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Vascular Access Cannulation and Care

A Nursing Best Practice Guide for Arteriovenous Graft

> Editor Maria Teresa Parisotto

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First edition: September 2016

European Dialysis and Transplant Nurses Association/ European Renal Care Association (EDTNA/ERCA)

Pilatusstrasse 35, CH 6003 Lucerne, Switzerland <u>www.edtnaerca.org</u>

ISBN: 978-84-617-4687-3

D.L.: M-32386-2016

Layout, Binding and Printing: Imprenta Tomás Hermanos Río Manzanares, 42-44 · E28970 Humanes de Madrid Madrid - Spain www.tomashermanos.com

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Vascular Access Cannulation and Care A Nursing Best Practice Guide for Arteriovenous Graft

Acknowledgements

This book is an initiative of Fresenius Medical Care Deutschland GmbH. We kindly thank the authors, the contributors and the reviewers for their collaboration and enthusiasm for this project.

The content created is an excellent example of multidisciplinary, international teamwork, developing a *best practice guide* for the most important aspect of the haemodialysis patient's care.

Editor

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²⁰ "The aim of science is not to open a gate to endless wisdom, but to set a limit to endless error"

Bertolt Brecht

Maria Teresa Parisotto and her nursing team have returned with a second *best practice guide* on vascular access (VA) handling, this time with a focus on the Cinderella of the family, the polytetrafluoroethylene (PTFE) graft.

Over the last two decades native AV fistula has been glorified as being the gold standard, the best vascular access a patient and the clinical team could dream of. The authors of this *best practice guide* actually state "if the patient is not a good candidate for an arteriovenous fistula, an arteriovenous graft should be considered...".

Health authorities, some agencies and large provider chains made a real push, trying to influence vascular access choice as if it were a black and white issue. For the Centers for Medicare and Medicaid Services (U.S. CMS), in 2014 VA choice accounted for 30% of their Quality Incentives Program, rewarding high AV fistula prevalence and penalising other vascular accesses, without consideration of patient case-mix. The results were identical, the prevalence of native AV fistulae increased, but we saw a reciprocal decline in grafts and mostly a rise in long-term catheters.

Coming from a country (Portugal) with an average of 17% of patients being dialysed through a PTFE graft, let me defend our case.

There has never been a randomised controlled trial comparing different VA choices with mortality or other outcomes. All large observational trials compared VAs achieved as opposed to the access that was intended. Meaning that intention to treat was not respected.

As 25 to 60% of all AV fistulae created either fail or required several procedures to boost maturation, and the graft group in most studies were patients in whom AV fistula failed, or graft was a first choice because of poor prognosis (age, precarious vascular territory, short life expectancy...), then we really cannot answer any question on which VA modality is the best. There is indeed a high risk of selection bias which may exaggerate the benefits of the fistula.

Applying a proportional hazard model to examine mortality in incident haemodialysis patients aged 65 to 90 years old in association with the type of VA, adjusting for case-mix and health status, Grubbs and co-workers found that the relative risk (RR) of AVF was 1.0, PTFE grafts 1.18, the transition from catheter to AVF 1.2, and from catheter to graft 1.38.

Using a decision analysis model on the best option for patients initiating haemodialysis with a long-term tunnelled catheter, Drew and colleagues demonstrated that the life-expectancy and the economic advantage of choosing a transition to an AV fistula instead of a graft was progressively lost as patients aged above 60 years, mainly in women and diabetics.

Vascular access is only one more example of the paradox between patient-centred care vs protocol-driven care, under the tyranny of quality metrics based on population studies.

Considering this poor reputation, we can only praise this initiative of Maria Teresa Parisotto et al. to "raise awareness of the importance of AV grafts as the second VA option …", bringing together an impressive group of experts in this field to provide recommendations for the care of patients being treated with this type of VA.

Cannulation delay after graft implantation is much shorter than with AV fistulas, K/DOQI guidelines suggested at least 14 days of maturation time and the DOPPS study, looking at 2.730 patients with grafts, demonstrated that there was no significant difference in outcomes with cannulation of AV grafts between 2 and 4 weeks.

However, the responsibility of the nurse establishing the extra-corporeal circuit goes way beyond the correct needling of the graft. They may make a huge difference in continuous patient education on the care of their access, as well as on the clinical monitoring of the patient graft before cannulation, as when the physician make rounds later on, it will not be possible for him to perform a proper physical examination with the patient connected to the extracorporeal blood circuit. I believe that this clinical assessment 3 times a week, associated with Kt/V monitoring each dialysis, is an unexpensive strategy that may play a more prominent role than monthly haemodynamic (VA flow-Qa, venous pressures, ...) and ultrasound surveillance, or even pre-emptive graft endovascular assessment, as so far they have been a major disappointment study after study. It is now well established that there is a strong agreement between physical examination by an experienced staff member and angiography in the diagnosis of outflow and inflow stenosis. As a matter of fact, absolute VA flow, or drop in flow in two consecutive measurements, measured either with flow indicators, or ultrasound, are inaccurate predictors of thrombosis

Primary reasons for failure of an AV access are thrombosis and infection, which are also the predominant operative factors in resource utilisation and expense.

When comparing fistulae with grafts, the primary failure rate was two times greater for fistulae than grafts (40% vs 19%), cumulative patency, however, did not differ significantly

between fistulas and grafts. It is important to note that compared with functioning fistulae, grafts necessitated twice as many angioplasties (1.4 vs 3.2 events per 1.000 accessdays) and significantly more thrombolysis interventions (0.06 vs 0.98 events per 1.000 access-days) to maintain patency. Also the rates of bacteraemia per 1000 access-days are 0.37 for fistulae and 0.39 for grafts.

According to the USRDS report of 2010, per person per year access expenditure is US \$8.683 for AV graft, and \$3.480 for AV fistulae, the overall patient expenditure also differed significantly associated with type of access; per person per year total expenditure was \$79.337 for patients with AV grafts and \$64.701 for those with AV fistula.

Although mostly a second option, the PTFE graft deserves and requires excellence of care, and I am sure that this new guide will help all the stakeholders, patients, nurses and physicians alike, in this quest to achieve the optimal management for all this patients.

Pedro Ponce, MD

Board Certified in Nephrology and Intensive Care Medicine Chief of Nephrology and ICU - Hospital Cuf in Lisbon Country Medical Director of NephroCare Portugal

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26 **2. Introduction**

To a large extent, the success of long-term haemodialysis depends upon the patient having a trouble-free vascular access (VA). VA-related complications remain a serious clinical problem, with VA failure being a major cause of morbidity, hospitalisations and mortality.

The arteriovenous fistula has been in use since it was first created over 40 years ago.

If a patient is not a suitable candidate for an Arteriovenous Fistula (AVF), an Arteriovenous Graft (AVG) should be considered before the insertion of a Central Venous Catheter (CVC).¹

The main cannulator in the dialysis community is traditionally the nurse; however, there are very few recommendations, guidelines and educational materials available for dialysis nurses at present in published literature, and almost every dialysis unit has its own technique and procedure. The large majority of available guidelines are mainly targeted at physicians and do not describe cannulation techniques.

In 2014 a Vascular Access Guide addressed to nurses was published. This Guide, which was developed by an international panel of experts, defined AVF cannulation practices based on the available clinical evidence, and provides recommendations for AVF cannulation and care.²

AVF remains the gold standard for haemodialysis access, demonstrating both improved survival and lower complication rates than either AVG or CVC.³ An AVG (synthetic or biological) is the second best option for haemodialysis and should be preferred over a CVC because of fewer complications and better survival rates.⁴ Arteriovenous grafts are preferred for older patients who have markedly decreased life expectancy.

The United States Renal Data System shows no difference in survival in incident haemodialysis patients ≥67 years between patients who had a graft placed as a first access compared with those who had a fistula.5

The success of the VA can be measured by its capacity to deliver an adequate blood supply (therefore, an acceptable blood flow rate), the survival of the access and the number of complications associated with it. Poor VA can result in increased hospital admissions, and/or inadequate dialysis leading to higher morbidity and mortality rates.

2.1 Aims for the use of this best practice guide

- To raise awareness of the importance of AVG as the second VA option for haemodialysis patients
- To provide recommendations for AVG cannulation and ٠ care practices based on the available clinical evidence literature and expert opinions, and so to minimise complications
- To improve quality of patient care

2.2 Groups likely to benefit from this best practice guide

- Nurses
- Physicians
- Healthcare assistants
- Patients
- Healthcare authorities

Nurses, in particular, play a crucial role in the management of AVG: therefore it is essential to focus on their educational needs and provide guidance in this area.

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²⁸ This *best practice guide* has been designed to help and support all involved staff on the most appropriate approach to manage, preserve and prolong the life of the AVG. Patient education is essential to ensure optimal AVG care.

2.3 Scope of this best practice guide

In scope:

- Arteriovenous Graft
 - * Responsibilities of the nurse
 - * Hygiene and infection control
 - * Assessment of the healing process
 - * Assessment prior to cannulation
 - * Cannulation techniques
 - * Needle removal and haemostasis
 - * Complications: prevention and detection
 - * Documentation and reporting
 - * Patient and/or family member education

Out of scope:

- Arteriovenous Fistula (AVF)
 - Central Venous Catheters (CVC)
- Patient self-cannulation

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32 **3. Background**

Vascular access for haemodialysis is closely linked to the history of dialysis. In the early days, the challenge of repeated VA use prevented dialysis from becoming a routine method of treatment.

In 1924 Georg Haas from Germany performed the first haemodialysis treatment in humans. In a 15-minute procedure, he used glass cannulae to access the radial artery and return blood into the cubital vein.⁶

In 1943, Willem Kolff from the Netherlands developed a "rotating drum kidney" with a larger filter surface area made from a cellophane membrane. The first patient he dialysed received 12 dialysis treatments, but the therapy was then stopped due to a lack of access sites, since placing each cannula required a separate incision along the artery.⁶

The outcome changed dramatically in the 1960s, when the idea of connecting an artery and a vein with rubber tubing and a glass cannula, originally considered by Nils Alwall from Sweden, was developed by Quinton, Dillard and Scribner into an external AV Teflon shunt. Their first patient survived for more than 10 years after the insertion of his first Teflon AV shunt in March 1960.⁷ The tapered ends of two thin-walled Teflon cannulas were inserted into the radial artery and the adjacent cephalic vein, respectively, in the distal forearm. When not in use for dialysis, the external ends were connected by a curved Teflon bypass tube and later replaced by flexible silicon rubber tubing.

In 1961, when unable to find a surgeon to place the necessary dialysis cannula, Stanley Shaldon used the Seldinger technique to insert catheters into the femoral artery and vein.⁸

The native AVF was born in 1966, when Brescia, Cimino, Appel and Hurwich published their landmark account of 14 side-toside anastomoses between the radial artery and the cephalic vein at the wrist. In 1968, Lars Röhl presented results from 30 patients with radial artery side to vein end anastomosis.⁹ Then, in 1977, the Gracz fistula was presented and subsequently modified by Klaus Konner. This was a proximal forearm fistula that relied on the perforating vein from the superficial to the deep forearm venous system to limit blood flow in the fistula and prevent occurrence of the steal syndrome in patients with peripheral artery disease due to age, hypertension or diabetes.¹⁰

In 1969 George Thomas attached Dacron patches to the common femoral artery and vein, which were then connected with a silastic tube and brought to the surface of the anterior thigh.¹¹

For patients with a lack of and/or exhaustion of peripheral veins, a new idea came up. Gilberto Flores Izquierdo (Mexico City)¹² and James May (Sidney, Australia)¹³ proposed to remove the segment of the saphenous vein between the groin and knee and to connect it in a U-shaped fashion in the elbow region with the brachial artery and a suitable vein. As a variant it was proposed to implant the totally mobilised vein to the great vessels in the thigh or to anastomose the distally mobilised saphenous vein to the femoral artery. The first step of using a graft in vascular access surgery was born!

In 1970 Roland E. Girardet from New York, USA, analysed his results with this novel technique.¹⁴ The first clinical results with a mandril graft were reported by Charles H. Sparks (Portland, USA) based on a series of animal experiments starting in 1965. He implanted a silicone mandril assembly consisting of a silicone rubber rod with a covering of two specially prepared siliconised knitted Dacron tubes.¹⁵ It was left in place for six

³⁴ weeks so that the Dacron mesh became organised after invasion of the surrounding tissue. The mandril was then removed and the endings of the matured subcutaneous tunnel were anastomosed to the native vessels. The first report on the use in haemodialysis patients was given by Beemer in 1973.¹⁶ Because of the unfavourable results and the availability of more successful prosthetic materials this technique was abandoned a few years later.

In 1972, three new graft materials, one biological and two synthetic, were introduced.

A modified bovine carotid artery biological graft (Arte-graft, Johnson & Johnson), a product of research by D.M.L. Rosenberg, was introduced for construction of vascular access in eight haemodialysis patients by Joel L. Chinitz (Philadelphia, USA). It was the first xeno-graft and received some acceptance during the 1970s.¹⁷

T. Soyer (Denver, USA) used expanded polytetrafluoroethylene (ePTFE) in animal experiments to replace various major thoracic and abdominal veins.¹⁸ In 1976 L.D. Baker Jr (Phoenix, USA) presented the first results with ePTFE grafts in 72 haemodialysis patients.¹⁹ The majority of these grafts were 8 mm in diameter. Numerous publications during the subsequent years demonstrated the value and the limitations of this prosthetic material, which has remained the first choice material for arteriovenous grafts even today.

Irving Dunn (Brooklyn, NY, USA) had chosen a Dacron velour vascular graft for creation of AV bridge grafts, initially in animal experiments and then in a uraemic female patient.²⁰ Subsequently, this material did not yield satisfactory results for vascular access, although in other fields of vascular surgery it has become well accepted as a graft material.

Since Dacron was not accepted, ePTFE continues to be the material of choice. This highlights the fact that in the field of vascular access for haemodialysis special criteria must be met by the graft material:

- Safety and ease of handling during surgery
- No formation of pseudo-aneurysms after repeated cannulation
- Low infection rates
- Easy surgical replacement of graft segments in case of complications
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4. Vascular Access for Haemodialysis

4.1 Vascular Access Types

There are three types of VA for haemodialysis with differing times to use:

- Central Venous Catheter can be used directly after insertion (see Figure 1)
- Arteriovenous Grafts can be used for dialysis treatment 2–3 weeks after placement; some of them (early cannulation graft)²¹ can be assessed for use within 24 hours of placement (see Figure 2)
- Arteriovenous Fistula assessment can be initiated 4 weeks after creation; it can be used for dialysis treatment 6 to 12 weeks after creation (see Figure 3).

The choice of VA is dependent on the vascular status and clinical condition of the patient, and the time available before initiation of haemodialysis.

AVG is associated with:

- Compared to AVF:
 - * Better mechanical strength
 - * Earlier use
 - * Decreased primary failure rates²²
 - * Higher complication rates²³
 - * Shorter patency
- Compared to CVC reduction in:
 - * Episodes of infections and thrombosis
 - * Medication costs

- * Hospitalisation episodes and days
- * Nursing workload



Figure 3. Arteriovenous Fistula

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5. Arteriovenous Graft

42 Successful dialysis treatment starts with a good access.²⁴ To achieve a well-functioning AVG, the multidisciplinary team, comprising a nephrologist, vascular surgeon, radiologist and CKD nurse, must perform a thorough pre-operative assessment.

AVF should be the first choice; however, if a patient is not a suitable candidate⁵ (e.g. when the patient's veins have been exhausted), an arteriovenous graft must be considered as the second option.

Graft can be used in two ways: as a simple connecting tube between an artery and vein, or acting as a vein substitute which can be repeatedly cannulated with fistula needles. The graft will not tolerate being cannulated as well as the patient's natural vein, therefore if a patient's own vein with proper length and diameter is available, this should be the preferred option.

5.1 Identify the candidate

For a haemodialysis patient, the aim is to have a functioning vascular access by the time the patient requires dialysis. However, the creation and maturation of a functioning vascular access can be a time-consuming process which requires careful planning including referral to surgeon, surgical evaluation, scheduling for surgery, maturation/healing, and if needed, the possibility for a salvage procedure in the event of primary access failure.

A timely referral of patients with Chronic Kidney Disease (CKD) to a nephrologist and/or vascular surgeon is strongly recommended (see Figure 4). This approach helps to preserve access sites and provides adequate time for planning the creation/placement of the VA.²⁵



A complete patient evaluation is recommended prior to an AVG placement (Table I).

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Peripheral circulation present?	Yes 🛛 No 🗖
Currently dependent or approaching CVC dependency?	Yes a No a
Fistula failing?	Yes 🛛 No 🗖
Diabetes mellitus?	Yes 🛛 No 🗆
Swollen arms and/or distended collateral veins?	Yes 🛛 No 🗖
History of multiple interventions (e.g. angioplasty)?	Yes 🛛 No 🗆
spkt/V less than 1.4?	Yes 🛛 No 🗖
Repeated reduction (>25%) of prescribed blood flow rate?	Yes 🗆 No 🗆
If yes I is checked for any box above, consider referring for a s assessment	surgical
An AVG should not be implanted if there is no peripheral circulation	
	1

5.2 Pre-operative assessment

Vascular access should be established prior to the actual need for haemodialysis, thereby avoiding emergency CVCs which have a higher risk of infection and are also associated with central venous stenosis.²⁶

Several assessments are required when planning vascular access surgery.

