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How to Improve Vascular Access Care

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Abstract

Preservation of a well-functioning vascular access (VA) is one of the most important and problematic areas in the care of dialysis patients. Providing high quality of care can reduce morbidity, improve quality of life and reduces costs. Given the increased complexity and the multidisciplinary character of VA care, it is a prerequisite to establish a dedicated multidisciplinary approach. An essential part of VA care is the management of the process before, during and after cannulation. A lack of knowledge and skills can have major implications for dialysis patients and may be related to VA outcome. Therefore, VA care requires continuous education of staff and patients, timely referral, adequate planning, and early identification or prevention of complications with elective treatment. Furthermore, access care data should be measured to continuously improve VA quality and measure the effects of the performance and effort.

Recommendations to Improve Patient Safety

- Education of patients and caregivers is an essential aspect for the successful creation and maintenance of a vascular access (VA).
- VA care requires an integrated, multidisciplinary approach including all parties involved in VA care, with close cooperation and clear, effective communication between team members to ensure patient safety and outcome.
- The VA coordinator works as part of the integrated, multidisciplinary team and plays a pivotal role in providing continuity and coordinated care.

- Cannulation of the VA requires a high level of awareness, specific knowledge and skills of the dialysis nurse.
- Each center should establish a computerized database for continuous data collection that is focused on indicators related to improve VA outcome.

Introduction

Vascular access (VA) care requires an integrated multidisciplinary approach including all parties involved in VA care, with close cooperation and clear, effective communication between team members to ensure patient safety and outcome.

Education of patients and caregivers is an essential aspect for successful creation and maintenance of the VA. Patient education programs on VA are associated with increased use of arteriovenous fistula (AVF) at dialysis initiation [1].

Due to the ongoing contact with patients, dialysis nurses play a pivotal role in the education of (pre-)dialysis patients and their family on all aspects of VA care such as VA types, vein protection for future fistula construction, the risk of adverse events with catheters, monitoring and surveillance, and complications. Patient education should be multidisciplinary and tailored to the needs of the patient with the aim of optimizing patient involvement in their own care. Because patients differ in their learning style, a variety of educations materials should be available, in combination with individual conversations, and access to expert patients.

High-quality VA care with creation of a safe care environment can only be achieved if all professionals involved are well educated on the VA standards, guidelines, policies, and procedures (fig. 1).

Education initiatives should include all multidisciplinary team members on VA (dialysis nurses/vascular access coordinator (VAC), nephrologists, surgeons, radiologists, and ultrasound technicians), emphasizing the importance of multidisciplinary care to achieve successful VA outcome. Education programs should be incorporated into the curriculum of the physicians and dialysis nurses. A structured curriculum should focus on core concepts such as (a) an understanding of the pros and cons of different VA types, (b) individualization of patient VA choice and peritoneal dialysis options, and (c) physical examination of a VA including a thorough understanding of the interpretation of the physical examination and subsequent actions required. These skills could be acquired through (a) a dedicated dialysis access lecture series, (b) a nephrologists and radiologist should observe endovascular procedures and learn the physical examination of the VA, (c) communication with a dedicated VA surgeon to understand the issues involved in access selection and placement, and

