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Abstracts

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1

Local and Systemic Effects of Vascular Access*A. Bakran*

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As soon as an arteriovenous (AV) fistula, whether autogenous or prosthetic, is created, there is an immediate transformation in local haemodynamics of blood flow which also has systemic cardiovascular consequences. The sudden introduction of a low resistance outflow connection with a vein, results in a dramatic increase in fistula blood flow. Factors which determine the magnitude of blood flow in fistulas, include proximity to the heart (size of artery is larger and gets smaller the further away from the heart), the length of the anastomosis (as an indicator of cross-sectional area), systemic blood pressure, and blood viscosity. In the commonest type of anastomosis, the end vein or graft to side artery, blood flow may flow from the feeding artery into both the vein/graft and distal artery. Until anastomotic length reaches 75% of the arterial diameter, the arterial flow is maintained in both directions. However, in practice anastomoses are usually greater than the diameter of the inflow artery, leading to not only antegrade flow into the fistula from that inflow artery but also retrograde flow from the artery distal to the anastomosis, resulting in an overall 20–25% increase in fistula flow. In proximal fistulas in particular, this ‘steal’ of blood flow can result in distal ischaemia.

A grasp of haemodynamics is useful in understanding the events following fistula creation. The events critical for haemodialysis purposes after fistula creation are increase in blood flow and fistula vein diameter. It is thought that blood vessels dilate as an adaptation response to increased blood flow in order to maintain optimum wall shear stress and, therefore, the greater the blood flow through a fistula, the greater the vein dilatation. Not all veins, however, continue to enlarge following fistula formation despite remaining patent. What causes this lack of fistula development? Whilst normal arteries have laminar flow, fistula flow has been shown to be highly turbulent and this may have an impact on clinical performance. The common sites for fistula stenosis have been shown to be at the anastomosis, along the ‘bend’ of the fistula and just as it straightens out. Experimentally, in vitro studies have shown that these are the sites of highly turbulent blood flow and are associated with high and low shear stress which lead to intimal hyperplasia. Minimising flow disturbance, thus, may be the key to improving fistula outcome.

Pari passu with fistula formation, increase in cardiac output occurs. Compression studies of chronic AV fistulas have shown that there may be a reduction in cardiac output of 8–13% due to a fall in left ventricular stroke volume. If fistula flow becomes even greater, then severe cardiac embarrassment can transpire, leading to heart failure. In one such reported case, cardiac output reached 19 l/min! Fistula monitoring would lead to early detection of both low and high flow situations and expedite appropriate management to optimise outcome for patients.

In conclusion, much research still needs to be performed in order to understand the cause of morbidity following and failure of vascular access. Understanding the haemodynamics underpinning vascular access is fundamental to that process.

2

Alternatives to Avoid Neointimal Hyperplasia*P. Roy-Chaudhury*

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Venous stenosis and thrombosis due to venous neointimal hyperplasia (VNH) is the most common cause of dialysis access failure. At a cellular level, venous neointimal hyperplasia (VNH) is characterized by smooth muscle cell/myofibroblast migration and proliferation, microvessel formation within the neointima and by a perigraft macrophage layer. More recently a number of novel mechanisms have been speculated to contribute to luminal stenosis. These include (i) vascular remodeling (ii) a special role for the adventitia and (iii) a possible contribution of bone marrow derived stem cells to neointimal hyperplasia. This presentation will provide an overview of the pathogenesis of neointimal hyperplasia with a special emphasis on novel ‘local’ therapeutic interventions such as radiation therapy, drug eluting stents and gene therapy.

3

Hemorheologic Factor and Vascular Access Function*J. Barbas*

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Basic Concepts

Rheology (flow-study) is a branch of mechanics concerned with deformation and flow properties of various materials under mechanical forces. The main categories of materials studied in rheology are solids, fluids and viscoelastic materials which show a combination of fluid and solid behaviour [1]. The term hemorheology was introduced by A.L. Copley, in 1951, for the rheology of blood and defined as ‘being concerned with deformation and flow properties of cellular and plasmatic components of blood in macroscopic, microscopic and submicroscopic dimensions, and with the rheological properties of

vessel structure with which blood comes in direct contact' [2]. Blood is a complex fluid composed of a suspension of cells in plasma. The cells are neither solid nor liquid, but liquid droplets each enclosed in a solid, elastic envelope. Therefore, blood does not fall in any simple category, although showing some viscoelastic properties similar to emulsions [3]. Because blood is not a homogeneous fluid, its flow properties depends on the rheological behaviour and interactions of the plasma and the erythrocytes. Leucocytes and platelets normally exists in low number and they do not contribute significantly to whole viscosity [3]. Therefore, the blood viscosity depends on the plasma viscosity, hematocrit, erythrocyte deformability and erythrocyte aggregation. High levels of plasma viscosity and hematocrit, high erythrocyte aggregation and low erythrocyte deformability increase the blood viscosity.

Hemorheology in Chronic Renal Failure

Most of the studies showed that the patients with chronic renal failure on conservative treatment or submitted to hemodialysis (HD) or peritoneal dialysis have high plasma viscosity, low erythrocyte deformability and normal erythrocyte aggregation [5–11].

In the hemodialysis patients the hemoconcentration at the end of the HD session is associated with a significant increase in plasma viscosity and hematocrit. The red blood cell deformability and aggregation are not different before and after hemodialysis [12]. However, as most of the patients are anemic and the hematocrit has a predominant effect, the blood viscosity is lower than normal. The increased plasma viscosity is due to the high levels of fibrinogen explained by the chronic inflammatory state of patients with renal failure, which is exacerbated by hemodialysis. The anemia is present in 90–95% of the patients with end-stage renal failure at starting chronic hemodialysis and depends predominantly on the low levels of erythropoietin. In the presence of high levels of fibrinogen the erythrocyte aggregation should be increased [13], but other authors [11] found normal values in their patients. The cause of low erythrocyte deformability is unknown [4, 5, 6, 9, 10, 11]. Nowadays, it is not yet possible to control the micro-inflammation, to decrease the fibrinogen and to normalize the plasma viscosity and it is also not possible to improve the erythrocyte deformability. But it is possible and mandatory to treat and correct the renal anemia!

Renal Anemia

It is well known that anemia of chronic renal failure is an independent risk factor for poor quality of life and high morbidity and mortality. Furthermore, the correction of renal anemia with human recombinant erythropoietin (EPO) has been of great benefit in improving the quality of life and mortality, even when that correction is partial to hematocrit of 33–36% (Hemoglobin of 11–12 g/dL). However, over the last 10 years, for sound clinical reasons as well as in an attempt to secure better quality of life and longer survival for our patients, various specialists groups studied the pros and cons of complete correction of renal anemia.

EPO, Correction of Anemia and Vascular Access

The eventual deleterious effects of the correction of renal anemia on the patency of the vascular access for hemodialysis have been evaluated in several studies, but the results are controversial.

Pathogenesis of Access Failures

The pathogenesis of the eventual fistula failures subsequent to EPO administration as treatment for renal anemia remains to be determined.

The increase of hematocrit and blood viscosity can facilitate the thrombosis by lowering the blood flow velocity, particularly in narrowed segments of the vessels, and by some procoagulation effects due to higher concentration of erythrocyte.

The remodelling the vein wall and subsequent stenosis can, eventually, be associated with hemodynamic changes related to the increase of the blood viscosity. According to Laplace's law, tensile stress is directly proportional to venous transmural pressure and radius, and inversely proportional to vein wall thickness. In response to increased blood pressure or shear stress or venous radius, the tensile stress is maintained within the physiologic range by thickening of the vessel wall. The shear stress is the dragging frictional force created by blood flow and depends on the product shear rate times blood viscosity. So, the increase in blood viscosity can increase the shear stress and, probably the remodelling and the stenosis of the vein.

To date, little investigation of the pathogenic significance of EPO in enhancing the internal hyperplasia and the vascular stenosis in the hemodialysis patients has been undertaken. Recently, N. Ikegaya et al. [14] found an elevated EPO receptor expression associated with increased expression of TGF- β_1 and fibronectin in severely narrowed fistula segments, when compared with patent fistula on cutaneous veins. So, EPO could be one of several growth factors contributing to vascular stenosis due to intimal hyperplasia and extra cellular matrix accumulation.

Partial Correction of Anemia

In 1989, some studies at the beginning of the clinical use of EPO to correct partially the renal anemia expected an increase in vascular access thrombosis due to an increase in the blood viscosity [15, 16].

Sundal and Kaeser [17], reporting for the European EPO Study Group, reported that 22 of 151 patients (14.7%) had access thrombosis, which was higher than before treatment. However, from the data presented it is not clear what the duration of the therapy for each patient was and also which was the type of access.

In 1990, the Canadian Erythropoietin Study Group [18] reported a significantly increased rate of access failure in patients receiving EPO (11 of 78) compared to patients receiving placebo (1 of 40). Most of the thrombosis occurred in synthetic grafts.

On the contrary, Esbach et al., reporting for the US Multicenter Group [19], found a rate of access thrombosis in patients treated with EPO of 0.3/patients year, which compared favourably to a rate of 0.5/patients year in a group of 1,111 patients not receiving EPO.

The controversy persisted and in 1993, based on the data available, J.W. Esbach concluded that treatment with EPO was not a cause of access thrombosis [20]. Based on the same data, Muirhead firmly believed that there was an accelerated rate of access failure during EPO therapy [21]. More recently, D.N. Churchill [22] evaluated 64 matched fistula pairs and 34 graft pairs with and without EPO treatment and found that EPO does not increase the probability of fistula thrombosis, but there is a significant association with an increased probability of synthetic graft thrombosis.

De Marchi [23] performed a cross-sectional and 3-year prospective, placebo-controlled, study in 30 hemodialysis patients with native arteriovenous fistula and confirmed that EPO therapy does not increase the risk of thrombosis.

Complete correction of anemia

The complete correction of renal anemia in hemodialysis patients associating normal or high blood viscosity and high or sometimes very high doses of EPO may, at least theoretically, increase the risks of vascular access stenosis and thrombosis.

However, there is some controversy concerning the effects of high doses of EPO and of normalization of hematocrit levels on the rheological parameters of patients on hemodialysis. Some authors showed no improving in the low erythrocyte deformability [24], while others found an improving and even a normalization [25, 26, 27]. K. Ludat et al. [27] also showed that the correction of anemia to a normal hematocrit level did not result in adversely high blood viscosity levels.

Furthermore, the clinical studies also obtain controversial results.

Besarab et al. [28] examined the risks and benefits of normalizing the hematocrit on hemodialysis patients with cardiac disease. They studied 1,233 patients, 618 assigned to achieve and maintain a hematocrit of 42 percent and 615 to a hematocrit of 30 percent. The incidence of thrombosis of both native fistula and graft was higher in the normal-hematocrit group than in the low-hematocrit group (39% vs. 29%; $p = 0.01$).

The Spanish Cooperative Renal Patients Quality of Life Study Group included 156 patients without severe comorbidities and malfunction of the vascular access. The mean hematocrit increased from 30.9 to 38% and there was no significant increase in vascular access thrombosis [29]. The Scandinavian Study [30] evaluated 293 hemodialysis patients randomised to reach a normal hemoglobin of 13.5–16.0 g/dL ($n = 157$) or a subnormal hemoglobin of 9.0–12.0 g/dL ($n = 136$). The incidence of vascular access thrombosis did not differ.

Conclusion

In hemodialysis patients, the risk of vascular access thrombosis and stenosis due to blood rheology abnormalities and to the partial or complete correction of anemia with EPO remains controversial.

Nowadays, placebo-controlled studies are not ethically acceptable, but further and well designed studies comparing patients with low-hematocrit (Hct 30–33%) to patients with normal-hematocrit (Hct 40–45%) would be welcome.

Meanwhile, we may admit that the risk of thrombosis and stenosis at least for native arteriovenous fistula, is not increased in patients without significant cardiovascular comorbidities and with well functioning vascular access.

The risk of thrombosis and stenosis is probably increased, particularly for synthetic grafts, in patients with cardiovascular comorbidities and malfunction of vascular access. Finally, we do not know whether the darbepoietin alfa has any stimulating effect on the intimal hyperplasia of the veins similar to recombinant human erythropoietin.

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4

The Patients who Frequently Clot Fistulae

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Vascular access remains the Achilles' heel of successful hemodialysis, and thrombosis is the leading cause of vascular access failure. Vascular access thrombosis can be the consequence of a previously unrecognized hypercoagulable state. This area of medicine is a rapidly expanding field, with the three most common causes for thrombosis being recognized within the past few years. Classification of the molecular causes for thrombosis can be made on the basis of their frequency or the severity of thrombosis with which the protein defect is associated.

The first protein defects associated with thrombosis, **antithrombin III deficiency and protein C and protein S deficiency**, are the most severe. Recent clinical literature suggests that patients with these consistent defects who have thrombosis should receive anticoagulation therapy for life.

The most common defects associated with thrombosis – resistance to activated protein C (factor V Leiden), hyperhomocysteinemia, and prothrombin 20210 – are fortunately less severe defects.

In 1993, Dahlback et al. showed a resistance to prolong the activated partial thromboplastin time by activated protein C (APC). Bertina et al. demonstrated that this phenotype, named **APC resistance** (APCR), is normally (>90%) caused by a single mutation of G1691-A change in the coagulation factor V (FV) gene. This point mutation results in a change arginine-glutamine in position 506 of the protein, which is one of the three cleavage sites for the inactivation of FV by APC. Prevalence estimates for **FV Leiden** vary in different countries.

In 1996, Poort et al. identified a single G to A nucleotide transition at position 20210 in the 3' untranslated region of the **prothrombin (FII) gene**, which was reported to be associated with an increased FII plasma level.

More recently, several studies have been trying to establish whether a significant thrombotic risk may be associated with **hyperhomocysteinemia and MTHFR C677T polymorphism**. Much less common causes for thrombosis, abnormal fibrinogens and plasminogens, are usually associated with less severe thrombotic states, although because their frequency is so low, few prognostic studies are available.

In addition to these well-characterized protein defects, a number of clinical syndromes are associated with variable degrees of thrombosis: heparin-induced thrombocytopenia and thrombosis syndrome, lupus anticoagulant and antiphospholipid syndrome, hyperactive platelets.

Differences in thrombotic risk seem to exist within carriers of the same molecular defect, suggesting the importance of combined genetic factors, a variable penetrance, or different interaction with acquired risk factors. The assessment of these different factors will make possible in future, its integration by algorithms which allows the calculus of the risk of each patient, and so, to perform an

effective prophylaxis and/or a safety treatment, adjusted to each individual case.

5

The Role of Non-Invasive Pre-Operative Vessels Evaluation

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Currently the most frequent problems with AV fistulae are primary failure and unsuccessful maturation with inability to cannulate the fistula or resulting in inadequate blood flow during hemodialysis treatment. Since the first AV fistula was created in 1965, a greater number of elderly and diabetic patients are accepted for long-term dialysis treatment and a rising proportion of patients are remaining on hemodialysis for more than 20 years. The quality of vessels is thought to play an important role. The assessment of the vasculature of the upper extremity is mandatory prior to fistula creation.

In many patients, especially obese patients, clinical detection of veins and evaluation of their potential for dilatation is impossible. Veins are destroyed by infusions or central vein catheters. Atherosclerotic or calcified arteries will deliver only a limited blood flow and will not undergo the adaptive flow-mediated dilatation necessary to deliver sufficient blood volume for fistula maturation. Duplex ultrasound is a promising method to establish certain morphological and functional parameters of peripheral blood vessels that is non-invasive and safe and may be used in lieu of venography and arteriography at facilities where this modality is available and reliable. The mapping of veins and measurement of the calibre of the arteries and veins by this technique correlates well with operative findings. In addition to morphological parameters, functional characteristics of vessels can also be evaluated by duplex sonography.

A standardised examination starting from the cephalic vein at the forearm up to the cephalic and basilic vein at the upper arm and from the radial and ulnar artery at the wrist up to the brachial artery is performed. Routine preoperative sonographic vascular mapping increases the detection of veins suitable for fistula creation. The ability of the vein to dilate can be predicted by measuring the increase in internal diameter after proximal vein compression. In failed group of AV fistulas internal diameter of vein increased after proximal compression during preoperative sonography in only 11.8% compared to 48% in group of successful AV fistulas. With deep inspiration, venous flow is increased because of low resistance to central venous flow. If there is a venous outflow disturbance (stenosis), Doppler vein signal is not changed.

