneurysmal AV access revision with aneurysm resection and Artegraft® (LeMaitre, New Brunswick, NJ) Collage Vascular Graft placement to avoid prolonged use of TDCs.

Methods: We reviewed all patients with aneurysmal AV access in which the access was revised with aneurysm resection and jump graft placement at a single institution from 2018 to 2021. Outcomes were time to cannulation, reintervention rates, time to reintervention and patency (primary, primary assisted and secondary). Patency rates were estimated with Kaplan-Meier Survival analysis.

Results: A total of 51 revised aneurysmal AV access in 51 patients were studied, of which 23.5% (n=12) had perioperative TDC placement. Three patients were done for emergent bleeding. The cohort was 62.8% male (n=32) with a median age of 58 years (IQR: 49-67). Most patients had brachiocephalic AVF (n=37 [72.6%]). Median follow up time was 280 days. Median time to cannulation was 2 days. Time to cannulation was significantly longer in patients with perioperative TDC as compared with those without TDC (24 days vs 2 days, P<0.001). Reintervention was required in 41.2% of patients (n=21), at median time of 47 days. At 30, 90, 180, and 365 days, primary patency rates were 84.3%, 78.3%, 66.6%, and 54.9%; primary assisted patency rates were 94.1%, 88.1%, 79.4%, and 79.4% and secondary patency rates were 100%, 97.8%, 91.6% and 91.6% respectively.
Conclusions: Revision of aneurysmal AV access (urgent or elective) with Artegraft as jump graft is safe, with acceptable short and mid-term patency results. This allows dialysis patients to continue to have a functional access, decreasing the need for a tunneled catheter and reducing the associated risk of sepsis and increased mortality. This should be considered for all patients with aneurysmal, dysfunctional fistulas to maintain AV access and avoid TDC placement.
Introduction

Aneurysmal degeneration of AV accesses is a frequent complication and has been reported to occur in 5-43% of AV accesses\(^1\)\(^{-4}\). In fact, it has been reported as the most frequent complication of AVF in some series\(^4\). Cannulation of an AV aneurysm should be avoided and their presence can thus limit cannulation sites\(^5\). Aneurysmal degeneration of AVF can result in increased flow and high output can place strain on the heart. It can also lead to thrombosis, decreased flow for dialysis, prolonged bleeding after puncture, skin compromise, poor cosmesis, and infection. Although rare, aneurysm rupture and life-threatening hemorrhage can result\(^3\).

Long-term tunneled dialysis catheters (TDC) use is associated with significantly increased mortality compared to the use of arteriovenous fistulas (AVF)\(^6\)\(^{-9}\). Infection related mortality, cardiovascular related morality and all-cause mortality have all been shown to increase when catheters are used for hemodialysis, with mortality increasing 40-70\%\(^9\). Additionally, TDC placement can contribute to central venous stenosis and limit future access options. For these reasons, the KDOQI guidelines favor AV access\(^5\).

In cases of symptomatic, large or rapidly expanding aneurysms, the KDOQI guidelines state that surgical management is reasonable based upon expert opinion\(^5\). However, there is no consensus on the optimal surgical management of AV access aneurysms. Multiple techniques to salvage aneurysmal AV access have been described; however, many of these techniques require delay in cannulation and use of TDC\(^10\)\(^{-18}\). To prevent TDC placement and its inherent risks, the authors utilize a resection and immediate use graft to revise aneurysmal AV fistulas.

Our objective was to determine the outcomes in hemodialysis patients in which aneurysmal AVF were revised with resection and use of the bovine carotid artery graft (BCAG; Artegraft \([\text{Artegraft, Inc, North Brunswick, NJ}])\) graft placement to avoid prolonged use of TDCs.
Methods

Study participants

We retrospectively reviewed and analyzed all patients who developed aneurysms after AV access creation and underwent revision at our institution. Patients were included from October 2018 to December 2021. The last day of follow up for events was January 24, 2022. Three patients required emergent revision due to life threatening hemorrhage and aneurysm rupture, the remainder of the cohort was done electively. Individual patient informed consent and approval from our institution’s review board was waived since only deidentified data were used.