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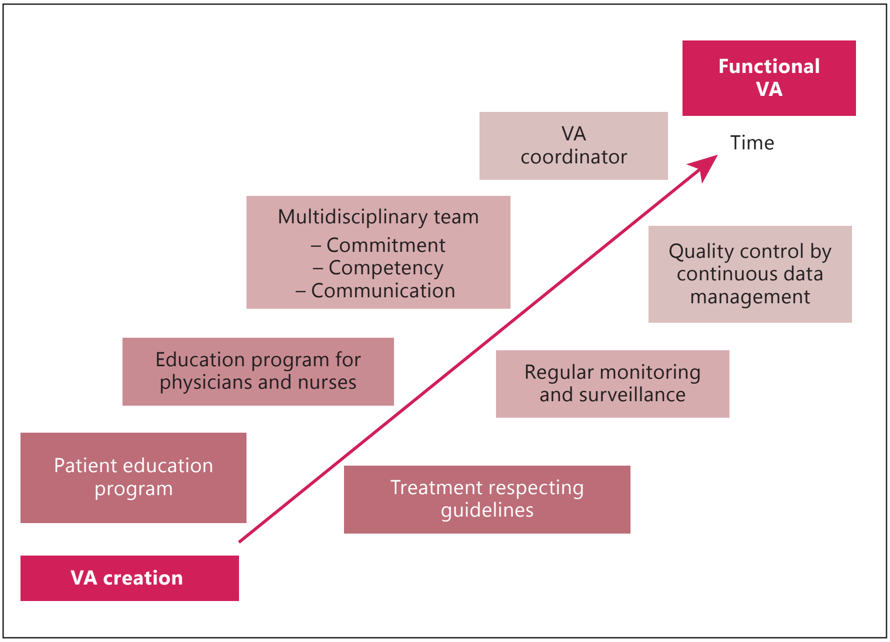

Fig. 1. Aspects that may help to create more functional VA.

(d) rotations at outpatient dialysis units with a skilled dialysis nurse to learn the challenges of cannulation of VA [2, 3]. Several ways of learning can contribute to improve VA outcomes such as didactic lectures, visual teaching (http://www.fistulafirst.org/HealthcareProfessionals/FFBIChangeConcepts/Change-Concept8.aspx), e-learning (www.fistulafirst.org/Home/VascularAccessAtlas.aspx), simulation training, and use of cadavers and animal models. Surgical experience and skills are associated with failure or success of fistulas. Studies showed that the probability of primary failure is strongly related to the center of access creation, suggesting an important role for the vascular surgeon's skills and decisions [4].

Maturation

Assessment of the VA is the key to determine the usability for cannulation with a minimal risk for complications and the ability to deliver the prescribed blood flow during dialysis. After creation, the VA should be monitored on a regular basis for maturity by a thorough physical examination of the fistula according to a standardized protocol (table 1).

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Table 1. Physical examination of new AVF

	Evaluation	Procedure	Normal	Abnormal
Inspection	Each treatment	Inspection of arm (hand and fingers), shoulder, breast, neck and face Always compare with contralateral arm	Normal healing of incision lines Patient has no complaints or symptoms related to AVF	Signs of infection/occlusion (phlebitis); redness, warmth, swelling, erythema, pain Edema of limb, chest, neck or face Hematoma Collateral veins of neck, upper arm or shoulder Accessory veins Signs of steal syndrome; pale, cyanotic, cold, decreased sensation, decreased function, absence of radial pulse Aneurysm
Palpation	Each treatment	Palpation of the thrill by placing fingers up the vein from the anastomosis along the drainage vein to the chest wall	A palpable continuous thrill felt through the entire vein, with higher intensity at the anastomosis The entire fistula is soft and easily compressible Presence of arterial pulse distal of the VA	Absence of thrill; occlusion of fistula Hyperpulsatile and firm/water – hammer; compressed or occluded Weak thrill; weak inflow Absence of radial pulse
	After 4–6 weeks	Caliber of the vessel	Vein depth <0.6 cm Vein diameter >0.6 cm Area of straight vein >10 mm	Small-caliber AVF Deep AVF >0.6 mm Limited straight portion for cannulation
Augmentation test	Each treatment	Complete occlusion of the inflow several cm beyond the arterial anastomosis to evaluate the inflow segment With side to side upper arm fistula; manually occlude one vein in order to detect presence of outflow stenosis	Major augmentation of pulse	Weak augmentation of pulse between anastomosis and compressed area; poor quality of inflow Thrill does not disappear; collaterals or side branches accessory veins
Capillary refill	Each treatment	Blanching the nail bed, and measure time interval until normal coloration	Capillary refill of the nail bed is <3 s	Signs of cyanosis of the finger tips and delayed refill of the nail beds of >3 s
Elevation test	Each treatment	Elevation of the extremity for examination of the normal collapse	Flattening and collapse of the entire fistula	Partial vein collapse; fistula distal to the point of stenosis remains distended No collapse of the venous segment upon arm elevation; outflow stenosis
Auscultation	Each treatment	Listen with stethoscope from the anastomosis moving upwards the drainage vein, paying attention to changes and the quality of the bruit (frequency and duration)	A low pitch, continuous bruit and audible on diastole and systole, with higher intensity near the anastomosis	High-pitched and only systolic component (discontinuous, systolic thrill); outflow stenosis Weak systolic thrill; inflow stenosis Intense and continuous bruit along the vessel until a root of the arm and in the precordial region; high flow