Morphological evaluation of arteries includes internal diameter, wall thickness, and the presence of calcifications and other abnormalities. The internal radial artery diameter has been used in several studies (from 1.5 to 2.3 mm) to predict the outcome of radio-cephalic AV fistulas (failure or dysmaturation) or to plan strategies for vascular access creation. Since reactive hyperaemia simulates the decreased vascular resistance after AV fistula construction, Doppler waveform before and during reactive hyperaemia can be used as a test for the ability of the artery to react properly after AV fistula construction. In our study AV fistulae were successfully created with 95.3% of feeding arteries with a hyperaemic resistance index <0.7

but only 38.7% of feeding arteries with a hyperaemic resistance index >0.7 . Internal diameter of the artery and resistance index during reactive hyperaemia measured before AV fistula creation are also predictors of the time required for maturation.

In conclusion, non-invasive assessment by duplex sonography is very helpful in locating veins that are not clinically visible and also provides information about functional characteristics of the veins including venous outflow. Duplex sonography is method of choice for evaluation of the arteries. Based on the morphological and functional characteristics of the arteries and veins determined by duplex sonography, the optimal site for AV fistula construction can be selected. It is important to create AV fistulae early, which results in earlier maturation and less stress for patients, and minimises subsequent surgical interventions and costs.

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6

Basilic Vein Transposition – Advantages

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Introduction: Like many other European surgeons, we have routinely used basilic vein transposition since the 1970's. Dagher (1976) reported a 70% functional patency rate at eight years. After a period of over-enthusiasm for arteriovenous grafts in the American literature there has been a renewed interest in basilic vein transposition since the release of the National Kidney Foundation-Dialysis Outcomes Quality Initiative Guidelines (1997) supporting autologous arteriovenous fistulae (AVF) in preference to grafts.

Technique: We use the 2-stage procedure. The first stage (elbow AVF) results in dilation and thickening of the vein which more easily resists extensive dissection and subcutaneous transposition at the second stage.

The preoperative condition of the vein is assessed by clinical examination, duplex scan and/or venous angiography; ultrasound examination is very helpful in obese patients; angiography is mandatory in cases of previous central venous catheter.

At the first stage a simple AVF is created at the elbow between the brachial artery and either the median antecubital vein or the proper basilic vein. Pneumatic tourniquet-induced prophylactic hemostasis is used, making arterial dissection unnecessary. A side to end anastomosis is done using a surgical microscope, no-touch technique and 8 to 10/0 ethilon sutures. If there is any doubt, the patency of the anastomosis is tested using a sterile Doppler probe. One month postoperatively a duplex scan is performed to check the maturation of the vein and measure the flow rate.

At the second stage performed two months later, the vein is totally dissected after continuous longitudinal skin incision, with suture-ligation of all branches and careful attention to adjacent neurovascular structures (medial brachial cutaneous nerve). The vein is marked on its anterior surface and divided at its lower extremity, flushed with heparinized saline solution without pressure dilation and placed in a semi-straight subcutaneous tunnel, taking great care to avoid any angulation or twisting. If the diameter of the vein is large enough a vein to vein anastomosis is created, but when the vein calibre is small a new arteriovenous anastomosis is done. Three weeks should elapse postoperatively before the first puncture.

Complications: Infection is rare. Venous stenosis, usually located at the upper part of the transposition, may be related to intimal hyperplasia occurring at the non-dissected vein level and is treated with percutaneous transluminal angioplasty (PTA). According to Turmel-Rodrigues (2000) thrombosis is amenable to percutaneous declotting with 76% immediate success rate and 68% secondary patency after 6 months (LTR). Bleeding must be prevented at puncture sites by PTA of any downstream stenosis and cutaneous flap mobilisation if necessary. In cases of distal ischemia we use distal prolongation, or the distal-revascularisation-interval-ligature procedure or the ligation of the fistula. High flow rates are corrected with distal prolongation or with radial artery transposition.

Results: Bourquelot (1990) used 2-stage microsurgical basilic vein transposition in 29 children (12 children <10 kg) and reported 82%, 75%, 65% and 62% primary patency rates after 1, 2, 3 and 4 years, respectively.

Coburn (1994) compared the primary patency rate of basilic vein AVF (n = 59) with the primary and secondary patency rates of PTFE (n = 47). The primary patency rate for basilic vein AVF (90%) was superior to that of PTFE (70%) at 1 year ($p < 0.01$), and at 2 years (86% vs. 49%, $p < 0.001$). Complications occurred two and a half times more frequently in the PTFE group than in the basilic vein group.

Rodriguez (2000) retrospectively analysed the types, duration and primary patency rates of 1,033 permanent vascular accesses in 544 consecutive patients treated over a 13-year period. The median duration of function of the humerobasilic transposition exceeded 5 years, in contrast to the brachiocephalic AVF with a median duration of function of 3.6 years and the average graft patency not exceeding 1 year.

Gibson (2001) evaluated failures and revisions in 2,247 hemodialysis accesses placed in incident patients. One hundred and eighty-one (8%) were venous transposition fistulas (mainly upper arm basilic vein transposition). Age was not found to be significantly associated with primary access failure. At 1 and 2 years, primary patency rates for venous transpositions were 43.5% and 27.7% respectively, compared with 38.2% and 24.6% for synthetic grafts ($p < 0.001$) and 56.1% and 39.8% for simple AVFs ($p = 0.008$). When compared with simple fistulas, vein transpositions and prosthetic grafts demonstrated equivalent secondary patency at 2 years. However vein transpositions and prosthetic grafts had a 32% and 91% higher incidence of revision, respectively. Long term patency rates were not available.

Recommended Strategy: Basilic vein transposition is indicated when creation of a distal or a proximal (cephalic) fistula is not possible.

Recently, some authors (Berardinelli 1998, Gibson 2001) have suggested that the basilic vein transposition could be the access of choice in elderly patients. In fact simple wrist AVFs should remain the primary procedure of choice for all dialysis patients because they have the best long-term patency rates and the lowest incidence of complications at any age (Mosquera).

If a distal ulnar artery to basilic AVF appears feasible it must be created first, before the basilic vein transposition.

Previous fore-arm grafts which might damage the basilic vein at the elbow must be avoided. Previous upper arm grafts which would produce venous stenosis at the anastomosis with the upper basilic vein are contra-indicated. On the other hand insertion of a brachial artery to axillary vein graft is possible after irreversible thrombosis of a basilic vein transposition.

Conclusion: Two-stage basilic vein transposition has been an excellent autologous angioaccess for many grafts and with significant mid and long-term patency rates for children and adults.

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7

Basilic Vein Transposition: Disadvantages

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In our institution we perform BVTs liberally before inserting a synthetic graft, but we must be aware of several disadvantages and drawbacks of this operation.

- The basilic vein is relatively short and because of the curve we must create, and the artery is deep we lose most of its length and only a very short portion of the vein becomes available for needle puncture.
- During tunneling the vein may undergo mechanical trauma from dissection and retraction and ischemic injury due to disruption of its microvasculature. The vein also is subject to tortion, kinking, distortion, and compression during this procedure.
- Two acute angles are created while skipping over the biceps muscle and turning under this muscle to make the anastomosis. This latter angle sometimes becomes too sharp and be the cause of failure.
- The procedure is time consuming and a tedious one. Takes about two hours to perform and usually general anesthesia is needed. This is a major surgery.
- Wound complications may occur more than expected because of larger incision and deeper dissection. Also dialysis related complications reported to occur more frequently.
- Nerves are in close proximity and nerve injuries may happen.
- Although most of the time it has a large caliber, it is fragile, and thin walled, thus subject to be easily injured and aneurysmal dilatation. This may cause thrombosis especially in hypotensive patients. Thrombectomy is almost never possible.

- Relatively long time is needed before it could be accessed.
- The procedure cannot be done in patients with big, fat upper arms.
- After maturation high output cardiac failure, arterial steal, pseudoaneurysm formation, subclavian steal syndrome may occur.
- Last but not least is the patients' and dialysis staff preferences. Position during dialysis sessions, difficulty of cannulation because of very short vein segment in the more sensible medial (inner) aspect of the arm are some of the complaints of patients and dialysis staff.

8

AV Fistula – How Far Should We Go? – Quite Far

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Since 1978, I have been intensely involved in providing vascular access for hemodialysis. Personally I made about 15,000 interventions for this purpose.

For financial reasons and the poor performance after sometime, the prosthetic graft should have a limited use. Thus, I preferably use autologous material to provide vascular access. The surgeon needs to focus more on clinical examination, and if a superficial vein is found with enough distance to allow a comfortable double puncture, that is where he must construct his access even if the vein is a branch of Basilic vein, lesser Safenous vein etc.

In all these years, it has been observed that in a bypass the critical point of the anastomosis is the distal angle, but in AV fistula the critical point is the heel of the anastomosis. Logically I think that transferring this angle to the middle will obtain a total flux from the artery to the vein and a soft positioning using a collateral or transforming the phlebectomy not cutting the belly of the vein but two longitudinal cuts in the middle of the vein, providing a T anastomosis.

Where do we find this bifurcation commonly on the anatomy of the arm? With practice, empirically, you will see on the anatomical snuff-box two bifurcations, four fingers transverse above the wrist for men and three fingers for women. This is also true for the Basilic vein. Ten centimeters below the elbow the cephalic vein has a good bifurcation and on the perforant vein of the H venous, also below the elbow, provide the best fistula on this location, durable and with high flux.

As long as the radial artery functions as the source flux for a fistula, and on that spot only the Basilic vein is left, it is preferable to transpose it to the radial artery due to a better flux and thus the decrease in time for the fistula maturation.

We only reserve endovascular procedures in selected cases where the patient can afford it or has insurance. If not I re-perform the fistula at another proximal spot, it is cheaper and it assures access with good flux in a healthy area.

When a thrombosis occurs, we provide a fast intervention so the patient can return to the hemodialysis program as soon as possible without the need of catheters installation.

Besides the thrombophylic disturbances, I find more difficulties to obtain access in nephrotics, patients that have been through chemotherapy, patients that developed ESRD due to a pielonephritis and the patients returning to hemodialysis after transplantation.

I have seen many cases of incoercible edema due to fistula done on a Subclavian vein territory that is thrombosed. This is, usually, due to an inadequate policy of not sending the patient in time for the confection of the fistula.

The use of catheters with cuff is more comfortable for the patient and accommodates the medical staff and the permanence of these catheters becomes dangerous because they only start to think of a permanent access when that catheter is thrombosed or infected.

When a Basilic vein transposition is provided in the upper arm, the thrombosis of this access facilitates the installation of a PTFE. However, the contrary doesn't seem to be true.

I compared 200 accesses that I was able to obtain information about, among 500 that I have done in the period, retrospectively. All of them were submitted to the confection of Basilic vein transposition and PTFE in the upper arm. The patency rate is clearly favorable to the Basilic vein transposition.

I do not recommend the use of the great Safenous vein except in special situations due to the fact that this vein has a thick muscular layer and does not dilate well with the tourbillon of the flux.

I am still enthusiastic about the use of Femoral vein transposition in desperate cases. It has been showed to be promising in the 78 cases I have operated with the cumulative patency rate of 68%, over a 4 year period.

According to my experience, these are the goals we must try to pursue: have less than 10% of immediate thrombosis, use PTFE in less than 1% of the cases, have less than 0.25% of infection, do all possible to avoid the installation of double lumen catheters, always advice transplantation as soon as possible and if clinical conditions allow and always make longitudinal incisions that help avoiding neural and lymphatic damage.

9

Native AV Fistula – How Far Should We Go? – Not So Far

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The arteriovenous fistula (AVF) is the type of vascular access most closely meeting the features of the ideal access: one that delivers an adequate blood flow, has a long lifespan, and a low complication rate (namely stenosis, thrombosis and infection). Studies have shown that the AVF is superior to both grafts and catheters in 4–5 year patency rates, the number and cost of subsequent surgical interventions, infection rates, and hospitalisation for other complications.

In the United States, the growth of the ESRD haemodialysis program has been accompanied by a decreased use of native AV fistulae and an increased use of synthetic AV grafts and silastic cuffed central catheters for permanent haemodialysis access. Primary AV fistulas although generally preferred are used less often also because of late referral of patients to nephrologists, and because of aging and diabetic populations with a limited number of suitable sites for the formation of primary AV fistulas, limits their formation. They currently constitute less than 20% of the prevalent haemodialysis access in the US. The reasons are numerous and include factors at every stage of caring for the dialysis patient.

Depending on disease process and concomitant medical problems, most patients will remain on some form of dialysis treatment for the rest of their lives. Others are evaluated for a possible renal transplant and placed on kidney transplant waiting lists, where they may remain for varying periods of time depending on their blood type, HLA matching, preformed antibody levels, medical urgency and other factors from the allocation system. In Portugal, the medium waiting time for a cadaveric kidney transplant is 25 months and even with a level of 20 donors per million of inhabitants, organ availability still remains the main limiting factor for organ transplantation programmes. Actually, living donation is an alternative just for selected cases but pre-emptive transplantation instead of dialysis, and the consequent avoidance of vascular access surgery, is especially suitable for patients with living related donors.

Of all patients starting dialysis 19.8% will die within their first dialysis year. Of all patients who die, it is estimated that 25% will die with inadequate vascular access or complications related to vascular access as a major contributing factor. Feldman and others have reported that access related morbidity accounts for almost 25% of all hospital stays for ESRD patients and may contribute to as much as 50% of all hospitalisation costs.

All patients needing vascular access should initially be considered for placement of a primary arteriovenous fistula. The most common limiting factor is the lack of a suitable native vein, often because of previous needle punctures by health professionals at medical institutions or by patients participating in IV drug abuse.

In diabetic and elderly patients, arterial inflow may be a limiting factor. In rare cases, the artery may be so calcified that surgery becomes technically difficult or impossible to perform. Early identification of patients with progressive kidney disease and the identification and protection of potential native fistula construction sites – particularly sites using the cephalic vein – by members of the healthcare team and patients, is crucial. Optimal autogenous conduit selection is facilitated by preoperative vein mapping.

Dialysis AV grafts have the following advantages (NKF Guidelines):

- a. Large surface area available for cannulation
- b. Technically easy to cannulate
- c. Short lag-time from insertion to maturation, in general, not less than 14 days should elapse prior to cannulation to allow healing and incorporation of the graft into local tissues
- d. Multiple insertion sites available
- e. Variety of shapes and configurations available to facilitate placement
- f. Easy for the surgeon to handle, implant, and construct the vascular anastomoses
- g. Comparatively easy to repair surgically

PTFE grafts offer reasonable patency and serviceability rates, either Impra or Gore-tex grafts can be used, some authors recommend Standard thickness ePTFE as the graft of choice (instead of thin wall) and others underlined the beneficial effect of the cuffed venous geometry.

Perhaps with native fistulas we shouldn't go so far, in older patients because long term patency and conservation of proximal access sites are of minimum importance due to their limited life expectancy.

Technical constraints also should be considered in diabetics and obese patients. And all dialysis patients should have their access planning integrated with their transplant plans, because many could even avoid dialysis access. Also the impact of the surgeon experience

needs to be underlined as the presence of a skilled surgeon may be more predictive of better dialysis access than other factors.

10

New Haemodialysis Catheters

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Haemodialysis catheters remain an important short to medium term vascular access alternative in patients without functioning arterio-venous fistulae. Since the late 1960's, frequent infections and thrombosis of non-cuffed, non-tunnelled (temporary) catheters, led to the development of soft tunnelled silicone catheters by the mid 1980's. A larger internal diameter, permitted blood flow rates in excess of 250 ml/min. and a Dacron cuff bonded to the catheter, improved catheter anchorage and reduced the risk of migration of bacteria down the catheter.

Double lumen catheters are now standard and are available in different tip configurations. The oval Permcath and double-D Vascath are examples of first generation tunnelled catheters. The second generation catheters are either the twin catheters, placed side-by-side in the same vein (Tesio catheter) or 2 catheter lumens bonded together and separated distally (Ash Split catheters).

One of the predisposing factors to catheter-related infections is the external location of catheters, which facilitates bacteria migration from the patient's skin. This led to the development of third generation catheter systems. These systems consist of a metallic port, implanted subcutaneously, connected to silastic catheters (Dialock Access) or connected to a single catheter by 2 devices placed side-by-side subcutaneously, with the 2 catheters placed next to each other in the same vein (Lifesite Haemodialysis System). The cost and expertise required to manage these third generation catheters, has limited their widespread use for haemodialysis.