Careful preoperative vascular assessment is performed with palpation of the radial, ulnar, and brachial pulses; an Allen's test is performed on both arms. The superficial veins of the arm should be carefully assessed (with and without the application of a tourniquet) in the proximal area. In some cases, the cephalic vein is readily evident at the wrist, antecubital fossa area, or in the lateral aspect of the upper arm. Once a decision has been taken to perform access surgery, no invasive procedures (e.g. venepunctures) should be performed in that arm.

If no superficial veins can be detected, the venous system should be assessed by duplex ultrasound examination.³ Patients with suspected central venous stenosis or prior catheters inserted on the ipsilateral side, or with abnormal findings on ultrasound, should be assessed by conventional venography. If central stenosis is found, they should be corrected preoperatively by endovascular techniques, or an alternate site (e.g. thigh) for access should be sought.²⁶

5.3 Selection of vessels

Successful creation and maintenance of arteriovenous dialysis access depends on a suitable arterial inflow and an adequate venous outflow (see Figure 5). With the increase of comorbid conditions related to age, diabetes and progressive vascular diseases, the VA creation becomes problematic.²⁷

Prior to placement of a graft it is important to determine the arterial inflow (condition of the arterial tree) and the outflow (venous circulation - size, depth and flow properties through the vein). This was demonstrated by Malovrh showing that conversion of a high resistance Triphasic Doppler flow signal to a low resistance Biphasic flow signal after the release of fist clenching resulted in a higher patency rate.²⁸

Vessel requirements for AVG placement include:

- Unobstructed arterial inflow
- Unobstructed venous outflow
- Minimal vein diameter of 4 mm.



5.4 Location and configuration

Ideally, using the non-dominant arm, the AVG should be placed as distally as possible. AVG can be a loop or straight configuration (see Figure 6 - 7).



Figure 6. Loop configuration

Figure 7. Straight configuration

Locations for the placement of AVG include the following:³

- Straight forearm (radial artery to cephalic vein)
- Loop forearm (brachial artery to cephalic vein)
- Straight upper arm (brachial artery to axillary vein)
- Loop upper arm (axillary artery to axillary vein)

Lower extremity grafts, loop chest grafts, axillary-axillary (necklace) grafts, and axillary-atrial grafts have also been constructed, but are uncommon.²⁹

The K/DOQI work group suggests a preference for a forearm loop graft rather than a straight configuration.³

An AV graft constructed in a loop fashion, between the radial artery and the superficial forearm veins, is the technique most frequently used. However, the use of deep forearm veins as an outflow for a VA, and their role as an alternative choice after a previously failed fistula, has scarcely been analysed.³⁰

Other configurations involve a position in the thigh in which a loop of graft material is connected end-to-side with the superficial femoral artery and end-to-end with the greater saphenous vein.

"AVGs in the lower limb have generally given less encouraging results than for the upper limb, because of increased rates of infection (41%), ischaemia (11%), and 2-year primary and

secondary patency rates of only 19% and 54% respectively. However, groin access is a useful option when upper extremities are unavailable and peritoneal dialysis has failed"³¹

5.4.1 Types of graft materials

The ideal graft material should be:

- · Resistant to cannulation trauma, not prone to infection
- Easy to handle (during surgical procedure)
- A close mimic of the native vessels
- Non-thrombogenic
- Immunologically inert
- · Able to retain tensile strength
- Manufactured at a reasonable cost

As previously mentioned, the most commonly used material for construction of AVG is polytetrafluorethylene (PTFE). This synthetic material is utilised in preference to other synthetic or biological materials, based on its availability, ease of implantation, structural integrity, ease of cannulation, longer patency and lower risk of disintegration with infection.²⁵

Other organic, semi-organic or synthetic materials that have been used to create prosthetic bridge grafts include bovine carotid or mesenteric vein, ovine collagen with mesh, homologous saphenous vein, polyurethane, poly(ether urethane urea), silicone and Dacron.³² None of these have shown improved survival or better patency than PTFE grafts.

Experience with the modified ePTFE is encouraging. Patency and bacteraemia rates are at least comparable to standard polytetrafluoroethylene grafts. Nearly three-quarters of patients achieved a definitive "personal vascular access solution"³³ from their early cannulation AVG (ecAVG).

5.5 Surgery

The placement of an arteriovenous graft anastomosed to native vessels requires careful planning and surgical expertise.

A vascular surgeon performs AV graft surgery, much like AV fistula surgery, in an outpatient centre or a hospital. If the surgery is performed in a hospital, similar to AVF surgery, the patient may need to stay overnight in the hospital; however many patients can go home after the procedure, with follow-up instructions on how to take care of the newly created AVG.

The procedure is usually performed under local anaesthesia with sedation, although for AVG with long tunnel, regional anaesthesia is preferred. Preoperative antibiotics may also be required.

A transverse or longitudinal incision is fashioned; a tunnel in a loop or straight configuration (depending on location and anastomosis) is then created. A counter incision is made and a tunnelling device, usually 6 mm in diameter, is used to pass the graft.

Once the graft has been tunnelled, the patient can be heparinised. The arterial and venous anastomoses are both performed in an end-to-side fashion.

For the venous side end, the graft may have a conic configuration, or it can be cut at a bias to increase the diameter of the anastomosis and decrease the chances of venous stenosis. For the arterial side end, large anastomoses are avoided to decrease the chance of developing steal syndrome.

The skin is closed over the completed anastomosis. It is not necessary to close the deep fascia. The radial artery pulse is checked prior to completing the operation.²⁶

The main goal of a graft placement is to have a well-functioning VA with no complications.

5.5.1 Surgical complications

The vascular surgeon may encounter intraoperative dysfunctional haemostasis, characterised by diffuse oozing throughout the wound and prolonging both the dissection and closure. This may manifest as external bleeding, haematoma, or pseudo-aneurysm. Generally it would be advantageous if uraemic patients with a higher risk of clinically significant bleeding could be identified by performing coagulation tests before access placement.³⁴

Acute ischaemic symptoms (such as loss of sensation or weakness) warrant immediate surgical correction (often ligation of the fistula/graft or AV anastomosis proximalisation with additional AVG is a good solution) to prevent the development of permanent injury³ whereas less severe symptoms and signs, such as paraesthesia and a sense of coolness with retained pulses, usually improve over a period of weeks with the development of collateral blood flow.

Ischaemic complications (such as inadequate oxygen delivery to the far extremity of the graft) after upper arm AV access surgery occur with widely varying frequency, depending on the experience and skill of the surgeon, and preoperative ultrasound and clinical assessment, location of the access, and the patient comorbidities as a result of shunting "steal" of arterial blood flow into the access thereby reducing perfusion of the more distal extremity. Incidence rates of ischaemic complications vary widely, but most often range between 1 and 9%.³⁵

Steal typically manifests a median of two days after the placement of a prosthetic arteriovenous graft, whereas steal

associated with an arteriovenous fistula is delayed as the blood flow through the access progressively increases as the fistula mature.⁵ Patients experience loss of sensation or weakness, paraesthesia and a sense of coolness with retained pulses.

Diabetic haemodialysis patients are at increased risk of ischaemic complications after access surgery often due to advanced atherosclerotic disease of upper arm arteries. Brachiocephalic accesses are also a major predisposing factor to ischaemic complications because the brachial artery provides the only blood supply to the forearm and hand. In the absence of collateral vessels around the elbow, diversion of brachial arterial blood through a graft may produce distal ischaemia, particularly in patients with previously compromised radial, ulnar, or palmar arch arteries. The antecubital area may also be the "watershed area" for the vasa nervorum of the three upper limb nerves.³⁷

Median nerve neuropathy has been reported and is thought to be due to postoperative limb swelling following AV graft insertion or via ischaemic injury by a vascular steal effect (ischaemic monomelic neuropathy).³⁸ Incidental damage during the procedure is also possible.

The high surface thrombogenicity of the AVG may be the cause of early thrombosis in the absence of other factors such as technical error, compressing haematoma/seroma (perigraft seroma is a typical early complication of PTFE graft)³⁹ or proximal venous occlusion.³¹

Intimal hyperplasia is responsible for stenosis at the graft-vein anastomosis site. Reasons for intimal hyperplasia include:

- Incompatibility between the vein and graft
- Anastomosis angle

- Boundary layer separation
- Enhanced particle residence time
- Increased sheer stress and high flow velocity of blood at the anastomosis

Polytetrafluoroethylene grafts rarely suffer from early failure, but have significant problems with later stenosis and thrombosis, and graft degeneration with pseudo-aneurysm formation due to repeated cannulation in the same area.

Moreover, there are differences between graft materials with regard to the type and the incidence of complications.²⁹

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6. Arteriovenous Graft Healing

After placement, depending on the graft material used, the patient usually waits 2 to 3 weeks for the AVG to "heal" before cannulation. However, in diabetic, elderly or malnourished patient this process may take longer. Healing occurs when the subcutaneous tunnel has filled with granulated tissue that will stabilise and reseal the graft after cannulation. The vascular access arm should be elevated as much as possible until swelling subsides, which may take as long as 3-6 weeks.^{40, 41}

During this time:

- There is tissue growth into the outer wall that stabilises the graft. This is important in the prevention of both infection and haematoma⁴¹
- The blood flow will increase to its maximum, although this maximum will be determined by the diameter of the graft at the distal end of the anastomosis
- The physician may advise that the patient undergo haemodialysis before adequate healing in order to avoid a CVC or to allow early removal of the catheter⁴¹

In some specific situations, early cannulation grafts may be considered.

Some newer graft materials such as the modified ePTFE have "low bleed" properties allowing cannulation within 24 hours of placement (see Figure 8).

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Figure 8. Cannulation site after needle removal in low bleed (left) vs standard graft material (right)

A functional AVG should be healed, ready for cannulation with minimal risk for infiltration, and capable of delivering the prescribed blood flow throughout the dialysis treatment

6.1 Monitoring of the healing

A thorough evaluation of a new haemodialysis AVG over the four week period after placement should be considered mandatory to detect any problem as early as possible and allow timely intervention.

The AVG healing can be monitored via:

- Clinical monitoring
 - Instrumental monitoring

6.1.1 Clinical monitoring

Monitoring strategies performed by an experienced healthcare professional, include physical examination of the AVG to detect signs suggesting pathological problems.

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Week 1	0	•
Inspection	 The dressing is clean and dry The skin around the dressing looks like it did before surgery The hand looks the same as it did before surgery. When the dressing is no longer needed, the surgery site is clean and dry Once healed, the skin over the graft looks like the skin around it 	 The dressing is wet or solied There is drainage on the dressing The arm is bruised and/or The hand is not the normal temperature and colour. There is redness, swelling, or drainage
Palpation	 Listen with the stethoscope to hear the normal bruit sound (whoosh-ing) along the length of the graft The bruit sounds like a "whoosh," or for some, like a drum beat 	 There is no sound, or the bruit is not as loud as the last time it was checked. Sound is different than the sound of a normal bruit
Auscultation	 Feel the graft Feel the thrill (this is a vibration or buzz that can be felt most prominently at the points of anastomoses) Pulse: A slight beating that feels like a heartbeat Fingers placed lightly on the graft move slightly 	 Cannot feel the graft and/or the hand of the affected arm is cold to the touch Cannot feel the thrill or it is weaker than the last time it was checked Pubatelie: The beat is stronger than a normal pulse. Fingers placed lightly on the graft rise and fall with each beat
Augumentation Test	N.B. Not performed in week 1	22
		59

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Week 2-3	\$	8
Inspection	 The graft and its configuration (straight or looped) are visible The cannulation segment is long enough to use two needles placed at least 5 cm (2") apart The skin over the graft looks like the skin around it 	 The graft and its configuration (straight or looped) are not visible. The arm is bruised and/or the hand is not the normal temperature and colour. There is redness, swelling or drainage
Palpation	 Listen with the stethoscope to hear the normal bruit sound (whoosh-ing) along the length of the graft The bruit sounds like a "whoosh," or for some, like a drum beat 	 There is no sound, or the bruit is not as loud as the last time it was checked Sound is different than the sound of a normal bruit
Auscultation	 Feel the graft Feel the thrill Feel the thrill Pulse: A slight beating that feels like a heartbeat. Fingers placed lightly on the graft move slightly 	 Cannot feel the graft. Cannot feel the thrill or it is weaker than the last time it was checked Pulsatile: The beat is stronger than a normal pulse. Fingers placed lightly on the graft rise and fall with each beat
Augumentation Test	N.B. Perform once. If normal, no need to repeat	The the
1	 Pulse is "strong and bounding" and may cause finger to rise and fall with each beat 	 Pulse does not become more forceful or "strong and bounding"

Week 4	Inspection The hand of before surge • The skin ove	Palpation Listen with the sound (whoo The bruit sound for the bruit sound for the bruit sound the sound	Auscultation Feel the thril Pulse: A slig Fingers plac 	vugumentation Test • N.B. If norm: repeated	Pulse is "strufinger to rise
8	f the affected arm looks the same as it did ery er the graft looks like the skin around it	the stethoscope to hear the normal bruit osh-ing) along the length of the graft unds like a "whoosh," or for some, like a	ll pht beating that feels like a heartbeat. Sed lightly on the graft, move slightly	lal at week 2 or 3, it does not need to be	ong and bounding" and may cause your e and fall with each beat
×	 The arm is bruised and/or the hand is not the normal temperature and colour There is redness, swelling, or drainage 	 There is no sound, or the bruit is not as loud as the last time it was checked Sound is different than the sound of a normal bruit 	 Cannot feel the thrill or it is weaker than the last time it was checked Pulsatile: The beat is stronger than a normal pulse. Fingers placed lightly on the graft rise and fall with each beat 	8 ()	 Pulse does not become more forceful or "strong and bounding"

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6.1.2 Instrumental monitoring

Serial measurements of intra-access pressure or flow detect anastomotic strictures and/or outflow problems. AV grafts begin to develop thrombi at flow rates (Qa) less than 600 ml/ min - well below the level required for adequate dialysis. Polo et al demonstrated superior patency and lower complication rates with the larger diameter graft (6-8 mm tapered graft versus 6 mm). Their results showed that the larger diameter graft produced a higher access flow rate and better primary and secondary patency rates.⁴³

The gold standard for assessing healing is the use of instrumental monitoring. There are several instrumental methods available for the monitoring and surveillance of the AVG (Table II).

Parameter	Method
Pressure surveillance	 Intra-Access Pressure (IAP) Static Venous Pressure (SVP) Dynamic Arterial Pressure (DAP) Dynamic Venous Pressure (DVP) Slow-Flow Venous Pressure (S-FVP).
Recirculation (using a non-urea based dilution method)	Ultrasound Dilution Test (UDT)

Table II. Available monitoring and surveillance methods

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Parameter	Method
Flow surveillance	Duplex Doppler Ultrasound (quantitative colour velocity imaging [DDU])
	Magnetic Resonance Angiography (MRA)
	Variable Flow Doppler Ultrasound (VFDU)
	Ultrasound Dilution Transonic (UDT)
	Glucose Pump Infusion Technique (GPT)
AN AN	Urea Dilution (UreaD)
2 ^H F	 Differential Conductivity (haemodynamic monitor [HDM])
NO PV	 In-line Dialysis (DD).
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7. Hygiene and infection control

Healthcare-Associated Infections (HCAIs) are recognised as a major cause of death worldwide. An effective hygiene and infection control programme/policy is essential, and healthcare staff must be trained appropriately and provided with the necessary resources/equipment to carry out tasks and procedures safely and effectively.

Infection is the second most important cause of graft failures after stenosis, responsible for 10-15% of AVG loss. Infection can lead to further complications such as pseudo-aneurysm, sub-acute bacterial endocarditis, epidural or brain abscess.⁴⁴ The best action is to prevent infection in the first place.

Infection prevention and control is a collective term used for those activities intended to protect people from infections.⁴⁵

Standard precautions prevent healthcare-associated transmission of infectious agents among patients and healthcare workers, and they must be applied to all patients –regardless of their infection status– in all healthcare settings. They are based on the assumption that all blood, body fluids, secretions, excretions (except sweat), non-intact skin, and mucous membranes may contain transmissible infectious agents.

7.1 Hand hygiene

The hands of Healthcare Workers (HCW) play a major role in the transmission of HCAIs.

In accordance with World Health Organization (WHO) goals, this *best practice guide* pursues the following prevention targets:

- Colonisation of patients with possible exogenous agents
- · Endogenous and exogenous infections in patients
- · Colonisation and/or infection in HCWs
- Colonisation of the healthcare environment

The Five Moments of Hand Hygiene Concept

The World Health Organisation (WHO)⁴⁶ defines five moments of hand hygiene. They correspond to the concept of patient area, healthcare zone and critical sites, and are applicable to all care activities in the clinic:

- 1. Before touching a patient
- 2. Before clean/aseptic procedure
- 3. After body fluid exposure risk
- 4. After touching a patient
- 5. After touching patient surroundings

In accordance with the WHO consensus recommendations, hand hygiene should routinely be performed by cleansing with alcohol-based hand rub.

There are indications when hands must be washed with soap and water.

Each HCW must be trained on when to use which methods of hand hygiene and how to carry out the respective techniques.

To ensure that hand rubbing or hand washing is carried out effectively, it must be ensured that alcohol-based rub or water

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and soap, respectively, covers the entire surface of the hands and wrists.