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Physical examination of the VA is essential to identify complications or dysfunction during the maturation process or during HD. Assessment of an AVF is more difficult than assessment of an arteriovenous graft (AVG).

Physical examination includes inspection (arm, shoulder, breast, neck, and face), palpation (from artery graft anastomosis to chest wall), and auscultation. Pulse augmentation and arm elevation tests, to evaluate the inflow and outflow tract, is also recommended [5]. Physical examination requires training, but is easily performed and has a high level of accuracy [5]. Robbin et al. [6] showed that an experienced hemodialysis nurse is able to predict the likelihood of AVF maturity with 80% accuracy with physical examination.

No consensus has been reached concerning the timing of first cannulation of the VA. The K/DOQI practice guidelines state that a good functioning access has a flow of approximately 600 ml/min, is less than 6 mm below the surface of the skin, and has a minimum diameter of 6 mm [7]. However, the changing demographics of the ESRD population, makes it difficult to create and maintain a well-functioning fistula that can meet these criteria. In clinical practice, the definition of maturation varies by local practice, and VA cannulation is based on the experience and skills of dialysis staff. In addition to physical examination, these parameters should be measured by Doppler ultrasound and finger pressure measurement at 6–8 weeks postoperatively to evaluate the blood flow and vessel diameter in the maturing AVF and prosthetic VA, and to identify complications such as hand ischemia, accessory veins, stenosis, high-output cardiac failure, aneurysms or venous hypertension. It also enables to determine the best cannulation sites. Depending on the fistula configuration, a mature forearm AVF will have a blood flow between 600 and 1,200 ml/min, while an upper arm AVF will have a flow of 600–2,000 ml/min.

Which Needles Do Best?

Hemodialysis adequacy depends – among other factors – on the effective blood flow through the dialyzer. The blood is pumped to and from the VA through dialysis needles; smaller needles have a larger flow resistance that decrease delivered Qb (table 2).

Therefore, it is critical to adjust the appropriate needle according to the desired blood pump speed and the available access flow rate in the VA in order to achieve dialysis efficiency (Kt/V). It is important to match needle gauge with blood flow rate (table 2). If the negative arterial pressure falls below –200 to –250 mm Hg, and the venous outflow pressure above +250 mm Hg, the needle size should be increased (i.e. smaller gauge number should be used). For can-

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Table 2. Recommended needle size for the state blood flow rate settings

Blood flow rate	Needle gauge	Inner diameter, mm
200 ml/min	18	0.838
<300 ml/min	17	1.067
300–350 ml/min	16	1.194
350–450 ml/min	15	1.372
>450 ml/min	14	1.600

nulation of AVG, the smallest gauge needle can be used that will achieve the desired blood flow. Needles are available from 14 to 18 gauge. Progression of needle size should be based on the assessment of adequate vessel size and intra-access flow (Q) [7].

