Aneurysmal Degeneration of the Inflow Artery after Arteriovenous Access for Hemodialysis

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WHAT THIS PAPER ADDS
This paper describes one of the largest experiences of the treatment of true aneurysms of the inflow artery after arteriovenous fistula creation for hemodialysis, and the largest published series using autogenous bypass revascularization, the first treatment line in most cases. As the autogenous bypass conduit, ipsilateral arm veins (when not dilated) can be used successfully, preserving leg veins or contralateral arm veins for other or future procedures. These results confirm the good initial and short-term outcomes using this technique. Other therapeutic options are also reviewed.

Objectives: After arteriovenous fistula creation, the arterial flow increase can lead to aneurysmal degeneration, even increased after fistula ligation or renal transplant immunosuppression. The aim of this study is to describe the therapeutic options and outcomes of true aneurysms of the inflow artery after arteriovenous fistula for hemodialysis.

Methods: Prospectively collected data of patients with true aneurysmal degeneration of the inflow artery after fistula creation (excluding pseudoaneurysms, anastomotic or infected aneurysms, or surgical complications), surgically repaired between January 2010 and February 2014 (cohort study) have been included. Patient demographics and access characteristics, symptoms, treatment, and follow-up have been reviewed.

Results: 12 patients (75% men, median age 63 years) were treated for aneurysmal degeneration of the axillary (1), brachial (6), or radial (5) artery. They had had a previous distal arteriovenous fistula (7 radiocephalic, 3 brachioccephalic, 2 brachiobasilic) created 15.6 years before (range 9.9–28.5) and the majority of them were currently ligated or thrombosed. Most patients were symptomatic (pain [6], distal embolization [1]). They were treated by means of a bypass (using the cephalic [3], basilic [4], or saphenous vein [2]), direct ligature (2), or excision with end-to-end reconstruction (1). No major complications or ischemic symptoms occurred before discharge. After a median follow-up of 8.6 months (3.1–36.5), one patient needed re-operation for new proximal brachial aneurysmal degeneration, and another presented with an asymptomatic post-traumatic thrombosis of the proximal axillary artery and brachial bypass. No other complications, bypass dilatation or ischemic symptoms occurred during follow-up.

Conclusions: Inflow artery aneurysmal degeneration can occur after long-term arteriovenous access. Surgical treatment by autogenous bypass exclusion in most cases (or ligation or end-to-end reconstructions in selected cases) is a safe and effective option.

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INTRODUCTION
Arteriovenous fistula (AVF) is the method of choice for achieving vascular access for hemodialysis in patients with end-stage renal disease because of its higher patency and lower complication rates. In spite of its better results compared with other access techniques, some specific complications can occur after AVF, including steal syndrome or venous aneurysm formation.

However, aneurysmal degeneration of the inflow artery is a less common complication after AVF. It has been described in case reports and series of cases of patients with long term AVF, probably due to the high flow in the artery over a long period, which is not prevented or avoided after fistula ligation or thrombosis, and is also associated with a history of renal transplant and immunosuppressive treatment. Management of these aneurysms can be challenging.
The aim of this work is to describe the authors’ experience of treating true aneurysms of the inflow artery after AVF and to review the literature.

MATERIALS AND METHODS

Our vascular access unit (UFAV, Hospital Clinic, University of Barcelona, Spain) offers a multidisciplinary approach for patients requiring vascular access for hemodialysis, and treating any complications related to it. For this particular work, a prospective observational study was designed including all patients treated for true aneurysmal degeneration of the donor artery after an AVF for hemodialysis, which were surgically repaired between January 2010 and February 2014. Indications for repair of these aneurysms were radial, ulnar, brachial, or axillary artery diameter larger than 30 mm or symptomatic aneurysms (embolization or significant pain). Any other disease including pseudoaneurysms, infected or anastomotic aneurysms, aneurysmal dilation of the original anastomotic area, vein aneurysmal degeneration or post-puncture artery lesions were excluded. During the same study period, 948 AVF and 214 surgical repairs of dysfunctional AVF were performed.

Patient details (demographics, history of hemodialysis, vascular access and renal transplantation, and current symptoms) were recorded in the prospective database. All aneurysmal cases were routinely examined with color duplex ultrasound (extensive examination of the arterial system from subclavian artery to palmar arch, in particular analyzing the extent of aneurysmal degeneration, presence of thrombus, patency of distal forearm arteries and presence of distal emboli; examination of possible vein conduits to repair the aneurysm was also performed in the same arm and legs). Selective AngioCT was performed.

The first line of treatment was always aneurysm exclusion and revascularization with autogenous conduits (superficial veins from the same arm, if not dilated because of the previous AVF, or from the leg [great saphenous vein]), but in localized aneurysms excision and end-to-end reconstruction was attempted. In forearm radial aneurysms, when the other main artery (ulnar) was patent with a patent palmar arch, simple aneurysm excision was planned.

