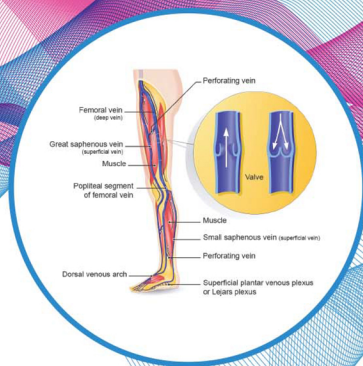
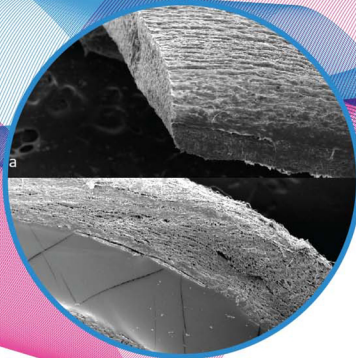


Innovations in Dialysis Vascular Access Surgery



Nova Biomedical



Archil B. Chkhotua
Editor

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UROLOGY RESEARCH PROGRESS

INNOVATIONS IN DIALYSIS VASCULAR ACCESS SURGERY

ARCHIL B. CHKHOTUA
EDITOR



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PREFACE

This book analyses the latest advancements in the very important topic of vascular access in haemodialysis patients. Dialysis patients are a continuously growing population all over the world. Long-lasting and well-functioning vascular access is a life-line for these patients. Therefore, successful creation and appropriate management of vascular access is of the utmost importance.

This book comprehensively reviews the different and most important issues related to vascular access management. It has 33 chapters discussing a wide variety of the most important topics including: principles of access creation in adults, paediatric and geriatric populations; types of anaesthesia; central venous catheters; early cannulation and hybrid vascular grafts; possible complications and principles of their management; quality of life in dialysis patients; etc. It consists of a review as well as original articles pertaining to the subject matter. The book also describes rare forms of arterio-venous accesses, last resort dialysis accesses, and life-saving approaches for the most challenging patients.

All of the authors are experts in the field. They represent 16 different countries across the world, making this book especially unique. The chapters are well-illustrated, making them easy to read. The authors hope that this book will offer the most contemporary and useful information for specialists involved in haemodialysis therapy.

Chapter 1 - The success of the artificial kidney was questioned for a long time and in its early days, opinion leaders and serious scientific journals recommended to stop its clinical use. This surprises in light of today's 2,8 million kidney patients who owe their lives to this therapy in 2016. The predominant argument against the clinical use of the artificial kidney was its alleged lack of safety and the more or less irreversible access to the patient's vasculature. Pioneers of dialysis, such as John. J. Abel, Georg Haas, Heinrich Necheles, Willem Kolff and Nils Alwall firstly applied glass cannulas inserted in a rubber tube and connected this aggregate to a blood vessel. However, blood clots occurred which could not be overcome by adequate intermittent and even continuous heparinization. This observation also held true for Nils Alwall's concept of a shunt system, because he still used glass cannulas and rubber tubing. The advent of biocompatible poly-tetrafluoro-ethylene (PTFE), as a material for both, indwelling tubes and the U-shaped shunt by B. Scribner and colleagues provided a successful reversible system for the treatment of chronic renal failure patients.

Chapter 2 - There are conflicting reports on the effects of diabetes on the outcomes of hemodialysis access procedures. While some authors reported deleterious effects of diabetes

on vascular access outcomes, others found no negative effects, and even there are reports of beneficial effects of some lesions frequently seen in diabetic vasculature. Why is there concern about diabetes and related vascular problems on vascular access procedures? What are the differences of diabetic patients and their vasculature from that of nondiabetics? Do they have an effect on hemodialysis vascular access outcomes? In order to find answers to above questions, recent literature on arterial disease in diabetes and end-stage renal disease (ESRD), and their effects on vascular access outcomes were searched. Diabetic vasculature, especially in patients with ESRD, has some specific problems, the most important of which seems to be the calcification and stiffening of the arteries. Although, mostly, conflicting and controversial reports were found on the effects of preexisting vascular problems due to diabetes and chronic kidney disease (CKD), recent large scale multicenter studies found that there is no important deleterious effect of diabetes on the outcomes of hemodialysis access procedures. There is also evidence that most of the problems encountered can be dealt with multidisciplinary work, careful patient selection, surgical skill, and experience.

Chapter 3 - Paediatric vascular access is a small but important discipline in managing children on chronic haemodialysis. In many centres a central venous catheter is seen as the only option for dialysis. However, there is growing evidence that an arteriovenous fistula is the optimal access for children on dialysis and a 'fistula first' policy should be pursued in many cases, especially where transplant options are limited.

Chapter 4 - The incidence of end-stage renal disease is highest in the >75-year-old-age population. Kidney transplantation is usually not indicated. Therefore, the renal replacement therapy is required to improve the quantity and quality of life. Nevertheless, there is a major debate related to the ethical approach of patients with inherent limited life expectancy. The global strategy of treatment in this frail and old population is almost the same compared to younger patients. However, nephrologists and vascular surgeons should adjust their management based on the specific characteristics such as major comorbidities and high risk of mortality. Native arteriovenous fistula is probably the best option, but early cannulation grafts must not be discarded to avoid permanent catheter. Moreover, the timing of the placement is crucial to limit the number of interventional procedures if created too early before start dialysis. These repetitive and unsuccessful reinterventions can further decline the quality of life. The association between all-cause of mortality and type of vascular access is still controversial with relative benefit of AVF and AVG compared to tunneled central venous catheter.