Evidently, the evolution from first to third generation catheters, in combination with such strategies as ultrasound-guided catheter insertion, adequate use of anticoagulants, intraluminal antibiotic locks and stringent nursing catheter care, have led to increased catheter survival and a reduction in catheter-related complications, in addition to improvement in blood flow rates and dialysis adequacy.

However, the challenge for the future remains in the better design of high performance haemodialysis catheters, to reduce the frequency of catheter dysfunction and long-term risks to our dialysis patients.

Fistula Ligation After Transplantation Save that Fistula

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The decision to ligate or maintain a fistula after transplantation has been based on experience more than data. Few studies have evaluated this and none have addressed all of the issues involved in making the decision. This is difficult due to the multiple systems involved in end stage renal disease as well as the burden on the body when a transplant (and subsequent immunologic alteration) is undertaken.

Some areas to consider are the likely duration of the transplant for that specific patient, whether the hemoaccess is native or synthetic, symptoms or risks related to left ventricular failure (LVH), signs of steal syndrome or neurologic pain related to the access, presence of aneurysms, signs of venous hypertension or infection, and patient concerns for comfort and cosmesis.

Data in the literature has been conflicting regarding the progression of LVH. There is some suggestion that LV mass is reduced after fistula ligation, but ejection fraction, cardiac index and renal plasma flow are unchanged. Systemic resistance and blood pressure are not affected.

High output cardiac failure can be associated with an AV access. This uncommon situation is best treated with fistula ligation. Many approaches are possible when dealing with venous hypertension but ligation is the simplest in a patient with a well functioning transplant. Infection can often be treated while maintaining the access, but ligation and excision are the most expedient.

The most common reason for ligating a fistula post transplant in our experience, is for a patient request. Some prefer to restore their body image as much as possible while others dislike the discomforts associated with a fistula. Since many hemoaccess sites thrombose after transplantation, only 5–10% require ligation in patients with stable renal function.

Cost of Preventive Angioplasty of Stenosis Surgical Point of View

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Occlusive complications, thrombosis and dysfunction for stenosis, are the most frequent complications observed in vascular access and the cause of final failure of most autologous or prosthetic fistulas. The main cause of stenosis is intimal hyperplasia, a pathology without pharmacological preventive treatment up to date.

Stenosis due to intimal hyperplasia can be treated by percutaneous angioplasty with or without stent placement or by surgical correction. Interventional radiology and surgery should be considered complementary and not competitive methods to deal with this frequent complication.

The choice of the treatment method would depend of: 1. Hospital resources. 2. Patient preference 3. Site of stenosis 4. Anatomical characteristics of stenosis.

Classification of vascular access stenosis: a. Perianastomotic in radiocephalic fistulas. b. Proximal forearm or arm venous stenosis c. Cephalic vein arch stenosis (close to the cephalic-axillary junction). d. Prosthetic stenosis (graft-vein and mid-graft) e. Central vein stenosis.

Perianastomotic Stenosis in Radiocephalic Fistulas

They account for almost 90% of stenosis observed in radiocephalic fistulas [1]. Angioplasty have been used with success by several authors to treat stenosis and thrombosis (almost all of them associated to stenosis) with success [2–5]. One year primary patency was between 44% to 64%. The surgical alternative is the creation of a new anastomosis proximal to stenotic vessels usually placed close to the fistula (fig. 1).

Fig. 1. Several examples of perianastomotic stenosis in radiocephalic fistulas.

This is a simple operation that can be made under local anesthesia and ambulatory surgery (fig. 2). Primary patency of 87% at one year have been reported [1]. No prospective randomized studies have been published comparing surgery to radiology in this cases, but in this special kind stenosis this studies seem to be not justified. Radiological treatment should be tried just whether a surgeon expert in vascular access is not available. A situation usually due to the placement of vascular access procedures in a low level of priority in the surgical waiting lists.

Fig. 2. Proximal anastomosis in radiocephalic fistula with perianastomotic stenosis.

Proximal Forearm or Upper Arm Venous Stenosis

Most of them are placed close to the puncture sites and surgery can complicate the nursing approach to dialysis (fig. 3). Angioplasty seem to be the best treatment because the 'nursing' costs (lost of puncture sites) can be worse than other economical considerations.

Fig. 3. Isolated upper arm stenosis and a possible surgical solution.

Surgical approach is substitution of stenotic vein by a graft or autologous vein. Patch angioplasty can be another solution but bad results have been reported with this technique [6]. Recurrence is quite common after surgical PTFE venous substitution, and should be treated with angioplasty whenever possible.

Cephalic Arch Stenosis (fig. 4)

A trial of angioplasty seem to be the best treatment for this kind of stenosis. In case of frequent re-stenosis a transposition of the cephalic to the axillary vein is the surgical solution (fig. 5). As the distal cephalic vein is never used for dialysis this procedure do not waste useful veins.

Fig. 4. Cephalic arch stenosis.

Central Stenosis

Very complex and risky intrathoracic operations have been described to treat central stenosis. Probably in this cases angioplasty

Fig. 5. Venous transposition to axillary vein.

should be tried routinely. The use of stents or cutting balloons in case of recoil or nondilatable stenosis should be considered [7].

Stenosis in Grafts

The most common stenosis in vascular access and the cause of most access failures. Very good primary patency (68% at 1 years) have been reported with a surgical bypass to a proximal dilated vein performed under local anesthesia and ambulatory surgery, and, therefore with reasonable cost [8] (fig. 6). Radiological studies showed a primary patency about 30% [3, 9–12]. This procedure is not free from re-stenosis and the venous bed is wasted step after step. In my opinion surgical repair can be reserved for cases in which angioplasty have to be repeated in less than six months. Re-stenosis after bypass can be again treated by angioplasty. In this way, veins should be spared for more time and this close collaboration between radiologist and surgeons could give the best results.

Fig. 6. Graft-vein stenosis treated with bypass to a proximal vein.

Economical cost have been analyzed at least in two papers. In one of them [13] in which the professional fees are included surgical cost were only about 500\$ less than radiological cost, (6,062\$, radiological, versus 5,580\$ surgical), but anesthesiologist fees were included in surgical cases. In the second report, excluding professional fees, mean radiological cost was 2,945\$ and surgical cost was 1,512\$ [14]. Both studies were performed in graft thrombectomy but the cost for treatment of preventive stenosis in grafts is not different at least in

our hospital. However, the saving in venous reserve have to be taken in account and both resources, radiological and surgical, used as complementary methods.

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Prevention of Central Vein Stenosis and Thrombosis

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The characteristics of quickness, easiness and safety to perform central vein catheterization (CVC) justifies the widespread of this procedure for acute vascular access in ESRD. Unfortunately, the use of CVC is associated with a lot of serious adverse events.

Stenosis of the deep chest veins hemodynamically significant represents one of the most serious long term side-effect of the central vein catheterization and it can be defined as a reduction of the normal vessel diameter (graft or draining venous system) accompanied by hemodynamic, functional or clinical abnormalities (Patel NH et al., 2001).

Endothelial injury, immune/inflammatory response and hemodynamic effects are classically defined as factors responsible of the stenotic lesion, that begins as a reactive fibrosis of the endothelium at the presence of a foreign body, but continues even after the catheter has been removed and leads soon or later to thrombosis of the venous outflow and inability to obtain further chronic dialysis access.

The most important expedencies to prevent *central vein stenosis* at the placement of the CVC or in the long run are identified in the recognition of the risk factors for difficult catheterization prior to the insertion by careful preoperative assessment of the patient, choice of an experienced physician, choice of the fit catheter, correct choice of vein to cannulate, use of ultrasonography during internal jugular cannulation, control of catheter dysfunction in the operating room, meticulous care of the catheter by dialysis staff and specific protocols, surveillance of the arteriovenous fistula functioning in the upper limb, pharmacological prophylaxis, cannulation periods as short as possible.

Clinical investigation should include the simple manoeuvres of Adson to detect preoperatively a hyperabduction syndrome from an *outlet thoracic syndrome*.

Nowadays, great most of the percutaneous catheters are introduced through the *internal jugular vein* (Baumbauer and Jutzler, 1980), as this procedure appears less prone to provoke vein stenosis in comparison of subclavian vein catheterization (Canaud 1986). However, stenosis that occurs at the level of innominate vein and superior vena cava can preclude the creation of any permanent vascular access in both of the upper limbs.

Direct ultrasound guidance of the needle during internal jugular catheterization reduces the time required for insertion, confirm venous patency and reduces the rates of complications (Randolph AG et al., 1996, Teichgraber UK et al., 1997) if compared with the *land-mark technique*.

When risk factors are anticipated for one type of catheterization, alternative route should be considered (Venus B, 1997) with a *procedure personalized* for the specific patient. Elevated static or dynamic pressures, decreased blood flow, elevated access recirculation in an upper limb arteriovenous fistula or unexplained reduction in Kt/V may be signs of underlying deep vein stenosis (Besarab A et al., 1996).

Anti-platelet therapy with dipyridamole, aspirin, ticlopidine and fish oil are also employed, but additional studies with drug trials need to draw a conclusion. More innovative strategies like heparin bonding to the intravenous catheter, use of low molecular weight heparin, endothelial seeding and *gene-therapy* need further investigation. *Cytotoxic drugs, ionizing radiation or antisense oligonucleotides* locally delivered constitute other modalities to reduce the proliferation of the vascular smooth muscle cells, minimising systemic toxicity and are promising approach for the prevention of venous stenosis.

However, the placement of a permanent dialysis access prior to the first dialysis treatment and avoidance the use of temporary catheters are the best strategy to prevent central vein stenosis.

Endovascular Strategy

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Dialysis patients in Japan have been increasing about 10,000 or more per year, and total number of patients has become about 220,000 now.

It is increasing also in our clinic every year, and has become about 560 patients now. At the same time, the blood access insufficiency is increasing. In our clinic, we have started balloon angioplasty treatment in 1997. Since then, thrombectomy and open repair has been replaced by endovascular technique for blood access insufficiency in most of the cases. In 2001, PTA has become first choice of treatment for blood access insufficiency except for the case that needs the reconstruction of the AV fistula. We have done 441 PTA treatments in 207 patients in 6 years [male:female = 126:81, average age: 59.9]. 435 cases were native A-V fistula, and graft cases were only 6 cases. There were 206 cases (46.7%) with Diabetes Melitus (DM). PTA was performed in all cases. In addition to PTA, PULSE SPRAY (P) was used in 65 cases, HYDROLYSER (H) was used in 13 cases, and both P+H was used in 2 cases. Primary cumulative patency rates are 92.8% at 1 month, 87.8% at 3 month, 68.3% at 6 months, and 47.5% at 1 year. Secondary cumulative patency rates are 85.3% at 6 months, 85.3% at 1 year.

Recently Cutting Balloon has become available for the vessels which POBA cannot dilate enough. We will report this treatment with evaluation by Intravascular Ultrasound (IVUS).

Central Vein Stenosis and Thrombosis: The Place of Surgery

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Introduction: Central venous obstruction arising from long-term or repeat catheterizations for haemodialysis access is a frequent problem in ESRD patients. If the draining vein of a functioning vascular access is obstructed, venous hypertension with arm swelling, pain and ulceration will occur. Surgery (patch angioplasty or bypass procedures) can be difficult and hazardous in these often multimorbid patients. Thus it seems necessary to define the relative value of interventional treatment (percutaneous angioplasty and stent implantation) in comparison to surgical reconstruction of central venous obstruction in haemodialysis patients.

Patients and Methods: From 1993 through 2002, 42 haemodialysis patients (3% of all access procedures, 5% of all access patients) presented with symptomatic mediastinal vein obstructions (disabling arm swelling in 39, distal ulcerations in three) on the side of a functioning access. Percutaneous angioplasty and stent implantation was possible in 27 patients (64%). When interventional

procedures were unsuccessful, veno-venous bypasses were implanted (7 patients, 17%), or access ligation was performed (8 patients, 19%). All patients were followed-up prospectively.

Results: Following stent implantation one asymptomatic pulmonary stent embolism (4%) and two stent misplacements (8%) were documented. The latter were successfully treated with another stent. In the surgical group, one patient died at eight weeks due to late complications of a cephalosporine-associated Lyell syndrome. Patency rates (life table-method) were not significantly different among the groups:

patency	primary		secondary	
	1 year %	2 years %	1 year %	2 years%
stents	68	58	92	85
bypasses	83	56	100	71

Conclusion: For central venous stenoses in haemodialysis patients, angioplasty and stent implantation can be recommended as a safe and durable means to restore patency. Still there is a role for bypass surgery in severely symptomatic central venous occlusions when stent implantation is impossible or has failed. In high-risk patients, however, access ligation should be performed.

Clinical Examination – The Forgotten Tool

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Monitoring the dialysis access, according to the NKF K/DOQUI guidelines, refers to the examination and evaluation of the vascular access, by means of physical examination to detect physical signs that would suggest the presence of pathology.

Evaluation of the new end-stage renal disease (ESRD) patient in preparation for the placement of a vascular access, is very important, we must do a careful medical history and a general physical examination.

Despite all this, not all vascular accesses are successful, the major cause of hospitalization for ESRD patients is failure of the dialysis access, thrombosis is the leading cause.

Physical examination can be used as a monitoring tool, easy to perform, inexpensive and with a high level of accuracy.

The examination differs from arteriovenous fistula and grafts.

Normally an arteriovenous fistula (AVF) has a thrill, with a soft compressible pulse; with a stenosis, the AVF becomes more pulsatile and firm, with a systolic bruit, that permits to localize the site of obstruction. An aneurysm in an AVF is a localized dilation of the vein, especially in repetitive puncture sites. Ischemia is rare, we must evaluate the skin temperature, the movements and the distal pulses, with abnormalities, the patient should be referred to the doppler/angiography.

Infection in AVF is one tenth of the arteriovenous grafts (AVG), normally we find a swelling and tenderness on examination, that is

easily treated, sometimes we have abscesses from puncture sites that must be drained or excised.

The physical examination of the AVG includes detection of the flow direction, recirculation detection, infection, venous stenosis, venous hypertension, pseudoaneurysm and ischemia. Sometimes, in new patients, we have to determine the flow direction, this is easily performed by occluding the AVG with the finger and palpating on each side for a pulse, the side without a pulse is the downstream side of the graft.

Venous stenosis is the leading cause of failure in ESRD patients. Important venous stenosis causes hemodynamic changes in AVG, the examiner must listen the graft with the stethoscope, the normal low pitched bruit change to higher bruit, we can palpate a thrill; with a central stenosis we find swelling of the access arm and collateral veins; duplex ultrasound or angiography will confirm the diagnosis.

Infection of an AVG accounts for 20% of all complication, is the second leading cause of failure. After surgery, normally, we find swelling in the entire graft. There are superficial and deep infections; the superficial are related to the puncture sites, localized areas of cellulites. The deep infections involves the graft and need surgery, we have arm swelling, pain erythema and the skin is warmer than normal.

Diabetics, elderly patients, peripheral vascular disease and patients with multiples access, are at risk of developing vascular steal syndrome. Fortunately the steal will be symptomatic in only a minority of patients. The examination must include the other arm, we can find a pale or cyanotic hand, cold with absent pulses, in severe cases there are ischemic changes of the skin with significant pain that increases during dialysis.

Vascular access grafts may develop pseudoaneurysms secondary to trauma, or true aneurysms due to degeneration of the graft material. Normally we find dilatation in the puncture sites. In patients with associated venous stenosis, the increased pressure in the graft results in formation of dilation at the site of graft defect.

The examination should evaluate the skin for scarring, ulceration or spontaneous bleeding; search for collateral veins suggesting venous hypertension and determine the size of the pseudoaneurysm, if it exceeds twice the diameter of the graft, should be referred to surgery. Physical examination can be an useful tool in preventing failure, it is simple, inexpensive and easily performed, doing it on a weekly basis, we can refer the patients for other tests of surveillance.