Rings, wristwatches and bracelets must not be worn when carrying out direct patient care activities. The only exception to this is a single plain wedding band, which must be manipulated during the hand hygiene process to ensure the skin underneath is effectively cleaned and dried.

Hand hygiene and keeping the AVG clean are the most important actions in relation to infection control.

7.2 Personal Protective Equipment and work uniform

Personal Protective Equipment (PPE), hand and face protection, aprons and gowns, serves to protect the HCW from hazards and preventable injuries in the workplace.

Some PPE items, such as gloves and masks, protect HCWs and patients:

- It must be ensured that PPE does not pose a hazard to others, e.g. PPE must be changed between patients
- PPE must be removed and discarded or disinfected after use
 - Hand hygiene must be performed after the removal of PPE

7.2.1 Gloving

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The wearing of medical gloves in a healthcare facility serves several purposes:

 Gloves protect the HCW from the exposure to blood and other potentially infected body fluids

- Gloves reduce the spread of microorganisms from the HCWs' hands to the environment, the transmission between HCWs and patients, and the transmission from one patient to another
- Gloves must be appropriate for the task at hand
- Sterile gloves must be worn for the connection and disconnection of AVG

7.2.2 Face and hair protection

The mucous membranes of the eyes, nose, and mouth need special protection during patient care activities that are likely to generate splashes or sprays of blood, body fluids, and secretions or excretions.

Mucous membranes are penetrated more easily by pathogenic organisms than intact skin. Therefore, for the connection and disconnection of AVG, a face shield/goggles and mask must be worn.

Hair protection will prevent the falling of skin and hair fragments over the VA and simultaneously protects the hair from splashes.

7.2.3 Aprons and gowns

Aprons and gowns are part of the PPE that is worn to comply with standard precautions⁴⁷ or contact precautions (to prevent transmission of infectious agents that are spread by direct or indirect contact with the patient or the patient's environment and for which transmission cannot be interrupted by standard precautions alone). 71

7.2.4 Uniforms

Uniforms are not considered as PPE. They do not protect against fluids because the cloth (usually cotton) is permeable.

They do serve several purposes:

- Provide the HCW with professional attire that supports the HCW in carrying out his or her work in the dialysis unit
- Prevent cross-contamination between the workplace and the home
- Convey a professional image to the patient

Do not perform any activities without the appropriate hand hygiene. Always wear personal protective equipment
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8. Arteriovenous Graft cannulation

The goal is to cannulate all AVGs safely and without causing damage to the patient's lifeline. It must be ensured that all dialysis staff members understand and master the basics of AVG management. The fundamental principles of VA care should be used to help train all dialysis healthcare professionals in order to improve the quality of care that dialysis patients will receive. There is a need for nurses to continue to gain knowledge through nursing research and education.⁴⁸

Proper cannulation is a fundamental aspect of maintaining a functioning AVG.

8.1 Competencies and responsibilities

Vascular access management is a complex chapter in dialysis care. Prolonging the life and patency of the AVG are the main objectives. Therefore, a highly-skilled dialysis nurse is required to ensure that the cannulation procedure is carried out with minimal or no complications.

At every dialysis session, and before each cannulation, ensure that the patient's AVG is functional and has no problems, in order to obtain the optimal blood flow ensuring an adequate dialysis.

The competencies and responsibilities required to achieve this are as follows:

Nurse

- Competence in:
 - * Assessing and monitoring
 - * Cannulation techniques
 - * Managing complications
 - * Patient education
- · Responsibility for:
 - * Ensuring patient comfort and safety
 - * Reporting and documenting all complications
 - * Liaising with the dialysis medical team to identify and manage complications early

Physician

- Responsibility for:
 - * Providing an optimal prescription for the preservation of the AVG
 - * Effective management of complications

8.2 Preparation and assessment

The procedures take place in the haemodialysis treatment room, ensuring the optimal conditions under the supervision of a Registered Nurse (RN). Evaluating the patient before haemodialysis treatment will assist the nurse to identify potential problems that may arise during the treatment. Listen attentively to the patient to detect any changes that could be relevant.

8.2.1 Preparation

Environment

- The room needs to be clean, windows closed, chair or bed and dialysis machine in the correct position
- Every haemodialysis room/section must have an adequate number of:
 - * Sinks with running water, hand soap dispensers, and disposable towels
 - * Disinfectant dispensers
- The surface area and equipment used for the preparation procedure must be cleaned and disinfected before and after each use
- The required materials should be placed on the disinfected surface area
- Adequate lighting should be provided during the cannulation procedure

Equipment

· Stethoscope.

Materials

- Skin disinfectant
- Drape
- Sterile gloves
- Sterile dressing pack (gauzes)
- Таре
- Syringes (e.g. flushing fistula needles or blood samples, if required)
- Tube for blood sample (if required)
- Needle (for sterile 0.9% saline solution, if required)

- Tourniquet only if the AVG is very soft (this is an indication of a low flow state and the AVG needs further evaluation)
- Fistula needles (see Table III)
- Waste bin
- Sharps container
- Medication (e.g. anticoagulants) according to physician's prescription

It is recommended that a complete sterile pre-defined kit for connection and disconnection procedures is available

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As a general guide, always select the smallest gauge and shortest length needle that will achieve the required flow rate. In most cases, a 2.5 cm (one-inch) needle is adequate and helps reduce the chance of damaging the back wall of the graft.

- A needle with an ultrathin wall and a back-eye can be useful in this regard
- The length of the needle chosen may vary with the depth of the graft in the tissue

Table III Recommended needle gauge according to prescribed blood flow rate

Blood flow rate	Recommended needle gauge
<300 mL/min	17 gauge
300–350 mL/min	16 gauge
350–450 mL/min	15 gauge
>450 mL/min	14 gauge

Nurse

- Perform hand hygiene according to WHO recommendations and wear PPE (refer to Chapter 7.2)
- Place the materials required on the disinfected surface
- · Ensure that the patient is relaxed and sitting comfortably
- Explain routine and non-routine procedures or activities to the patient, as required

Patient

- Wear comfortable clothes (remove jewellery if present)
- Wash the access arm with soap and water (see Figure 9); if not able to do so, the HCW should provide assistance
- Ensure AVG is easily accessible



Figure 9. Patient washing AVG arm

8.2.2 Assessment

A physical assessment must be carried out before every cannulation regardless of when the AVG was placed.

The flow direction within an AV graft cannot be so easily identified. Ideally, the surgeon should provide a diagram indicating the location of the graft and the direction of the blood flow.

If a diagram is not available, flow direction can be determined with the following simple technique: apply momentary pressure to the mid-point of the graft with the finger. Detect the thrill in the graft; the side with the strongest pulsation is the arterial side (direction from which blood enters the graft).

In the case of unfamiliarity with the patient's AVG, seek advice from an experienced senior nurse and check the patient's clinical file.

AVG physical examination is important to evaluate the proper function (see Table IV) and to detect possible signs of complications (refer to Chapter 8 and Chapter 9).

Document every assessment and report any abnormalities to the senior nurse and/or physician

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8.2.3 Skin preparation

Proper needle site preparation by both the patient and nurse reduces infection rates. Site selection should be done prior to the final skin preparation.

Prepare the patient's skin:

- Patient must wash the AVG area prior to arriving at the haemodialysis station, removing dirt and oils from the skin. If unable to do so, the HCW should assist
- Start at the chosen cannulation site, disinfect the area using one of the following solutions:
 - * 2% chlorhexidine gluconate / 70% isopropyl alcohol. Using a back and forth friction, scrub for 30 seconds. This antiseptic has a rapid (30 seconds) and persistent (up to 48 hours) antimicrobial activity on the skin. (see Figure 10)
 - * 70% alcohol. Alcohol has a short bacteriostatic action time and should be applied in a circular motion, from inside to outside, for one minute prior to cannulation (see Figure 11)
 - 10% Povidone iodine needs to be applied and left for two to three minutes and must be allowed to dry prior to needle insertion. (see Figure 12)
- Follow the manufacturers' instructions for disinfectant contact time
 - Allow the area to dry
 - Repeat skin preparation if the site is touched by the patient or nurse once skin preparation has been applied but prior to cannulation

Please note that during all phases of needle insertion, particular attention must be taken to avoid contamination of the disinfected cannulation area.

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Figure 10. Skin preparation before cannulation: back and forth friction



Figure 11. Skin preparation before cannulation: circular motion



Figure 12. Skin preparation before cannulation: povidone iodine applied and left

8.3 First cannulation

The timing of the first cannulation of vascular access is critical for appropriate management of haemodialysis (HD) patients. Current guidelines are based on professional opinions rather than scientific evidence.

The graft material defines the timing of the first cannulation:

- Standard PTFE earliest 2 weeks after placement
- Early cannulation arteriovenous graft (ecAVG):
 - * ePTFE 24 to 48 hours after placement
 - * Latest generation graft material e.g. GORE[®] ACUSEAL Vascular Graft - 2 to 4 hours after placement³³

A newly implanted PTFE graft (standard graft material) should not be cannulated until swelling has reduced enough to allow palpation of the graft — ideally 3 to 6 weeks after placement. Therefore, no attempt should be made to cannulate the graft for at least 14 days after placement.⁴⁹ It is recommended to use a venogram or other non-contrast investigation to evaluate central veins in patients with swelling that does not respond to augmentation test, or that persists >2 weeks after AVG placement.

In selected cases, a physician may decide that a patient must undergo haemodialysis shortly after the vascular access graft has been implanted. Extra precautions must be taken with these patients because the danger of venous outflow damage, significant tissue swelling, haematoma formation, and infection is high.

Early cannulation arteriovenous grafts, such as the GORE[®] ACUSEAL Vascular Graft, have "low bleed" properties permitting cannulation within 24 hours of implantation. They

may provide an alternative to central venous catheters (and associated complications) in patients requiring urgent haemodialysis treatment, although postoperative swelling may make it difficult to locate the graft and place the needle. A sketch from the surgeon can be extremely helpful in these cases. Gentle digital pressure can be used to temporarily displace the swelling. This makes it easier to locate the graft by touch or by listening for the bruit with a stethoscope. Some dialysis units are starting to use ultrasonography to facilitate successful cannulation. A misplaced needle may damage the graft or puncture the back wall.

Suggested guidelines for accessing grafts include skin disinfection, sterile gloves, and 17 gauge dialysis needles for the first three dialysis treatments within the first 2 weeks of implantation. The literature suggests using blood flows up to 250 ml/min. Initial attempts to perform dialysis via the new AVG should be performed cautiously by an experienced nurse.

Only nurses identified as competent in best cannulation practice techniques should be assigned to cannulate newly implanted AVG

8.3.1 Procedure

For a successful cannulation of a new AVG, the following steps are required:

a. Align with physician to decide first cannulation time

- Identify the AVG location, type of graft material (synthetic or biological), which may require different timing for the first cannulation
- c. Before cannulation:

- * Prepare environment (refer to Chapter 8.2)
- * Prepare materials (refer to Chapter 8.2)
- * Follow the hygiene requirements (refer to Chapter 7)
- * Prepare the patient (refer to Chapter 8.2)
- * Assess the AVG (refer to Chapter 8.2)
- d. Explain the procedure to the patient. Help the patient to overcome any fear of the initial cannulation
- e. Identify the direction of the blood flow in the AVG (especially for looped graft)
- f. Do not use a tourniquet or any form of vessel engorgement technique (e.g. patient or a staff member compressing the arm) unless the AVG is soft
- g. Use 17G needles for the first three cannulations
- h. Select the cannulation sites at least 4–5 cm away from the anastomosis
- The arterial needle should point antegrade direction with bevel down (see Figure 13-1), unless specific situations (e.g. short length of the AVG) require positioning it retrograde. In case of arterial needle in retrograde direction, the position of the bevel should be upwards (see Figure 13-4):
 - * Antegrade arterial needle pointing in the direction of blood flow
 - Retrograde arterial needle pointing against the direction of blood flow

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1. Arterial needle antegrade bevel down



2. Arterial needle antegrade bevel up







- j. The venous needle must always be placed in antegrade direction and preferably with bevel up
- k. Secure and support the access using one of the following techniques:
 - The "three-point" technique (see Figure 14):
 - Stabilise the access with the thumb and forefinger
 - Pull the skin taut towards the cannulator
 - Compress the dermis and epidermis. This allows easier cannulation and temporary interruption of pain



Figure 14. The "three point" technique

- * The "L" technique:
 - Hold thumb and index finger as an "L"
 - The thumb should hold the skin taut over the AVG, and the index finger should stabilise and help engorge the graft (see Figure 15)



Figure 15. The "L" technique

- I. Insert the needle
 - * Use an appropriate angle of insertion depending on the depth of the access as indicated by the surgeon (the insertion angle is measured from the skin to the needle hub – see Figure 16). The needle enters the skin and tissue first, and then into the graft

* General recommendations are:

- 0.0 cm 0.4 cm deep = 15° 20° angle, 2.5 cm (1") needle
- 0.5 cm 0.9 cm deep = 30° 45° angle, 2.5 cm (1") needle
- 1.0 cm 1.5 cm deep = 45° angle, 3 cm (1.25") needle.

N.B. steeper angles increase the risk of perforating the back wall of the graft.



Figure 16 Angles of insertion

- * Gently insert the needle through the graft wall while maintaining the selected angle
- * Holding the graft in place may aid in accurately piercing the graft wall. Watch for blood flashback into the cannula
- * After confirming an adequate blood flashback, advance the needle for no more than 0.3 cm (one-eighth of an inch) to ensure the needle tip is positioned well inside the graft⁴¹
- If the blood flashback does not appear or seems sluggish, verify the needle position and, if required, adjust it. However, avoid prolonged needle adjustment
- * A decrease or lack of blood flashback may be due to one of the following:

- Bevel of the needle is pressed against the graft wall
- Needle is only partially in the graft lumen
- Needle has passed through the back wall of the graft
- Graft has low blood flow due to obstruction.41
- * To prevent side wall infiltration, advise the patient not to move the arm with AVG during cannulation/ treatment⁵⁰

Do not "flip" or rotate the bevel of the needle 180°. Flipping, can lead to stretching of the needle insertion site, which can cause oozing during dialysis treatment and can damage the graft

- m. Secure the needle to minimise the risks of needle dislodgement; consistent procedures for securing the needle must be defined and implemented in each dialysis centre and should be part of the training plans:
 - Tape the needle when it is in the proper position
 - To avoid the needle tip from moving DO NOT press the needle shaft flat against the skin as this can cause damage to the graft wall
 - * Secure the needle using a minimum of three strips of tape: one to fix the wings, a second on top of it to secure the needle and a third one to secure the needle tubing (see Figure 17)
 - * To prevent needle movements in case of deep grafts place a sterile gauze under the needle wings



Figure 17. Needle taping

- n. Continue with the procedure of connecting to the extracorporeal blood circuit
- o. Use a blood flow up to 250 mL/min for the first 5 treatments

Absolute adherence to aseptic technique is critical in early cannulation. It is advisable to wear sterile gloves and face masks as surgical incisions have not had sufficient time to heal adequately

8.4 Cannulation techniques

The cannulation of an AVG is an important procedure carried out by the dialysis nurse. Choosing the correct cannulation site and technique are fundamental factors for the maintenance of the vascular access and to achieve an optimal dialysis session.

Cannulation of the AVG must be performed by using rope ladder technique. Area needling must be avoided. Do not cannulate in the area of:

- Pseudo-aneurysm
- Infection
- Within 2.5 cm of an anastomosis
- · Recent surgical revision/reinforcement of one limb

8.4.1 Rope ladder

The rope ladder is also known as site-rotation technique.

It is important to know which AVG sites have been used during the previous treatments in order to avoid "one-site-itis." To track this history, keep a chart to map the position and date of cannulation (see Figure 18).



Figure 18. Chart to map the position and date of cannulation: An example of best practice for rope ladder technique rotation: Arterial (A) to Venous (V): A1 to V1; A2 to V2; A3 to V3; A4 to V4; A5 to V5

It is recommended that:

* Arterial needle is cannulated first

- *) New sites are at least 1 cm away from previous sites, along the straight section of the graft, unless otherwise specified in the patient treatment plan
- * Let two to three weeks elapse before puncturing closer than one centimetre from a previous site⁴¹

- * In case of a straight graft or the use of only one limb of a loop graft, the arterial and venous needle should be inserted minimum 5 cm apart
- * Access is kept visible at all times
- It is not recommended to use the following areas for cannulating:
 - * Sites within 4 5 centimetres of the anastomoses
 - * Along the tightly curved section of a loop graft because it is difficult to properly position the needle
 - * Along the section of the loop graft where external reinforcing rings help prevent kinking

N.B. Cannulation should be considered as surgical procedure with risks of contamination and infection. For this reason, it is important to perform aseptic preparation of the skin⁴¹

Advantages

- Allows skin healing of previous cannulation sites
- Allows sealing of previous graft cannulation sites
- Uses the entire length of the AVG, avoiding development of soft/weak areas in the graft material
- Reduces formation of fibrous tissue thus avoiding development of large holes
- Reduces the risk of pseudo-aneurysm formation
- Improves survival of the graft

Disadvantages

- Pain during cannulation
- Poor acceptance by the patient

Procedure

 Perform the cannulation (refer to Chapter 8.3.1 Procedure)

8.4.2 Buttonhole

Buttonhole technique (BH) is considered ideal for AVF. To date no strong scientific evidence supporting the use of BH for AVG has been produced.