Chapter 5 - Dialysis therapy either by hemo- or peritoneal dialysis is the treatment of choice for the patients with chronic kidney disease. Hemodialysis is the most frequently used option for this purpose. For the adequate dialysis it is extremely important to have a well functioning vascular access. Native arterio-venous fistula(AVF) is the best choice for vascular access in terms of functional longevity and lowest complication rates. Regional and local anesthesia can be used for dialysis arterio-venous fistula (AVF) formation in end-stage renal disease patients. Brachial plexus block offers several advantages over local anesthesia. However, there is a lack of controlled studies comparing these two forms of anesthesia in dialysis AVF operations. In this prospective, randomized study we've compared effectiveness of regional and local anesthesia in dialysis AVF operations. It was a prospective, randomized study. 103 patients with end stage renal disease underwent AVF operations on upper limb. The patients have been randomly divided in two groups. Group I: 49 patients in whom the operations have been done under the local anesthesia; and Group II: 54 patients in whom the

operation has been performed under the vertical infraclavicular block. Duplex sonography evaluation of upper arm vessels was performed pre-operatively and at 1, 3 and 6 months postoperatively. Following parameters were measured on duplex scan: vessel diameter, blood flow rates (PSV and EDV), resistive index (RI) and pulsatility index (PI). Significantly less number of patients with regional anesthesia required additional perioperative analgesics as compared with the local anesthesia group. Time to postoperative pain initiation, need for postoperative pain killers was significantly better in Group II as compared with the Group I. Duration of operation was significantly less in regional as compared with local anesthesia. Postoperative PSV and EDVs were negatively correlated with patient age. The fistula maturation time was positively correlated with age. The vein diameter, postoperative PSV and EDV have been significantly increased in Group I as compared with Group II. The postoperative PI has significantly increased and RI has significantly decreased in Group I as compared with Group II. The total number of dialysis punctures was higher in regional as compared with the local anesthesia. Regional anesthesia provides significantly better analgesia as compared with the local anesthesia in AVF operations. It significantly improves the duplex sonography parameters after AVF formation. It can be a method of choice for some forms of fistula operations.

Chapter 6 - As dialysis treatment is widely extended to more complex patients, it is becoming evident that vascular access (VA) is the key point of care system. Central venous catheters (CVC) can be considered process quality indicators in the dialysis field and there is concern about their increase both at the beginning of treatment and in prevalent patients. Data gathered in two different decades (1998 and 2013) from surveys made in Italy by the same group demonstrated recently a marked shift toward catheters. Almost 40% of dialysis centers (DC) start dialysis with a CVC in more than 40% of their patients; in 38.8% of DC the prevalence of CVC is higher than 20%, while the prevalent cluster in 1998 was less than 5%. Procedures on CVC already prevail on AV fistulae procedures. Although in this country nephrologist had ever had the control of vascular access, the evolution of VA setting was bad. Comparison with other countries shows similar examples, even though it is possible to counteract this tendency, as observed in USA. The authors don't know the real weight of epidemiology on the choice of the vascular access and it is evident that the selection of patients and VA is strongly affected by clinical conditions, resulting in selection bias for CVC. Nevertheless, efficient methods of benchmarking have been proposed and should be used to allocate resources. Analyzing VA under the point of view of Lean Management it comes clear that CVC are rich in wastes and poor of value, therefore they add costs to the treatment. Cluster analysis of CVC prevalence suggests the lack of a shared organizational model, both among different countries worldwide and Italian dialysis centers; a centralized control is then suggested, as experienced successfully in organ transplantation.

Chapter 7 - Hemodialysis (HD) catheter insertion being an invasive procedure, is associated with complications. The occurrence of complications can be reduced by ultrasound guided catheter insertion. In particular, arterial puncture, arterial cannulation and lung injury are minimised by the use of real time ultrasound guidance. However, catheter malposition occurs more often than expected and has important implications for patient safety. The purpose of this chapter is to provide a focused review of HD catheter malposition and a pragmatic framework for managing Jugular HD cathetermal position. This does not purport to be an exhaustive review of the subject.

Chapter 8 – *Background*. The aim of this study was to examine the effect of ethnicity, socioeconomic group (SEG) and comorbidities on provision of vascular access for haemodialysis (HD). This was a retrospective review of two databases of HD sessions and access operations from 2003–11. Access modality of first HD session and details of transplanted patients were derived from the renal database. Follow-up was until 1 January 2015. Primary failure (PF) was defined as an arteriovenous fistula (AVF) used for fewer than six consecutive dialysis sessions. AVF survival was defined as being until the date the AVF was abandoned. Ethnicity was coded from hospital records. SEG was calculated from postcodes and 2011 census data from the Office of National Statistics. Comorbidities were calculated with the Charlson Comorbidity Index. Five hundred incident patients started chronic HD in the study period. Mode of starting HD was not associated with ethnicity ($P = 0.27$) or SEG ($P = 0.45$). Patients from ethnic minorities were younger when starting dialysis ($P < 0.0001$). Some 928 AVF patients' first AVF operations were analysed: 68% Caucasian, 26% Asian and 6% Afro-Caribbean. Half were in the most deprived SEG and 11% in the least deprived SEG. PF did not differ by ethnicity ($P = 0.29$), SEG ($P = 0.75$) or comorbidities ($P = 0.54$). AVF survival was not different according to ethnicity ($P = 0.13$) or SEG ($P = 0.87$). AVF survival was better for patients with a low comorbidity score ($P = 0.04$). The distribution of transplant recipients by ethnic group and SEG was similar to the distributions of all HD starters. Ethnicity and socioeconomic group had no effect on mode of starting HD, primary AVF failure rate or AVF survival. Ethnic minorities were younger at start of dialysis and at their first AVF operation.