Revision technique

Revision was done with surgical excision of the aneurysmal portion of the fistula and the overlying skin. Aneurysmal excision was chosen in patients who had a complication from aneurysmal AV access (i.e. bleeding, skin ulceration, skin thinning, pending rupture). All patients underwent either pre-operative or intra-operative fistulogram with treatment if necessary to relieve any outflow stenoses seen prior to revision. Perioperative TDC placement was only performed if the dialysis center had difficulty with cannulation. Interposition with Artegraft as jump graft was then done to salvage the AV access. The graft was tunneled lateral to the skin incision to allow for immediate cannulation post-operatively of the newly placed Artegraft (Figure 4.). Patients were not routinely anticoagulated after revision. They were placed back on their outpatient antiplatelet or anticoagulation regimen. 11.8% of our cohort were on pre-operative anticoagulation.

Outcomes

We evaluated both postoperative complications such as thrombosis, hematoma formation, stenosis, and infections. Outcomes were time to cannulation, reintervention rates, time to reintervention and patency (primary, primary assisted and secondary). By definition, patients were
considered to have primary patency until it is lost when reintervention is required to maintain patency, the access is thrombosed or abandonment of the AV access, whichever occurs first. Primary assisted patency was defined as any patency that ensues after reintervention except interventions for thrombosis. Patients were considered to have secondary patency after reintervention for thrombosis.

Statistical methods

All statistical analyses were performed with Stata/SE 16.1 (StataCorp LP, College Station, Texas). The baseline characteristics of study participants and outcomes were analyzed and presented. Continuous variables were presented as median with the corresponding interquartile range, while categorical variables were presented as counts and percentages. Patency rates were estimated with Kaplan-Meier Survival analysis. For comparative analyses, statistical significance was accepted when P values of tests ≤ 0.05.

Results

A total of 51 revised aneurysmal AV access in 51 patients were studied. Three patients were done for emergent bleeding. The cohort was 62.8% male (n=32) with a median age of 58 years (IQR: 49-67). A total of 31 patients (60.8%) had diabetes. Most patients had brachiocephalic AVF (n=37 [72.6%]). A total of 12 patients (23.5%) had perioperative TDCs; 9 placed preoperatively and 3 placed intraoperatively. Median follow up time was 280 days. Median time to cannulation was 2 days. Time to cannulation was significantly longer in patients with perioperative TDC as compared with those without TDC (24 days vs 2 days, P<0.001). Additional details about the study participants are displayed in Table 1.
The most common complications were thrombosis and hematoma formation. Thrombosis occurred in 15.7% (n=8) of patients at a median time of 80 days whereas hematoma formation occurred in 7.8% (n=4) of patients at a median time of 4 days, with one patient requiring reintervention during the index admission, Table 2. Reintervention to maintain patency was required in 41.2% of patients (n=21). The median time to reintervention was 47 days (IQR: 19-160 days). Primary patency was 84.3% at 30 days, 78.3% at 90 days, 66.6% at 180 days, and 54.9% at one year (Figure 1A); primary assisted patency rates were 94.1% at 30 days, 88.1% at 90 days, 79.4% at 180 days, and 79.4% at one year (Figure 1B) and secondary patency rates were 100% at 30 days, 97.8% at 90 days, 91.6% at 180 and 91.6% at one year (Figure 1C).

Discussion:

Our study demonstrates that placement of immediate use AVG for aneurysmal AV access is a safe option for revision of access that is at risk of rupture, as well as emergent salvage of access that has already ruptured. We demonstrate acceptable primary, primary-assisted and secondary patency rates in our cohort of patients, as well as a high rate of technical success in cannulating the newly created AV access within 48 hours after creation. Previous studies have demonstrated early cannulation of Artegraft® is safe either when used as a primary access or during revision, similar to our findings. Importantly in the majority of our cases, patients were able to avoid TDC placement and the intended risks that occur with prolonged tunneled dialysis catheter use. As we previously discussed, limiting the time that patients are dependent on TDCs is a necessity in the care of patients on hemodialysis due to their high risk of morbidity and mortality.