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Monitoring Access Function: The Role of Duplex Scanning

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Introduction: Doppler ultrasound has a central role in the evaluation and diagnosis of vascular pathology and is used routinely in the evaluation and follow-up of patients with carotid and peripheral vascular disease. Since the 1980's Duplex ultrasound has also been used to identify and evaluate patients with access dysfunction. It is the only mobile and non-invasive technique that can provide anatomic imaging and physiologic data (access flow and velocity profiles). These capabilities allow identification of subsets of patients at high

risk of developing access thrombosis and determining the cause of physiologic changes (decreases in access flow, increases in venous pressure) identified by other techniques. Numerous investigators have shown that ultrasound accurately identifies access stenosis and with Doppler technology, assess the functional implications of lesions. Despite these abilities, ultrasound based vascular access management programs have become less common US. This is primarily due to lack of reimbursement and the availability of other surveillance methods. Recently there is a renewed interest in color flow Doppler ultrasound. This has been spurred by the success of preoperative imaging by Doppler ultrasound to increase successful AV fistula placement and the growing availability of smaller, simpler, less expensive machines that are easier to operate. Also, the accuracy of other access surveillance methods (access flow, static and dynamic venous pressure) has been questioned. Arterial inflow disease is increasingly recognized as a cause of access dysfunction. It is relatively easy to clarify these issues with duplex ultrasound. The ability to identify (image) pathology and diagnose false positive monitoring studies without the need for more expensive invasive studies make Doppler ultrasound attractive.

Currently, the major use of duplex ultrasound is in the evaluation of appropriate vessels for AV fistula creation. A full review of this topic is being presented by others and is therefore beyond the scope of this review. However, it is important to note that preoperative imaging by duplex ultrasonography has resulted in significant increases in successful AV fistula creation in programs utilizing this technique.

Vascular Access Monitoring and Surveillance: Doppler ultrasound can accurately identify significant access stenosis. Previous studies have shown excellent correlation with angiography both for imaging and for referral for intervention. Identified >50% stenotic lesions correlate with the future development of graft thrombosis. When coupled with access flow measurement, ultrasound based programs have decreased graft thrombosis to the range of <0.2-0.4/patient/year, similar to the best results achieved by other surveillance methods. These advances were generally noted in studies from the early 90's. To be effective ultrasound based monitoring including imaging of the entire access including inflow and venous outflow vessels and measurement of access flow must be performed at least every 3 months. With the restriction of reimbursement, these programs were not sustainable and have been generally abandoned. More recently programs utilizing limited Doppler studies including bi-monthly measurement of access flow and imaging of only the venous anastomosis have emerged. This combination of measurement of flow and stenosis gives a more complete evaluation of an access than physiologic data alone. In over 1,300 cases, abbreviated studies identified over 85% of PTFE grafts with a significant abnormality on a complete Doppler ultrasound examination and had a 79.7% sensitivity and an 88.6% specificity for >50% stenosis anywhere in the PTFE graft or venous runoff.

New Opportunities: The advent of lightweight portable ultrasound machines is beginning to alter the role of Doppler ultrasound. New scanners such as the SonoSite (SonoSite Inc, Bothell, Wa.), provide high resolution and color flow in an easily portable package, some as small as a notebook. These type systems and the improved systems that follow have the potential to change practice from the use of imaging purely for prearranged, vascular laboratory based diagnostic studies to its use as an inherent part of physical exam both by physicians and nurses alike. This offers the possibility of use for monitoring and diagnosis of the whole range of vascular access issues including planning, determining future access sites, surveillance and documentation of pathology and for diagnostic and interventional

purposes at the bedside. This change in practice pattern is already occurring in vascular surgery. As the ease and cost of entry barriers decline with the rapid improvement and miniaturization of ultrasound technology this trend will likely accelerate and broaden to other disciplines. In a sense duplex ultrasound will become the stethoscope of the next decade. This exciting prospect will bring increased ability to the bedside and change the focus from performing 'tests' to individual care and diagnosis.

Conclusion: Color flow Doppler ultrasound of the dialysis access provides imaging of access anatomy and access flow measurement. It's accuracy, portability and non invasive nature make Duplex ultrasound well suited for both access surveillance and diagnostic imaging. Even when performed as a limited study (measurement of access flow and imaging of only the venous anastomosis), the combination of measurement of flow and stenosis identifies patients at high thrombosis risk and gives a more complete evaluation than physiologic data alone. Access management programs based on Doppler ultrasound have been highly successful and have produced outcome data as good or better than provided with other techniques. Utilization of these approaches result in decreased access thrombosis to rates <0.1–0.2/patient/year in AV fistula and <0.2–0.4/patient/year in PTFE grafts. Doppler ultrasound should be included as a part of integrated hemodialysis access management programs.

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Functional Evaluation of Preventive Vascular Access (VA) Intervention

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We prospectively monitored the blood flow rate (Q_A) of 86 VA (arteriovenous fistula AVF 82.6% or graft AVG 17.4%; mean VA duration 25.53 ± 44.09 months) during hemodialysis (HD) in 78 ESRD (mean age 63.48 ± 12.63 yr; mean time on HD 33.76 ± 47.79 months; 17.4% diabetes) patients (pts) over 2 yr period. Q_A was measured at least every 4 months by the ultrafiltration (UF) method (Yarar et al., *Kidney Int* 1999;56:1129) using the Crit Line III Monitor (overall mean Q_A $1,175.63 \pm 483.54$ ml/min). The mean arterial pressure MAP (diastolic plus 1/3 pulse pressure) and Kt/V (Daugirdas' second generation, single-pool) were measured simultaneous with Q_A . Twenty-three VA (23/78, 29.5%) met criteria of positive evaluation PE (absolute $Q_A < 700$ ml/min 69.6%, Q_A decreased >20% from baseline 30.4%). The angiography AG was performed in most PE pts (22/23, 95.6%) and all of them showed VA stenosis $\geq 50\%$. Six explored PE pts (6/22, 27.3%) were lost to follow-up (4 death, 2 transplantation) and most of the remaining 16 explored PE pts (11/16, 68.7%) were referred for corrective VA intervention (int).

Eleven EP pts (mean age 67.64 ± 10.11 yr; mean time on HD 15.45 ± 20.52 months; 27.3% diabetes) underwent elective VA (radial AVF 90.9% and femoral AVG 9.1%; mean VA duration 15.36 ± 25.77 months) int (angioplasty PTA 36.4%, revision surgery SUR 63.6%). PE causes: $Q_A < 700$ ml/min 72.7%, Q_A decreased >20% from baseline 27.3%. Mean percentage of VA stenosis: 79.2%. One PTA pt (9.1%) thrombosed VA 3 months after int. Mean time between int and the first Q_A post-int: 14.56 days. Mean Q_A increased from 544.27 ± 85.06 ml/min before int (Q_A pre) to 967.64 ± 289.82 ml/min after int (Q_A post) (mean $DQ_A = 423.36 \pm 281.47$ ml/min) ($p = 0.001$). No difference was found when the highest recorded mean Q_A before int (820.55 ± 407.57 ml/min) and mean Q_A post were compared ($p = 0.124$). Mean MAP remained stable after int (90.15 ± 13.63 mmHg vs. 95.61 ± 11.97 mmHg, $p = 0.082$). Mean Kt/V improved from 1.36 ± 0.17 just before int to 1.44 ± 0.18 just after int without any change in dialyzer type or HD duration ($p = 0.020$). Mean DQ_A did not differ for diabetic pts vs. nondiabetic pts ($p = 0.31$), for young pts (age <65 yr) vs. older pts (age ≥ 65 yr) ($p = 0.63$) and for PTA pts vs. SUR pts ($p = 0.18$). We found an inverse correlation between mean DQ_A and mean Q_A pre for PTA pts ($r = -0.963$, $p = 0.037$) and a positive correlation between mean DQ_A and mean Q_A post for SUR pts ($r = 0.985$, $p = 0.001$).

We conclude that 1. Monitoring Q_A by the UF method is useful to assess the hemodynamic response to preventive VA int. 2. Mean Q_A

post was similar to the highest recorded mean Q_A before int. 3. The HD effectiveness (Kt/V) improves after int. 4. Mean DQ_A is related to mean Q_A pre for PTA pts and mean Q_A post for SUR pts.

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Actual Trends in Vascular Access Surgery

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Introduction: The rapid increased of the number of hemodialysis patients was accompanied by an higher rate of access related morbidity. For this contributed the changed clinical pattern of patients in dialysis. They are older, with more co-morbidities and have longer life expectancy.

In their first publication, Brescia e Cimino described the arteriovenous fistula in 17 patients with an average age of 45 years, but nowadays the average age of these patients is about 65 years old. More than 50% have other co-morbidities, mostly diabetes, that accounts for 20 to 40%. The longer life in dialysis is other factor responsible for the increasing number of patients with vascular access problems.

The past experience, particularly related with the use of synthetic grafts, also contributed for the actual trends in vascular access (VA) surgery. Recently, large studies from USA, where the synthetic grafts account for 60 to 80% of the VA, improved our knowledge of their natural history in terms of patency and rate of complications.

Finally, the maintenance of a patent VA is one of the most significant portion of the dialysis cost, which made it a very important political and financial issue. For this high expenditure mostly contribute the high rate of hospital admissions due VA problems, reaching rates of 25% of the total hospitalisation.

For all these reasons, VA problems reached an important place in medical knowledge. Nowadays more and more papers are published everyday, there is a growing interest in this area of investigations and the Vascular Access Society was created. Also, the document of the National Kidney Foundation, DOQI, dedicated one of their five chapters to Vascular Access Guidelines.

More differentiated surgeons are dealing with VA, including creation and revision. Furthermore, surgical procedures for hemodialysis are the most common vascular surgical operations performed in the United States. To solve VA problems a new concept of Vascular Access Centres has been developed in some countries and some of them reached good results with this integrated multidisciplinary approach.

Actual Trends: The Cimino-brescia arteriovenous fistula was introduced in 1966 and it is still the 'gold-standard' for vascular access. Since then, all the subsequent techniques were not improvements, but ways of dealing with the exhaustion of suitable veins for fistula creation. Indeed, the studies performed demonstrated a clear superiority of native fistulas in terms of patency, revisions and complications. So, surgeons are now committed to maximize the use of native veins for VA creation. For that reason, some hidden veins have become more popular, as is the case of the basilic and median ulnar. Coburn (1998) published a comparative study of basilic vein and PTFE grafts and demonstrated that primary patency rate for basilic

vein compared favourably to PTFE at 1 year (90 vs 70%, $p < 0.01$) and at 2 years (86 vs 49%, $p < 0.001$). Complications also occurred two and a half times more frequently in the PTFE group than in basilic vein group ($p < 0.05$).

In spite of the good long term results, the increased use of fistulas is accompanied by a primary early failure that range from 8 to 30%. To improve early patency, pre-operative duplex ultrasound vein mapping should be performed in selected patients. In fact, with this protocol it has been demonstrated a significative reduction of early failures, from 36 to 8.3% (Silva, 1998). Preoperative vein mapping also resulted in a change in the planned surgical procedure in 31% of the patients (Allon and Robin, 2002).

To achieve better results, it is also essential to have an active attitude towards non-maturing fistulas. The 'wait and see policy, it may grow' is not accepted anymore. Surgical or percutaneous intervention, including stenosis correction, collateral ligations and superficialization of deep veins, is mandatory. It is not well defined whether the use of non penetrating clips for anastomoses allows better healing and therefore better results (Schild AF, 1999).

Finally, early referral to the Nephrologist and to access surgery is essential, because it permits time for fistula maturation and contributes for a better protection of suitable veins in pre-dialysis period. This also avoids the necessity of central catheters. A recent French study noted that patients with late referral, 73% initiated dialysis with a catheter and only 12% with a fistula. In contrast, among patients with early referral, 29% initiated dialysis with a catheter and 53% with a fistula (Roubicek, 2000).

Synthetic Grafts: Although synthetic grafts are considered inferior to native fistula in terms of primary patency and rate of complications, they still have a very important role in vascular access surgery, permitting to create a definitive life-line to dialysis, in the absence of suitable veins for fistula. Really, for prosthetic arteriovenous grafts, the 1 year primary unassisted patency rate was only 49% compared with 62% for native fistula (Woods, 1997). This study also revealed that, after adjustments for the effect of age, sex and co-morbidity conditions, the risk of thrombosis was 71% lower for an AV fistula than for an AV graft, with a relative risk of 0.39.

While new advances are made in the technologic field to improve prosthesis, we learned that grafts require close monitorization of its function and timely salvage procedures to improve their patency. So, the concepts of assisted patency or secondary patency are now essential in the analysis and report of results. Using an aggressive salvage policy approaching malfunctioning grafts, some authors demonstrated a 50% patency rate at 2 years.

The revision procedures include thrombectomy, excision and segmental substitution, bypass and patching of stenosis, or resection of aneurysms. In addition to direct surgery, the percutaneous angioplasty is of most importance in dealing with the stenotic and thrombotic events.

New Developments: Since PTFE was first used for VA surgery, in 1973, it remained the best material for arteriovenous grafts. The most recent modifications of this prosthesis respected to better hemostasis, permitting early cannulation. However, further improvements trying to get biomaterials, as similar as possible to native veins, are welcome. So, actually, one of the most interesting areas of investigation is the biocompatibility at molecular, cellular and mechanical levels.

The ideal prosthesis has to be thromboresistant, while rapidly incorporated in the surrounding tissues. The thromboresistance depends on the surface characteristics, mainly on the proteins and cells

that tend to adhere. One of the major objectives is the total endothelialization of the prosthesis in humans. Some experimental approaches have been made evaluating and suggesting the application of shear stress and retroviral transduction of endothelial cells to stimulate endothelialization. Other alternatives are the lining of inner surface with various matrix components, such as gelatine or fibronectin.

As the most important cause of graft failure is due to progressive development of neointimal fibroplasia in the anastomotic areas due partially to hemodynamic factors, different prosthesis conformation was introduced. This type of synthetic material (Venaflor) can apparently improve flow, avoiding shear stress and, perhaps, intimal hyperplasia. Pharmacological approach to interfere with intimal hyperplasia at local and systemic levels has also been developed.

Finally, as infection is other important complication of synthetic grafts antibiotic bound prosthesis and other materials more resistant to infection are presently object of research.

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Actual Trends in Vascular Access – The Radiologist's Contribution

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Venous imaging before creation of a dialysis access is still under-used in many institutions. Many surgeons still think and write that pre-operative venous imaging by either ultrasound or venography is of little value and they only arterialize veins that are visible at clinical examination. Such an attitude against the evidences of the literature should not be accepted by the referring nephrologists since it means that prosthetic grafts are placed in many patients who have veins appropriate for the creation of autogenous fistulae.

The role of the interventional radiologist in 2003 starts soon after fistula creation. From the 3rd or 4th week after creation surgery, any clinical suspicion of delay in maturation indicating insufficient fistula flow should be imaged rapidly. Non-invasive ultrasound (US) examination should be performed first to rule out the deep location of a well-developed vein which requires surgical transposition to a more superficial location whenever possible.

Ultrasound can also show evidence of an isolated stenosis located at the anastomosis. If this is in the forearm it should rather be treated by the creation of a new anastomosis whenever technically feasible. In all other cases, angiography by direct arterial puncture at the elbow is required. An underlying stenosis, whether venous or arterial, short or long, and often underestimated by US examination, is unmasked in all cases and is amenable to percutaneous dilatation in the vast majority of cases. The initial success rate of the endovascular approach is very high and the long-term salvage of the fistula by the association of surgical and endovascular means can reach 90% at 1 year.

Radiologists with a background of diagnosis and interventional vascular radiology know that, apart from fistulas with excessively high-flow, which is never the case for immature fistulas, there is no opacification of venous collaterals without significant stenosis of the main draining vein. Such collaterals disappear after sufficient dilatation of the stenosis, leading to maturation of the fistula. Ligation or embolisation of collaterals in immature fistulas is not logical in the vast majority of cases.

All published series concerning percutaneous treatment of thrombosed native fistulas report that an underlying tight stenosis is unmasked in close to 100% of cases, which means that preventive treatment of such stenoses could have avoided acute thrombosis.

However, we also know that native fistulas are much less prone to thrombosis than prosthetic grafts and that not all stenoses threaten access patency. The challenge is to detect stenoses that will worsen and to tolerate non-threatening stenoses.

Flow rate monitoring appears to be one the best tool to detect active stenoses whose decreased luminal diameter decreases fistula flow proportionally. Some series have already demonstrated a clear reduction in the thrombosis rate of monitored native fistulas. The suggested thresholds are a decrease of 20% at 2 monthly examinations in fistulas with a flow rate below 1 L/min.

In mature fistulas, it must be borne in mind that the performance and results of percutaneous dilatation are very much operator-dependent. This apparently simple, minimally invasive, procedure

provides conflicting results because inexperienced operators frequently either underdilate stenoses that should be treated aggressively or dilate stenoses that are contraindications to any treatment because of underlying excessively high flow (elbow fistulas) or precarious arterial supply to the hand (diabetics, elderly), or simply because these stenoses would never threaten fistula patency. In particular central veins stenoses should be treated only in cases of handicapping arm edema since they are rarely responsible for underdialysis or for thrombosis of an arteriovenous access.