Chapter 9 - The native vessel arteriovenous fistula (AVF) is well known for having a higher survival than arteriovenous graft (AVG). However, the progressive exhaustion of the vascular tree sometimes makes this second choice the only one possible. The classic radial cephalic fistula (RC AVF) is generally known as the first vascular access for hemodialysis to take into account. The forearm basilic vein may be underestimated for this purpose; instead, it can be used for the creation of an ulnar basilic arteriovenous fistula (UBAVF). Otherwise it can be used to create a mid-arm radial basilic fistula through transposition of the vein (RB mid-arm AVF). The authors describe three patients on dialysis treatment by using the forearm basilic vein through a transposition technique. The first patient started dialysis in 2007 with a proximal left brachial basilic bidirectional retrograde AVF; later the access underwent poor venous drainage due to blockages in both main veins which was solved by a direct bypass to the basilic vein by a short transposition of this latter. The second patient is on chronic dialysis treatment since 1975 and after 2009 with a RB mid-arm AVF, which, eight years later, is still working very well. The third patient started dialysis in 2008; she underwent a transposition of basilic forearm vein in 2012 after the thrombosis of the previous access. The mid-arm fistula was then rescued by an angioplasty procedure and positioning of a stent “viabahn” in 2013 and it worked till 2015 when the patient died for a lymphoma evolved. This limited experience suggests that a RB mid-arm AVF has proven to be a valid option in selected cases, ensuring a good dialytic efficiency and a survival over the years, possibly even superior to grafts. Furthermore, these kinds of access do not prevent the rescue by endovascular procedures currently available. The observation of the back side of the arm to design the creation of a fistula is mandatory before considering the use of a graft. However, it has to be taken into account that the access packaging is rather complex and more difficult than a classic RC AVF. On the other hand, UBAVF is easier to do because vessels are close and the technique does not require transposition, but it has a greater risk of steal syndrome, because

the radial artery is often compromised by previous interventions and the blood flow to the hand is guaranteed only by the ulnar artery.

Chapter 10 - The radial-cephalic (RC) arteriovenous fistula (AVF) is most commonly used in patients on hemodialysis. However, when the radial artery or cephalic vein is not suitable to create an AVF, alternative options are needed. Major guidelines recommend more proximal to the elbow and upper-arm AVF. However, if AVFs are created in the proximal upper limb, not only the area to puncture for hemodialysis but also a possibility of AVF renewal would be limited in the future. To prevent this, the authors had chosen the ulnar-basilic (UB) AVF in the distal forearm for the second option of the first AVF. In this chapter, the authors present their surgical method. The authors also reviewed studies about UBAVF in PubMed. Studies where in primary and secondary patency, as well as dialysis access-induced distal ischemia had been shown were included. Five studies, including the authors' previous research study, were included in this review. Primary patency rate at one-year after AVF creation ranged from 25.0-70.9%, whereas secondary patency rates ranged from 54-85.5%. The prevalence of dialysis access-induced distal ischemia was 0-1.8%. Thus, although the primary patency is not satisfactory, the secondary patency rate is high and risk of hand ischemia is low in the UB-AVF. The authors recommend UB-AVF as an alternative to RCAVF for primary AVF in patients on incident hemodialysis.

Chapter 11 - Vascular access is the corner stone of renal replacement therapy. The continuous search for new, unusual and exotic dialysis access configurations is necessary to prolong the life expectancy of chronic renal failure patients. Axillary vessels have been the target for many trials to create more dialysis access sites for patients with exhausted limb options. They are still infrequently used despite of their relative length and wide diameter. The 1st reported trial on axillary vessels was in 1975 by Manning and his group, where they used bovine carotid graft as a necklace graft passing from one axillary artery to the contralateral axillary vein. Since then, many configurations have been described. In 2003 Baron and his group used the axillary vessels in the arm to create prosthetic arm loop using PTFE grafts. Shortly after that, many authors, including their group, reported on using the same technique with comparable results to that of brachial-axillary arteriovenous grafts. This technique recruits the axillary vessels in the arm preserving the axillary vessels in the chest for future access. In 2008 Baptiste used the ipsilateral axillary vessels in the chest to create a prosthetic chest wall loop with PTFE grafts. This was followed by multiple reports of acceptable results of this technique, with lower complication rates compared to lower limb access. Exhaustion of all venous sites for access creation is not uncommon. Failed access site, repeated indwelling catheter insertion and central venous occlusion can all happen in the same patient, rendering the venous site inaccessible for access creation. This represents a real challenge to access creation surgeons in more than few occasions. In 1969 Brittinger introduced the concept of relying on the arterial side only to conduct hemodialysis. He used subcutaneously transposed superficial femoral artery as a conduit for hemodialysis. Some trials were done after that to use the same concept. These reports were not promising until 2005, when Zanow and his group published their results on creating arterial-arterial chest wall prosthetic loop using a PTFE graft interposed in the course of the axillary artery. Their results were very promising and the technique had the advantage of reduced cardiovascular complications of arteriovenous accesses. Khafagy and his group later used the same technique on the brachial artery with acceptable results. In this chapter, the authors will try to critically

appraise the reported studies in the literature discussing the use of axillary vessels in creation of dialysis access.