8.4.3 Area

This technique involves repeated cannulations concentrated over a small area (2–3 cm) of a graft.

The repeated needle cannulation in one area, also known as "one-site-itis",⁴¹ damages the graft material causing tearing or shredding (see Figure 19), leading to the formation of pseudo-aneurysms and loss of the graft.



Figure 19. Damage of the graft material due to "one-site-itis" cannulation

The importance of cannulating along the entire length of the prosthetic graft cannot be overstated.⁴¹ Area cannulation must be avoided!

8.4.4 Troubleshooting during cannulation

Troubleshooting during cannulation of an AVG includes:

- Incorrect angle of entry:
 - * Too shallow can lead to upper wall damage and possible infiltration
 - * Too steep can lead to back wall damage and possible infiltration, formation of a large haematoma and subsequent graft compression and/or graft thrombosis
- Presence of resistance during needle advancement
- Needle tearing is not a common occurrence. If this happens at the start of AVG use, it may be due to poor cannulation technique. In extreme cases it is manifested by:
 - * Thickened area
 - * Haematoma
 - * Discolouration of the skin area

In case of incorrect angle of entry (too shallow/steep), withdraw the needle partially and re-direct it using a proper angle according to the depth of the graft (refer to Chapter 8.3.1).

If resistance is experienced at any time during needle advancement or when changing the position, the needle should be withdrawn and redirected at a different angle. In cases where additional cannulation attempts are necessary, remove the first needle if possible and dispose of it. Apply light pressure to the cannulation site until bleeding stops, then insert a new needle following the procedure described in Chapter 8.3.

Investigate unusual resistance or pain occurring during cannulation. Once the needle is fully inserted and the wings taped, the patient should not experience discomfort. Persistent pain may indicate needle puncture of the back wall of the graft. In this condition, flow will often be sluggish and erratic upon aspiration. Correct such problems before continuing with dialysis.⁴¹

8.4.5 Trypanophobia (fear of needles)

Fear of needles, known in the medical literature as trypanophobia, is the extreme fear of medical procedures involving introduction of any kind of needle in the body (intravenous, intramuscular or hypodermic). The medical literature suggests a number of treatments have been proven effective for specific cases of needle fear.

The following are some of the behavioural therapies⁵² that have been shown to be effective in some specific cases:

- Staff and patient interactions can help relax and calm the patient. Patient–nurse communication is a powerful tool to use in all cannulation procedures
 - Avoid using the words "stick" or "needling"; instead use terms like "cannulate", "insert" or "place" when discussing the positioning of the fistula needle into the AVG
 - Words alone can cause or reduce fear
 - Choose the words wisely!

8.5 Needle removal and haemostasis

The procedure of needle removal by the nurse is as important as the cannulation of the AVG. Needle withdrawal must be done carefully in order to prevent tearing of the graft wall, to achieve optimal haemostasis.

For the first cannulations there is an increased risk of haematoma formation; therefore haemostasis must always be performed by skilled nursing staff, ensuring that both skin and graft needle insertion sites are being compressed at the same time.

Procedure

- a. Prepare materials (refer to Chapter 8.2)
- b. Assist the patient to put on a sterile glove so that he/she can apply pressure on the access site (if able to do so after an appropriate training)
- c. Stabilise the needle and carefully remove the tape fixing the wings to prevent excessive manipulation leading to possible damage to the graft wall and subsequent enlargement of the cannulation site
- d. Remove all tape carefully. Some patients may have dry and/ or very thin skin and care should be taken not to damage it
- e. The venous needle should be removed first. If the arterial needle is removed first, the pressure applied on the venous site after needle removal has a tourniquet effect at the arterial site which may cause a re-bleed and possible subsequent haematoma
- f. Each needle should be withdrawn slowly, keeping the same angle as that of insertion, until the entire needle has been removed. Digital pressure should be applied only after the

needle is completely out of the access to prevent damage to the graft wall

- g. Compression with two fingers is essential, if needle insertion angle allows (e.g. lower than 30°), which does not restrict the blood flow through the vascular access to avoid bruising. One finger should be positioned over the external insertion site (skin) and the second over the internal insertion site (graft). Pressure should be sufficient to stop bleeding but not so strong to stop the flow of blood through the vascular access
- h. Compression that restricts the flow of blood through the access may cause clotting and does not help to achieve a faster haemostasis (see Figure 20)



Figure 20. Haemostasis pressure: An example of best practice for haemostasis is the use of a sterile glove and compression with two fingers, which does not restrict the blood flow through the vascular access.

- i. Thrill should be felt above and below the site of pressure. If the thrill is absent, the pressure on the access should be reduced until it is palpable. The presence of a thrill above and below the pressure sites proves that the compression does not restrict the blood flow through the vascular access
- j. Haemostasis time varies between patients but also depends on graft material, cannulation angle, depth, coagulation time, type of skin and possible presence of stenosis; however, it is usually around 10-15 minutes⁴¹

k. Checking for haemostasis early will break the forming clot and re-start bleeding. The haemostasis process is completed when there are no signs of bleeding after releasing the pressure

N.B. Low-bleed materials⁵³ require light pressure to be applied on the cannulation sites.

- I. During the first cannulation (or until the graft vessel is fully surrounded by fibrous tissue), maintain the compression for up to 20 minutes to avoid bruising or bleeding that may otherwise complicate the proper healing of the AVG. In patients with prolonged bleeding, coagulation abnormalities, platelet dysfunction and venous stenosis an assessment of the anticoagulation should be ruled out. In the meantime, cellulose haemostatic dressings can be considered
- m. Repeat the same procedure for the second needle (usually the arterial one)
- n. Apply haemostatic plaster or tape sterile gauze over each site. Do not wrap tape completely around the arm. Check for thrill above and below the dressing. Cannulation sites are protected from bacterial contamination until a protective scab is formed. Wrapping tape around the arm can create a tourniquet effect, restricting blood flow
- o. Remove patient glove (if patient was holding sites)
- p. When using topical haemostatic agents, care must be taken to ensure that cannulation sites have clotted and not just the needle insertion sites on the skin. Blood may leak out into the subcutaneous tissue surrounding the graft. This often happens when the patient stands up to exit the dialysis centre, at which time a cannulation site can begin rebleeding if the clot over the skin puncture site is dislodged. If re-bleeding is not visible from the skin puncture site but has occurred subcutaneously, ecchymosis areas will be

present when the patient returns for his/her next dialysis treatment

q. Always discharge the patient from the unit with an adhesive dressing or a gauze pad placed over the cannulation sites



8.6 Complications related to Arteriovenous Graft cannulation

8.6.1 Infiltration/haematoma

Definition

Infiltration means that a needle has been dislodged from inside the vessel (fistula or graft) during needle placement or during a dialysis treatment, ending in a haematoma.

Haematoma is a localised swelling that is filled with blood caused by a break in the wall of a blood vessel and/or graft. In haemodialysis, it is usually caused by blood leaking from the vascular access to the surrounding tissues (see Figure 21).



Aetiology

Haematoma results from needle infiltration. Needle infiltration of a new AVG may be a relatively frequent complication, which occurs most commonly if:

- The graft is deep
- The area for cannulation is swollen (3-6 weeks after graft insertion)

• The surrounding tissues around the graft are not healed

Infiltration and related haematoma may be caused due to poor cannulation skills, needle manipulation, depth of the access or patient moving access arm during dialysis. Moreover, an additional cause could be the late development of the surrounding tissue around the graft which helps reduce bleeding.

An excessive compression during haemostasis, especially with the use of venepuncture clamps or special tourniquets for haemostasis, may damage vascular access walls and may also end in the formation of haematoma.

Signs and symptoms

Common signs of infiltration are sudden-onset sharp pain, swelling, and/or skin discolouration.

Signs of haematoma are bruising to the skin or hardened lumps; colour changes from a blue/purple to a yellow/brown.

Management

In the early stage of formation, haematoma may be controlled or reduced by the application of ice for around 15 minutes (never in direct contact with the skin to avoid skin burn) to reduce the rebound effect which may result in increasing the haematoma. Depending on the size/volume, haematoma may require surgical correction and/or antibiotic prophylaxis.

Do not attempt to insert a needle through a haematoma. Beside the infection risk, the needle will often clot requiring cannulation of the graft at a new site. This reduces the available space and complicates cannulation as pressure on

the previous cannulation site must be maintained to prevent enlargement of the haematoma.

Prompt referral to a physician for removal and correction of the haematoma may be indicated depending on the severity.

The use of the correct techniques, during and after cannulation, will greatly reduce the number of haematoma. Haemostasis technique is particularly important after needle withdrawal.

8.6.2 Pseudo-Aneurysm

Definition

A pseudo-aneurysm (false aneurysm - see Figure 22) is a local disruption of at least one layer of the graft wall (at the site of cannulation or anastomoses) caused by a leakage of blood from the access into the surrounding tissue with a continuing communication between the originating vessel and the resultant adjacent cavity. With time, it may develop a fibrotic sac but this is devoid of endothelium or vascular wall structure giving the perception of an "aneurysm".⁵⁴



Figure 22. AVG Pseudo-aneurysm

Aetiology

Pseudo-aneurysm is a relatively rare complication of graft dialysis access (2% to 10%). Two factors are primarily responsible:56

- Repeated needle cannulation within the same area compromises the integrity of the prosthetic graft material and thinning of the overlving skin
- Presence of a venous anastomotic or outflow stenosis ٠ causes increased intra-graft pressure. This pressure may force blood through the prosthetic graft needle cannulation holes into the peri-graft tissue resulting in a pseudo-aneurysm

Moreover, an additional factor for pseudo-aneurysm occurrence is surgical site infection.

Pseudo-aneurysms are at risk of complications such as erosion of the overlying skin and rupture of the graft that may be a fatal event.

Signs and symptoms

Pseudo-aneurysms usually present as a painful, tender, pulsatile mass. The overlying skin is sometimes erythematous. Any of the above changes in the overlying skin require urgent evaluation to prevent rupture.

This area shows depigmentation of the skin that can also be evident but has no particular significance other than its association with thinning of the skin.

However if the integrity of this thin covering layer becomes compromised, rupture can result in significant haemorrhage.

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Other complications may be present such as:57

- Prolonged bleeding after needle removal
- Poor eschar formation after needle removal •
- Spontaneous bleeding from access sites ٠
- Rapid expansion in pseudo-aneurysm size
- Exposed graft

Management

Some pseudo-aneurysms resolve with controlled compression. while others require treatment to prevent haemorrhage, uncontrolled leakage or other complications.

Diagnosis can be confirmed using either ultrasound or angiogram, which will reveal arterial blood flow into the pseudo-aneurysm.

Many options exist for the treatment of pseudo-aneurysms. Whilst in the past surgery was the gold standard treatment, several less invasive radiological treatment options are popular today such as ultrasound probe-guided compression,58 ultrasound-quided thrombin injection or intravascular stent placement.

Cannulation in the exact area of a pseudo-aneurysm must be avoided.

Pseudo-aneurysms can be prevented by rotating the cannulation sites using rope ladder technique.

8.6.3 Infection

Infection

An infection is the result of an invasion of the body by pathogens and the effects of their presence in the tissues.

Aetiology

Infection of AVG is mainly due to migration of micro-organisms from the skin to the graft or blood stream during cannulation, related to poor aseptic technique or poor patient hygiene. It can also be caused by contamination of the post-surgical perianastomosis haematoma or lymphocele.^{59,60}

The synthetic material of AVGs, commonly ePTFE, is porous and therefore provides an opportune medium for the formation of biofilms, causing general infection. Biofilms make the resident microbes resistant to both natural and pharmacological defences.⁶¹ Access infection is more likely to occur in thigh grafts than in upper extremity grafts due to the potential for enteric organism contamination.⁶² For this reason, placement of AVGs in thigh sites is usually a last resort.⁶³ Grampositive organisms are the main cause of graft infections, with Staphylococcus aureus being the most common AVG related bacteria.⁶⁴ Infections caused by S. aureus are prone to more complications and worse outcomes than other infections.

Overall infections account for approximately 20% of VA loss with VA being the source for the majority of cases of bacteraemia events in haemodialysis patients. The incidence of AVG infection is from 9% (forearm) to 20% (thigh).⁶² Staphylococcus Aureus and Epidermidis are the predominant pathogens.^{47, 48} Bacteraemia frequently occurs during cannulation without infection of the AVG.

Risk of infection associated with AVGs includes:

- Insufficient antisepsis during surgical procedure
- Poor patient and staff hygiene
- Severe pruritus and scratching over needle sites
- Repetitive cannulations
- Needle placement procedure with risk of contamination (poor aseptic technique) or haematoma formation^{65, 66}
- Pseudo-aneurysms
- Seroma
- Vintage

Other risk factors are:

- · History of multiple infections
- Number of surgical revisions
- Obesity
- The use of AVG as an intravenous route for drug abuse and use of the AVG for intravenous medication administration during surgical procedures⁶⁷
- Thrombosed and abandoned AVGs⁶⁸

Moreover, patients on dialysis have compromised immune function, and those with diabetes are more prone to infection and poor wound healing.

The consequences of an AVG infection include:

- Dependence on CVC which may lead to multiple vascular access procedures
- Loss of access site
- Lengthy hospitalisation
- High patient mortality risk
Signs and symptoms

Clinical signs of VA infection are (see Figure 23):

- Localised redness
- Tenderness
- Warmth
- Oedema
- Extravasation of local serous or purulent fluid
- Increased body temperature

Even in the absence of these clinical signs, infection may be present especially if the patient presents with unexpected sepsis or abnormal inflammatory parameters.⁶⁹⁻⁷²



Figure 23. AVG infections

Infection of the AVG may be either superficial or deep. Superficial infections do not involve the graft itself and are generally related to the cannulation site. On physical examination, superficial infections appear as small lesions (e.g. small white spots on the skin) with minimal or no inflammation, swelling or pain and sometimes purulence.

If signs and symptoms of infections are observed, refer to a physician for further prescription.

Management

An AVG infection is a serious clinical problem and should be treated for at least two weeks using appropriate antibiotics. Positive skin and blood culture tests mean that cannulation at the infected site must be avoided and the arm rested.73 If VA infections are suspected or diagnosed frequently in a haemodialysis unit, a re-evaluation of the unit's hand hygiene protocol should be initiated.73 Strict infection precautions and aseptic technique are important in preventing and minimising access infection.63 If the infection cannot be treated with antibiotics the total removal of infected AVGs and placement of a new access device at a remote site may be required. Because potential access sites are limited, partial graft excision to salvage a site is also an acceptable method for treating graft infection.74 Clinically silent infection of a clotted PRINTING PERMI AVG that is no longer being used should be considered.75

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9. Complications related to Arteriovenous Graft

9.1 Stenosis

Definition

The lumen of blood vessels that form the AVG can become constricted or narrowed by the proliferation or thickening of their inner layer (see Figure 24). This process is called AVG stenosis. Clinically significant graft stenosis is defined as \geq 50% reduction in luminal diameter judged⁷⁶ by comparison with either the adjacent vessel or graft and with the presence of abnormal clinical findings, such as decreasing intra-graft blood flow (less than 600 mL/min) or elevated static pressure within the graft.⁷⁷



AVG stenosis can occur anywhere along the vessel track; it may develop at the inflow (arterial side), middle part and outflow (venous side) of the AVG. Irrespective of where it occurs, stenosis increases the chances of AVG failure. Underlying stenosis can be an important predictor of graft thrombosis.

Aetiology

Stenosis of an AVG may occur due to endothelial damage/ injury, which leads to the up-regulation of endothelial cell adhesion on the surface.

According to Michael Allon,⁷⁸ factors contributing to the neointimal proliferation and fibromuscular hyperplasia include "shear stress generated by the turbulent blood flow and the mismatch in elastic properties around the anastomosis leading to excessive mechanical stretch. Activated platelets and inflammatory cells also secrete oxidants and other toxins that directly injure the vessel wall. Finally, angioplasty of stenotic lesions exacerbates neointimal hyperplasia, resulting in accelerated restenosis".

The majority (60%)⁷⁹ of grafts occlude due to progressive stenosis of the venous anastomosis but may be observed anywhere within the venous system composed of the bridge graft, the anastomoses and the draining veins (i.e. the arterial side, the AV grafts itself, or the venous anastomoses side and central venous). The combination of surgical trauma to vein wall and endothelium during graft implantation, compliance mismatch between graft and vein, and flow disturbances in the anastomotic area is believed to be the cause of the stenosis.⁸⁰

Intra-graft (or mid-graft) stenoses are found in the cannulation segment of grafts. They result from excessive ingrowth of fibrous tissue through puncture holes.

A healthy AVG is generally characterised by a soft, diffuse thrill and soft bruit, both with systolic and diastolic components. A venous stenosis is suggested by a strong pulse over the graft and by a localised, accentuated thrill and a high-pitched bruit, both of which may lack diastolic components.

The vessel of the AVG can become stenotic over time as the lumen of the blood vessel become constricted or narrowed by the thickening of the inner layer.

Signs and symptoms

The clinical manifestations differ according to the location of the stenosis.

Stenosis located at the arterial side will reduce pulse and thrill which suggests inflow stenosis due to the arterial anastomosis of the feeding artery. Arterial inflow stenosis may be assessed by evaluating pulse augmentation with complete occlusion of the graft on a short distance away from the arterial anastomosis. The pulse over a normal AV graft is augmented by this manoeuvre. The degree of this augmentation is directly proportional to the quality of the arterial inflow.