One method used to select the appropriate needle size is a visual and tactile examination, which depends on the experience. This examination allows the cannulator to determine which needle gauge would be most appropriate, based on the size of the vessels in the fistula. Alternately, place 17- and 16-gauge needles with the protective cap in place (prevents a needle stick) over the cannulation site. Use the needle size that is equal to or smaller than the vein (without the tourniquet) for the cannulation [7].

To reduce needle penetration of the back wall of the vessel, the shortest needle length should be chosen (20–32 mm). The dialysis staff may alter needle lengths in order to reach deep accesses. The arterial needle should always have a back eye to ensure that the optimal flow is achieved; this prevents suction of the needle to the inner vessel wall and therefore reduces the rate for rotation of the needle.

Needles are available as sharp or blunt ones. Sharp needles have a cutting edge and a silicone coating for optimum insertion, and low flow resistance. Blunt needles are designed/developed for the buttonhole cannulation technique; they are rounded on the top and do not have a sharp, cutting edge like traditional needles. Two specific embodiments are described: an all stainless-steel version and a plastic version with a sharp or a blunt mandrin, which is removed after cannulation.

The venous needle must always point toward the venous return (antegrade) to encourage better venous return. Arterial needle placement can be antegrade (in the direction of the blood flow) or retrograde (against the direction of the blood flow). The antegrade puncture of the arterial needle would not increase the risk of recirculation if the access blood flow is significantly greater than the blood pump flow [7, 8]. There is no evidence that retrograde cannulation in

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grafts leads to 'flap' creation that may be kept open with the blood flow after needle removal, and delay hemostasis or contribute to insertion-related complications.

Once the needle is cannulated, it is crucial to tape and monitor dialysis needles and blood lines securely to prevent complication such as infiltration and completely or partially needle dislodgement. Needle dislodgement is a serious potential complication of hemodialysis therapy. Especially, venous needle dislodgement can give injury or can be fatal. Therefore, every dialysis unit should develop clear guidelines for securing the needles and blood lines to reduce the risk. VA and needle sites should be visible at all times during hemodialysis. Staff and patients should be aware of the risk and consequences for needle dislodgement. Additional protection can be provided by devices intended to detect blood loss to the environment [9].

The technique of needle removal is as important as cannulation to protect the VA from damage and to facilitate proper hemostasis. Needles should be removed at the same angle as they were inserted. When the needles are removed, hemostasis should be obtained by applying mild, digital direct pressure over the needle sites, using two-digit technique, one finger at the skin (external), and one finger at the blood vessel wall (internal), for at least 10 min. In general, prosthetic grafts require a longer time to achieve hemostasis. Prolongation of the compression time is suspect from a proximal stenosis.

Cannulation Technique

Cannulation of the VA is a basic but essential part of the dialysis treatment, and remains stressful to patients and medical staff. With today's population, cannulation of the VA requires a high level of awareness, specific knowledge and skills of the dialysis nurse. A deficit in cannulation skills can have negative consequences for patients' VA. Studies showed that a great percentage of patients encounter cannulation-related problems such as infiltrations, hematoma formation, infections and aneurysms resulting in catheter use and single-needle dialysis. Needle infiltration due to a fragile vessel wall, is a relatively frequent complication in newly mature fistulas, which occurs most commonly in older patients [10, 11]. Single-needle dialysis may be a valuable option for patients with an immature fistula or cannulation-related complications, although the single needle technique requires careful monitoring of the dialysis dose.