Chapter 12 - Lower limb vascular access is an alternative option when the upper limb is either not available or desirable. Larger blood vessels, relatively insensate lateral aspect of the thigh, relative comfort during hemodialysis related to not having to use the arms and avoiding upper limb scars are some of the attributes that make the lower limb an attractive option in selected patients. This chapter provides a broad overview of a variety of lower limb access options described in the literature. The selection of the most appropriate lower limb access modality for each patient must involve consideration of the arterial and venous anatomical limitations, with equal importance placed on the ease of use of the cannulatable conduit.

Chapter 13 - The vascular access surgeon often encounters the challenging task of repeatedly establishing vascular access in the era of long-term survival on hemodialysis. The surgical strategy to identify an alternative native vessel for vascular access is an important consideration to the treating team when all the conventional vascular access sites fail. Vascular anatomy of upper and lower limbs can be exploited to the maximum in creating native fistula before considering graft. The various rare forms of Arterio-Venous Fistula (AVF) described include lower limb-ankle, superficial femoral/saphenous vein transposition fistulae and upper limb-Gracz fistula, and translocated superficial femoral vein and saphenous vein fistula. These forms of AVF have acceptable patency rates and fewer complications than synthetic grafts.

Chapter 14 - Venous catheters provide access for hemodialysis (HD) when patients do not have functioning access device. Obstruction of jugular, femoral or even external iliac vessels further depletes options. Subclavian approach is prohibited. Catheterization of inferior vena cava requires specialized equipment and skills. The purpose is to assess a new lifesaving HD vascular access approach for patients with nonfunctioning access device in the ordinary sites. This entails insertion of a retrograde temporary HD catheter in the superficial femoral vein, directing the catheter distally, toward the foot which is firstly published by the author at 2014. The authors included 10 end-stage renal disease (ESRD) patients retrospectively who are on regular renal replacement therapy and need urgent HD with nonfunctioning access device in the ordinary sites. Patients were divided into 2 groups. Group 1 included 8 patients subjected to insertion of non-cuffed HD catheters and group 2 included 2 patients subjected to insertion of cuffed HD catheters by the retrograde femoral vein approach. Successful insertion of 10 retrograde femoral vein catheters in the superficial femoral vein. The mean age was 60.20 ± 9.35 years and 6 patients were females. The mean renal replacement therapy duration was 7.90 ± 3.34 years. The mean non-cuffed catheter days were 5.38 ± 8.34 days which increased in case of the 2 cuffed catheters to 17 and 105 days. The mean blood pump speed was 246.00 ± 50.15 mL/min. Urea reduction ratio and Kt/V at 3 hours HD session were 47% and 1.5, respectively, which increased with increasing session duration. The ultrafiltration volume was 2-3 L/session which increased up to 6 L/session in case of using slow low-efficiency dialysis. No major complications were observed during insertion or the post-insertion period except thigh pain in one patient and exit site insertion in the case of long duration. This is a newly applied lifesaving HD vascular access approach for selected ESRD patients with no available HD vascular access at the ordinary sites with accepted HD adequacy.

Chapter 15 - Last resort or salvage vascular access describes the variety of procedures employed to achieve vascular access when standard arteriovenous fistulae and grafts have

failed. Salvage procedures can be required following failure of endovascular treatment of central vein stenosis, or arterial insufficiency. Patients in such a scenario represent a great challenge for the vascular access surgeon, however successful management can be exceptionally rewarding. In this chapter The authors will outline the assessment and management strategies that can be applied in last resort situations. With a focus on arteriovenous grafts, the potential configurations (peripheral grafts, central grafts and arterio-arterial grafts) and anticipated outcomes from the available evidence, this chapter outlines the various strategies that can be applied to achieve vascular access when all hope appears to be lost.