Arterial inflow stenosis will induce a low blood flow through the AVG, causing changes in the negative arterial pressures using a 15G needle and blood pump speed of 350 mL/min.

Stenosis located at the intra-graft or venous outflow side of the AVG will develop a very strong pulsating blood flow through the AV graft (hyperpulsatility) suggesting an increase in downstream (in the direction of flow) resistance occurring due to a venous stenotic lesion. The intensity of this pulse is directly proportional to the severity of the stenosis. For this reason, a very strong pulsating AV graft should be considered as a severe dysfunction.

Narrowing of the vein or graft lumen will determine a strong bruit and thrill due to turbulent flow occurring at that point, whilst above the stenosis it may have no bruit or thrill at all.

Additionally, due to the increased resistance that occurs, the diastolic component of both the thrill and bruit become

increasingly shortened as the stenosis progresses. With severe stenosis, the thrill and bruit may become completely absent and the pulse very strong.

During dialysis, low negative arterial pressures (e.g. -80 mmHg, using a 15G needle and blood pump speed of 350 mL/ min) and high positive venous pressures are observed (e.g. +300 mmHg, using a 15G needle and blood pump speed up to 350 mL/min).

Arm elevation tests, which are commonly performed to evaluate for venous stenosis in a fistula, are not effective for the evaluation of venous stenosis in a synthetic graft due to the higher levels of intra-access pressure.

Stenosis located at the central vein: The physical findings of significant central vein stenosis (probably caused by a previously placed CVC) differ from those of venous stenosis in the haemodialysis access or peripheral veins. The physical examination in a patient with a severe central venous stenosis may reveal an upper extremity oedema, which can be massive. Subcutaneous collateral veins are frequently evident over the arm, chest and neck.

In spite of a significant outflow stenosis, the pulsation over the AVG is generally minimal and frequently not apparent. It is not a strong pulse as in peripheral venous stenosis because the pulse is dampened by the intervening veins between the AVG and the central stenosis.

Often, especially in thin-chested individuals with a cephalic arch or subclavian lesion, a localised thrill and bruit can be detected over the anterior chest, just below the clavicle. These stenoses are usually associated with previous insertion of CVCs that may have caused scarring of the subclavian vein resulting in a high resistance at the venous side of the AVG.

Management

Regular physical examination of the AVG (before and after each haemodialysis session) should reveal potential problems such as reduction of pulse and thrill or hyperpulsatility, etc. The patients should be taught to inspect their AVG on a daily basis. Physical examination of the graft should be directed toward the early detection of signs of possible stenosis thus preventing under-dialysis. Studies have suggested that physical examination provides a reasonably accurate screening test for AV graft stenosis, although it may not be as accurate as it is for detecting AV fistula stenosis.⁸¹

In general, a stenotic lesion associated with an AV graft that produces abnormalities detectable by physical examination such as absent thrill, discontinuous bruit, or oedema in the extremity distal to the graft, is likely to be significant enough to warrant evaluation by diagnostic ultrasound and/or radiological imaging in preparation for treatment. The development of any such lesion, whether related to inflow or outflow, increases the risk of AV graft dysfunction, which can result in inadequate dialysis and eventually thrombosis and potential loss of the AVG.

Early detection facilitates correction of the stenosis (by angioplasty or surgical revision) prior to thrombosis occurring. Stenosis should be treated if the diameter is reduced by more than 50%, otherwise it will cause reduced access flow and decreased dialysis dose, or prolonged bleeding from the needle puncture sites. Only clinically significant stenosis should be treated.

Duplex ultrasonography can be used to better confirm the diagnosis of stenosis, irrespective of its location and is a more appropriate initial imaging modality since it is non-invasive.

The precise location and diameter of the stenosis should be recorded for further interventions.

Significant access dysfunction can be treated by endovascular technique (considered the gold standard) with a high expectation of success.⁸² However any type of program to preemptively identify and treat stenosis necessarily results in a substantial number of superfluous angioplasties. To complicate matters, the vascular injury resulting from angioplasty may actually stimulate neointimal hyperplasia and accelerate graft re-stenosis, and potentially graft loss, especially in patients with diabetes.⁸³

Since grafts should be implanted only in patients with exhausted peripheral veins, vein-saving procedures like Percutaneous Transluminal Angioplasty (PTA) or patch angioplasty should be favoured to graft extensions to more central venous segments, even though the latter may have superior patency rates.

When PTA repeatedly fails, additional implantation should be considered. When a stent or a patch fails, graft extension is still possible.⁸⁴

9.2 Thrombosis

Definition

The formation of a clot (thrombus) in the AVG is defined as thrombosis. In AVG, thrombosis is the leading cause of failure and loss of AVG patency (see Figure 25).

Aetiology

The major AVG complication is thrombosis, it can occur either soon after its creation or as a late event. This problem is often related to venous stenosis (outflow vein or central venous drainage) that causes increased outflow resistance, or due to stenosis within the conduit or the arterial anastomosis, resulting in reduced arterial inflow.⁸⁵ More than 90% of thrombosed grafts have a stenotic lesion.^{78, 81, 86}

High fibrinogen levels, reduced levels of protein S or protein C, factor V Leiden mutation, or lupus anticoagulant should be taken under consideration. Haematocrit levels >40% are associated with increased risk of thrombosis. Parameters that predispose towards thrombosis formation following dialysis include: hypotension (most common cause), haemoconcentration and vascular instability (due to excessive ultrafiltration), hyper-viscosity (polycystic kidneys) and firm or prolonged compression of the AVG for haemostasis. Occlusion of the access with tight bandages or clamps has been claimed by some authors to favour late fistula thrombosis.⁴⁸

Other causes can include reduction of blood flow, due to hypovolaemia, associated or not to dialysis. Infections may also induce thrombosis.

Signs and symptoms

The patient is often the first to notice a loss of palpable pulse or thrill in the AVG. The typical clinical scenario is sudden thrombosis, at times with only moderate degrees of stenosis. Indepth examination of the AVG may reveal loss of bruit and thrill.

Nurses can easily suspect thrombosis when poor flow of the AVG is present during haemodialysis. Thrombosis may be accompanied by increased flow volume in collateral veins or increased distal oedema.



Figure 25. AVG Thrombosis

Management

An organised management approach including regular assessment of the clinical parameters during dialysis as well as the dialysis dose is crucial. Trends in these variables are very important.

Careful assessment of Erythropoiesis Stimulating Agents (ESA) response and blood pressure is part of reducing risk. Patient and carers should also be educated in regular examination of their access and be given clear instructions in the event of suspected thrombosis. Changes in the pulse and the thrill of an AVG are not as obvious as in an arteriovenous fistula due to resistance of graft material. Nevertheless, the pulse and the thrill in the AVG should be evaluated along its entire length from the arterial to the venous anastomosis.

Management options include:

- Percutaneous approach, either pharmacological agents, mechanical clot disruption, or a combination (pharmacomechanical thrombolysis)
- Surgical thrombectomy

Percutaneous thrombolysis

If pharmacological agent is used there should be no contraindications to thrombolytic therapy (such as recent surgery, a bleeding disorder or severe hypertension). A fistulogram should be performed thereafter to identify any associated stenoses, which can be treated with angioplasty.³ Mechanical thrombolysis is another option for recanalising thrombosed grafts.⁸⁷ Clinically significant pulmonary embolism is a possible adverse effect of percutaneous thrombolysis.⁸⁸

Surgical thrombectomy

Surgical thrombectomy offers similar results as percutaneous thrombolysis, but it may lead to early re-thrombosis if associated stenoses are not treated.

However, surgical thrombectomy is still the preferred treatment for early post-surgical thrombosis (i.e. 0-4 weeks post-operative).

9.3 Seroma

Definition

Perigraft seroma is defined as a sterile collection of ultrafiltration of plasma⁸⁹ confined within a non-secretory fibrous pseudomembrane surrounding a vascular graft.⁹⁰

Aetiology

Perigraft seromas are rare complications of PTFE grafts which are difficult to treat with frequent recurrences.⁹⁰

It usually forms slowly, beginning within 30 days after implantation of the graft (25% of the cases),⁸⁹ predominantly

in the arterial limb of the graft where intraluminal pressure is higher, although it can appear in venous limb in case of central vein thrombosis.⁹¹ The primary suggested cause of seroma is failure of the surrounding connective tissue to incorporate the graft. "Graft wetting", or "graft weeping", is one of the contributing factors. In addition, some humoral fibroblast inhibitors may prevent the maturation and proliferation of perigraft fibroblasts, resulting in poor graft incorporation.⁹²

Several predisposing factors of perigraft seromas have been identified, including high pressure flow rate, low haematocrit, decreased oncotic pressure in malnourished patients, and extensive manipulation of the graft.⁸⁹

Signs and symptoms

Perigraft seroma is soft on palpation, but can become firm and gelatinous over time. Expanding seromas cause pressure necrosis and erosion through the skin and may ultimately result in rupture.

Management

Surgery is generally indicated for expanding seromas before pressure necrosis and erosion through the skin occurs. Graft compression as well as ultrasound guided percutaneous drainage may also be an indication in the first line treatment.

9.4 Complications caused by the Arteriovenous Graft

9.4.1 Cardiac complications

Definition

The presence of an arm located VA, especially proximal with high flow, demands a high cardiac output. This situation can

cause an exacerbation of pre-existing conditions such as Congestive Heart Failure (CHF), Left Ventricular Hypertrophy (LVH), pulmonary hypertension, right ventricular dysfunction, coronary artery disease and valvular heart disease.⁹³

Aetiology

CHF is highly prevalent among patients with ESRD and the causes are multifactorial. In patients with upper arm or femoral graft,⁷⁰ and the presence of large vessel AVG or multiple VAs it can be exacerbated. The access flow rate through an AVG varies from 400 mL/min to 3000 mL/min. CHF may result from systolic or diastolic dysfunction due to left ventricular hypertrophy.

Signs and symptoms

In these patients, cardiac failure and distal arm hypoperfusion results in 16.2% of all complications.⁹³ They can also experience orthopnoea and/or dyspnoea, jugular vein distension, and bilateral lung crepitation.

Management

Echocardiography is used to assess left ventricular (LV) dimensions and function. Regular chest X-rays should be performed in order to assess the cardiothoracic index.⁹⁴

The benefit of surgical intervention (narrowing/banding or closure) in a functioning AVG should be weighed against the known potential life threatening complications associated with the vascular access closure. These interventions in a functioning AVG should only be performed when severe changes in cardiac output are present. Long-term cardiac function is unaffected by the presence of an internal VA in most patients.

9.4.2 Steal syndrome

Definition

Steal syndrome is clinically defined as distal hypoperfusion (more peripheral) to the haemodialysis access due to the access diverting an excessive amount of blood away from the distal artery.⁹⁵

It can have serious consequences for an individual, ranging from access loss to loss of function of the limb through neurological or ischaemic damage, or pain during dialysis.

Aetiology

Steal syndrome develops in 2.7 - 4.3% of arteriovenous grafts (AVGs) and 1% of arteriovenous fistulae (AVFs).⁹⁵ It is common in patients with co-existing vascular disease, diabetes, narrow arteries, absent wrist pulse, Raynaud's phenomenon, amputations, vasculitis, and patients who have had multiple VA attempts.^{59, 70, 96}

Increased resistance in the distal arteries (microvascular and macrovascular disease) contributes to the diversion of blood into the AV access, exacerbating distal hypoperfusion and frequently resulting in ischaemic symptoms.⁹⁷

Hand ischaemia may be related to steal or arterial obstruction associated with the placement of an AV graft which can cause a reversal of distal flow without adequate collateral circulation or can be due to reduced antegrade flow alone.

Patients with normal radial and/or ulnar pulses are unlikely to develop steal syndrome.

Signs and symptoms

Physical findings depend upon the severity of the problem onset (acute vs chronic) and pre-existing vascular conditions.

Asymptomatic "steal," manifested by pulse deficits, Doppler signal attenuation, and distal flow reversal, may be present with any AV access but only becomes symptomatic when blood flow is shunted (stolen) from tissue beds distal to the arterial anastomosis.

Symptomatic steal syndrome may present as (see Figure 26):

- Slight limb coldness
- Diminished, altered sensation (numbness, tingling, paraesthesia)
- Pale nail beds, fingers and hand (due to poor capillary filling)
- Severe pain in the hand (e.g. during exercise, HD)
- Rest pain in the affected extremity
- Diminished or absent pulses
- Mononeuropathy with intrinsic muscle weakness
- Severe neuropathy (e.g. atrophy, loss of function, tissue loss)
 - Appearance of non-healing ulcers and digital cyanosis or gangrene can be present in the later stages^{59, 70}



Figure 26. Ischemic signs of steal syndrome

A grading scheme has been proposed by Tordoir et al ⁹⁸:

- Stage 1: Pale/blue and/or cold hand without pain
- Stage 2: Pain during exercise and/or haemodialysis
- Stage 3: Rest pain
- Stage 4: Ulcers/necrosis/gangrene

Management

An Allen test can be used to predict steal syndrome prior to VA creation, although it is not an accurate predictor. During physical examination of a patient with a cold and painful arm, a comparison of the affected side versus the non-affected side and assessment of the radial and ulnar pulse in both extremities is helpful. Radiological or surgical interventions may be required to resolve the problem.

Banding is a technique that has commonly been used to correct these access dysfunctions by reducing access flow. The introduction of a high-resistance band is a reasonable treatment for a low-resistance venous pathway, which has transformed a functional access into a pathologic shunt. However, complexities in sizing the band and the resultant

poor long-term outcomes have led to near abandonment of banding and the development of alternative treatments such as Distal Revascularization with Interval Ligation (DRIL) and Proximalisation of the Arterial Inflow (PAI).⁹⁵

In 2006, a new banding technique was developed by Dr. Gregg Miller called "Minimally Invasive Limited Ligation Endoluminal-assisted Revision (MILLER)" for treating high flow accesses and reducing steal syndrome. The procedure utilises an inflated angioplasty balloon as a sizing dowel inside the access for consistent, repeatable banding. For best results intra-access flow measurements using Transonic's HVT100 Endovascular Flowmeter should be taken before banding (to determine a baseline) and then after the procedure to identify satisfactory flow reduction.

After the post-procedural flow measurement the physician can determine if the balloon size used was appropriate and then adjust the band if necessary.⁹⁹

Reduction of the size (width) of the anastomosis (arterial end) and AV graft closure are other valuable options and should be considered as well.

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10. Graft Monitoring and Surveillance

Pre-emptive surveillance programmes for VA should be carried out in all dialysis centres and should be performed on a regular basis. Also, when combined with a timely correction of any dysfunction, this may increase patency rates and decrease the incidence of complications.

During the dialysis session there are some warning signs that should alert health care professionals, such as increased cannulation difficulties, clot aspiration, inability to reach desired blood flow, changing in dynamic pressures and prolonged haemostasis time.

These programmes should combine both clinical monitoring and surveillance methods.

10.1 Arteriovenous graft clinical monitoring

Clinical monitoring includes:

- Physical examination
- Standardised dynamic arterial and venous pressures
- Bleeding during and after treatment

10.1.1 Physical examination

Physical examination (refer to Chapter 8.2.2) performed on a regular basis, is a simple and accurate procedure used to detect common problems e.g. AVG stenosis in the vascular access. Physical examination techniques are easily learned and should be mastered by clinical staff working with dialysis patients.¹⁰⁰

As previously discussed, the most common complications related to AVG are venous and arterial stenosis, thrombosis, pseudo-aneurysm formations, infection and ischaemia.

Therefore, physical examination should be conducted to assess any signs of each potential problem.

Any abnormal findings such as absent thrill, discontinuous bruit, presence of oedema distal to the graft and/or collateral veins should be documented and reported immediately according to the normal channels in each unit.^{101, 102}

10.1.2 Standardised dynamic arterial and venous pressure

Dynamic pressures are simpler to perform and record, but are less sensitive and less specific for outlet stenosis than static pressure measurements; however, if averaged for mean arterial pressure and trended together with each treatment, they have been found to be predictive of access thrombosis.¹⁰³

An increased dynamic negative arterial pressure during consecutive dialysis sessions could also be a sign of AVG stenosis or low access flow. Pre-pump arterial pressure (AP) monitoring helps to make sure the correct blood flow is delivered to the patients. It also prevents a non-functioning vascular access from being used.

An increased dynamic venous pressure during consecutive dialysis sessions is more significant than a single high value. For any clinical relevance (suspected venous stenosis) there must be three consecutive measures above 150 mmHg under the same technical conditions.¹⁰⁰ Patients with increased dynamic venous pressures during consecutive sessions require venography or a Doppler ultrasound examination to investigate for venous stenosis.

This method is the least expensive and simplest surveillance technique available for AVG.

10.1.3 Bleeding during and after treatment

Bleeding associated with AVG usually occurs due to poor cannulation technique, anticoagulation medication and haemostasis.