While previous studies have shown that AVG placement in the setting of patients undergoing HD results in fewer catheter days than if they were to have AVF placement, less work has evaluated the feasibility of revising aneurysmal AV fistulae/grafts already in place and its
ability to decrease catheter use\textsuperscript{19}. Alternative options for management of aneurysmal fistulas include ligation and creation of a new AV access or other techniques to revise the aneurysmal AV access. Revisional techniques that have been studied include various techniques to reduce aneurysmal diameter including stapled plication, partial aneurysmectomy and reinforced venous aneurysmorraphy. Most of the previously described techniques required TDC placement and prolonged time until cannulation\textsuperscript{10,16,18,20}. Vo et al performed aneurysm plication using a linear stapler to resect the redundant aneurysm down to a 6-8mm diameter, with staple line positioned laterally to avoid cannulation. They report no wound complications and no mortality in 30 days. These patients were not cannulated until 4 weeks post-operatively and thus required TDC use\textsuperscript{12}. Partial aneurysmectomy is one of the more promising of the alternative revision options however several technical variations have been described. Alhmeni et al studied partial aneurysmectomy in 36 patients where they resected diseased skin and aneurysm wall followed by suture repair of the aneurysm wall and overlying skin using surrounding healthy tissue. Their patients did not require TDC placement, and they report primary patency of 56\% and primary assisted patency of 97\% at 6 months. This technique has the advantage of avoiding graft placement and subsequent thrombotic complications. In fact, no reported complications were seen in their series. Despite their promising results they had a smaller sample size and did not have long term follow-up\textsuperscript{11}. Woo et al also describe a technique of partial aneurysmectomy performed in 19 patients where they excised excess length, reduced the luminal diameter, and reconstructed the fistula over a catheter guide. However these patients were not cannulated immediately and all underwent TDC placement with a median TDC removal at 8 weeks post-op, no specific complication rate was reported but 2 deaths occurred and 6 of their 19 patients required reintervention or ligation.\textsuperscript{10} One disadvantage of partial aneurysmectomy is there remains potential for recurrent aneurysmal degeneration.
address this short-coming techniques to reinforce the vein have been attempted. Berard et al
wrapped a polyester mesh around the vein to serve as an exoprothesis in 33 patients. The report
primary patency at 1 year of 93% but their patients were not cannulated for 30 days and all patients
required TDC placement. The authors did not report a specific complication rate, but had
hematoma formation prior to discharge in two patients, skin necrosis requiring explant in one
patient and stenosis requiring intervention in one patient. There are many advantages of the
technique utilized by the authors of this manuscript. Namely, the ability to immediately cannulate
for dialysis allows for avoidance of prolonged dialysis catheter use.

 Additionally, resection with interposition graft placement using other conduits (rGSV, PTFE) have been studied. Pierce at al performed interposition graft replacement for aneurysmal
AVF revision, using PTFE in 3 patients and reverse great saphenous vein (rGSV) in 7 patients and
report a lower thrombosis rate in rGSV grafts at 14% compared to PTFE (33%) but are limited by
a small sample size. In a randomized prospective study comparing PTFE to bovine carotid artery
as conduits for hemodialysis access, bovine carotid artery demonstrated superior outcomes with
lower thrombotic complications and less frequent need for interventions to maintain patency.
Arhuidese et al also compared bovine carotid artery to PTFE in hemodialysis access in a
retrospective review of 120 patients, they found no significant difference in primary or primary
assisted patency although there was improved secondary patency with bovine carotid artery They
found secondary patency was 71% vs 51% at 6 months, 67% vs 48% at 12 months, and
67% vs 38% at 24 months for bovine carotid artery vs PTFE. However, there are also studies
suggesting equivalence between the two conduits, including a systemic review by Kostakis et al
that found no significance difference in complications or patency rates between the two conduit
choices. Notably the above studies were evaluating new access creation but their results are likely
applicable to hemodialysis access revision as well and contributed to our choice to use of Artegaft® as the conduit for these patients.

Another advantage of aneurysmal resection with jump graft interposition is in preserving future access sites. By revising and not immediately creating new HD access we are able to increase the longevity, thereby maintaining future access site availability when primary and secondary patency of these grafts are lost. Refraining from placing additional access in less desirable locations such as the dominant upper extremity or lower extremities may have substantial quality of life benefits for our patients. Pike et al, found lower extremity accesses have poor primary patency rates in a retrospective review of outcomes from the vascular quality initiative. Others have demonstrated that avoiding central catheters and utilizing fistulas for hemodialysis increases quality of life for patients. Given our desire to limit the use of TDC in active dialysis patients, most aneurysmal AV access are treated with aneurysm resection with prosthetic jump graft placement. Even in instances of graft infection with rupture, we feel it prudent to perform this technique. Plication and other techniques aimed at avoiding prosthetic use, is considered to salvage an aneurysmal access in patients who are not actively using the access for hemodialysis needs. Based on our promising results we recommend consideration of revision by aneurysm resection and Artegaft® interposition graft for all patients with aneurysmal, dysfunctional fistulas to maintain AV access and avoid TDC placement.