Chapter 16 - For many reasons, early cannulation can be considered as a distinctive concept of vascular access (VA). In fact from the beginning, haemodialysis (HD) was conducted through the immediate cannulation of not-arterialized vessels and subsequently, by the Sixties, through glass or Teflon shunts immediately after their setting. In 1966 Brescia, Cimino and Apple's experience permitted to obtain a definitive, safe and stable access for HD that, conversely, needed a certain time for maturation. The importance of vascular access fistula was the possibility to extend HD to chronic kidney disease. At the same time, the authors started to think to vascular access as something not usable in urgency. However, already during Seventies, while the need for a VA immediately cannulable rose, evidences demonstrated the impossibility of an early cannulation of native vessel VA due to the high risk of haematoma, pseudoaneurysms and consequent thrombosis. The introduction of prosthetic shunts in 1976 was immediately followed by tempt of early cannulation. Different strategies were adopted to minimize the risk of haematoma such as undersized tunnelling. Nevertheless, authors described accelerated thrombosis facilitated by early puncture of the graft. Mainly for this reason, in the early 1990s, industrial manufacturing was encouraged and commercialized new self-sealing graft especially designed for early cannulation. Diastat (W.L. Gore, Flagstaff, AZ – US) was composed of a self-sealing PTFE-silicon graft and plasma tetrafluoroethylene with a thicker-walled mesh cannulation segment in the middle, covered with several layers of PTFE fibres and an outer layer of a thin fenestrated PTFE. Fusion Vascular Access Graft (Boston Scientific, Natick, MA – US) was a two-layers graft composed of an inner ePTFE layer and outer composed of woven polyester. Rapidax (Vascutek, Glasgow, UK) was a tri-layer graft composed by an internal and external ePTFE layer with a middle elastomeric membrane designed for sealing. Vectra (Thoratec Laboratories, Pleasanton, CA – US) was a tri-layer polyetherurethane urea graft combined with silicon and reinforced by spiral polyester fibers. More recently Flixene (Atrium, Hudson, NH – US), AVflo (Nicast, Lod, Israel) and Acuseal (W.L. Gore, Flagstaff, AZ – US) were delivered. Flixene is a tri-layers ePTFE graft made of expanded tetrafluoroethylene layers of different porosity and shaped in different configurations (standard wall, graduated wall, tapered, Intraluminal Flow Guard). AVflo is a unique vascular access graft that exploits the properties of electrospun polyurethane nanofabric. Finally, Acuseal is a tri-layer ePTFE with an inner heparin-bonded PTFE layer that gives noticeable results in terms of primary and especially secondary patency. In fact, covalent end-point attachment of heparin has been demonstrated to diminish fibrin formation and thrombin-mediated platelet activation. Despite many articles have been recently published demonstrating the effectiveness and safety of these grafts, as point out in a recent review, data inconsistency did not allow a specific graft recommendation.

Chapter 17 - The arteriovenous graft (AVG) Flixene™ offers near-immediate cannulation and has become an essential tool in the provision of haemodialysis access at Waikato Hospital. As per the National Kidney Foundation Kidney Disease Outcomes Quality Initiative Clinical Practice Guidelines for Haemodialysis Adequacy 2006, arteriovenous fistulae is the preferred access but this is frequently unachievable due to late presentation and inadequate vasculature. A paper published by the vascular surgery unit at Waikato Hospital provided evidence for the safety and success in cannulation within 72 hours. This chapter summarises the paper, reviews the current literature on Flixene™, then details the phase of consolidation and next stage of evolution at Waikato Hospital for this near-immediate AVG and the unique nature of the local population using home haemodialysis.

Chapter 18 - There is an increasing number of patients with multiple failed hemodialysis access and poor vascular anatomy, which are associated with serious comorbidities. Within this population, there is a subset of patients whose vascular sites present problems for a new surgical access and, therefore, a Central Venous Catheter (CVC) is often used in order to continue hemodialysis. In addition, the use of catheters is associated with a heightened risk of mortality and morbidity; thus, when a native arterio-venous fistula (AVF) cannot be constructed, a graft could be a better choice than a CVC in many cases. The expanded polytetrafluoroethylene (ePTFE) grafts (AVG) are the most commonly used vascular prostheses for hemodialysis worldwide; however, they tend to be vulnerable to stenosis at the venous outflow, which is generally followed by access thrombosis. Today, advances in prosthetic technology have provided an innovative graft, namely the *GORE® Hybrid Vascular Graft*, which is designed for performing a sutureless venous anastomosis that can prolong access patency by improving outflow patterns. Moreover, this device, due to its unique deployment system, enables the creation of access even in challenging and deep anatomy, generally not suitable for conventional grafts. These improvements may allow better performance and broader use of AVGs, thus reducing the use of CVC. In this chapter, the characteristics of the device, aspects of implantation techniques, indications and clinical outcomes are reported, along with a review of the available literature.

Chapter 19 - Hemodialysis is the leading renal replacement therapy worldwide and vascular access represents a critical issue for patients with terminal kidney failure. The superiority of fistulas and grafts over central venous lines is well recognized. However, there is a wide variation in vascular access preferences. Whether grafts should be considered as a secondary option compared to native fistulas is also a matter of debate. In the last decade, new arteriovenous vascular grafts have been developed with enhanced self-sealing properties and reduced thrombogenicity. Clinical trials in humans are currently available for the following devices: Flixene™, Acuseal™, Vectra™, Rapidax™, and AVflo™. Preliminary reports show better primary and secondary patency rates compared to standard polytetrafluoroethylene grafts with fewer complications. The authors' two-year experience with AVflo™ confirms these findings with primary and secondary patency rates as high as 56% and 82%, respectively. Cumulative thrombosis rate was 25% and 67% of grafts could be successfully rescued. There were no surgical site infections observed. Early cannulation grafts can be safely punctured within few days after placement and their self-sealing properties prevent formation of fluid collections around the prosthesis thus reducing puncture-related complications and infections. These extraordinary features allow to provide a more suitable vascular access to patients with difficult vascular anatomy, poor quality vessels, reduced life expectancy or in a need for urgent dialysis treatment. Reduction of incidental patients

requiring temporary lines, increase of prevalent patients with permanent surgical access, and resource optimization are theoretical advantages offered by early cannulation grafts over standard grafts and poorly planned arteriovenous fistulas. Larger randomized clinical trials and cost-effectiveness analysis are currently in progress.