The training and qualifications of physicians performing such procedures are unfortunately sometimes questionable. As an illustration, 1-year primary patency rates after dilatation of stenosis in forearm fistulas range from 26 to 70%.

The largest series published to date showed that the outcome of native forearm fistulae after either dilatation or declotting is much better than that of upper arm fistulas, which is better than prosthetic grafts. The dedicated interventional radiologist is therefore well placed to support the all autogenous fistula policies supported by official guidelines, whereas sporadic surgical articles still support premature graft placement as soon as the first attempt at creation of a native forearm fistula fails.

Indications for stent placement must be limited to acute dilatation-induced ruptures that are not controlled by reasonably long low-pressure balloon tamponade and to clearly insufficient results of dilatation (central veins and upper arm fistulas). This means that stents should never be placed in forearm fistulas, except for rupture control, since residual stenosis after dilatation in the forearm is always the consequence of the use of a balloon of insufficient diameter.

In addition, the interventionist should not place a stent that would overlap a major venous confluence, for example the confluence of the subclavian and internal jugular veins, which would preclude future placement of a central catheter.

Trials using cutting balloons, covered stents and coated stents are in progress, with the goal of improving outcome after percutaneous treatment since, as after more invasive surgery, restenosis remains a key problem after percutaneous treatment.

A compilation of recent literature seems to show a slight advantage for surgery over interventional radiology in the success and patency rates for treatment of dysfunctional and thrombosed grafts. This compilation however fails to remind all the methodological flaws of several local randomized studies denounced in 'Letters to the Editor'. More over the drawbacks of surgery, invasiveness and consumption each time of some centimeters of healthy vein, are never acknowledged. Finally, there was no comment about the fact that the 40% rate suggested at 1 year by the DOQI guidelines after surgical declotting of prosthetic grafts was achieved by none of the 3 most recent studies, whose rates range from 23 to 26%.

For autogenous fistulae, the wide differences in the published success rates plead obviously in favour of the endovascular approach. Although randomized studies would be ideal, the question arises whether it would be ethical to refer patients with a thrombosed autogenous fistula for surgery when the available literature shows disappointing results in the best surgical hands compared to interventional radiology in experienced hands. However, in this as in many areas, the role of the learning curve and the expertise of the interventionist are essential because there are many technical problems to be overcome.

As interventional radiology has now been proven to be able to save fistulas which are unsalvageable by open surgery, it can be claimed in 2003 that there is a loss of opportunity for patients

dialyzed in centres not working in close cooperation with dedicated interventionists. Nephrologists should encourage a truly multidisciplinary approach to vascular access and have the courage to oppose their colleagues who still deny the value of endovascular techniques.

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The Nephrologist's Point of View – Multidisciplinary Approach in a Vascular Access Program – Is It Relevant to the Outcome?

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Nephrologists are responsible for the treatment of renal patients on dialysis. This means they must correct the problems that the patients have during the natural course of the disease but, more important and in order to optimise the results, they must work in a preventive or proactive way. This is true for medical practice in every speciality but has been shown to be very relevant in what concerns the function of the vascular access (VA) and the consequent outcomes of dialysis. It is well known that more than 50% of the grafts with a significant stenosis will clot in 6 months, and if the VA has a blood flux under 600 ml/min the clotting risk is twofold in comparison to those having a flux above 1,000 ml/min. Continuous monitoring and correction of parameters like these will be very effective.

We know that a good quality of life and long survival both depend, among other factors, on the adequacy of dialysis. We also know that a good dialysis cannot be reached without a VA that is not working properly. To plan a proactive work about the VA on the dialysis centre, the nephrologist must create a monitoring routine. In the dialysis centre there must be answers to questions like: number and percentage of AV fistulas, grafts (PTFE) and catheters, with their respective duration or complication rate; results of interventions over complications; should the problems be corrected by surgery or interventional radiology. The answers to questions like these will identify the problems that the nephrologist faces in order to give patients the most appropriate treatment. Next, specific goals must be created and the other professionals informed about them. Here are some examples of these goals: every patient must have the most appropriate VA; develop mechanisms for continuous search of the VA at risk; create data about the complication's rate of the vascular accesses and define targets; establish routines that may maximize the life of the vascular accesses. To accomplish this it will be necessary to gather a multidisciplinary team, having a Coordinator and integrating professionals from several areas: nephrologist, nurse, radiologist and vascular surgeon. Besides the identification of problems and planning of the respective corrective measures, the main responsibility of the Coordinator is to promote contact among all the elements of the team in search of the best solution for the patient.

Several groups have reported their experiences with this proactive approach, already with some years, and the results are undoubtedly good.

Multidisciplinary Approach in a Vascular Access Program – Is it Relevant to the Outcome?

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Patients with chronic illnesses must navigate a complex regimen of multiple physicians, medications, and therapeutic approaches. This is certainly true in the case of End-Stage Renal Disease (ESRD). Coordination of the medical team improves patient care and can reduce hospitalizations. However, this level of coordination is difficult to accomplish.

In the case of ESRD there are at least five participating specialties: primary care physicians, nephrologists, interventional radiologists, anesthesiologists, and surgeons. We attempt to define the proper roles of each of these specialties. Also discussed is the use of temporary catheters, timing of cannulation, the dialysis center, access thrombectomy, and infections in vascular access.

We conclude by maintaining, a well structured and organized multidisciplinary team approach is the most practical and efficient way to achieve quality care for ESRD patients. This is accomplished by a higher incidence of arteriovenous fistulae, decreased use of temporary catheters, increased long-term patency, less hospitalization, and fewer repeat surgeries.

Multidisciplinary Approach in a Vascular Program – Is it Relevant to the Outcome? – The Radiologist's Opinion

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A multidisciplinary approach to vascular accesses is essential to provide the best vascular access to patients undergoing hemodialysis. From its very beginning the development of the DOQI guidelines rely upon the participation of experts from multiple disciplines. The NKF – K/DOQI vascular access work group members concluded that the quality of life and overall outcomes for hemodialysis patients would be improved by increasing the placement of native fistulae and detecting access dysfunction prior to access thrombosis, so their long-term patency could be enhanced as much as possible.

The ability to prevent and correct access thrombosis is likely when there is a multidisciplinary team approach, with a consensus about the goals among all interested parties (nephrologists, surgeons, radiologists, dialysis nurses, and patients), and when there is a prospective tracking of outcomes with continuous quality assessment.

However some occurrences act as barriers to the improvement of such a team, so they need to be pointed out:

1. Insufficient resort to preoperative imaging.
2. Underestimation of the value of some surgery techniques that make possible to get successful anastomosis (such as transposed AV fistulas), leading to place too many prosthetic grafts.

3. Failure of monitoring the vascular access function.
4. Insufficient development of endovascular techniques that can save dysfunctional and thrombosed fistulas unsalvageable by conventional surgical techniques.
5. Failure of a restriction of vascular access procedures to surgeons with demonstrable interest and experience, as well as insufficient training (or lack of motivation) of radiologists to perform interventional radiology procedures.
6. Lack of communication among the involved parties of the multidisciplinary team.
7. Failure of an early referral of patients for placement of vascular access, as well as to the management of access dysfunctions or thrombosis.
8. Unreasonable reimbursement systems, so misconducts are sometimes explained by shortsighted economic considerations whereas appropriate strategies finally proves to cost less in the long-term.

Vascular Access Centers Present and Future

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Current dialysis access centers are characterized by crisis management with problems such as clotting being diagnosed at time of dialysis treatment initiation. In contrast, and by design the future center functions in a proactive fashion and is more likely to diagnose problems during protocol surveillance leading to prevention measures. Current access surgery and interventions are prone to high failure rate, tend to be delayed and 'add on' cases at high cost and overuse of central vein catheters to temporize patients waiting for days to weeks for more definitive procedures. The future dialysis patient is treated in a facility where surgeons and interventional radiologists work together or independently as each case scenario mandates. The turn around time is a few hours, without delay, seldom requiring catheter placement at a markedly reduced cost to society and at a predicted overall immediate success rate over 90%.

Partly because of lack of leadership and accountability, patient follow up and data collection is often poor in the current system. The ideal access center has a mission statement with the patient's welfare at highest priority, and has a clear line of command.

Because of great geographical variations, level of local technical and financial support systems, we can only do the right thing for our fellow man at right time, in the right amount, and for the right reason. Our efforts must occur within the framework of our conscience, skills and knowledge, modeled by the culture and society laws in which we live.

Vascular Access Centers – Pro

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The placement and maintainance of a well-functioning vascular access remain the lifeline for the dialysis patient and is often the bottleneck for dialysis treatment. Traditionally, vascular access creation and salvage have been hospital-based services using surgical and percutaneous techniques. However, due to this hospital-based system and the increasing and aging population, patient morbidity, hospital stay and healthcare costs have increased too.

A dedicated vascular access care facility focusing on all aspects of access management, including preplacement imaging, best access creation, postoperative monitoring and elective or acute intervention may improve vascular access outcome and decrease morbidity and costs. The vascular access center (VAC) should be equipped with sufficient and optimum devices and staffed with dedicated nurses, nephrologists, vascular access surgeons and interventional radiologists. For preplacement imaging, non-invasive vessel assessment with the aid of Duplex scanning performed by vascular technicians should be available. This duplex scanning may also be helpful in the diagnosis of difficult access problems and in the follow up of fistula maturation. Ultrasound-guided placement of jugular vein catheters is an integrated tool of the VAC.

An integrated surgical and interventional unit enhances the application of hybrid procedures as surgical/percutaneous thrombectomy combined with angioplasty. A fixed or portable C-arm fluoroscope, producing digital subtraction images and road mapping, aims to complex interventional procedures and in addition completion angiography after surgical access procedures. Data management of all procedures is of utmost importance and an appropriate data base and computer/laptop must be available. In particular, a VAC should standardize procedures and follows protocols. Therefore, vascular access guidelines (KDOQI/European guidelines) can be very helpful in fulfilling this task.

Placing and maintaining an appropriate vascular access for the dialysis patient will reduce the number of hospitalisations and procedures, improving quality of life. This can be achieved by a freestanding vascular access center with dedicated nurses, nephrologists, surgeons and interventionalists, delivering high quality-patient care.

in elective access procedures [1]; it has been also proposed that the creation of highly specialized vascular access centers will help to a better application of an improved quality of care. However we need centres for not frequently performed complex surgical procedures in order to increase the 'critical' number of patients needed to get and maintain expertise; e.g. there are centers for thoracoabdominal aneurysms, for liver transplants etc but not for embolectomies or carotid endarterectomies. Angioaccess is one of the most frequently performed vascular procedures [2, 3] and is not a complex operation as in many units nephrologists report excellent results [4].

There are accusations that vascular surgeons are unwilling to be involved in access surgery but an explanation may be that many of them have never been exposed to this type of surgery during their training. Data from two European countries suggest that more than half trainees in Vascular Surgery have had limited or no training in angioaccess [5, 6]. Embolectomies and amputations are equally 'non-glamorous' as access surgery is, but vascular surgeons never refused to be involved in these procedures. Other procedures also require an integrated approach as e.g. carotid endarterectomies require vascular surgeons, neurologists and interventionalists but no proposals for special centres have been made! There are indications that training defect regarding access surgery affects also other involved disciplines (nephrologists, radiologists).

Conclusion: Access surgery centres will become isolated islets of excellence. Quality standards should be reached in every single renal unit; the latter will be achieved by introducing formal training in angioaccess in all involved disciplines.

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Vascular Access Centres – The Case Against

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Access surgery has been characterized as the 'Cinderella of dialysis' as questions have been raised concerning the quality of creation and management among various renal units in almost all countries. There is evidence that discrepancy exists among international guidelines and reality of care. An integrated therapeutic approach has been proposed as well as the use of quality-index (minimum success rate)

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New Method for Tunneling in Vascular Access Surgery

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Vascular Bridge Grafts of the upper extremity have been in use for more than 25 years. All types of conduits have been employed; investigators have continually searched for a graft with superior properties. We describe a prospective randomized study comparing the new Atrium Slider Graft with the Atrium Hybrid PTFE Graft; the latter has been used for a number of years. The Slider Graft is also made of PTFE. For this study, both grafts were 6 mm in diameter and 40 cm in length. The major difference in the grafts is that the Slider Graft has a low friction polyethylene sheath over its entire length and at one end, the graft and the polyethylene sheath are attached to a metal tip. This tip has male threads, which may be inserted firmly into a Kelly Wyck, Atrium, or any other standard non-sheath tunneling system. The primary objective of this trial is to determine the safety and efficacy of the Slider Graft as compared to the Hybrid PTFE Graft in vascular access surgery. The secondary objective is to evaluate how tunneling effects graft performance. We randomized 60 subjects for this study with two equal arms. During surgery we measured various parameters including ease of tunneling, tunnel bleeding, graft weeping or sweating, and immediate patency. To assess swelling of the arm we measured circumference 7 cm above the wrist and 20 cm above the wrist prior to surgery and in follow-up visits of 1 week, 1 month, and 3 months. Long-term patency was also assessed at these visits and at 6 and 12 month visits. Our results to date show that tunneling with the Slider Graft is superior both in tunneling time and tunnel bleeding. Further, the Slider Graft virtually eliminated the complication of graft sweating and seroma development. The patency rate of the Slider Graft showed a superior trend when compared to the Hybrid Graft. We are currently completing a 12 month follow-up. In summary, we feel the Slider Graft has significant advantages when compared to the Hybrid Graft.

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Side-to-side Brachio basilic Fistulas – Retrospective Study

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Purpose: Retrospective analysis of 77 side-to-side brachio basilic fistula. Most fistulas were performed in patients with basilic and cephalic vein connected by a median vein.

Materials and Methods: We analysed 77 brachio basilic fistulas, performed in 73 patients from 1978 to 1999. Sixty-six % of these patients were male and their average age were 49.6 ± 17.4 (range: 5–79). Seventeen were above 65 years (12%) and 7 were diabetic (5%). Follow-up was carried out in 96% of the patients. Thirty-six of these fistulas (47%) were the first vascular access of the patient.

Results: There was not early failure. The complication rate was 0.14/fistula-year. These complications included: dysfunction for venous stenosis, 11; venous hypertension, 9; steal syndrome, 8; difficult puncture, 8; thrombosis, 7; aneurysm 5. Due to lose of cephalic vein puncture site partial proximal vein transposition was performed in 11 cases. Primary cumulative patency was 89%, 64% and 53% at 1, 3 and 5 years. Secondary patency was 95%, 80% and 70% at the same years.

Conclusion: The brachio basilic fistula, as a second option if a radiocephalic fistula cannot be performed, increases the possibility of autogenous access. This kind of fistula are a good alternative, with a long patency rate and low complication rate.

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Maturation of Radiocephalic Fistulas: A Role for Matrix-degrading Proteins?

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Background: Maturation of autogenous radial-cephalic arterio-venous fistulas (RCAVF) for hemodialysis is believed to depend on the radial artery (RA) remodeling capacities. Vascular remodeling in this notion is initiated by a sudden increase in shear stress (SS) inducing an acute lumen increase and subsequent structural alterations through extracellular matrix degradation. We hypothesised that matrix degrading proteins (MMPs) and their inhibitors (TIMPs) play an important role in RCA maturation.

Patients and Methods: In a total of 12 patients (8 male; 71 ± 7 years) planned for RCA creation, RA diameter and SS were assessed before and 3, 6, 24, and 52 weeks after surgery. Serum MMP-9, MMP-2, TIMP-1, and TIMP-2 were determined before and 3 weeks after surgery. For statistical analysis the Wilcoxon-signed-rank-test and multiple regression were used.

Results: All RCAVFs matured well. RA SS increased at 3 weeks after RCAVF creation (0.20 vs 3.09 Pa, $p = 0.018$) and remained at this level after 52 weeks. RA diameter also increased at 3 weeks (2.2 vs 4.2 mm, $p = 0.018$) and remained increased at 52 weeks. The MMP-2/TIMP-2 ratio as a measure of MMP-2 activation tended to be higher at 3 weeks (85 vs 198%, $p = 0.123$). The baseline diameter related to the MMP-2/TIMP-2 ratio before surgery ($r = 0.92$, $p = 0.001$). The MMP-2/TIMP-2 ratio at 3 weeks after surgery related to the diameter at 6 ($r = 0.73$, $p = 0.04$) and 24 weeks ($r = 0.94$, $p = 0.015$) and the pre-operative MMP-9/TIMP-1 ratio related to the 1 year RA diameter ($r = 0.81$, $p = 0.005$). These observations were not confounded by heart rate, mean arterial or pulse pressure.