Vascular access bleeding is among one of the most frequently observed complications.^{100, 104} However, compared to other access complications, the clinical significance of bleeding-related access complication has not been studied.^{34, 104} The independent effect of AVG usage on access cannulation site bleeding remains unknown, although it had been associated with increased chance of access bleeding complications in a smaller study.¹⁰⁵ In addition, HD patients might bleed slightly with every dialysis treatment as a result of clotted dialysis membranes, frequent blood sampling or bleeding from the vascular access.^{106, 107}

Bleeding control following needle removal is an important issue for both caregivers and patients. A long delay significantly impacts the patient's quality of life by extending time to discharge, increases nursing workload, consumes valuable staff time usually dedicated to monitoring patient treatments and is likely to disturb the overall haemodialysis schedule and organisation of the dialysis unit.

Moreover excessive post-dialysis puncture site bleeding has recently been found to be significantly associated with lower haemoglobin levels in an observational study.^{107, 108} Also access stenosis can affect the bleeding time. In addition, cannulation complications such as vascular breach can significantly affect bleeding time independently of other parameters (such as stenosis or antiplatelet agents and oral anticoagulant prescription).

Post-dialysis cannulation site bleeding could also be aggravated by the increasing prevalence of elderly patients in dialysis units.

10.2 Arteriovenous graft surveillance methods

Clinical monitoring can successfully point out a significantly important stenosis in 70 to 90% of the cases, however there are limitations. Access surveillance methods are more consistent and reproducible, relying on dedicated equipment, with the premise that a graft stenosis results in an increased pressure and/or a decrease in access blood flow,

Surveillance methods include:

- Dialysis efficiency
- Measurement of blood recirculation
- Intra-access blood flow measurement (Qa)
- · Standardised static venous pressure
- Duplex ultrasound
- Imaging techniques

10.2.1 Dialysis efficiency

Current parameters routinely used to assess dialysis adequacy are Kt/V and urea reduction rate (URR). Indirect measurements can also be obtained by monitoring potassium, phosphate, urea, and serum creatinine concentrations.

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10.2.2 Measurements of blood recirculation

Blood recirculation measurement may indicate a stenosis in the AVG. Nevertheless it will be a late diagnosis, since access recirculation will not be present until internal access flow drops to a range between 350 – 500 mL/min, which places an AVG at a very high risk of thrombosis.¹⁰⁹

More than one method is available to evaluate blood recirculation.

Blood sample

Two-needle measurement of blood recirculation comprises the following steps and should be performed after 30 minutes of dialysis with ultrafiltration switched off:

- Take arterial (A) and venous (V) blood samples from the respective lines
- Reduce the blood flow rate to 120 mL/min for 10 sec then switch off the blood pump. Clamp the arterial line above the sampling port and take a systemic arterial sample (S) from the arterial line port
- Continue dialysis
- Measure urea levels in the A,V and S samples¹⁰⁰
- Recirculation is defined as S–A/S–V x 100

Thermodilution

The thermodilution method makes it possible to determine the total blood recirculation with a non-invasive temperature bolus technique, and thus detect vascular access problems that could reduce the efficacy of dialysis. This method can be used to assess both grafts/fistulae and cardiopulmonary recirculation.

The Blood Temperature Module (BTM) is a quick, precise, non-invasive measurement of the recirculation. During the treatment, independent from the temperature regulation, the automated measurement based on the thermodilution procedure can be activated at any time by pressing a button. The BTM initiates a brief temperature change in the dialysis fluid circuit which is transferred to the blood in the dialyser. Using the venous temperature sensor in the measuring block of the BTM, the temperature peak is registered, time recorded and subsequently compared with the registered course of temperature in the arterial temperature sensor. The ratio

between the two temperatures integrals is calculated and the resulting recirculation percentage is displayed.

Within a few minutes, a first estimate of the VA function and the efficacy of the running treatment are provided.

If the value is lower than 10%, recirculation is categorised as "low"; this may be due to cardiopulmonary recirculation only. A value higher than 20% indicates considerable VA recirculation and the VA should be examined for the presence of any possible stenosis.¹¹⁰

10.2.3 Intra-access blood flow measurement (Qa)

Intra-access blood flow can be obtained by more than one method: ultrasound dilution, thermodilution and online conductivity monitoring.

Access flow measurement obtained by reversed recirculation technique is a simple and efficient method described by Krivitsky.¹¹¹

Typically Qa measurements should be performed on a monthly basis or when necessary.

When access flow falls below 600 mL/min or there is a decrease of more than 25% from baseline value, the risk of AVG thrombosis increases. Nonetheless, low Qa values should be correlated with other data and if necessary confirmed at the next possible dialysis treatment.

So, a trend of reduced access flow values is a very important predictive factor for stenosis. Therefore, consecutive measurements are more useful than a single measurement.¹¹²

10.2.4 Standardised static venous pressure

Static venous pressure is the pressure in the access in the absence of extracorporeal blood flow, or prior to the initiation of haemodialysis. This is more reliable than dynamic pressure as there are fewer variables (needle size, blood flow, machine type). It is corrected for the distance between the access and the drip chambers as the height will add additional pressure (0.76 × Δ height) and is also normalised for mean arterial pressure has been shown to be predictive of graft stenosis.¹¹³ Although thresholds of this ratio have been suggested as indicators of stenosis, analysis of trends in individual patients, just as in dynamic venous pressure readings, seems to be more reliable.¹¹⁴

Venous pressure readings in AVGs are more predictive of outlet stenosis close to the anastomotic site, which is the most common place for stenosis to develop, but less accurate for distal stenosis. Pressure readings, if used for surveillance, need to be performed frequently (every 1 to 2 weeks) to improve accuracy.¹¹⁵

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10.2.5 Duplex ultrasound

Doppler ultrasound provides accurate anatomical and haemodynamic information, also measuring the access flow. This examination can be performed as part of a routine surveillance programme, to detect early VA problems, or suspected dysfunction. However, limitations for its use are lack of staff and/or knowledge in the HD unit.

10.2.6 Imaging techniques

Angiography

Angiography is an imaging technique used to visualise the inside, or lumen, of the AVG. This is traditionally carried out by injecting a radio-opaque contrast agent into the blood vessel.

Patients with suspected venous or arterial stenosis require angiography of the AVG from the arterial inflow up to the venous outflow as far as possible. Care should be taken during these examinations, as the effect on residual renal function of using contrast media could be detrimental. When performing angiography, interventional procedures can be done simultaneously, resolving the cause of access dysfunction.

Magnetic resonance flow measurements

This is an accurate but very expensive procedure.¹⁰⁹ Recently, Contrast-Enhanced Magnetic Resonance Angiography (CE-MRA) has been introduced for examining failing VAs. CE-MRA is non-invasive, does not use ionising radiation, and provides an angiographic map of the complete vasculature of the VA. However, a major limitation of CE-MRA is the absence of magnetic resonance-guided access intervention.

It is unclear if the use of Magnetic Resonance (MR) contrast agents such as gadolinium-based contrast agents (GBCAs) can trigger Nephrogenic Systemic Fibrosis (NSF). Nevertheless, it is appropriate to assume for now that a potential association might exist for all GBCAs. The use of the preventive measures discussed earlier may minimise the risk of developing NSF, as recently reported by investigators at the University of Wisconsin.¹¹⁶

The usefulness of haemodialysis in the prevention of NSF is unknown. However, to enhance and increase the GBCA

Vascular Access Cannulation and Care A Nursing Best Practice Guide for Arteriovenous Graft

elimination, it is recommended that patients undergo a haemodialysis session no later than 2 hours after the administration of the GBCA. A second haemodialysis session should be considered within 24 hours of the first session.¹¹⁷

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11. Reporting of Arteriovenous Graft incidents

AVG dysfunction remains a major contributor to morbidity and mortality of haemodialysis patients. Regular monitoring and surveillance of all risk factors related to AVG, as well as any comorbidity that may influence its function and preservation, are recommended.¹¹⁸

11.1 What, when and why to report

All factors that may influence the patency and survival of the AVG should be reported. Many of the risk factors for AVG failure are associated with comorbid conditions that decrease the likelihood of its survival.

Current guidelines recommend that vascular access monitoring and surveillance are part of the dialysis care provided to patients with ESRD in order to identify problems and intervene at an early stage.

"Prevention is better than cure"; early diagnosis translates into early intervention prolonging access patency and survival. It is important to clarify that surveillance and monitoring are complementary and must be combined.

AVG's patency and functionality must be reported as described in Table V.
	2		
Problems identified	What to report	When to report	Why to report
Signs of neuropathy	Post-operative limb swelling following AV graft insertion, ischaemic injury by a vascular steal effect (ischaemic monomelic neuropathy)	During post-operative surveillance as soon as swelling and/or injury by a vascular steal effect are detected	Early reporting can provide an opportunity for timely intervention
Failure of AVG feeding artery or outflow vein to dilate	Swelling in the limb	When swelling does not respond to arm elevation or persists beyond 2 weeks after AVG implantation	Early recognition of a dysfunctional AVG can provide an opportunity for timely intervention
Infiltration / Haematoma	All events of infiltration Presence of haematoma including size and affected area Incorrect use of cannulation technique	As soon as the infiltration takes place and/or haematoma appears	Early recognition of a haematoma can prevent the risk of thrombosis and/or stenosis

Table V: Reporting Arteriovenous Graft complications

Why to report	Prolonged bleeding may be a predictor of significant outflow stenosis anywhere along the flow path including central vein stenosis, inadequate anti- coagulation therapy, other comorbidities (e.g. liver failure)	Reporting can decrease patient morbidity and costs associated with hospitalisation. Various reports indicate that the most frequent cause of hospitalisation among ESRD patients is complications associated with the VA ¹¹⁹
When to report	When prolonged bleeding time occurs on at least two consecutive treatments	As soon as any signs of infection are recognised
What to report	Prolonged bleeding time after needle removal	The patient presents with signs/symptoms of infection (refer to Chapter 8.6.3)
Problems Identified	Increased haemostasis time	Signs of infection



Why to report	Regular monitoring of access blood flow can predict the presence of AVG malfunction and provide an opportunity for early intervention to prevent or reduce thrombosis in the graff ^{94, 120} Regular surveillance of the AVG is recommended for detecting and treating stenosis and in order to prevent thrombosis and failure. Early diagnosis of graft dysfunction followed by angioplasty or elective surgery can prolong graft function. Thrombectomy is effective in more than 90%
When to report	Persistent swelling in the AVG limb with oedema of the shoulder, breast, supractavicular, neck and face, and an abnormal augmentation test Persistent pain in the AVG during treatment Patient has progressively increasing intra-access venous pressure
What to report	Elevated dynamic or static venous pressures Prolonged bleeding time after needle removal Presence of oedema Development of multiple collateral draining veins present at some distance from the anastomotic site (e.g. over the chest)
Problems Identified	Signs of stenosis located downstream (from venous site to central veins)

Signs of steal syndrome	A difference in temperature and colour between the fingers of the hand on the AVG limb and the contralateral limb Poor arterial blood flow to the hand due to high flow through the AVG lschaemic pain at rest accompanied by atrophic changes such as ulceration, necrosis and gangrene	As soon any signs of steal syndrome have been detected (steal syndrome of the limb can be easily confirmed by asking the patient about symptoms, or by physical examination) Report whenever the patient has a pale or cold hand with or without pain during exercise and/or haemodialysis	Reducing or correcting the problems associated with distal limb ischaemia can prevent loss of limb and AVG
Inadequate Blood Flow	The prescribed blood flow is not achieved during the treatment	When the blood flow rate is less than prescribed value When elevated negative arterial pre-pump pressures prevent achieving the prescribed blood flow, thus reducing dialysis efficacy	Achieved blood flow rates less than prescribed values may lead to under-dialysis and may indicate urgent need of AVG revision
			5

Problems Identified	What to report	When to report	Why to report
	Recirculation values exceeding 5%	During surveillance measu- rements using the non-urea-based dilution method	Early reporting of recirculation graft
Recirculation	Recirculation values exceeding 10%	During surveillance measu- rements using the two- needle urea-based dilution method	dysfunction is important to correctly investigate and detect the cause, before loss of vascular access occurs. The nurse should report all changes in the AVG and risk
	Recirculation values exceeding 20%	Changes to the needle placement	functionality to prevent its failure
			2

A new pseudo-aneurysr formation must be investigated immediatel and should be addresse as early as possible to prevent rupture and severe bleeding	na are Early reporting can be soft on provide an opportunity f timely intervention	
As soon as a pseudo aneurysm is recogni	When signs of seron visible (graft appears palpation)	
A pseudo-aneurysm is a disruption of the wall of the graft. The skin immediately on top should be examined for evidence of thinning, ulceration or spontaneous bleeding	Seroma is a pocket of serous fluid formed as a result of ultrafiltration of plasma across a prosthetic graft	
Signs of pseudo- aneurysm	Signs of Seroma	

Reporting responsibilities

Dialysis units should establish a protocol for monitoring and surveillance of vascular access, and define methodologies for reporting the findings. Studies indicate that the introduction of these protocols is very important because they can achieve a higher primary and secondary patency therefore resulting in lower patient morbidity.^{122, 123}

Each dialysis unit should appoint a vascular access coordinator to manage the database and the referral of patients with dysfunction related to the patency/survival of the AVG. The vascular access coordinator should do a systematic observation of the findings, correlating various variables monitored in the charts. Trend analysis is more useful than any single measurement and should be used to predict and prevent access failure.

According to the protocol established in the dialysis unit, the vascular access coordinator must notify the physician responsible for the patient regarding all findings. To ensure timely and effective actions, the multi-disciplinary team must use the same reporting language, therefore providing consistency of communication.

For better assessment, regular multidisciplinary meetings should discuss the data of those patients presenting with dysfunctional factors, which will require further investigation.

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11.2 Reporting tools

Tools, either manual or electronic, must be created to store the data collected.

A computer-based programme for monitoring and surveillance should be created. The results and findings of the vascular access monitoring (physical examination and/or non-invasive surveillance methods) should be inserted into the database. The data from all treatments may also be collected in electronic format directly from the haemodialysis machines and inserted into a computerised system. In this way, a database for documentation of procedures and complications is developed for all patients.

To facilitate analysis, an algorithm should be formulated to generate an automatic warning if there is a deviation in the indicators of AVG dysfunction.¹¹³

11.3 Interventions

Before referral, the causes of dysfunction should be determined. Depending on the results, the corrective actions should be related to each single complication (refer to Chapter 8.6 and Chapter 9).

11.4 Post-intervention follow-up

Regular monitoring and surveillance allows the multidisciplinary team to be involved in a coordinated, structured manner in the identification of patients with a dysfunctional graft.

Some examples of re-evaluation and/or re-assessment are:

- Review of hygiene and aseptic procedures to ensure that they are being correctly followed
- The cannulation technique in use should be checked to ensure that it is the most appropriate one
- Evaluation of patient and staff education levels to determine future educational needs

The AVG must always be evaluated after an interventional procedure, in order to assess the efficacy of the surgical intervention

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And for the Care of Arteriovenous Graft

12. Patient Education for the Care of Arteriovenous Graft

Patient education is defined "as any set of planned educational activities designed to improve patients' health behaviours and health status".¹²⁴ Its main purpose is to maintain or to improve patient health status. However, patient education goes beyond this main purpose as, an informed and educated patient can actively participate in his or her own treatment, improve outcomes and help identify errors before they occur.¹²⁵

Educating patients who are undergoing haemodialysis is a very important part of holistic patient care. Healthcare professionals must communicate important messages that can be difficult both for the patient to hear and for the carer to deliver.

Haemodialysis patients have a role to play and must be educated on the care and management of their VA and have knowledge on how to deal with any vascular access emergencies that may arise within their own home environment.

Whenever it has been decided that the patient will have an AVG implanted they must become aware of their roles and responsibilities. These roles and responsibilities mean that the patient must be aware that the creation of vascular accesses is not endless. In order to preserve the vessels prior to AVG implantation the patient and healthcare team should take care to preserve the vessels by avoiding the following:

- The use of vessels for blood sampling
- Intravenous injections and infusions
- Invasive arterial pressure measurement
 - The use of the arm for radiological investigations (contrast medium substances)

Arteriovenous Graft care

After the surgery for the creation of an AVG the following information is important for the patient to know:

- Keep the arm warm and dry after surgery
- Keep the arm extended and elevated above the level of the heart; place it on a pillow while lying down and hold it up while sitting¹²⁶ (if the graft is implanted in the lower arm)
- Monitor the surgical wound for changes in temperature, redness, pain levels and drainage, and contact the staff if any of these observations are present
- Observe for wet or soiled dressings
- They may experience some bruising, swelling and discomfort in their arm. This is normal and pain medication may be prescribed¹²⁶
- Avoid putting any pressure on the arm¹²⁶
- Ask the nurse to inspect the new AVG at each session if already on dialysis treatment

Important general advice includes:

- Use the other hand to feel the thrill three times a day
- Avoid sleeping on the AVG arm
- Avoid wearing tight sleeves that may act as a tourniquet on the AVG or on the vessels above the AVG
- Avoid carrying heavy weights (e.g. while shopping, lifting children, lifting furniture, or at the gym)
- Avoid violent sports or activity that may cause a trauma to the AVG
- Make sure that staff are made aware of the presence of the AVG via signalling bracelet and avoid blood

pressure measurements, blood sampling and intravenous injections or infusions on the AVG arm in case of hospital admission

When can the Graft be used?

Patients should be informed that after graft implantation, it is necessary (depending of the graft material) to wait several weeks before cannulating it.