Finally, close clinical and imaging (ultrasound) follow-up at 1, 3, 6, 12 months, and yearly thereafter was also performed. Descriptive parameters (number and percentages, or medians and ranges) were obtained using the Statistical Package SPSS, Version 15.0. Time-to-event (arterial reconstruction primary, assisted primary and secondary patency at 6 months and 1-year follow-up) was analyzed with the Kaplan–Meier survival analysis.

RESULTS

Between January 2010 and February 2014, 12 patients (75% men, median age 63 years [range 31–83]) with a previous history of arteriovenous accesses in the upper extremity were surgically treated for arterial aneurysmal degeneration in the same arm. All patients had a previous history of hemodialysis, initiated a median of 18.3 years (11.5–30.2) before aneurysm treatment. All patients also had a previous history of renal transplant, receiving a median of 2.0 (1–3) transplants per patient, and none of them was currently under hemodialysis treatment.

In the involved extremity, the patients had previous functional AVF (7 radiocephalic, 3 brachioccephalic, 2 brachiobasilic), originally placed distal to arterial aneurysm, and created 15.6 years (9.9–28.5) before. At the time of surgery, six of these AVF had already thrombosed, five had been ligated previously because of an excessive dilation of the vein (4) or steal syndrome (1), and only one was still patent, and was ligated at the time of surgery.

Most patients were symptomatic when referred to the clinic (pain in the aneurysm and swelling in 6, and distal embolization in 1), in addition to evident aneurysmal swelling in the arm in all cases (Fig. 1). Systematic ultrasound (color duplex) examination showed fusiform aneurysmal degeneration of the radial (5), brachial (6), or axillary (1) artery. Aneurysm median diameter was 40.5 mm (30–55), 83% with extensive intraluminal thrombus. No cases presented multiple separate aneurysms.

After individual case examination and discussion, nine cases were treated by means of aneurysm excision and
revascularization with autologous bypass, using the ipsilateral cephalic (3) or basilic (4) vein, or the great saphenous vein (2) as conduits (Fig. 2). In two radial aneurysms with a patent ulnar artery and palmar arch, direct aneurysm ligation and excision was performed, and in one localized brachial aneurysm, excision with arterial tortuosity straightening and end-to-end brachial artery reconstruction was performed (Table 1).

There were no intra- or postoperative major complications, and discharge was 2.5 days (2–4) after surgery. There were no immediate complications, wound infections or significant hematomas.

After a median follow-up of 8.6 months (3.1–36.5), no patients were lost, and no wound infection, hematomas, bypass dilation, or stenosis had been detected. One-year primary, assisted primary, and secondary patency were 100%. However, two complications occurred after 1-year follow-up. In one patient, 22 months after the initial brachial aneurysm exclusion and brachial—brachial bypass revascularization with basilic vein, a new rapid aneurysmal degeneration of the proximal brachial artery was detected, requiring proximal brachial aneurysm exclusion and additional axillary to previous brachial—brachial bypass revascularization using another ipsilateral arm basilic vein segment. No complications occurred in the intra- or postoperative period, and both bypasses were patent without further complications 15 months later.

The second event was observed in a patient with a previous uncomplicated brachial—brachial bypass after a blunt trauma to the operated arm 15 months after surgery, followed by mild and transitory coldness of the arm, without critical ischemia or claudication. After late consultation, axillary artery and bypass thrombosis were diagnosed, but left untreated due to absence of symptoms (Fig. 3).

During the study period, only one of the patients in the series required dialysis, and because of the patient’s preference, a switch to peritoneal dialysis was performed.

**DISCUSSION**

Some studies have described an increase in the inflow artery (brachial or radial) diameter in the extremity with an AVF3,4,6,7,11 accentuated by AVF flow3 and the time after fistula creation,4 and not prevented by fistula ligation or thrombosis. The mechanism is still unclear, but probably the increase in arterial flow following AVF produces an increase in wall stress and a decrease in wall thickness; these changes upregulate the local production of vasodilator agents (nitric oxide) and matrix metalloproteinases 2 and 9, which are also associated with adaptive arterial remodeling by internal elastic lamina fragmentation and arterial enlargement.9,10 Renal transplantation also seems to increase inflow artery aneurysmal degeneration,3 probably due to immunosuppression and corticosteroid therapy (which has already been related to the induction of aneurysms).3,12

However, it rarely led to true aneurysmal degeneration, which is an uncommon and late complication after AVF creation,5,13,14 affecting 4.5% of AVF,4 7–19 years after fistula creation4 (in this series, 15.6 years later). Although it is a long-term enlargement, a rapid increase in aneurysmal diameter is usually described from a few days to months before consultation.4,6 The most common symptoms are pain or swelling, in addition to evident swelling of the dilated artery in the arm. Distal embolization can often occur (described in 30% of cases)4 due to mobilization of the normally present thrombus within the aneurysm (83% of our cases). Nerve compression and paresthesia have also been described occasionally, but rupture is extremely rare.4,6,13,14 Arterial diameter is usually increased in all inflow arteries, but the most extensive aneurysmal degeneration usually affects the distal part of the brachial artery, in the cubital fossa4 (Fig. 1), probably due to its higher turbulence proximal to bifurcation.