Conclusions: MMPs are upregulated after RCAVF creation and are related to RA diameter increase. Therefore, we suggest that RCAVF maturation may be influenced by the differential expression of MMP-2 and -9.

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Preliminary Experience with a New Intra Wall Radially Supported e-PTFE Graft

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A new e-PTFE graft (Intering, WL Gore, Flagstaff AZ, USA) with intrawall laser induced spaced radially supported enforcement rings was used in 3 distinct clinical vascular access settings.

1. Graft revision requiring crossing the antecubital fossa ($n = 20$), resulting in graft survival at 6 months of 72% (fig. 1a). 2. Graft extension revisions or bypass of stenotic segments ($n = 15$), with graft survival of 65% at 6 months (fig. 1b). 3. Complete graft forearm loop for dialysis ($n = 8$), with all grafts functioning (100%) at 6 months (fig. 1c).

The internal radial support within the graft wall itself represents a significant advantage over current external plastic rings. The radial support structure can be cut through at desired angles to be included in anastomoses. Second, the enforced segment allows suturing, further improving compliance at the anastomosis site. The main indication for the Intering graft as reported here is to negotiate angling or kinking of the graft, i.e. when crossing joints. The value of this graft in a whole graft configuration is being evaluated.

Fig. 1a-c: Intering applications: **a.** Crossing the antecubital fossa ($n = 20$), **b.** Graft extension revisions or bypass of stenotic segments ($n = 15$) and **c.** Complete graft forearm loop for dialysis ($n = 8$). Each graph examines patient, graft and clot free survival. The tick marks on the curves represent events for each survival category.

Comparative Assessment of Intimal Hyperplasia Development After 14 Days in Two Different Experimental Settings: Tissue Culture vs Ex-vivo Perfusion (EVS) of Human Saphenous Vein

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Background: Ex-vivo perfusion of human vessel segments under standardized conditions seems to be a well-suited setting for this purpose and was used to assess venous segments regarding functional, histomorphological, immunohistochemical and molecular alterations 14 days of vein culture and ex-vivo perfusion.

Materials and Methods: The ex-vivo vein support system (EVS) consists of an incubator containing a perfusion chamber and a pump allowing to perfuse the vessel segments by use of a laminar flow while maintaining a constant perfusate temperature ($37^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$), pCO_2 (35–45 mmHg), pO_2 (>200 mmHg) and pH (7.41 ± 0.05). After harvesting 5 cm segment of human saphenous vein during bypass surgery, the segment is divided in two. A segment is cultured in a Pyrex dish and the other one is perfused by use of the EVS during 14 days. Testing of vasomotion (acetylcholine, sodium nitroprussiate and norepinephrine, computer-assisted histomorphometry (KS 400 Zeiss®), immunohistochemistry (CD31, CD34, Factor VIII, MIB 1, alpha-actin) and expression of fibrinolytic factor (PAI-1 determined by Northern blot analysis) were performed before and after perfusion on each segment.

Results: 10 venous segments were cultured and perfused for 14 days. Each of the vessel segments showed preserved smooth muscle function before and after perfusion in both groups, however, none of these segments showed acetylcholine-induced vasomotion, neither before nor after perfusion. Histomorphometry revealed significant IH development in both systems after 14 days. Expression of CD31, CD34 and alpha-actin was demonstrated in all segments after culture and perfusion indicating muscular and endothelial integrity in both groups. PAI-1 mRNA expression appears to be increased twice after culture and perfusion, without significance between the two groups.

Conclusion: Culture and ex-vivo perfusion of human vessel segments are valid settings for the assessment of IH development under standardized conditions. The EVS perfusion has the advantage to reproduce human hemodynamic conditions.

Outcome of Surgery for Vascular Access in Patients Commencing Haemodialysis

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Objective: Assessment of surgical vascular access procedures for haemodialysis.

Design: Retrospective cohort audit of patients commencing haemodialysis.

Materials and Methods: Secondary patency was calculated from the date of surgery until access failure, death, transplant, conversion to peritoneal dialysis, or loss to follow-up, with all surgical procedures undertaken including immediate failures and fistulae failing to mature included in distinction to most Renal Registries which only record patency from commencement of dialysis, possibly excluding early failures and deaths.

Results: 445 operations were undertaken in 197 patients over 87 months comprising 273 access creations and 172 revisions. Median follow-up was 26 months with a mortality of 9.4 deaths per 100 patient-years including 8 deaths within 30 days of surgery. Autogenous access was initially created in 147 (75%) patients with 142 based on the radial artery whilst 50 prosthetic grafts, including 46 PTFE grafts and 40 forearm loops, were placed. Patients receiving grafts were more likely to be older, female and die in follow-up. Grafts had higher secondary patencies of 89%, 75% and 68% at 1, 2 and 4 years compared to 69%, 63% and 55% for autogenous access. This difference was significant ($p = 0.049$) when the effects of the presence of diabetes and peripheral arterial disease were accounted for but more frequent revisions were required for prosthetic access. The patencies of prosthetic grafts is higher and that of autogenous accesses similar to recent reports of vascular access patency despite significant differences in reporting methods. The final access placed was autogenous in 110 (56%) and prosthetic in 87 (44%) patients.

Conclusions: High secondary patency of vascular accesses including for prosthetic grafts, high autogenous utilisation and relatively infrequent reintervention have been demonstrated although variations in reporting methods make these differences in reported patencies difficult to interpret.

The Hemodialysis Access Center – An Integrated Vascular Access Management Program

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Background: Access related morbidity is responsible for 25% of stays in hospital in dialysis patients in the USA. We have developed algorithms for an integrated approach to the creation of arteriovenous fistulas (AVFs) and maintenance of functional patency, under the direction of a dedicated vascular access surgeon. Pre-operative imaging, anesthetic and surgical techniques, together with a post-operative surveillance program, were implemented in a program to maximize primary arteriovenous fistula (PAVF) creation and to significantly improve functional patency in both PAVFs and bridge graft fistulas (BGFs).

Design: Descriptive study.

Methods: High-resolution duplex ultrasonography was added to careful clinical assessment in timing, planning and follow-up of the dialysis access. Supraclavicular brachial plexus block, which allowed the use of an arterial tourniquet and gave a post-operative sympathectomy type effect, was used preferentially for anesthesia, and together

with meticulous surgical technique, prevented spasm. Access puncture, post-operative follow-up and surgical revisions were planned in close cooperation with the nephrology team. After surgery patients entered a program of frequent and regular AVF surveillance and maintenance. Prophylactic surgical revisions and endovascular interventions were performed routinely according to ultrasonography findings in order to prevent thrombosis. Thrombolysis and thrombectomy were performed without delay when AVFs thrombosed, minimizing the usage of central venous access and salvaging the central veins. No patients were excluded from studies that we have reported.

Results: Six hundred thirteen AVFs were constructed from the establishment of the Access Center in 1999 until 2002. The ratio of PAVF:BGF construction rose from 35% before 1999 to 70% in 2001 and 2002. The early (1-month) failure rate was <1% for PAVFs and 5.6% for BGFs. For PAVFs the 18-month functional patency was 98.6%. For BGFs the 12-month functional patency was 91.4%. There were 13 interventions in 73 PAVFs over an 18-month period, and 155 interventions in 158 BGFs over a 3-year period.

Conclusions: High functional patency rates for AVFs can be achieved in the setting of an integrated vascular access management program comprising good planning, attention to anesthetic and surgical technique, close follow-up and aggressive intervention (when indicated).

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Management of Aneurysms of Vascular Access for Hemodialysis

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The aneurysms are complications of vascular access for hemodialysis with multi manifestations (skin erosion, infection, thrombosis, embolism, hemorrhage, nerve compression).

Aim: The aim of this project is the presentation of our experience on management of aneurysms of vascular access for hemodialysis and the discussion over the prevention measures of aneurysms manifestation of vascular access as well as the necessity for prompt management.

Patients and Methods: From September 1991 to December 2002, 31 patients suffering from end stage renal disease, with aneurysms of their vascular access for hemodialysis were managed (17 female and 14 male, aged 30–72 year). In 19 cases it was found to be vein aneurysm, in 7 cases anastomotic aneurysm whereas in 5 cases pseudoaneurysm of vascular access created using PTFE graft. In 11 patients 14 complications were manifested (2 skin erosion, 3 infection, 5 thrombosis, 4 hemorrhage). In all cases the aneurysms were existed. In 1 case the restoration was done by direct anastomosis, in 1 case by PTFE patch, in 3 cases by more proximal arteriovenous anastomosis and in 16 cases by using bridge PTFE graft keeping at the same time the function of vascular access whereas in 10 cases the vascular access was abolished.

Conclusion: In conclusion prevention measures should be taken in order to avoid the manifestation of vascular access aneurysms, whereas emphasis should be given on prompt management of aneurysms aiming at the avoidance of the appearance of complications and at the maintenance of vascular access function.

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Prospective Randomised Multicentre Study on Conventional vs Hooded Access Graft-to-vein Anastomosis – Preliminary Results

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Introduction: The high frequency of venous anastomotic stenosis is the main reason for the low patency rates of haemodialysis access grafts. In computerised simulations and in-vitro studies, hooded anastomoses showed optimised flow patterns. After the end of the run-in phase, preliminary results of a prospective randomised multicentre study comparing both patterns of anastomosis are presented.

Materials and Methods: Beginning in July 1999, ESRD patients were randomised after informed consent, when an upper arm bridge graft had to be implanted for initiation or maintenance of haemodialysis therapy, i.e., when autologous superficial veins with sufficient calibre for successful access creation were absent on both arms. Following randomisation either a conventional carbonised ePTFE prosthesis (IMPRA Carboflo™, 6 mm or 7 mm; group C) or a hooded graft (IMPRA VenaFlo™, 6 mm or 7 mm; group H) was implanted. Patients have been followed-up at regular intervals for up to two years. Primary, primary assisted and secondary patency rates were calculated according to the Kaplan-Meier method. Detailed pre-study calculations had shown that a minimum of 410 grafts was necessary for sufficient statistical analysis.

Preliminary Results: The run-in phase ended in June 2002, when 418 patients (group C: 207, group H: 211) had been enrolled (62% female, 38% male, mean age 64.4 years). Most of the patients (75%) had one or more access procedures on the same arm before implantation of the graft under study. These and other epidemiological data did not differ significantly between the two study groups. Preliminary life table-analysis was calculated after more than half of the patients had reached one of the predefined end points (24 months of follow-up, death, transplantation ...). Primary patency of group H (group C) grafts was 73.6% (61.2%) at one year and 63.3% (47.4%) at two years ($p < 0.05$), whereas primary assisted and secondary patency rates of both groups did not differ significantly. There was, however a consistent trend to better assisted primary and secondary patency rates for hooded grafts.

Conclusion: Preliminary results of a prospective randomised multicentre trial on haemodialysis access grafts indicate that a hooded graft-to-vein anastomosis may provide better patency rates than a conventional end-to-side anastomosis. Even with this optimised anastomotic design, however, failure rates still are high. Grafts therefore remain a secondary access option for patients with exhausted superficial veins unsuitable for creation of autologous arteriovenous access.

Multicenter Results of Using a Mesenteric Vein Bioprosthesis as a Conduit for Hemoaccess in Patients with Multiple Failed ePTFE Grafts Placed in the Leg

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Placement of thigh AV fistulas is noted to occur in <10% of all access procedures. These grafts are usually fraught with an infection rate as high as 30% as well as a multitude of complications. We report the results of a prospective multicenter trial evaluating the use of a mesenteric vein bioprosthesis (MVB) (ProCol[®], Irvine, California) in patients who have had multiple failed ePTFE graft failures for hemoaccess. Grafts were placed in 76 legs at four centers between October 1999 and December 2002. Covariants were consistent with a high-risk group and were similar between the two groups. The MVB group had an average of 2.63 prior grafts, and the ePTFE cohort averaged 2.08 prior grafts.

Primary and secondary patency rates were analyzed by Kaplan-Meier with log-rank probability estimates. The 12-month primary patency rate was 48.5% in the MVB group and 31.1% in the ePTFE cohort ($p < 0.08$). Secondary patency rate for the MVB group at 12 and 24 months was 73.7% compared to 53.9% and 37% for ePTFE ($p < 0.01$).

The occurrence of all adverse events in the 76 grafts was significantly less in the MVB group ($p < 0.01$). The rate of infection requiring surgical intervention associated with the MVB cohort was 0.08 events/graft/year vs 0.25 events/graft/year experienced with ePTFE ($p = 0.04$). As a result of a lower incidence of complications, the number of interventions performed on these patients was markedly favorable for the MVB cohort at 0.49 interventions/graft/year vs 1.29 interventions/graft/year ($p < 0.01$).

In a complex patient population where a leg graft is implanted, the MVB cohort presented with patency rates comparable to those reported for upper extremity access. Additionally, complications of infection and thrombosis were low for the MVB cohort. The MVB graft should be considered the graft of choice for those patients requiring a graft in the lower extremity.

Multiphase Contrast-Enhanced Magnetic Resonance Angiography for Detection of Stenoses in Forearm Arteriovenous Fistulae for Haemodialysis

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Digital subtraction angiography (DSA) of haemodialysis arteriovenous fistulae (AVF) often fails to identify stenoses due to over-projection and sub-optimal depiction of vascular structures. The purpose of this study was to assess the diagnostic value and accuracy of contrast-enhanced MR angiography (CE-MRA) in patients with flow-declined haemodialysis AVF.

Patients and Methods: Fifteen patients with dysfunctioning AVFs (8 radiocephalic/7 graft AVF) underwent CE-MRA. Dysfunction was defined as a flow decline of >25% within 1 month or a flow <600 mL/min. CE-MRA was performed during injection of 35 mL of Gadolinium. The CE-MRA sequence consisted of a time resolved series of 10 scans, each lasting approximately 10 seconds. All patients were scheduled to undergo DSA at which an intervention was carried out if a stenosis >50% was seen. Two observers quantified the number and degree of stenosis in the failing AVFs. Image quality for CE-MRA and DSA were scored on a 3-point scale and stenoses were measured. Interobserver agreement was calculated with kappa statistic and diagnostic performance was analyzed with receiver-operator characteristics (ROC) analysis.

Results: Image quality was scored significantly better on CE-MRA (observer 1: CE-MRA 2.0, DSA 1.3, $p = 0.001$; observer 2: CE-MRA 2.0, DSA 1.4, $p = 0.002$). Interobserver agreement for detection of $\geq 50\%$ stenosis was 0.81 (95% CI: 0.71–0.92) for CE-MRA and 0.69 (95% CI: 0.55–0.84) for DSA. ROC analysis revealed a mean area under the curve of 0.78. On patient level, at the 50% threshold, mean sensitivity, specificity, positive predictive value and negative predictive value were 100% (95% CI: 69–100%), 10% (95% CI: 0–78%), 70% (95% CI: 38–92%) and 100% (95% CI: 50–100%). At a 75% threshold, mean sensitivity, specificity, positive predictive value and negative predictive value were 75% (95% CI: 20–99%), 78% (95% CI: 39–98%), 55% (95% CI: 12–96%) and 89% (95% CI: 52–100%).

Conclusion: CE-MRA is an accurate method for detecting stenoses in flow-declined haemodialysis AVFs.

Perigraft Seromas Complicating Prosthetic Bridge Arteriovenous Fistula – Solution with Autogenous Vein Interposition

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Perigraft seroma is a collection of clear and sterile ultrafiltered serum, encased by a fibrous pseudocapsule, developing around a patent prosthetic vascular graft. It has been reported with both Dacron and polytetrafluoroethylene (PTFE) prosthesis implanted as arteriovenous bridge fistula or in arterial reconstructive procedures. In arteriovenous bridge fistulae, seromas appear as painless lumps around the arterial anastomosis. Although most seromas remain stable and complication-free for long periods of time, some patients with prosthetic grafts require treatment because of impending necrosis of the overlying skin. Several techniques for the correction of this complication have been described in small series or isolated case reports.