Chapter 20 - The unfortunate fate of most dialysis access is the development of stenosis. For AVGs, this stenosis most often occurs just downstream from the graft-to-vein anastomosis. New evidence suggests that treatment of stenoses at this site with stent grafts is more durable than balloon angioplasty. For AVFs, the site where stenosis is prone to develop depends on the type of fistula. For radiocephalic fistulas, the stenosis tends to occur within the juxta-anastomotic segment, which can be treated with surgical revision or percutaneous transluminal balloon angioplasty. For brachiocephalic fistulas, the characteristic site of stenosis is the cephalic arch, whose treatment often necessitates high-pressure balloon angioplasty. Stent-graft placement can be used in cases of early interval recurrence. Surgical techniques such as cephalic vein turndown or intentional flow reduction also show promising results for refractory cephalic arch stenosis. Finally, brachial artery to transposed basilic vein fistulas characteristically develop stenosis at the proximal swing segment, for which balloon angioplasty is the standard of care. Monitoring and surveillance techniques help detect the presence of these stenoses.

Chapter 21 - This chapter describes the authors' experience and literature review on central venous stenosis and occlusion in dialysis patients. The introduction discusses the incidence of central venous occlusive disease (CVOD) in end stage renal disease (ESRD) patients and its long term effects on the patency of dialysis access. The possible etiologic mechanisms, clinical presentation and the diagnostic studies available will be discussed next. In the final section the authors will describe their approach in treating CVOD and the reported experiences in the literature specific to each procedure. The authors conclude that CVOD is a devastating problem and the treatment should be individualized according to each patient's clinical condition.

Chapter 22 - Central vein stenosis (CVS) is increasing in prevalence due to frequent use of central venous catheters and devices. Presence of CVS leads to characteristic symptoms of venous outflow obstruction for the entire extremity, which should lead to a high suspicion of this diagnosis. Elucidation of location and severity of stenosis requires central venography. Untreated CVS renders the affected extremity unsuitable for placement of arteriovenous access. While asymptomatic CVS should not be intervened, endovascular intervention with angioplasty and/or stent placement is required in symptomatic cases and is less invasive than open surgical approach. Currently, the results of endovascular and surgical interventions are suboptimal despite recent advances. However, a reasonable duration of secondary patency is achievable with repeated interventions. Recent use of covered stents has led to reports of improved primary and secondary patency though there are a number of considerations in placing a central venous stent. In case of complete occlusion recanalization of occluded central veins is often feasible, but long term results are generally poor. A hybrid graft-catheter device can be useful in many cases. Surgical approach is primarily used for severe symptoms to reduce the flow or to ligate the AV access. A surgical bypass of stenosis does remain an option when feasible. Early AV access placement and avoidance of catheters remain the best strategy to prevent this dreaded complication of vascular access for hemodialysis.

Chapter 23 - Endovascular Stents have become important tools in the management of the dialysis vascular access. Recent improvements in stent technology, and ease of placement, led

to an increase in their use in the outpatient setting. The developments of the Nitinol stent with unique thermal memory properties, as well as the flexible stent-graft have been significant forward leaps. The classic indications for stent placement in the dialysis circuit include treatment of dialysis access stenosis, central vein stenosis, aneurysmal segments, and angioplasty-associated vascular rupture. The ability of endovascular stents to provide immediate and short-term benefit for the dialysis access is undisputed. However, there is uncertainty about their long-term benefits. In this Chapter, the author first discusses general concepts pertaining to stent types, characteristics, indications, and technical matters during placement. The author then expands on outcomes following their placement in certain specific locations to manage specific lesions within the dialysis vascular circuit. In doing so, the author highlighted the most relevant literature when available, shared personal experience when applicable, and referenced alternative surgical treatment options when feasible.

Chapter 24 - The aim of the multidisciplinary team committed to the care of vascular access (VA) for haemodialysis, is to prolong as much as possible the functional patency of the access. Stenosis is definitely the most frequent complication of arterio-venous VA. Whereas the best surveillance strategy it is still a matter of debate, some evidence is now available about treatment indication and options. The available body of evidence on the best strategy facing this complication of VA is reviewed.

Chapter 25 - Arterovenous grafts (AVG) present a feasible solution for creating a vascular access in patients who are unsuitable for autogenous fistula (AVF). The quite poor outcomes associated with AVG are largely due to neointimal hyperplasia in the venous anastomosis. The authors demonstrated that the condition called “arterialized vein” could improve functioning and midterm patency rate of an AVG. the Gore Hybrid Vascular graft provided a new effective solution for patients unsuitable for AVF- However these graft are not free from complications.

