Arteriovenous graft for hemodialysis, graft venous anastomosis closure – current state of knowledge. Minireview

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Background. The use of artificial vascular grafts (arteriovenous graft, AVG) is indicated in patients in hemodialysis programs if the subcutaneous venous bed is exhausted or unsuitable for arteriovenous fistula (AVF) creation. The native fistula should be the hemodialysis access of first choice: AVF has better results in terms of function and potential complications. However, the use of AVG is necessary in some patients. In these patients, extensive clinical examination, color duplex sonography and angiography should be performed prior to indication. The technique of graft implantation requires respect for geometric relations for the graft anastomoses to minimize the formation of intimal hyperplasia mainly on the venous anastomosis. The main complications of AVG are stenosis on the venous anastomosis (VAG), causing closure of graft and graft infection. The cumulative function of AVG is 59-90% in the first year and 50-82% in the second year. Arteriovenous graft stenosis leading to thrombosis is a major cause of complications in patients undergoing hemodialysis. The purpose of this review is to summarise current knowledge of the diagnostics and treatment of graft thrombosis and discuss the issue in combination with relevant publications via Pubmed database.

Conclusion. The most frequent cause of failure of AVG for hemodialysis is stenosis and closure by VAG. AVG closure can be addressed surgically, endovascularly (amenable to thrombectomy by radiological or surgical means) and by hybrid performance.

Key words: renal replacement therapy, arteriovenous graft for haemodialysis (AVG), venous anastomotic stenosis (VAG), AVG thrombosis, surgical thrombectomy, balloon angioplasty, stentgraft (SG)

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INTRODUCTION

A well-functioning vascular access is essential for efficient hemodialysis treatment. In the case of failure or inability to create autologous arteriovenous fistula (AVF) for hemodialysis (HD), arteriovenous graft (AVG) is used as access to HD. AVG is an artificial vascular prosthesis which is inserted between the arterial and venous circulation. AVG is cannulated during hemodialysis and the patient is connected to a dialysis machine.

The expanded polytetrafluoroethylene (PTFE) prosthesis is considered the gold standard in terms of material. Grafts manufactured from PTFE have gained wide acceptance. The advantages of using PTFE grafts are short maturation time (3 to 4 weeks) and multiple potential access sites. Their overwhelming disadvantage is their propensity for venous outflow stenosis caused by endothelial and fibromuscular hyperplasia. Most grafts fail, due to intimal hyperplasia and stenosis on the VAG, leading to thrombosis.

A large number of modifications exist in regard to position and caliber of AVG. In contrast to the United States, in European conditions, AVG is used as the last option for providing access to HD before central venous catheter (CVC) which is associated with a high percentage of infectious complications. AVG function is limited;

the primary patency at 6 months is 58% and at 18 months 33%, secondary patency is 76% and 55%, respectively¹. The secondary patency of the AVG (e.g. patency after intervention) is usually 50% at 3 years and is typically associated with repeated procedures to maintain patency².

In the Czech Republic, AVG creation is indicated only in patients with exhausted autologous subcutaneous venous circulation, prior to CVC introduction. This is in contrast to situation in U.S., where despite the National Kidney Foundation Kidney Disease Outcome Quality Initiative (NKF KDOQI guidelines) (ref.³) recommendation AVG is used as primary access to HD. Therefore our AVG patients are generally older and have more complicated health issues than those with AVG in the U.S. For this reason, complications resulting from AVG use are more common and more difficult than in the U.S.

Hence in the Czech Republic, creation of AVG must be appropriately indicated and maximal effort is required to preserve AVG function. The policy accepted in the United States - creation of autologous fistula following AVG occlusion - is not possible under our conditions³. It is clear, however, that AVG has its advantages: AVG may be appropriate in patients with exhausted access sites. AVGs offer a short maturation period and are more amenable to thrombectomy by radiological or surgical means.