Many of the cannulation-related problems can be prevented with proper cannulation techniques. Therefore, it is important that only an experienced dialysis nurse with excellent cannulation skills cannulates newly matured fistulas. Every

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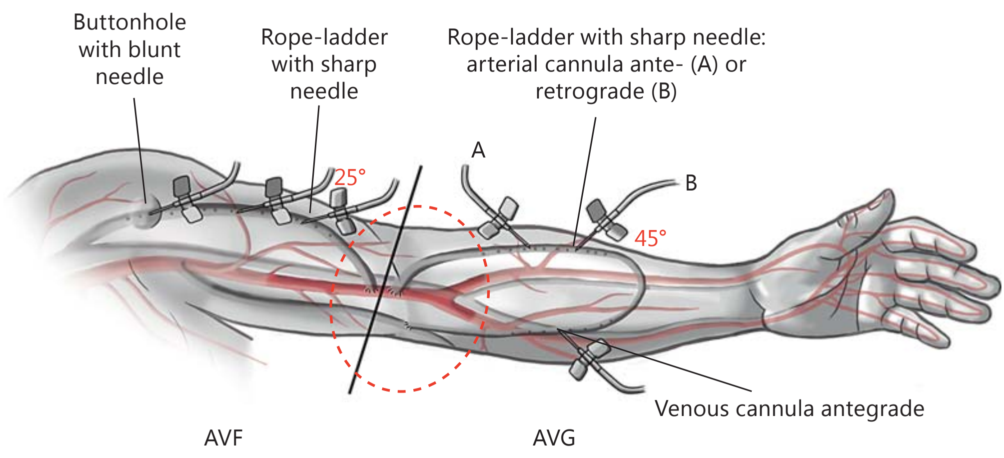

Fig. 2. Ideal cannulation technique for AVFs and AVGs.

dialysis department should develop and implement a standardized protocol for cannulation of the VA, in particular 'new fistulas'. The evidence-based practice protocols should be with clear and detailed instructions about the cannulation procedure and interventions for complications. Ultrasound-guided cannulation may facilitate successful cannulation of difficult accesses.

There are two methods for cannulation of the VA (fig. 2).

The conventional cannulation method is the rope-ladder technique (RL). For every dialysis, two new sites are chosen for needle placement and the whole access length is used for cannulation, with a minimum of 2–3 cm between the tips of the arterial and venous needles, at least 3 cm from the anastomosis, and avoiding the previous sites. Based on the assessment of the VA, the unique angle of insertion is chosen, which is generally 25° for the AVF and 45° for the AVG [7]. To allow rotation of the needle sites, a cannulation segment of 10 cm is required [10]. The RL is advised for the cannulation of AVG, to avoid graft disintegration. In daily practice, often the same area of the VA is cannulated (so called area technique), for reasons of comfort and ease, a complicated cannulation route, or a short length of vein segment, which weakens the fistula wall and leads to formation of pseudoaneurysms and stenosis [12]. Although it is not preferable, the area technique is very often used.

Another cannulation method, the buttonhole technique (BH), was first used with patients who had limited AVF cannulation sites [13]. It requires repeated cannulation with sharp needles at exactly the same spot, using the same angle and same depth of penetration to create a tunnel track, preferably performed by

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a single cannulator to prevent the risk of multitrack formation. Because creation of the BH track can be difficult, especially in units with multiple cannulators, various devices can be used to assist BH track creation, such as the polycarbonate peg (BH Stick®, Nipro Corporation, Osaka, Japan) [12] and the recently developed surgical implanted vascular needle guide VWING [14]. With the use of the polycarbonate peg, a sterile 5-mm-long thumbtack-shaped polycarbonate peg is inserted toward the tunnel created by the removed dialysis needle once hemostasis has been achieved. For a period of 2 weeks, the peg is left in place between dialysis treatments and is removed before the next cannulation [15]. The VWING is a subcutaneous titanium needle guide sutured directly on the top of the AVF to guide the needle [14]. These approaches might be effective in the creation of tunnel tracks for buttonhole cannulation.

Once the track is formed (8–12 times), subsequent cannulators should use blunt needles, and must follow exactly the direction and angle of the developed track to minimize vessel trauma, which may extend VA lifespan [16–18]. A recent article reported that the concept of the BH is to create a 'vasculocutaneous fistula' of a very narrow diameter. Obliquity and length, between 5 and 10 mm, are two key components that help hemostasis and function [19].