Chapter 26 - The incidence of aneurysms of arteriovenous fistula in haemodialysis patients is reported to be as high as 60%. Although the clinical presentation of arteriovenous fistula aneurysm is often asymptomatic, symptomatic cases should be associated with serious complications. Despite the development of various surgical and endovascular procedures to treat arteriovenous fistula aneurysms, clinical guidelines are limited in terms of when and how to intervene. The objective of this chapter is to discuss the definition, aetiology, classification, clinical presentation, indications and methods for treatment of arteriovenous fistula aneurysm. The authors’ experience and a non-systematic literature review of articles published between January 1973 and June 2016 were used as the source of information for this chapter. Databases searched include Medline, Science direct, Scopus and the Cochrane Database of Systematic Reviews. Eligibility criteria were aneurysm of arteriovenous fistula and treatment techniques. Information regarding aneurysms and pseudoaneurysms involving prosthetic arteriovenous access were not included in this chapter. Indications for treatment of arteriovenous fistula aneurysm are patient discomfort, bleeding prevention and low or high flow. The diameter of the arteriovenous fistula aneurysm is not a sole indication for treatment. The most frequently used techniques for treating arteriovenous fistula aneurysm are resection with interposition, remodelling and stent graft implantation. Arteriovenous fistula aneurysm is characterized by an enlargement of all three vessel layers to a diameter of more than 18 mm. In asymptomatic aneurysms, conservative treatment is recommended. The main indications for treatment of a symptomatic aneurysm are patient discomfort, bleeding prevention and low or high flow. The diameter of an arteriovenous fistula aneurysm and

cosmetic issues should not be used as the sole indications for treatment. Although various surgical and endovascular techniques have been described, no prospective comparative study between these techniques exists and no particular method is recommended.

Chapter 27 - Limb ischemia caused by a dialysis arterio-venous fistula is a rare but serious complication. The severity of symptoms vary from subtle, transient paresthesia, to rest pains and necrosis in the most advanced cases. The pathogenesis of this kind of ischemia is complex and usually multifactorial. The diagnosis is mainly made on the basis of clinical symptoms, however angiography of the entire arterial inflow arteries from the aortic arch to the digital arteries and of the dialysis fistula should be performed in order to plan for proper treatment. Treatment methods should be selected individually for each patient and adjusted to the clinical situation. The aim of treatment of ischemia triggered by a dialysis fistula is twofold - alleviating distal ischemia and maintaining efficient dialysis access. For the treatment of ischemia provoked by a dialysis fistula different invasive procedures may be performed – from the simplest dialysis fistula ligation, endovascular corrections to complicated vascular reconstructions.

Chapter 28 - Thrombosis and stenosis result in failure of vascular access and have a great impact on the quality of hemodialysis (HD) patients. Recognition of prognostic factors contributing to poor patency of vascular access will be helpful in distinguishing high risk patients susceptible to access failure. Disappointedly, there are limited valid methods to enhance the patency of vascular access until now. Many patients still suffered from repeated interventional therapy for failed vascular access and even need cuffed catheterization because of lacking suitable vessels for rebuilding of arteriovenous access. Far infrared (FIR) therapy is a novel therapeutic modality demonstrated to effectively enhance the primary patency rate of arteriovenous fistulas (AVFs) and post-angioplasty patency rate for arteriovenous grafts (AVGs). Besides, it is also shown to be beneficial in promoting maturation of AVF. Utilization of FIR therapy can help HD patients to reduce the need for interventional therapy and further preserve their blood vessels.

Chapter 29 - Existing evidence on the effect of antithrombotic medication on reducing early and late fistula failure is inconclusive. Antithrombotic use carries risks in patients with end stage renal failure and could increase the risk of needling complications as a result of bleeding. The objectives of this study are to determine the effect of antithrombotic agents on early and late fistula failure and on the risk of interrupted start of cannulation of the fistula. Retrospective analysis of 2 prospectively maintained database of access operations and dialysis sessions of 671 patients who had their first fistula between 2004 and 2011. Early failure was defined as failure to reach six consecutive dialysis sessions at any time with two needles on the index form of access. Fistula survival was defined as the time from when the fistula was first used to fistula abandonment. Primary failure rate was similar between patients on antiplatelet (18.8%), anticoagulants (18.4%) or no antithrombotic medication (18.8%; $p: 0.998$). Being on any antithrombotic medication did not have a significant effect on AVF survival ($p: 0.86$). Antithrombotic medication did not increase complicated cannulation rates, defined as the percentage of patients failing to achieve six uninterrupted dialysis sessions from the start ($p: 0.929$). In the authors' observational retrospective cohort study antithrombotic medication had no significant effect on primary failure rate, long term fistula survival or initial complicated cannulation rates. Patients already on antithrombotic medication can continue taking them without increasing the risk of interrupted dialysis. The authors performed a retrospective analysis of patient records and vascular access and dialysis

databases of 671 patients. The authors found that antithrombotic medication had no significant effect on primary failure rate, long-term fistula survival or initial complicated cannulation rates.

Chapter 30 - Arteriovenous fistulae (AVF) for the purpose of renal replacement therapy (RRT) will continue to increase in prevalence due to both the shortage of available kidneys and the increase in incidence of renal disease, such that it would not be uncommon for the primary care physician to see these patients. It is important therefore that non-specialist medical colleagues are both comfortable and able to manage AVF related problems and to recognise their manifestation. This chapter will attempt to summarise the most common complications and clinical problems that a primary care physician is likely to see and how to assess and treat these patients in the clinic.