Typical complications associated with the use of AVG are stenotic and thrombotic complications of the venous anastomosis of the graft (VAG) and graft infection. Summarising the facts of infection is not the subject of this review but we can note that AVG infection occurs 10 times more frequently than with AVF, is often associated with dialysis access closure, and that silent AVGs are often a source of infection^{4,6}.

Stenosis and subsequent closure VAG is caused by myointimal hyperplasia⁷. Its formation is influenced by hemodynamic biophysical mechanisms resulting from the geometry of the graft and so-called compliance mismatch between vein and graft^{8,9}.

VAG stenosis is often associated with other stenoses at the venous site behind VAG - called skip lesions. It is not possible to prevent the emergence of VAG. Antiplatelet and anticoagulant therapy do not significantly prevent the risk of graft thrombosis^{10,11}. Prevention of thrombosis of AVGs with anticoagulant therapy is associated with high risk of bleeding while the effect of graft thrombogenicity is uncertain¹². Antiplatelet therapy through various antiplatelet agents (clopidogrel, aspirin, dipyridamole) or in combination, does not reduce the incidence of thrombosis of AVG and significantly increases the risk of bleeding¹³, particularly the combination of clopidogrel and aspirin¹⁴.

Thrombosis of AVG occurs at flow rates 600 mL/min, a value that is twice the requirement for adequate flow hemodialysis, 300 mL / min (ref.¹⁵). Its development is detected as decrease in the quality of dialysis, monitoring AVG using ultrasonography flow measurement and data obtained from angiography. The most common screening tests are access blood flow and dialysis venous pressure measurements. Monitoring functions of AVG using color duplex sonography is considered to be a key method^{16,17}.

VAG stenosis should be treated surgically or endovascularly in the case that parameters for angioplasty of venous stenosis are present – 50% stenosis is noted and only when associated with one of several indicators of graft dysfunction-abnormal physical findings, decreased access flow rate below 600 mL/min and elevated static intraluminal pressure³. Stenoses in AVG can be surgically treated and interventionaly. Percutaneous methods (PTA) are less invasive than surgery. The predominant endovascular methods used are – stenosis angioplasty (PTA) (ref.¹⁸) and angioplasty with stenting (PTA + stent) (ref.¹⁹). Percutaneous procedures have several advantages over competing surgical procedures. They also lead to better acceptance by patients.

VAG treatment by PTA or PTA + stent is not durable. As a result of neointimal proliferation, recurrent restenoses occur even when using a stent for in-stent stenosis²⁰. To date, there is no better method than PTA, even though this has been modified (ultrahigh pressure balloons²¹, cutting balloons²², external beam radiation therapy²³).

Progress in resolving stenosis VAG may be angioplasty using self expandible stent graft (SG). It is assumed that in-stent restenosis may be prevented using ePTFE materials. The stent is coated with ePTFE inside and this material is identical to material from which AVGs are

manufactured²⁴. This endovascular approach converts the initial surgical end-to-side venous anastomosis into an end-to-end anastomosis providing more laminar in line flow. However, there are doubts about the long-term results of PTA and SG. This method is an alternative to surgical therapy²⁵.

Surgical therapy is open surgical revision-VAG stenosis. According to the NKF KDOQI guidelines (as of 2006) AVG stenoses greater than 50% are indicated for angioplasty or surgery³. Surgery is reserved for patients in whom intraluminal angioplasty has failed and stent implantation is indicated. After three angioplasties, the patient should be referred to a surgeon¹³. Surgical preparation of venous anastomosis especially on the brachial or axillary vein is difficult. Treatment of a stenotic segment often requires the use of patches, and surgical revision provides unsatisfactory results, as it often leads to restenosis. Surgical treatment (new anastomosis, patch, bypass) can eliminate the problem but new lesions can occur in adjacent locations, leading to progressive loss of needling segments or of potential sites for new vascular access²⁶. However, surgical revision stenotic VAG is losing its importance.