The BH is not just a variation on the RL, but is an entirely different way of performing cannulation and requires different attitudes and skills of the dialysis nurse. Several studies have compared the cannulation of the BH versus the RL technique and showed potential benefits of the BH with reduced risk of access-related complications such as needle infiltration and subsequent hematoma formation, aneurysm formation, and cosmetic appearance, cannulation ease and less pain.

However, recent randomized studies found that the BH is associated with an increased risk of infectious complications [20–23]. Infection induced by the BH should not be underestimated, and requires an aseptic and correct technique of the procedure with careful attention to scab removal to reduce the infection risk. Although in the last years much has been published about the BH versus RL, best practices have not been determined. Further research is required to provide information regarding the long-term outcome of the BH compared to the RL technique. The BH may have advantage for patients with a short or complicated cannulation segment or for self-cannulation. Continuous training, education and evaluation of the VA technique to prevent or minimize complications are mandatory.

When choosing the most appropriate cannulation technique, it is important that the specific AVF, patient characteristics, patient preference and nursing experience are taken into account.

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Multidisciplinary Approach

VA care requires continuous education of staff and patients, timely referral, adequate planning, early identification or prevention of complications with elective treatment. Given the increased complexity and the multidisciplinary character of VA care, it is a prerequisite to establish a dedicated multidisciplinary approach involving the patient, dialysis nurses/VAC, nephrologists, surgeons, radiologists, and ultrasound technicians. The fact that different professionals are involved may lead to fragmentation of management and care, with a lack of overview and insufficient knowledge about VA standards or responsibility of the different professionals. To prevent this, it is a prerequisite to establish a dedicated approach by implementing structured multidisciplinary quality improvement program based on international guidelines, in every dialysis facility. Close collaboration, commitment, competency and communication between the team members, are mandatory to deliver the highest quality of care and improved VA outcomes. A regular multidisciplinary access meeting to discuss relevant issues, find solutions and evaluate outcome data is essential. Studies demonstrated that the implementation of a VA care pathway to streamline the processes increased patient satisfaction and reduced hospital days and costs while achieving acceptable outcomes for access surgery [24].

Vascular Access Coordinator

The VAC works as part of the integrated, multidisciplinary team and plays a pivotal role to provide continuity and coordinated care by being an advocate and liaison between all the involved parties.

The responsibilities of the VAC are:

- maintain collaborative relationships and streamline communication between the multidisciplinary team;
- support staff to ensure ongoing monitoring and surveillance of the VA, and coordinate intervention if necessary;
- troubleshooting for all VA-related problems;
- ensure the practice is evidence based and identifies quality improvement;
- ensure quality education and competency of staff/patients;
- oversee data collection and management.

To achieve this goal, it is important that the VAC is a dedicated person who has the ability to be flexible, to organize, and effectively communicate and collaborate with all members of the VA team. A coordinated multidisciplinary approach proved to be effective with improvement of patient outcomes in VA care

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such as greater patient satisfaction, reduced number of hospitalizations and reduction of the average waiting time for treatment [25, 26]. Overall, this strategy enables the delivery of an individualized plan of VA care, with emphasis on patient safety and outcome.

Data Collection and Management

Access care data are measured to continuously improve VA quality process and measure the effects of the performance and effort. Each center should establish a computerized database for continuous collection that is focused on indicators related to improvement of VA outcome including the number and types of VA placement, hospital admissions (and days), waiting time for VA construction, catheter use, results of surgical/ radiological procedures and complication rates. Data should be reviewed weekly/monthly at multidisciplinary meetings.

These data allow multidisciplinary evaluation and review of outcomes and if necessary to make adjustments to the VA process. Clinical outcomes enable to improve decision making and benchmarking to the national and international standards. Furthermore, it is valuable for research to discover relevant knowledge and improve VA care.

Disclosure Statement

The author has no conflict of interest to declare.

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