After inflow arterial aneurysm diagnosis, close follow-up with clinical and ultrasound examination (every 6 months) and selective AngioCT examination have been performed. Indications for surgical repair (usually not clearly set in

### Table 1. Description of aneurysms, operation performed and conduits used.

<table>
<thead>
<tr>
<th>Aneurysm location</th>
<th>n</th>
<th>Surgery</th>
<th>Conduit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radial artery</td>
<td>3</td>
<td>Radial—radial bypass</td>
<td>2 Forearm accessory cephalic v.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 Forearm basilic v.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Ligation</td>
<td>—</td>
</tr>
<tr>
<td>Brachial artery</td>
<td>5</td>
<td>Brachial—brachial bypass</td>
<td>1 Arm cephalic v.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 Arm basilic v.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2 Leg great saphenous v. (leg)</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>Aneurysm excision and end-to-end brachial artery reconstruction</td>
<td>—</td>
</tr>
<tr>
<td>Axillary artery</td>
<td>1</td>
<td>Axillary—brachial bypass</td>
<td>1 Arm basilic v.</td>
</tr>
</tbody>
</table>

v.: vein; n: number.
Figure 3. Complications occurred during follow-up in two different patients (color Doppler ultrasound images): new rapid aneurysmal degeneration of the proximal brachial artery after previous distal brachial aneurysm exclusion with brachial—brachial bypass (A) and axillary, brachial and bypass thrombosis after blunt arm trauma (B).

previous publications)\(^4\,\,6\,\,13\,\,14\) include arterial diameter greater than 30 mm or with complications (distal embolization or pain), and technically feasible (patent and not excessively dilated inflow and outflow arteries). Indeed, huge and extensive dilatation of the whole subclavian, axillary, and brachial arteries are difficult to repair and very prone to complications. This threshold (30 mm) was a local decision due to the absence of a clear diameter limit in the literature, and because smaller diffuse arterial enlargement (10–20 mm) is often seen in these patients, without symptoms or complications. However, a lower threshold (20 mm) could probably be used for radial aneurysms.

Like most published cases, the preference is to use autogenous conduits (rather than prosthetic grafts or allografts)\(^4\,\,\,6\,\,13\,\,14\). But in contrast to other groups that use the great saphenous vein, ipsilateral arm vein of the same affected extremity, when not dilated or altered by previous AVFs, is preferred. The reason is to allow a quicker procedure with lower morbidity, and to preserve leg veins for future procedures in the arms or other vascular reconstructions. Furthermore, patients with reconstruction of an arm aneurysm will not be good candidates for future AVF in the same arm (risk of new aneurysmal degeneration or bypass complications), so superficial veins in the same arm will not be used in the future. And there have been no bypass dilatations or complications related to arm veins.

Results using autogenous bypass reconstruction in this series are good (only one case of post-traumatic asymptomatic thrombosis and one re-intervention due to aneurysm progression) and similar to other series, although long-term results are still not available. This is the largest published series of autogenous bypass reconstruction of aneurysmal degeneration of the inflow artery after AVF (9 autogenous bypass, 2 ligations and 1 end-to-end reconstruction). Other large series have been published by Marzelle et al.\(^4\) (3 autogenous, 4 prosthetic and 1 allograft bypass, and 2 medical treatments, reporting 2 re-interventions due to aneurysm progression and 1 bypass thrombosis after 20 months mean follow-up) and Chemla et al.\(^5\) (6 autogenous bypass, 7 end-to-end reconstructions, without thrombosis or severe complications after 16 months median follow-up). This higher frequency, in some groups, of brachial end-to-end reconstruction instead of bypass revascularization, in localized brachial aneurysms after brachiocephalic AVF, is probably due to dilation of the anastomotic area or localized anastomotic aneurysms (not included in this work) more than true and diffuse arterial enlargement, in which case treatment is easier.

Systematic duplex screening of arterial aneurysms in patients with previous AVF is not recommended, probably because it is not cost-effective and detection is easily performed by physical examination; thus, specialists treating hemodialysis patients should be aware of this complication, perform systematic physical examination of patients with previous AVF, and refer the patient for duplex scan when arterial aneurysm degeneration is suspected. Prevention of this complication by early AVF ligation after renal transplantation cannot be recommended, as the benefit is only theoretical (arterial aneurysms can appear even if the AVF is ligated or thrombosed) and the patient loses the AVF which may be needed for hemodialysis in the future.

In conclusion, inflow artery aneurysmal degeneration can occur after long term AVF. Surgical treatment by autogenous bypass exclusion using ipsilateral arm or leg vein is a safe and effective option in most cases. In selected cases, end-to-end reconstructions of localized aneurysms or ligation of radial aneurysms can also be performed.

CONFLICT OF INTEREST
None.

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None.

REFERENCES