Arteriovenous graft complications

Patients should be educated and informed on how to recognise the following complications and any treatments that may be required. It should be very clear to patients that when they feel that "something is wrong" they should immediately contact their dialysis unit. Patients should be taught to recognise the following signs:

Thrombosis

The clinical diagnosis of AVG thrombosis is based on the absence of thrill and bruit. Patients should notify the dialysis unit immediately if:

The AVG thrill is weak or cannot be palpated, as the graft will need immediate attention. Advise the patient that a hospitalisation and possibly surgery may be necessary

- Notice any unusual appearance or feel of the AVG (alterations to skin or arm, damaged skin, any abnormal lumps, swollen or painful area, and altered sensation in the arm)
- The AVG has been injured, which causes serious damage; the patient should check the AVG for swelling,

bruising and any altered sensation in the arm although the thrill is normal

- A pulsating hard knot felt under the skin (may indicate graft damage because of repeated needle puncturing in the same place)
- A spreading bruise after completion of a dialysis session (may indicate graft bleeding under the skin)

Infection

Patients must be educated to:

- Understand basic principles of aseptic procedures
 which will be performed during dialysis
- · Perform hand washing before and after each treatment
- Wash the VA before each treatment
- Recognise, prevent and report any signs and symptoms of infection, such as:
 - * Redness
 - * Fever
 - * Swelling, warmth to touch
 - * Pain
 - Exudate

Pseudo-aneurysm

Patients should understand, through proper education that the importance of rotating puncture sites is crucial and cannot be overstated.

Patients should also be reminded to never scratch off a scab over a pseudo-aneurysm (as it may itch the temptation is to scratch) since this may result in opening a direct communication to the blood flow in the graft and leads to severe haemorrhage.

Patient Dos and Don'ts

Dos

- Make sure the arm is washed and clean before each dialysis session
- Vary needle cannulation sites
- Apply light pressure to stop bleeding after the dialysis needles are removed
- Have the nurse check to make sure bleeding has stopped before applying dressing and leaving the dialysis centre

Don'ts

- Touch the area where the needle is to enter after skin disinfection or during dialysis
- Wear tight sleeves, watches, or bracelets over the graft
- Carry heavy loads (e.g. shopping bags) against or on the graft
- Sleep on it
- Have blood pressure taken in the same arm
- Use the graft for routine blood tests (except during a dialysis session)
- Use the graft for intravenous drug treatments

Patient should also check regularly that the flow is adequate through the graft. An inadequate supply of blood through the graft can cause difficulty in blood removal and could lead to graft occlusion. To ensure that the patient's graft is getting adequate blood flow, he/she has to know how to feel the entire length of the arm for the thrill.

Patient education/information requires energy and time from the nursing staff, but once the basics for teaching patients are established, morbidity and mortality can only improve.

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13. From Empiric Evaluation to Clinical Research Evidence

"Haemodialysis patient survival is dependent on the availability of a reliable vascular access. In clinical practice, procedures for vascular access cannulation vary from clinic to clinic. We investigated the impact of cannulation technique on arteriovenous fistula and graft survival. Based on an April 2009 cross-sectional survey of vascular access cannulation practices in 171 dialysis units, a cohort of patients with corresponding vascular access survival information was selected for follow-up ending March 2012. Of the 10,807 patients enrolled in the original survey, access survival data were available for 7.058 patients from nine countries. Of these. 90.6% had an arteriovenous fistula and 9.4% arteriovenous graft. Access needling was by area technique for 65.8%, ropeladder for 28.2%, and buttonhole for 6%. The most common direction of puncture was antegrade with bevel up (43.1%). A Cox regression model was applied, adjusted for withincountry effects, and defining as events the need for creation of a new vascular access. Area cannulation was associated with a significantly higher risk of access failure than rope-ladder or buttonhole (see Figure 27). Retrograde direction of the arterial needle with bevel down was also associated with an increased failure risk. Patient application of pressure during cannulation appeared more favourable for vascular access longevity than not applying pressure or using a tourniquet. The higher risk of failure associated with venous pressures under 100 or over 150 mmHg (see Figure 28) should open a discussion on limits currently considered acceptable".127

The characteristics of the 7058/10807 (65%) patients enrolled in the survey for whom access survival data were obtained are shown in Table VI.

Characteristic	Value
Mean age, years	63.5 ± 15.0
Female, %	38.5
Diabetic, %	27.1
Native fistula, %	90.6
Graft, %	9.4
Median dialysis vintage, months	43.2
Lower arm access location, %	51.2
Antiaggregant treatment during follow-up, %	51.1
15G needle size, %	63.7
16G needle size, %	32.2
Cannulation technique, %	
Area puncture	65.8
Rope-ladder	28.2
Buttonhole	6.0
Antegrade direction of arterial puncture, %	57.3
Upward bevel orientation of needle, %	70.2
Needle rotated after insertion, %	42.0
Median blood flow, mL/min	350-400

Table VI. Patient characteristics for whom access survival were available





13.1 Recommendations for best cannulation practice

In summary, the previously mentioned study revealed that area cannulation technique, despite being the most commonly used, was inferior to both rope-ladder and buttonhole for the maintenance of VA functionality (particularly AVF).

For AVG, the rope-ladder technique should be THE choice. Changing puncture site at each treatment reduces the risk of graft material damage.

Moreover, repeated cannulations damage the PTFE material or elasticity of the vascular wall biografts and skin, leading to the formation of pseudo-aneurysms with a tendency for stenotic folding at the border of the aneurysm, leading to the appearance of narrowed areas post-aneurysm and increased bleeding time.

Area cannulation technique MUST be avoided.

Buttonhole technique, considered ideal for AVF, is not used for AVG. To date, there is no strong scientific evidence supporting its use.

With regard to the effect of needle and bevel direction, the combination of antegrade positioning of the arterial needle with bevel-up orientation was significantly associated with better access survival than retrograde positioning with bevel down. However, taking into account other parameters such as flap creation during needle insertion, the recommendation is to cannulate the VA using the combination of antegrade positioning of the arterial needle with bevel-down orientation (see Figure 29). Under this condition, the intraluminal flow maintains the vessel flap tight to the needle, thus reducing the risk of extraluminal haematoma during treatment and haemostasis (see Figure 30). In case retrograde arterial

needle direction is the only option; the bevel orientation should be upwards.



Arterial needle antegrade bevel down



Arterial needle antegrade bevel up

Figure 29. The risk of extraluminal haematoma formation, is reduced with arterial needle antegrade and bevel down (left) vs bevel up (right)



Figure 30. The risk of extraluminal haematoma formation, during treatment and haemostasis, is

reduced with arterial needle positioned antegrade (left) vs retrograde (right)

Results referring to the type and location of access and the technical parameters (i.e. venous pressure) were as follows: there was an increased risk for access failure for grafts vs fistulae, proximal location vs distal, right arm vs left arm, and for the presence of a venous pressure >150 mmHg vs pressures between 100 and 150 mmHg. Further investigations are required to clarify the topic fully.

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14. Conclusions

A good knowledge is necessary to enable the nurse to assess, plan, implement and evaluate the care given to patients before, during and after cannulation of the AVG and to deal with complications.

Proper cannulation is crucial for the long-term survival of VA and is a fundamental skill that the nurse must develop. AVG cannulation should be always carried out by a nurse who is an expert in the art of cannulation. Cannulation procedure is an important moment for the expert nurse to demonstrate and transfer her/his knowledge and expertise to novice cannulators. This will ensure the continuing education of healthcare staff engaged in patient care within the haemodialysis unit.¹²⁸

There are currently no studies describing the optimal cannulation technique for grafts however, it is presumed that repetitive cannulations in a small region of the graft (one-site-itis) can cause disruption and fragmentation of the graft material resulting in a weakening of the wall, with subsequent expansion ¹²⁹ leading to an increased risk of pseudo-aneurysm formation.

Therefore, the rope-ladder technique is the preferred method as it encourages the regular use of the entire length of the graft. This technique has resulted in less pseudo-aneurysm formation and reduced material deterioration as a result of fewer punctures per area. Thus the rope-ladder technique is strongly recommended for cannulation of AVG.^{84, 130}

Haemodialysis patients have a role to play and must be educated on the care and management of their VA and have knowledge of how to deal with any VA emergencies that might arise within their own home environment.¹²⁸

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15. Appendix

15.1 Table of abbreviations

A	Arterial blood sample
AV	Arteriovenous
AVF	Arteriovenous Fistula
AVG	Arteriovenous Graft
BTM	Blood Temperature Monitor
CE-MRA	Contrast-Enhanced Magnetic Resonance Angiography
CHF	Congestive Heart Failure
CKD	Chronic Kidney Disease
CVC	Central Venous Catheter
DD	In-line Dialysis
DDU	Duplex Doppler Ultrasound
DRIL	Distal Revascularisation-Interval Ligation
DAP	Dynamic Arterial Pressure
DVP	Dynamic Venous Pressure
ecAVG	Early Cannulation Arteriovenous Graft
ePTFE	Expanded polytetrafluoroethylene
eKt/V	equilibrated Kt/V
ESA	Erythropoietin Stimulating Agent
ESRD	End Stage Renal Disease
GBCA	Gadolinium-Based Contrast Agents

GPT	Glucose Pump infusion Technique
HCAI	Healthcare Associated Infections
HCW	Healthcare Workers
HDM	Haemodynamic Monitor
IAP	Intra Access Pressure
KDOQI	Kidney Disease Outcome Quality Initiative
Kt/V	Dialysis adequacy
LVH	Left Ventricular Hypertrophy
MILLER	Minimally Invasive Limited Ligation Endoluminal- assisted Revision
MR	Magnetic Resonance
MRA	Magnetic Resonance Angiography
NSF	Nephrogenic Systemic Fibrosis
PAI	Proximalisation of the Arterial Inflow
PPE	Personal Protective Equipment
PTA	Percutaneous Transluminal Angioplasty
PTFE	Polytetrafluoroethylene
RN	Registered Nurse
s N	Systemic arterial sample
S. aureus	Staphylococcus aureus
SVP	Static Venous Pressure

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16. Bibliography

- Vascular Surgery University of Southern California Department of Surgery Keck School of Medicine of USC, Areas of Expertise, Vascular Access. Available from http://www.surgery.usc.edu/vascular/ vascularaccess.html. Accessed Jul 27, 2016.
- Parisotto, MT and Pancirova, J, eds. Vascular Access Cannulation and Care: A Nursing *Best Practice Guide* for Arteriovenous Fistula. 2nd ed.; 2015. ISBN: 978-84-617-0567-2. Available from http://www.edtnaerca.org/pages/education/publications.php.
- Hemodialysis Adequacy 2006 Work Group. Clinical practice guidelines for hemodialysis adequacy, update 2006. Am J Kidney Dis, 2006. 48 Suppl 1:S2-90.
- Ravani, P, Palmer, SC, Oliver, MJ, et al. Associations between hemodialysis access type and clinical outcomes: a systematic review. J Am Soc Nephrol, 2013. 24(3):465-73.
- DeSilva, RN, Patibandla, BK, Vin, Y, et al. Fistula first is not always the best strategy for the elderly. J Am Soc Nephrol, 2013. 24(8):1297-304.
- Konner, K. History of vascular access for haemodialysis. Nephrol Dial Transplant, 2005. 20(12):2629-35.
- Quinton, W, Dillard, D, and Scribner, BH. Cannulation of blood vessels for prolonged hemodialysis. Trans Am Soc Artif Intern Organs, 1960. 6:104-13.
- 8. Seldinger, SI. Catheter replacement of the needle in percutaneous arteriography; a new technique. Acta radiol, 1953. 39(5):368-76.
- 9. Brescia, MJ, Cimino, JE, Appel, K, et al. Chronic hemodialysis using venipuncture and a surgically created arteriovenous fistula. N Engl J Med, 1966. 275(20):1089-92.
- 10. Gracz, KC, Ing, TS, Soung, LS, et al. Proximal forearm fistula for maintenance hemodialysis. Kidney Int, 1977. 11(1):71-5.
- 11. Thomas, GI. A large-vessel applique A-V shunt for hemodialysis. Trans Am Soc Artif Intern Organs, 1969. 15:288-92.
- Flores Izquierdo, G, Ronces Vivero, R, Exaire, E, et al. [Venous autologous graft for hemodialysis (original technic). Preliminary report][Article in Spanish]. Arch Inst Cardiol Mex, 1969. 39(2):259-66.
- May, J, Tiller, D, Johnson, J, et al. Saphenous-vein arteriovenous fistula in regular dialysis treatment. N Engl J Med, 1969. 280(14):770.
- Girardet, RE, Hackett, RE, Goodwin, NJ, et al. Thirteen months experience with the saphenous vein graft arteriovenous fistula for maintenance hemodialysis. Trans Am Soc Artif Intern Organs, 1970. 16:285-91.
- Sparks, CH. Die-grown reinforced arterial grafts: observations on long-term animal grafts and clinical experience. Ann Surg, 1970. 172(5):787-94.
- Beemer, RK and Hayes, JF. Hemodialysis using a mandril-grown graft. Trans Am Soc Artif Intern Organs, 1973. 19:43-8.
- Chinitz, JL, Tokoyama, T, Bower, R, et al. Self-sealing prosthesis for arteriovenous fistula in man. Trans Am Soc Artif Intern Organs, 1972. 18(0):452-7.
- Soyer, T, Lempinen, M, Cooper, P, et al. A new venous prosthesis. Surgery, 1972. 72(6):864-72.
- Baker, LD, Jr., Johnson, JM, and Goldfarb, D. Expanded polytetrafluoroethylene (PTFE) subcutaneous arteriovenous conduit: an improved vascular access for chronic hemodialysis. Trans Am Soc Artif Intern Organs, 1976. 22:382-7.
- Dunn, I, Frumkin, E, Forte, R, et al. Dacron velour vascular prosthesis for hemodialysis. Proc Clin Dial Transplant Forum, 1972. 2:85.
- Schild, AF, Schuman, ES, Noicely, K, et al. Early cannulation prosthetic graft (Flixene) for arteriovenous access. J Vasc Access, 2011. 12(3):248-52.
- Oliver, M. Overview of chronic hemodialysis vascular access. In: Basow, D, ed. UpToDate: Waltham, MA. Accessed Jun 4, 2016.
- Young, EW, Dykstra, DM, Goodkin, DA, et al. Hemodialysis vascular access preferences and outcomes in the Dialysis Outcomes and Practice Patterns Study (DOPPS). Kidney Int, 2002. 61(6):2266-71.
- 24. Counts, CS, ed. Core curriculum for nephrology nursing. 5th ed. Pitman, NJ. American Nephrology Nurses' Association, 2008.
- 25. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis, 2006. 48 Suppl 1:S176-273.
- Khwaja, KO. Dialysis Access Procedures. In: Humar, A, Matas, AJ, and Payne, WD, eds. Atlas of Organ Transplantation, 2009:35-58.
- Konner, K, Hulbert-Shearon, TE, Roys, EC, et al. Tailoring the initial vascular access for dialysis patients. Kidney Int, 2002. 62(1):329-38.

- Malovrh, M. Non-invasive evaluation of vessels by duplex sonography prior to construction of arteriovenous fistulas for haemodialysis. Nephrol Dial Transplant, 1998. 13(1):125-9.
- 29. Miller, CD, Robbin, ML, Barker, J, et al. Comparison of arteriovenous grafts in the thigh and upper extremities in hemodialysis patients. J Am Soc Nephrol, 2003. 14(11):2942-7.
- Skandalos, I, Chatzibaloglou, A, Tsalis, K, et al. Prosthetic graft placement using the deep forearm veins in hemodialysis patients: a preliminary report. Nephron, 2000. 85(4):346-7.
- Berardinelli, L. Grafts and graft materials as vascular substitutes for haemodialysis access construction. Eur J Vasc Endovasc Surg, 2006. 32(2):203-11.
- Berardinelli, L and Vegeto, A. Lessons from 494 permanent accesses in 348 haemodialysis patients older than 65 years of age: 29 years of experience. Nephrol Dial Transplant, 1998. 13 Suppl 7:73-7.
- Aitken, EL, Jackson, AJ, and Kingsmore, DB. Early cannulation prosthetic graft (Acuseal) for arteriovenous access: a useful option to provide a personal vascular access solution. J Vasc Access, 2014. 15(6):481-5.
- Padberg, FT, Jr., Calligaro, KD, and Sidawy, AN. Complications of arteriovenous hemodialysis access: recognition and management. J Vasc Surg, 2008. 48(5 Suppl):55s-80s.
- Ballard, JL, Bunt, TJ, and Malone, JM. Major complications of angioaccess surgery. Am J Surg, 1992. 164(3):229-32.
- Lazarides, MK, Staramos, DN, Kopadis, G, et al. Onset of arterial "steal" following proximal angioaccess: immediate and delayed types. Nephrol Dial Transplant, 2003. 18(11):2387-90.
- Dyck, PJ, Conn, DL, and Okazaki, H. Necrotizing angiopathic neuropathy. Three-dimensional morphology of fiber degeneration related to sites of occluded vessels. Mayo Clin Proc, 1972. 47(7):461-75.
- Goldstein, LJ, Helfend, LK, and Kordestani, RK. Postoperative edema after vascular access causing nerve compression secondary to the presence of a perineuronal lipoma: case report. Neurosurgery, 2002. 50(2):412-3; discussion 14.
- 39. Garvin, PJ, Castaneda, MA, and Codd, JE. Etiology and management of bovine graft aneurysms. Arch Surg, 1982. 117(3):281-4.