In the present report we describe a successful corrective procedure with autogenous vein interposition in perigraft seroma complicating PTFE arteriovenous bridge fistula. Eight hemodialysis patients aged 40–81, on hemodialysis for 1 month to 20 years, with PTFE arteriovenous bridge fistula, developed a perigraft seroma. The seroma and its pseudocapsule were resected. Then, the transuding segment of prosthesis was replaced with reversed greater saphenous vein, placed along the same route. Follow-up extended from 1 to 14 months. Five patients died of unrelated causes, with their fistulae patent. One of them underwent successfully thrombectomy of the graft 7 months later and died 7 months thereafter. Three patients are alive: two with their fistulae patent at 1 and 6 month follow-up; one had his fistula thrombosed and abandoned 6 months later.

This procedure resulted in immediate resolution of the seroma with preservation of the arteriovenous graft, leaving the shunt immediately available for cannulation at the unreplaced segment. Long-term results are unavailable due to the high death rate in this series. Although small, this series raises the possibility that perigraft seroma may be associated with a poor survival prognosis.

Prospective Randomized Study Comparing 6 mm and 6–8 mm Upper Arm Grafts for Dialysis

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Purpose: Comparison of two different diameters of PTFE upper arm grafts (Stretch Gore-Tex graft): 6 mm and 8 mm tapered to 6 mm at the arterial size (6–8 mm).

Methods: Prospective, randomized study. January 1997–January 2002. Nondiabetic patients aged less than 70 years in which

no autogenous fistula could be performed either at the wrist or the at the elbow crease. Surveillance program was performed with access flow studies (Transonic®) and fistulography and treatment of stenosis performed in patients with accesses flows lower than 600 ml/m.

Results: Seventy patients were included (35 of 6 mm and 35 of 6–8 mm). Age, gender and N. of patients with temporary dialysis catheters matched closely in the two groups. Complication rate (N. of episodes needing surgical or radiological repair per year of follow-up) were as follows: 6 mm grafts: 0.45/graft/year. 6–8 mm grafts: 0.19 graft/year ($p < 0.01$). Primary patencies: 6 mm grafts: 0.74, 0.62, 0.49 at 1, 2 and 3 years. 6–8 mm grafts: 0.91, 0.78 and 0.78 at 1, 2 and 3 years. ($p < 0.05$). Secondary patencies: 6 mm grafts: 0.94, 0.85, 0.85 at 1, 2 and 3 years. 6–8 mm: 0.97, 0.90, 0.90 at 1, 2 and 3 years. (Not Significant). Maximal access flow was 975 ml/m (CI: 889–1,060) for 6 mm and 1,397 ml/m (CI: 1,112–1,672) for 6–8 mm graft ($p < 0.01$).

Conclusions: In a nondiabetic population of patients aged less than 70 years, 8 mm grafts tapered to 6 mm at the arterial site have a significant lower complication rate and better primary patency. Under an access flow surveillance program and prompt treatment of stenosis both kinds of grafts reached a similar secondary patency, but 6 mm grafts needed double number of rescue procedures.

Wrist Arterio-Venous Graft Fistulas for Early Hemodialysis Cannulation

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Background: Due to the urgency of hemodialysis need, patients can be divided in 3 groups. The ones who are in need of hemodialysis as soon as possible, the patients who are to be involved in a hemodialysis program in a couple of days and the ones in months. The first two groups are usually managed with percutaneous catheter placement and suffer subsequent complications of catheterization. In the light of the safety of early cannulation of PTFE arterio-venous grafts, this study assesses the results of a new technique, which disposes of the need for catheterization and its possible complications. The technique also allows consequently reconstructed radio-cephalic and brachio-cephalic fistulas to be cannulated earlier than expected since the vein is already matured due to the previous AV access.

Materials and Methods: From December 2000 to November 2001, 5 patients who were in need of urgent dialysis within 48 hours were included in the study. Three of the patients were male and 2 were female. The mean age of the patients was 59 (55–67) years. A PTFE graft of 6 mm was interposed between the radial artery and the cephalic vein at the wrist.

Results: An effective hemodialysis was achieved in all of the patients in a mean duration of 34.4 hours (16–48). Five episodes of thrombosis were utilized with thrombectomy in 2 patients. A consequent AV fistula was reconstructed in 2 patients. These native fistulas were cannulated in 24 hours.

Conclusion: This new technique, which shares common backgrounds with formerly used external AV shunts and the possibility of

early cannulation of PTFE grafts is a promising one in patients who require an immediate hemodialysis within hours and it avoids the subsequent unwanted results of subclavian and jugular catheters.

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Results of Proximal Re-Anastomosis in Stenosed Brescia-Cimino Fistulae

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Introduction: Stenosis of the vein close to the arteriovenous anastomosis is the most frequent cause for late failure of Brescia-Cimino fistulae (BCF). Although since decades proximal re-anastomosis has been regarded as the surgical standard treatment, success rates of this procedure have rarely been published. Considering the increasing activities of interventional radiologists surgical position finding seems necessary.

Methods: Over three years 30 anastomotic BCF stenoses were treated in 28 patients. In 15 patients the stenosis had caused fistula thrombosis. In all cases the fistula vein was re-anastomosed to the proximal radial artery immediately above the venous stenosis. All patients could be followed up (average 12 months). Each fistula functioning after 24 hours was classified as procedural success. For calculation of patency rates (life table analysis), however, usability of the needling segment of the access was assessed.

Results: Procedural success rate was 100%. One fistula thrombosed on the second postoperative day after a successful dialysis session due to an overlooked proximal stenosis of its feeding radial artery. In five fistulae stenoses developed after 4 to 13 months. In only one fistula this was a true re-stenosis of the newly created anastomosis (0.03/patient/year). Two of the stenoses occurred in the needling segment of the access vein and within its central venous outflow, respectively. Overall (surgical plus interventional) revision rate was 0.3/patient/year, and primary (secondary) patency was 80% (95%) at one year and 67% (87%) at two years.

Conclusion: In BCF proximal re-anastomosis is a simple and effective therapeutic option for anastomotic venous stenosis. Re-intervention rates are low and procedural success rates as well as primary and secondary patency rates at least equal those of interventional radiology.

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Technical Aspects of Implantation of Venaflow™ Grafts as AV-Angioaccess

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It is a well recognized fact that intimal hyperplasia at the venous anastomosis is a major cause for complications seen in arteriovenous prosthetic grafts used for hemodialysis. Hemodynamic phenomena

may induce the development of intimal hyperplasia. Based on this knowledge, C.R.BARD/IMPRA manufactured a new vascular graft design. The bulb-like shape of the venous end-to-side anastomosis is the basic idea of the Venaflow™ vascular graft. The special design is achieved by a prefabricated cuff attached to the venous anastomosis. The trimmed cuff leads to an enlargement of anastomotic room with a curved vein floor. Flow studies related to this device suggested that blood flow patterns were optimized in comparison to conventional AV grafts. A calming down of the flow was proven, which was caused by a large vortex with clockwise rotation due to flow separation from the inner wall. The impact area on the floor of the vein is much larger diffusing the pressure. We have an experience of 700 Venaflow™ grafts implanted at different sites since 1992, during first time in self made configuration. That allows to recommend practical remarks for implantation.

1. The venous anastomosis has to be placed outside of flexional crease.
2. The minimal vein diameter at maximal dilatation should be greater than 3 millimetres.
3. Venous side branches at anastomotic site should be ligated.
4. The prefabricated cuff of Venaflow™ graft has to be trimmed referring to the vein diameter.
5. The created anastomosis has to be presented with typical bulb-like shape.
6. Dead water regions at anastomosis have to be avoided.
7. The length of narrow segment of preferred tapered grafts has to be adjusted to blood pressure and diameter of artery.

Given remarks are proved and demonstrated by experimental and clinical facts and examples.

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Comparative Evaluation of Subcutaneously Transposed Basilic Vein vs Polytetrafluoroethylene Prosthesis in Creation of Vascular Access for Hemodialysis

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As the survival of hemodialysed patients become more extended, many procedures to achieve angioaccess are often required. Since the usage of polytetrafluoroethylene (PTFE) grafts has significantly improved the results of angioaccess operations, this method became a standard at many institutions. However, it should always be considered to use an autologous vein and avoid an implantation of a synthetic graft.

Thus, the aim of this study was to compare the usefulness of PTFE grafts to subcutaneously transposed basilic vein (STBV) as an AVF on arm.

To achieve the purpose of the study we selected 914 patients operated on at our institution between January 1984 and July 2002. In 472 patients AVFs using STBV were created (group A), while in 442 patients we used PTFE grafts (group B). The groups were comparable with respect to age, sex, comorbidity, and duration of hemodialysis.

There were 568 females and 346 males among the patients. Median age was 45 years (range, 2–71). Duration of hemodialysis ranged from 0 to 144 months (mean, 37.1 months). One year and 5 years primary patency rates were 78.9% and 37.5% for group A and 71.3% and 35.0% for group B, respectively. One year and 5 years cumulative patency rates were 86.6% and 66.9% for group A and 81.1% and 57.2% for group B, respectively ($p < 0.05$). The incidence of complications leading to a loss of the fistula was 21% in group A and 31.9% in group B ($p < 0.05$). Among them the most common was thrombosis (9.7 % in group A) and infection (18.2% in group B).

As we found significant differences in patency and complication rates between two evaluated methods, we conclude that STBV AVF is a superior one comparing to PTFE fistulas.

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An Underestimated Resource for Difficult Patients – The Lower Limb A-V Fistulas

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This report deals with early and long term results obtained out of 110 angioaccess grafts placed in the groin of 99 dialysis patients (56 women, 43 men, aged 52.8 ± 17.4 yrs, range 5–79 yrs), on dialysis for 202.5 ± 117.5 months, range 33–396 months, coming from all over Italy because of no suitable veins in the upper limb, bilateral thrombosis of central veins and failed peritoneal dialysis.

The personalized guidelines, based on a 35 year-experience, foresee a careful policy of native vessel preservation, also in the lower limb. The construction of superficial femoral artery-saphenous vein graft in a straight configuration is advisable, if the diameter of the saphenous vein above the knee is over 4 mm (34 times). Really, the straight configuration allows the re-utilization of the same vessels in a more proximal area for the construction of a new access in a loop configuration, when the previous fails or the saphenous vein is too small (57 times). Common femoral artery (7), femoral vein (6), both of them (4) and iliac artery-vein (2) have been also adopted for a loop graft, whilst we preferred not to use the popliteal artery, due to high risk of critical ischemia of the lower limb.

Graft materials employed for these access grafts in the thigh were: native saphenous vein (3 times), homologous saphenous vein (33 times), Bovine Carotid (18 times), sheep ovine Omniflow® (52 times), new bovine ureter Synergraft® (1 time), other prostheses (3 times). With a mean of 17 year follow-up, the mean function was 29.4 ± 31.7 months (range 0–146 months). No lethal complication occurred in any of our patients. The global primary patency was 41%, 21% and 18% at one, three and five year, respectively. The secondary assisted patency was 77%, 50% and 46% at the same time intervals.

Four femoral shunts were lost due to infection. In case of deep infection, the lower limb A-V fistulas was always dismantled.

Although a relative high number of re-operations (136) were required to maintain this cumulative secondary patency, prosthetic grafts for vascular access placed in the groin represent an efficient and long lasting durable access procedure.

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A Xenograft for Vascular Access: A New Start to an Old Idea?

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Glutaraldehyde fixed xenografts and allografts have been tried before for vascular access for haemodialysis but have proved difficult to use and prone to dilatation.

Access created with polytetrafluoroethylene grafts give immediate high flows and can be needled early. However, they are prone to early failure when used in sub-optimal cases such as infection or central venous stenosis and have poor long-term patencies.

Reported here is a small consecutive series of our first use of a novel xenograft used in highly unattractive cases that have undergone multiple previous access procedures.

Bovine ureter is completely purged of cells leaving a conduit of bovine collagen without any fixative agent being applied (Synergraft by Cryolife). After implantation the graft becomes repopulated with human fibroblasts, which lay down new collagen, and the graft develops blood vessels and an endothelial lining.

We have used this graft in the upper arm in ten patients. These patients will be described. Graft patency is 9/10 with one unexpected occlusion at 42 days. Six grafts are mature enough for needling, at the time of submission of this abstract and are being used for dialysis without complication.

Hypothetically, this graft may be superior to previous grafts as it has a wall compliance between that of an artery and a vein which may limit myointimal hyperplasia, has a substantial wall thickness to avoid dilatation, can repair wall damage from needling, can remove infection from needle tracts and develop a recipient endothelium to resist thrombosis. Time will show if these benefits can be realised in practice.

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Modelling Arterial Steal in Radiocephalic Arteriovenous Fistula

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Following the creation of an arteriovenous fistula (AVF), the haemodynamics in the vascular network in the arm and hand is significant altered and this may lead in a small number of cases to ischaemia distal to the AVF, or steal syndrome. Steal syndrome is characterised by symptoms of numbness and coldness of the hand, paraesthesia, pain and if severe, may lead to tissue necrosis. It is often associated with high flow in the AVF and particularly when there is underlying arterial disease. However, the exact mechanisms remain unresolved and an understanding of the local haemodynamics may provide an insight into the possible mechanism. To investigate the local haemodynamics after the creation of an AVF, an electrical resistance model which assumes time-independent flow was used. This

model was verified in an in vitro flow circuit under steady and pulsatile flow conditions. The redistribution of flow in the presence of stenoses in various artery segments was also investigated.

The in vitro pressure-flow measurements in both steady and pulsatile flow compared well with the results of electrical circuit simulations for cases without a stenosis. When a stenosis of 75% area reduction was present, good agreement was obtained in steady flow. The direction of flow in the distal radial artery was antegrade (towards the hand) at low fistula flow and became retrograde as fistula flow increased. The presence of a severe stenosis in the brachial artery was found to have the strongest influence on flow to the hand.

We have validated an electrical resistance model of a radiocephalic AVF by comparing the predictions with measurements in vitro. A major advantage of this model is that it can be analysed using standard circuit simulation software. The model is useful in providing insights into the possible haemodynamics consequences of creating an AVF with or without the presence of a stenosis in the arterial segments.

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Single Center Review of Infections Associated with Vascular Access Procedures in Over 1,500 Procedures

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The objectives of this study were to establish accurate infection rates and causes for vascular access procedures and provide information helpful in identifying means of reducing infections. Between January 1, 1996 and December 31, 2001 (sixty months), a single surgeon (AFS) performed 1,574 consecutive vascular access procedures (850 patients) in one academic medical center. Recently, a retrospective review of these records was completed and revealed 87 subjects, or 10.2% of this patient population underwent removal of access grafts or fistula for infection. In these 87 patients, 131 grafts and one fistula were removed. This means that 8.4% (132/1,574) of the total surgeries were for infection. This review included evaluation of repeat infection, causative organism, and HIV status. Cause of infection fell into five major categories. Of our 87 patients, 26 had multiple graft infections. Increasing diabetes and hypertension lead to increased end-stage renal disease requiring more vascular access procedures. Following thrombosis, infection is the most common complication in vascular access. Therefore, mechanisms to reduce infection would be well received. This data suggests that operative infection accounts for only 6% of infective procedures and when the entire population is considered the operative infection rate is 0.51%. However, infections secondary to routine dialysis make up over 50% of this infective operative population. We noted that 17% of the infective operations were in previous infected grafts that were not initially completely removed and 23% developed in non-functional grafts. Multiple graft infections played a significant role in our investigation and warrants further evaluation.

Radiology

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Use of a Cutting Balloon for Percutaneous Transluminal Angioplasty of Hemodialysis Fistulas and Intravascular Ultrasound Evaluation

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In spite of using high-pressure balloons, sometimes fail to open arteriovenous access completely in hemodialysis patients. Recently, there are many reports that the 'Cutting Balloon' was effective in those cases. The 'Cutting Balloon' was applied for long stenosis of native venous and evaluated by Intravascular Ultrasound (IVUS). Case Report: A 65-year-old male, non-DM, suffered with dysfunction of Brescia-Cimino forearm fistula. The patient had undergone the first balloon dilation 7 months earlier. There was no remarkable residual stenosis at that time, however, about 10 cm stenosis at the same lesion was found. The 'Cutting Balloon' (*Peripheral Cutting Balloon*TM, Boston Scientific) was inflated to diameter of 6 mm with 6–9 ATM and it was easy to open. The vessel wall were observed with IVUS (*Sonicath Ultra*TM, Boston Scientific) before and after PTA. The stenotic lesion was clearly opened roundly and surface of the wall was smooth without sever destruction. This suggests that the restenosis will less occur in cutting balloon angioplasty than ordinal PTA.