Chapter 31 - Vascular access guidelines recommend routine screening for the timely detection of stenosis using clinical assessment (monitoring) and device-based surveillance relying on access blood flow (Qa) and static intra-access pressure (sVPR, static venous pressure ratio) measurements, or duplex ultrasound (DU). The authors revised the available literature on monitoring sensitivity (SE) and positive predictive value (PPV) to detect stenosis, and predict incipient thrombosis, and its effect on access thrombosis and survival rate by comparison with surveillance in randomized controlled trials. In fistulas physical examination (PE), the cornerstone of monitoring, had much the same diagnostic performance as the Qa criteria recommended in the guidelines for referral and treatment (Qa <500 ml/min), while Qa <300 ml/min proved to be the best tool in predicting thrombosis. In grafts, monitoring performed significantly less well in diagnosing stenosis and predicting thrombosis than sVPR or DU. In randomized controlled trials on fistulas, Qa surveillance enables a significant halving of the risk of thrombosis and access loss by comparison with monitoring alone when Qa criteria highly sensitive to stenosis are considered. In grafts, neither Qa nor DU, nor sVPR are able to reduce thrombosis or access loss rates by comparison with monitoring alone. The authors' analysis indicates that regular monitoring should be the backbone of any vascular access stenosis screening program (possibly associated with Qa surveillance for fistulas), and PE should be part of every teaching program for caregivers involved in hemodialysis.

Chapter 32 - Access monitoring and pre-emptive angioplasty is known to decrease the incidence of AVF/AVG thrombosis. The effect on increase the longevity and functionality of Arterial-Venous access (AV access) in end-stage renal disease (ESRD) patients is not settled. Thrombosis is the leading cause of vascular access complications and is almost always associated with the presence of stenosis. Percutaneous transluminal angioplasty (PTA) is an accepted treatment of stenotic lesions in AV access (NKF 2001). The purpose of this study is to assess the effect of follow up of ESRD patients in the dialysis access center with preemptive angioplasty on access thrombosis. This is a single center observational interventional study extended over 9 years (Jan 1, 2006 to Dec 31, 2014) at the Dialysis Access Center of Pittsburgh, PA. The study is divided into 2 periods, period A (from Jan 2006 to December 2009), where follow up program was not in place. Period B extends from (January 1, 2011 to December 31, 2014). In this period, a follow up of patients with preemptive angioplasty of AV access has been implemented. The authors decided not to include 2010 as the program is implemented at the end of that year and including this year might skewed the data. All patients with ESRD on HD are seen in the Dialysis access center of Pittsburgh for access monitoring and interventional PTA if deemed necessary. Patients'

data were abstracted from the electronic medical records. The study is approved by the IRB of Lifeline corp. During period A; a total of 4139 encounters with a mean of 1034, (1653 angioplasties with mean of 413/year, 375 angiogram, mean 94/year, and 303 thrombectomies of AVF/AVG with a mean 76/year) were carried out. Thrombectomies constituted (7.3%) of the total procedures performed. In period B, a total of 6229 encounters with mean of 1557 encounter/year were performed, (3202 angioplasties, mean 801/year, 950 angiograms, mean 238/year, and 196 thrombectomies, mean 42/year) were done. Thrombectomies were decreased almost 2 folds in this period (7.3% to 3.15%). The percentage of patients being dialyzed via TDC decreased in period B from 31.895% to 17.38%. The numbers of thrombectomies have also been decreased from average 76 to 42 /year (7.3% to 3.15%). After implementing the program, as illustrated in period B, compared to the national average, the frequency of thrombectomies (3.15% vs. 9.6%) and TDC use (17.38% vs. 18%), have showed significant improvement. Meanwhile, the number of PTA has doubled from an average of (413 to 801/year) between the 2 periods. The authors' fistula rate has gone up from 48.7% to 66.2% between the 2 periods. Mild increase of the AVG use (12.07% to 18.07%) has also been observed. However, the use of TDC has decreased from (31.42% to 17.38%). These results are consistent with the motto of (fistula first and catheter last). The growth of PTA may explain the positive impact of this program on the number of thrombectomies as well as maintenance of access functionality in ESRD patients. The rate of PTA has gone up from (39.85% to 51.25%). This trade off may be acceptable if access patency and functionality have to be maintained. It is not clear whether the follow up program with preemptive angioplasty would have a positive effect on the access expenditure and access longevity in this group of patients. Follow up of ESRD patients in the dialysis access center and preemptive angioplasty if need be is an acceptable means to decrease the number of failed accesses, thrombectomies, as well as the use of TDC in ESRD patients.

Chapter 33 - Vascular access-related problems are responsible for 50% of the hospitalizations of dialysis patients, and can contribute at least in part, for the high morbidity and mortality rates found in these patients. Health-Related Quality of Life (HRQoL) is a multidimensional concept that includes patient's perspective on physical, mental, and social domains, and has been used to assess well-being in dialysis patients. Well-being is the ultimate outcome of end-stage renal disease (ESRD) patients. ESRD patients under dialysis showed lower HRQoL scores when compared with general population, and also with other chronic diseases patients. Arteriovenous fistula use as vascular access is associated with higher HRQoL scores in several domains when compared with those using central venous catheter, particularly those using arteriovenous fistula in left forearm. These results show that the best choice for vascular access in dialysis patients was arteriovenous fistula in the left forearm (dominant arm), if not contraindicated. In this book chapter a revision of the impact of the type of vascular access, and location of the arteriovenous fistula on patient's perception of HRQoL has been performed.