- National Kidney Foundation. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis Adequacy, Peritoneal Dialysis Adequacy and Vascular Access. Am J Kidney Dis, 2006. 48 Suppl 1:S1-S322.
- Techniques for the Care and Cannulation of A-V Prosthetic Grafts. Available from http://www.goremedical.com/resources/downloads/ featured/acusealvg/content/AP0064EN2.HEMODIALYSIS.BRO.FNL. MR.pdf. Accessed Aug 1, 2016.
- FistulaFirst. Dialysis Professionals "Ready, Set, Go" The Steps to Catheter Freedom. Available from http://esrdncc.org/wp-content/ uploads/2015/10/Graft-Healing-Staff.pdf. Accessed Aug 1, 2016.
- Polo, JR, Ligero, JM, Diaz-Cartelle, J, et al. Randomized comparison of 6-mm straight grafts versus 6- to 8-mm tapered grafts for brachialaxillary dialysis access. J Vasc Surg, 2004. 40(2):319-24.
- 44. Patel, PP, Altieri M., Jindal TR, et al. Current Status of Synthetic and Biological Grafts for Hemodialysis. In: Penido MG ed. Hemodialysis - Different Aspects. InTech. 2011. Available from http://www.intechopen.com/books/hemodialysis-different-aspects/ current-status-of-synthetic-and-biological-grafts-for-hemodialysis. Accessed Aug 1, 2016.
- Dougherty, L, Lister, S. (eds). The Royal Marsden Hospital Manual of Clinical Nursing Procedures. Marsh. 2011.
- 46. World Health Organization WHO. Guidelines on Hand Hygiene in Health Care. Geneva: World Health Organization. 2009.
- Centers for Disease Control and Prevention (CDC). Invasive methicillin-resistant Staphylococcus aureus infections among dialysis patients--United States, 2005. MMWR Morb Mortal Wkly Rep, 2007. 56(9):197-9.
- Fan, PY and Schwab, SJ. Vascular access: concepts for the 1990s. J Am Soc Nephrol, 1992. 3(1):1-11.
- 49. Jindal, K, Chan, CT, Deziel, C, et al. CHAPTER 4: Vascular Access. Journal of the American Society of Nephrology, 2006. 17(3 suppl 1):S16-S23.
- Grainer, F. Plastic (non-metal) fistula cannula: from concept to practice. Ren Soc Australas J., 2014. 10(1):44-46.
- Van Waeleghem, JP, Chamney, M, Lindley, EJ, et al. Venous needle dislodgement: how to minimise the risks. J Ren Care, 2008. 34(4):163-8.

- Shabani, DB and Fisher, WW. Stimulus fading and differential reinforcement for the treatment of needle phobia in a youth with autism. J Appl Behav Anal, 2006. 39(4):449-52.
- Schanzer, H, Martinelli, GP, Bock, G, et al. A self-sealing dialysis prosthesis. Coaxial double PTFE-silicone graft. Ann Surg, 1986. 204(5):574-9.
- Mudoni, A, Cornacchiari, M, Gallieni, M, et al. Aneurysms and pseudoaneurysms in dialysis access. Clin Kidney J, 2015. 8(4):363-7.
- Yasim, A, Kabalci, M, Eroglu, E, et al. Complication of hemodialysis graft: anastomotic pseudoaneurysm: a case report. Transplant Proc, 2006. 38(9):2816-8.
- Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access, Guideline 6 Treatment of arteriovenous graft complications. Am J Kidney Dis, 2006. 48 Suppl 1:S243-47.
- Little, M and Woo, K. Non-thrombotic complications of chronic hemodialysis arteriovenous vascular access. Dec 04, 2013. UpToDate[®], Jan2015. Jan, 2015.
- Elliott, JM and Kelly, IM. Ultrasound guided compression of femoral artery pseudoaneurysms: modified digital technique shortens repair time. Clin Radiol, 1999. 54(10):683-6.
- Kaufman, J. Major complications from vascular access for chronic hemodialysis. In: Nissenson, A and Fine, R, eds. Handbook of Dialysis Therapy. 4th ed. Philadelphia, PA: Saunders-Elsevier; 2008.
- Vogel, S. Access to bloodstream. In: Gutch, C, Stoner, M, and Corea, A, eds. Review of Heamodialysis for nurses and dialysis personnel 5th ed. St Louis, MI: Mosb1993:110–25.
- 61. Vas, SI. Infections related to prosthetic materials in patients on chronic dialysis. Minerva Urol Nefrol, 2004. 56(3):259-64.
- Harish, A and Allon, M. Arteriovenous graft infection: a comparison of thigh and upper extremity grafts. Clin J Am Soc Nephrol, 2011. 6(7):1739-43.
- National Kidney Foundation. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Clinical practice guidelines for vascular access and research recommendations. Am J Kidney Dis, 2006. 48 Suppl 1:S176-322.
- Minga, TE, Flanagan, KH, and Allon, M. Clinical consequences of infected arteriovenous grafts in hemodialysis patients. Am J Kidney Dis, 2001. 38(5):975-8.

184

- Bachleda, P, Utikal, P, Kalinova, L, et al. Infectious complications of arteriovenous ePTFE grafts for hemodialysis. Biomed Pap Med Fac Univ Palacky Olomouc Czech Repub, 2010. 154(1):13-9.
- Lafrance, JP, Rahme, E, Lelorier, J, et al. Vascular access-related infections: definitions, incidence rates, and risk factors. Am J Kidney Dis, 2008. 52(5):982-93.
- Anderson, JE, Chang, AS, and Anstadt, MP. Polytetrafluoroethylene hemoaccess site infections. Asaio j, 2000. 46(6):S18-21.
- Akoh, JA. Prosthetic arteriovenous grafts for hemodialysis. J Vasc Access, 2009. 10(3):137-47.
- Challinor, P. Haemodialysis in renal nursing. In: Thomas, N, ed. 3rd ed. Bailliere Tindall; 2008:181-222.
- Besarab, A and Raja, R. Vascular access for hemodialysis. In: Daugirdas, J, Blake, P, and Ing, T, eds. Handbook of Dialysis. 3rd ed. Philadelphia PA: Lipincott Williams & Wilkins; 2001.
- Ball, LK. Improving arteriovenous fistula cannulation skills. Nephrol Nurs J, 2005. 32(6):611-7; quiz 18.
- 72. Doss, S, Schiller, B, and Moran, J. Buttonhole cannulation--an unexpected outcome. Nephrol Nurs J, 2008. 35(4):417-9.
- McCann, M, Einarsdottir, H, Van Waeleghem, JP, et al. Vascular Access Management II: AVF/AVG cannulation techniques and complications. J Ren Care, 2009. 35(2):90-8.
- Schutte, WP, Helmer, SD, Salazar, L, et al. Surgical treatment of infected prosthetic dialysis arteriovenous grafts: total versus partial graft excision. Am J Surg, 2007. 193(3):385-8; discussion 88.
- 75. Ayus, JC and Sheikh-Hamad, D. Silent infection in clotted hemodialysis access grafts. J Am Soc Nephrol, 1998. 9(7):1314-7.
- Asif, A, Gadalean, FN, Merrill, D, et al. Inflow stenosis in arteriovenous fistulas and grafts: a multicenter, prospective study. Kidney Int, 2005. 67(5):1986-92.
- 77. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis, 2006. 48 Suppl 1:S248-73.
- Allon, M. Strategies other than treatment of stenosis to prevent thrombosis of hemodialysis vascular access grafts. Jul 15, 2013. UpToDate[®] Jan, 2015.

- Beathard, G. Percutaneous angioplasty for the treatment of venous stenosis affecting hemodialysis access graft. Feb 14, 2011. UpToDate[®], Jan2015.
- Mickley, V. Stenosis and thrombosis in haemodialysis fistulae and grafts: the surgeon's point of view. Nephrol Dial Transplant, 2004. 19(2):309-11.
- Robbin, ML, Oser, RF, Lee, JY, et al. Randomized comparison of ultrasound surveillance and clinical monitoring on arteriovenous graft outcomes. Kidney Int, 2006. 69(4):730-5.
- Beathard, GA, Arnold, P, Jackson, J, et al. Aggressive treatment of early fistula failure. Kidney Int, 2003. 64(4):1487-94.
- Chang, CJ, Ko, PJ, Hsu, LA, et al. Highly increased cell proliferation activity in the restenotic hemodialysis vascular access after percutaneous transluminal angioplasty: implication in prevention of restenosis. Am J Kidney Dis, 2004. 43(1):74-84.
- Tordoir, J, Canaud, B, Haage, P, et al. EBPG on Vascular Access. Nephrol Dial Transplant, 2007. 22 Suppl 2:ii88-117.
- Maya, ID, Smith, T, Young, CJ, et al. Is surgical salvage of arteriovenous grafts feasible after unsuccessful percutaneous mechanical thrombectomy? Semin Dial, 2008. 21(2):174-7.
- Allon, M. Overview of the treatment of stenosis and thrombotic complications of hemodialysis arteriovenous grafts and fistulas. Mar 29, 2013. UpToDate[®], Jan2015.
- 87. Sofocleous, CT, Cooper, SG, Schur, I, et al. Retrospective comparison of the Amplatz thrombectomy device with modified pulse-spray pharmacomechanical thrombolysis in the treatment of thrombosed hemodialysis access grafts. Radiology, 1999. 213(2):561-7.
- Beathard, GA. Mechanical versus pharmacomechanical thrombolysis for the treatment of thrombosed dialysis access grafts. Kidney Int, 1994. 45(5):1401-6.
- Ching-Wei, Tea. Arteriovenous graft complicated with perigraft seroma. Nephrol Dial Transplant Plus, 2010. 3:189-90.
- Dauria, DM, Dyk, P, and Garvin, P. Incidence and management of seroma after arteriovenous graft placement. J Am Coll Surg, 2006. 203(4):506-11.
- Eid, A and Lyass, S. Acute perigraft seroma simulating anastomotic bleeding of a PTFE graft applied as an arteriovenous shunt for hemodialysis. Ann Vasc Surg, 1996. 10(3):290-1.

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- Ahn, SS, Machleder, HI, Gupta, R, et al. Perigraft seroma: clinical, histologic, and serologic correlates. Am J Surg, 1987. 154(2):173-8.
- Alkhouli, M, Sandhu, P, Boobes, K, et al. Cardiac complications of arteriovenous fistulas in patients with end-stage renal disease. Nefrologia, 2015. 35(3):234-45.
- 94. Murphy, S and Parfrey, P. Management of ischemic heart disease, heart failure, and pericarditis in haemodialysis patient. In: Nissenson, A and Fine, R, eds. Handbook of Dialysis Therapy. 4th ed. Philadelphia, PA: Saunders-Elsevier; 2008.
- Miller, GA, Goel, N, Friedman, A, et al. The MILLER banding procedure is an effective method for treating dialysis-associated steal syndrome. Kidney Int, 2010. 77(4):359-66.
- Beathard, G. Physical diagnosis of the dialysis vascular access. In: Gray, J and Sands, J, eds. Dialysis Access: A Multidisciplinary Approach. Philadelphia, PA; 2002.
- Asif, A, Leon, C, Merrill, D, et al. Arterial steal syndrome: a modest proposal for an old paradigm. Am J Kidney Dis, 2006. 48(1):88-97.
- Tordoir, JH, Dammers, R, and van der Sande, FM. Upper extremity ischemia and hemodialysis vascular access. Eur J Vasc Endovasc Surg, 2004. 27(1):1-5.
- Minimally Invasive MILLER Banding Instructional Video. Available from http://www.transonic.com/about-us/news/minimally-invasivemiller-banding-instructional-video/. Accessed Aug 12, 2016.
- 100. Levy, J, Morgan, J, and Brown, E. Screening for arteriovenous fistula/ graft stenosis and thrombosis. Oxford Handbook of Dialysis. 2nd ed. Oxford, UK: Oxford University Press; 2005.
- 101. Banerjee, S, Wright, CF, and Barone, GW. Vascular Access Monitoring: A Key to Optimum Hemodialysis Care. Dialysis & Transplantation, 2008. 37(9):372-74.
- 102. Allon, M. Physical examination of the arteriovenous graft. Oct. 29, 2014. UpToDate[®], Jan2015.
- 103. Frinak, S, Zasuwa, G, Dunfee, T, et al. Dynamic venous access pressure ratio test for hemodialysis access monitoring. Am J Kidney Dis, 2002. 40(4):760-8.
- 104. Elseviers, MM and Van Waeleghem, JP. Complications of vascular access: results of a European multi centre study of the EDTNA/ERCA Research Board. Edtna erca j, 2003. 29(3):163-7.

- 105. Yu, A, Egberg, N, and Jacobson, SH. Haemostatic complications in haemodialysis patients: effect of type of vascular access and dialysis filter. Scand J Clin Lab Invest, 2003. 63(2):127-33.
- 106. Nissenson, A and Fine, R. Clinical dialysis. McGraw-Hill, New York; 2005.
- 107. Lin, CL, Chen, HY, Huang, SC, et al. Increased blood loss from access cannulation site during hemodialysis is associated with anemia and arteriovenous graft use. Ther Apher Dial, 2014. 18(1):51-6.
- 108. Awobusuyi, JO, Mapayi, FA, and Adedolapo, A. Blood loss during vascular access cannulation: quantification using the weighed gauze and drape method. Hemodial Int, 2008. 12(1):90-3.
- 109. Kumar, V, Depner, T, Beserab, A, et al. Arteriovenous access for haemodialysis. In: Daugirdas, J, Blake, P, and Ing, T, eds. Handbook of Dialysis. 4th. ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007.
- 110. Schneditz, D, Wang, E, and Levin, NW. Validation of haemodialysis recirculation and access blood flow measured by thermodilution. Nephrol Dial Transplant, 1999. 14(2):376-83.
- Krivitski, NM. Theory and validation of access flow measurement by dilution technique during hemodialysis. Kidney Int, 1995. 48(1):244-50.
- 112. Rodriguez-Hernandez, JA, et al. ACCESO VASCULAR EN HEMODIÁLISIS 4. Vigilancia y seguimiento del acceso vascular. Angiologia, 2005. 57(2):146-57.
- 113. Besarab, A, Sullivan, KL, Ross, RP, et al. Utility of intra-access pressure monitoring in detecting and correcting venous outlet stenoses prior to thrombosis. Kidney Int, 1995. 47(5):1364-73.
- 114. Vascular Access 2006 Work Group. Clinical practice guidelines for vascular access. Am J Kidney Dis, 2006. 48 Suppl 1:S176-247.
- 115. White, JJ, Jones, SA, Ram, SJ, et al. Mathematical model demonstrates influence of luminal diameters on venous pressure surveillance. Clin J Am Soc Nephrol, 2007. 2(4):681-7.
- Shellock, FG and Spinazzi, A. MRI safety update 2008: part 1, MRI contrast agents and nephrogenic systemic fibrosis. AJR Am J Roentgenol, 2008. 191(4):1129-39.
- 117. Kanal, E, Barkovich, AJ, Bell, C, et al. ACR guidance document for safe MR practices: 2007. AJR Am J Roentgenol, 2007. 188(6):1447-74.

- Wasinrat, J, Siriapisith, T, Thamtorawat, S, et al. 64-slice MDCT angiography of upper extremity in assessment of native hemodialysis access. Vasc Endovascular Surg, 2011. 45(1):69-77.
- 119. Reinhold, C, Haage, P, Hollenbeck, M, et al. Multidisciplinary management of vascular access for haemodialysis: from the preparation of the initial access to the treatment of stenosis and thrombosis. Vasa, 2011. 40(3):188-98.
- Hawkins, C. Nurses' roles in influencing positive vascular access outcome. ANNA J, 1995. 22(2):127–29.
- 121. Besarab, A, Hall, B, El-Aje, IF, et al. The relation of brachial artery flow to access flow. J Am Soc Nephrol, 1995. 6(438A).
- 122. Chow, J, Rayment, G, San Miguel, S, et al. A randomised controlled trial of buttonhole cannulation for the prevention of fistula access complications. J Ren Care, 2011. 37(2):85-93.
- 123. Fluck, R and Kumwenda, M. Renal Association Clinical Practice Guideline on vascular access for haemodialysis. Nephron Clin Pract, 2011. 118 Suppl 1:c225-40.
- 124. Lorig, K. Fraser Publications; Ivanhoe, V. Common sense patient education. 1991.
- 125. Kent Chiro-Med Wellness Clinic. Patient education. Available from http://www.kentchiromed.com/portfolio-view/patient-education/. Accessed Aug 8, 2016.
- 126. Texan vein and vascular. Dialysis Treatment. Available from http:// www.texanvv.com/Arteries/Dialysis.aspx. Accessed Aug 4, 2016.
- 127. Parisotto, MT, Schoder, VU, Miriunis, C, et al. Cannulation technique influences arteriovenous fistula and graft survival. Kidney Int, 2014. 86(4):790-7.
- 128. Nassar, GM and Ayus, JC. Clotted arteriovenous grafts: a silent source of infection. Semin Dial, 2000. 13(1):1-3.
- 129. Siedlecki, A, Barker, J, and Allon, M. Aneurysm formation in arteriovenous grafts: associations and clinical significance. Semin Dial, 2007. 20(1):73-7.
- Murphy, F. The ongoing challenges with renal vascular access. Br J Nurs, 2011. 20(4):S6-S14.

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