One serious complication is acute thrombotic occlusion of AVG on the basis of a stenosed VAG. This is an emergency life-threatening complication in vascular surgery, when the patient does not have access to HD. Immediate treatment of AVG or other access to HD is required and central venous cannulation may be technically difficult in these patients. AVG thrombosis can be treated surgically or endovascularly. The cause - stenosis and subsequent closure VAG, can also be treated surgically or endovascularly. A number of studies have evaluated these methods and it is clear that a combination of methods is beneficial.

At the end of the 90s of the last century occluded AVG treatment was dominated by surgical thrombectomy combined with either patch angioplasty to widen the outflow vein or a jump graft to bypass a stenotic area. Operative thrombectomy is performed using a Fogarty catheter. This is followed by angiography in the angiography suite to detect any residual thrombi and to identify the causative stenosis. A metaanalysis by Green et al. supports the use of surgical thrombectomy for the treatment of thrombosed prosthetic vascular access grafts. An analysis comparing surgical thrombectomy, mechanical thrombectomy and thrombolysis for thrombosed pharmacomechanical AVG concluded that surgical thrombectomy provides superior results to other forms of treatment. The use of endovascular techniques has found surgery to be inferior in terms of both primary patency and technical failure rates²⁷⁻²⁹. Later work also confirmed that the outcome of surgical treatment of thrombosed AVG depends on whether additional graft revision with patchplasty or graft interposition has been done. Surgical thrombectomy alone is inadequate for treating a thrombosed dialysis graft. The underlying graft outlet stricture requires direct surgical revision or balloon angioplasty during surgery or intervention in the angiography suite to ensure long-term patency of the graft³⁰.

Better results are obtained by thrombectomy surgery, balloon angioplasty with stent placement, graft thrombectomy plus angioplasty with self-expanding nitinol stent placement. The higher price guarantees patency compared with thrombectomy plus plain balloon angioplasty of the venous anastomosis³¹. AVG function after thrombectomy is also associated with the timing of performance - urgent thrombectomy is recommended, deferring worse long-term function AVF (ref.³²). More recently published studies have predominantly appeared after the year 2000 and showed improved success rates of endovascular techniques. The data collected by Uflacker et al. provided a prospective comparison of mechanical thrombectomy (Amplatz thrombectomy device) and surgical thrombectomy (de clot) performance in thrombosed AVG.

For both techniques, venous anastomosis was checked by intraoperative angiography, surgical thrombectomy was treated surgically (patch angioplasty, reanastomosis) and in endovascular treatment balloon angioplasty of the venous stenosis was performed. The results of the performance of both methods were comparable. No statistically significant differences were found³³.

It is clear that to correct an underlying outlet stenosis after thrombectomy AVG is important. Simultaneous treatment of the underlying stenosis is an integral part of any declotting procedure. The results of VAG stenosis balloon angioplasty are comparable to that of surgical revision³.

CONCLUSION

An innovative view on the treatment of clotted AVG with stenosis of VAG was provided by experience with the stent graft insertion in the functional stenotic VAG (ref.²⁴). It is possible to perform surgical thrombectomy of clotted AVG using a Fogarty catheter with subsequent angiography, in the operating room and with intraoperative endovascular treatment of a stenotic VAG with balloon angioplasty and stent graft placement.

In our experience, the procedure can be performed under local anesthesia from the side of the arterial anastomosis. The disadvantage is the high cost of the procedure.

The use of AVG for vascular access is associated with some disadvantages. The main disadvantage is development of VAG stenosis which leads to AVG thrombosis. Graft function should be assessed by means of a clinical evaluation of the clinical or hemodynamic indicator recommended by NKF KDOQI guidelines³. According to this findings, angiography is indicated²⁴. Treatment of thrombosis may be surgical or endovascular. Good secondary function of AVG requires treatment of the stenosis on the VAG. Better results can be achieved by endovascular treatment methods.

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