This study is not without limitations, one of which is our sample size and demographic. This study was performed at a single institution over the course of 3 years. Although our sample size is small, it is the largest sample size reported to date for revision of aneurysmal AV dialysis access. It is worth noting that a large portion of the complications resulting in secondary interventions were encountered early on within this study. As surgeon experience grew with small
refinement in tunneling technique, complication rates dropped significantly in the later portion of the study. This suggests that our results for primary patency may improve with increasing surgeon experience in performing the procedure.

The purpose of this study was to evaluate the practice of aneurysm resection with interposition graft placement as a viable option for revision of aneurysmal HD access when compared to other previously described methods. Though we have demonstrated adequacy of this method with benefits to the patient and possible reduction in morbidity, as well as mortality from TDCs, going forward it would be pertinent to study and compare these methods of interventions directly. As with any study assessing surgical procedures, outcomes can be operator dependent.

Future evaluation should include larger multi-institutional studies and evaluation of long-term functional patency.

Reference:


FIGURE LEGENDS

Figure 1. Patency rates
A. Primary patency
B. Primary assisted patency
C. Secondary patency

Figure 2. Pre-operative, intra-operative and post-operative images of revision technique
### Tables

#### Table I. Baseline characteristics of study participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>N (%) or median (IQR)</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>58 (49-67)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>19 (37.3)</td>
</tr>
<tr>
<td>Male</td>
<td>32 (62.8)</td>
</tr>
<tr>
<td>Access type</td>
<td></td>
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<tr>
<td>Radiocephalic AVF</td>
<td>6 (11.8)</td>
</tr>
<tr>
<td>Brachiocephalic AVF</td>
<td>37 (72.6)</td>
</tr>
<tr>
<td>Arteriovenous graft</td>
<td>8 (15.7)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>26.7 (23.1-32.1)</td>
</tr>
<tr>
<td>Obesity</td>
<td>17 (33.3)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>31 (60.8)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>10 (19.6)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>10 (19.6)</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>7 (13.7)</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>23 (45.1)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>1 (2.0)</td>
</tr>
<tr>
<td>Anticoagulation</td>
<td>6 (11.8)</td>
</tr>
<tr>
<td>Tunneled dialysis catheter (TDC)</td>
<td>12 (23.5)</td>
</tr>
<tr>
<td>Preop TDC</td>
<td>9 (17.7)</td>
</tr>
<tr>
<td>Intraop TDC placement</td>
<td>3 (6.0)</td>
</tr>
<tr>
<td>Time to canulation, days</td>
<td>2 (1-3)</td>
</tr>
<tr>
<td>Without TDC</td>
<td>2 (1-3)</td>
</tr>
<tr>
<td>With TDC</td>
<td>24 (4-31)</td>
</tr>
<tr>
<td>Follow up time, days</td>
<td>280 (115-577)</td>
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</table>
### Table II. Complications and outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N (%)</th>
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</thead>
<tbody>
<tr>
<td>Complications</td>
<td>18 (35.3)</td>
</tr>
<tr>
<td>Thrombosis</td>
<td>8 (15.7)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>4 (7.8)</td>
</tr>
<tr>
<td>Stenosis</td>
<td>1 (2.0)</td>
</tr>
<tr>
<td>Infection</td>
<td>2 (3.9)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (5.9)</td>
</tr>
<tr>
<td>Reintervention</td>
<td>21 (41.2)</td>
</tr>
<tr>
<td>Time to reintervention, days</td>
<td>47 (19-160)</td>
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<tr>
<td>Patency type</td>
<td>30-day</td>
</tr>
<tr>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Primary, %</td>
<td>84.3 (71.1-91.8)</td>
</tr>
<tr>
<td>Primary assisted, %</td>
<td>94.1 (82.9-98.1)</td>
</tr>
<tr>
<td>Secondary, %</td>
<td>100</td>
</tr>
</tbody>
</table>
Kaplan-Meier survival estimate

Primary Patency, %

Time Since Access Revision, days

Number at risk

51  33  19  14  9
Fig 4. Pre-operative, intra-operative and post-operative images of revision technique