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Arterial Access for Native Dialysis Fistula Thrombectomy, a Review of a New Service in a District General Hospital

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Purpose: Failure of dialysis access is a common problem in renal replacement therapy. We present a review of the first 3 years of fistula salvage in our unit, for primary success and continued patency, the value of arterial access is discussed.

Methods: 19 thrombectomies were performed in 13 patients. 10 had 1 procedure, 2 had 2 procedures and 1 has had 5 procedures. In 5 patients' thrombectomy failed and 2 required a second intervention for success. Thus 8 of 13 (62%) were successful. There were no procedure related complications. 1 patient died at 3 days of unrelated causes. At 243 days 7 fistulas are still functioning with only one requiring further interventions. 1 year Kaplan-Meier secondary patency is 67%. Of

this group 7 of 13 had arterial access (antegrade brachial or retrograde radial) 2 twice and one 4 times. 5 were successful and 2 failed, 2 were successful following a second procedure. There were no complications from arterial access.

Discussion: Intervention in our centre has been introduced with a high rate of success and a zero complication rate. Arterial access to the fistulas has shown to be a useful technique requiring a single puncture for access to the entire fistula. Arterial access requires no compression of the venous fistula, at the end of the procedure, avoiding post procedure thrombosis.

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Prospective Randomized Study Evaluating the Effectiveness of Brachithrapy in the Prevention of Re-Stenosis of Vascular Access after Balloon Angioplasty – Preliminary Results

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Background: Aim of this study was to evaluate the effectiveness of localized brachithrapy to reduce the incidence of re-stenosis of vascular access grafts in haemodialysis patients after balloon angioplasty.

Methods: We performed a single center randomized controlled study. Haemodialysis patients with graft as vascular access were divided into two groups: Group A balloon angioplasty alone, Group B balloon angioplasty and brachithrapy (Microselectron HDR-Nucletron, 12 Gy), at the moment of the need for balloon angioplasty, with monthly measurement of blood flow (ultrasound dilution, Transonic HD01) according to surveillance protocol. Any new stenosis in different positions of the graft, even in the same patient, was considered as a new case. The correct position of the brachithrapy catheter was obtained with color-doppler ultrasonography. It was possible to perform only one localized brachithrapy for each stenosis.

Results: In 14 patients (age 67.3 ± 9.7 years, haemodialytic age 82.2 ± 91.4 months) we randomized 21 cases of stenosis, 12 to Group A and 9 to Group B. After a median follow-up of 9.49 months (interquartile range 7.3–17.1 months), the incidence of need for PTA was 1.57 patient-year and 1.30 patient-year in Group A and B respectively. No statistical difference was found ($p = 0.68$). During the follow-up the incidence of thrombosis was 0.2 patient-year and 0.12 patient-year in Group A and B respectively. No statistical difference was found ($p = 0.72$). We did not find any kind of localized brachithrapy-related complication.

Conclusion: These are only preliminary results obtained in a few number of cases. However, it seems to appreciate a reduction in PTA procedures with a parallel more important reduction in the incidence of thrombosis, in the same time without related complications. This allows us to continue the study in order to obtain a more significant number of cases.

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Duplex Ultrasound Commonly Identifies Pre-Clinical Stenoses in Autogenous Arterio-Venous Fistulae

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Introduction: Although autogenous arterio-venous fistulae (AVF's) are the access route of choice for haemodialysis, it is recognised that abnormalities (stenoses, multiple venous branches) can reduce maturation potential or dialysis efficiency and may result in fistula thrombosis. Early detection and treatment of these abnormalities before they are clinically apparent may improve fistula function.

Aim: To determine whether ultrasound examination of autogenous AVF's identifies abnormalities before these are apparent clinically.

Methods: A sequential series of patients undergoing autogenous AVF formation were studied prospectively with duplex ultrasound examination of the inflow artery, anastomosis and outflow vein. Ultrasound data were compared to clinical outcome. All patients completed at least 6 months follow up.

Results: 88 AVF's were created in 80 patients (42 radiocephalic, 33 brachiocephalic, 13 brachio basilic). The male:female ratio was 1.1 to 1.0; the median age was 66 (range 17 to 83). At 6 months, 16 patients (16 fistulae) had not required dialysis. Clinical assessment of the 72 AVF's being used showed that dialysis was successful in 64 (88%), that there were difficulties with needle access in 2 (3%), that 2 (3%) fistulae occluded and that there were 4 (6%) deaths. Ultrasound assessment of the 88 AVF's that were fashioned showed that 39 (44%) had no detectable abnormality, that 35 (40%) had an identifiable stenosis, that 4 (5%) had multiple venous branches diverting fistula flow, that 2 (2%) had failed to mature (both pre-dialysis patients) and that 4 (4.5%) had occluded (including 2 in pre-dialysis patients). The 4 (4.5%) deaths were all dialysis patients.

Conclusion: Duplex ultrasound commonly identifies venous stenoses in the first 6 months after AVF formation before the stenoses are clinically apparent. This information would enable earlier intervention which may improve fistula outcome.

Soft Tissue Anchored Transcutaneous Device (T-port) for Patients with Long-Term Catheter Carrier

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Purpose: To evaluate safety, efficacy and clinical results of a transcutaneous soft tissue anchored device (T-port, Transcutan AB) in patients with long-term use of catheters such as biliary drainage, gastrostomies and peritoneal dialysis.

Materials and Methods: Twenty patients who have either biliary drainage (12), gastrostomy (4) or peritoneal dialysis catheter (4) were offered a T-port implantation in local anesthesia.

Results: There were no technical problems to implant the T-ports. The wound around the T-port healed well in all patients. There were no sign of infection around the ports during a follow-up period between 3–12 months. Leakage and infection alongside the tubes were not observed. The tubes were easy to exchange through the ports. The life quality was considerably improved with less local problems and improved cosmetic results.

Conclusion: The T-port considerably improve the quality of life by preventing infection, leakage and a catheter dangling outside the body.

A Novel Technique for Percutaneous Treatment of Stenotic Vascular Access Lesions Preliminary Experience with the CVSi™ PolarCath™ System

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Intimal hyperplastic stenotic lesions are the major cause for malfunction and thrombosis of hemodialysis vascular access. Elective percutaneous transluminal angioplasty (PTA) of these lesions expand the lifetime of arteriovenous fistulas (AVF) by prevention of thrombosis. However, primary patency after PTA is low due to restenosis. A new PTA technique using cryoplasty, resulting in a cooling of the vessel wall, has favourable effects on restenosis rate in coronary and superficial femoral artery lesions. Therefore we started a pilot study to determine the feasibility of the PolarCath System for the treatment of vascular access stenoses.

Method: The CVSi PolarCath System consists of 4 to 7 mm sized expandable balloons that are inflated by nitrous oxide gas. The

CVSi catheter is tracked to the stenotic site over a 0.035 guidewire under fluoroscopic guidance. After positioning the balloon is inflated for 20 seconds resulting in a balloon surface temperature of -10°C . From experimental data it was showed that vessel wall temperature decreased to -4°C . After deflation the balloon is withdrawn and completion angiography performed.

Patients: Five patients with a decline in vascular access flow, as measured by Transonic flow device, were allocated to angiography and subsequently PTA. Four venous anastomotic and one venous outflow stenosis (diameter reduction $>50\%$) were successfully treated by the PolarCath System. No patients side effects occurred. After a mean follow up of 14 weeks (range 6–21 weeks), no restenoses were noticed by duplex scanning. Four of the 5 AVFs functioned well. One AVF thrombosed due to unnoticed intragraft stenosis.

Summary: The novel PolarCath™ System is a feasible technique for the treatment of hyperplastic lesions in vascular accesses. The influence of cryoplasty on restenosis rate has to be determined in a randomised trial.

Treatment of Venous Stenosis or Occlusion Centrally to Arteriovenous Fistulas (AVFs) in Haemodialysed Patients

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Purpose: To study the direct and mid-term results of the percutaneous transluminal angioplasty (PTA), including stent placing, for treatment of the stenosed or occluded veins of the arms in haemodialysed patients with AVFs.

Materials and Methods: Between January 2001 and February 2003, 19 patients with AVFs presented with unilateral swelling of the arm underwent a venography. Ten of them had a central venous stenosis, while in the rest 9 a complete occlusion was noticed. Eleven patients (10 with stenoses, 1 with occlusion) underwent PTA plus stent placement. Nitinol stents were used with an average diameter of 11.09 mm and an average length of 49.1 mm. As six patients had occlusions longer than 3 cm, no attempt of recanalization was even dared. In two more patients with shorter occlusions was no success in passing through a hydrophilic wire. All the patients were then followed up clinically and a venography was performed only when there were symptoms which indicated that. The average follow up time was 10 months (1–24 months).

Results: The 11 procedures were technically successful, without any complications. In 10 cases the swelling of the arm subsided considerably 24–72 hours after the procedure. In one case the swelling started to subside at the 8th day and improved completely one day later. Six patients had a repeat PTA due to restenosis. This happened between 2½–14 months (average 7.1 months) following the first intervention. Three of them underwent another PTA (on the 3rd, on the 3rd and a half, and on the 5th month).

Conclusion: PTA and stent placement is a simple and effective therapeutic option for central venous stenosis or even occlusions, which happened in haemodialysed patients with AVFs. The above mentioned treatment could give a hope of prolonging the function of the fistulas.

Stents in Hemodialysis Grafts and Fistulas Draining Veins

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Purpose: To analyze retrospectively the effectiveness of endovascular self – expandable stent placement for treating repeated stenoses or occlusions in peripheral or central veins draining shunts for hemodialysis.

Materials and Methods: In the interval from 1/2000 to 11/2002 (35 months) we implanted 35 stents in 28 patients (15 men and 13 women) in the age ranges from 39 to 89 years (mean age 63 years). Twenty stents were implanted in central veins in 14 patients. For early restenosis or for suboptimal result of percutaneous angioplasty in seven patients and for occlusion in seven patients, too. Fifteen stents were implanted in peripheral draining veins in fifteen patients. For frequent repeated restenoses (in 5 patients) or occlusions (in 7 patients) and for vein rupture during angioplasty in three patients. One patient has stents in both central and peripheral veins. Mean follow was 12 months. During follow up four patients died.

Results: All procedures were technically successful, the only complication in connection with stenting was one stent dislocation during deployment, which was solved by second stent placement. An early occlusion of stent in peripheral vein occurred in two patients, both were sent to surgeon. Patients were divided into two groups, first with those with stents in central veins and the second one with peripheral vein stenting. In the first group the primary patency rate was 38% at 6 months, 20% at one year, the secondary patency rate at 6 months was 88 % and 80% at one year. In the second group was the primary patency rate at 6 months 43% and 0% at one year, the secondary patency rate was 100% at 6 months and 100% at one year.

Conclusion: Stent placement in central veins helps to treat the lesions which can not be easily treated surgically. Stenting in peripheral veins is solution for endovascular procedure complication (rupture) or suboptimal result of recanalisation. In cases of frequent restenoses or occlusions can stenting only prolong the interval between interventions.

Nephrology

Cross-over Trial Comparing Blood Flow (Q_A) and Color-Doppler Ultrasonography Surveillance Followed by Intervention in Haemodialysis Grafts

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Background: It is widely accepted that graft surveillance combined with correction of stenosis before thrombosis prolongs graft survival. Aim of this study was to compare a surveillance protocol with Q_A (Flow study) with color-doppler ultrasonography (CDU study).

Methods: In this study, 12 patients (age 61 ± 11.9 years, haemodialytic age 112 ± 96.1 months in Flow study and 122 ± 96.1 months in CDU study) were first assigned to the Flow study and then followed for 10 months. All grafts had monthly Q_A measurements by ultrasound dilution (Transonic HD01). In case of more than 35% Q_A reduction, we performed a CDU control to detect the presence of stenosis. Stenoses were corrected by angioplasty with CDU guidance. The same 12 patients were then assigned to the CDU study and were followed for other 10 months. All grafts in the stable patients had monthly CDU control, at the beginning, and then bimonthly control. During CDU control we detected the peak systolic velocity (PSV) at artery anastomosis, medium graft and venous anastomosis, and, in case of stenosis, before and in correspondence of it. We also measured blood flow in the same point of the graft. In case of detection of more than 75% stenosis (morphological reduction of diameter and haemodynamical changes, doubling of PSV), an angioplasty with CDU guidance was performed.

Results: Blood flow during the two follow up periods was: 942 ± 187 ml/min in Flow study and $1,040 \pm 190$ ml/min in CDU study, there was not statistical difference ($p = 0.19$). During the Flow study the incidence of grafts thromboses was 0.3 patient-year and 0.1 patient-year in Flow and CDU study respectively. No statistical difference was found ($p = 0.16$). The number of CDU-PTA procedures, during the follow-up period, was 1.3 patient-year and 0.4 patient-year in Flow and CDU study respectively. No statistical difference was found ($p = 0.13$).

Conclusion: In case of surveillance protocol with Flow study, blood flow measurement is able to detect those grafts with stenoses, and only in these, we performed a CDU. In CDU study we directly performed a CDU control; the study of the morphological and haemodynamical problems found by CDU, leads the decision to perform a CDU-PTA. CDU seems to be sufficient to detect and correct vascular access stenoses and seems to reduce the use of PTA procedures to the minimum, without increasing the incidence of thrombosis.

Prospective Monitoring of AV Graft Blood Flow with Hematocrit Dilution Technique for Venous Stenosis Detection

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Thrombosis is the leading cause of arteriovenous (AV) graft failure and results primarily from venous outflow stenosis. Prospective monitoring of AV grafts for stenosis detection using blood flow measurements, when combined with timely correction, improves long term graft patency.

A prospective, non-randomized, observational, intervention trial was conducted in three outpatient dialysis units, to evaluate clinical utility of vascular access blood flow (Q_A) monitoring with the hematocrit dilution technique (Crit-Line III[®] device) as a predictive tool of AV graft stenosis and failure. The criteria for malfunction requiring angiography were defined as: a. Q_A below 600 ml/min; b. Q_A drop $\geq 25\%$ compared to the flow measured in the previous month, in grafts with a Q_A value not higher than 1,000 ml/min; c. dynamic venous pressure above 150 mmHg confirmed in three consecutive dialysis. Measurements were performed monthly and in the week following angiography. Impaired grafts underwent percutaneous angioplasty or surgical revision.

Seventy one AV grafts in 69 chronic hemodialysis patients were included. During one year of follow-up, graft monitoring resulted in 57 positive tests followed by angiography, and in 55 cases a significant stenosis was detected. 41 cases had a successful angioplasty, with a significant Q_A increase after procedure ($p < 0.01$). Estimated combined sensitivity, specificity, negative and positive predictive value of our monitoring protocol in predicting stenosis were 82.1%, 89.5%, 54.8% and 96.9%, respectively. There were 23 thrombotic episodes (graft thrombosis rate of 0.46 patient/year) submitted to mechanical thrombolysis and percutaneous angioplasty for a significant venous stenosis. In 9 episodes the preceding test was positive, but these grafts clotted before angiography could be done.

In conclusion our vascular access monitoring protocol is an effective method to detect AV grafts stenosis and prevent their failure, but the power to predict thrombotic episodes is low.

Nine Months of Follow-up of Vascular Access (VA), Autologous Fistula and PTFE Grafts by Ultrasound Dilution Technique

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We have analysed 9 months of vascular access follow-up by ultrasound-dilution technique (Krivitski) in 511 vascular access in

499 HD patients, (59.1%) males with a mean age 64.23 ± 13.98 years, from 13 Spanish HD units. Parameters evaluated: 1. type of VA: autologous in 78.3% (80.3% Radiocephalic and 19.7% in elbow) and PTFE graft in 21.7%.

According the age we found significant difference between % of PTFE higher in females < 65 years in relation with males. Overall summary considering all vascular access in first and 9 months later: Didn't find significant differences between mean access flow and venous pressure in the two measures. Drop-out of the study 61 VA; 115 decrease the access flow of 239 VA (48.1%), $< 20\%$ 56 (48.7%) and $> 20\%$ 59 (51.3%), 11 remain with the same access flow.

AVF malfunction appeared 41/239 (17.1%) divided in: Autologous malfunction 23 (5.9%): 15 of them (65.2%) Access flow < 600 ml/min, resolved by: 14 PTA, 5 news, 4 insertion PTFE, and PTFE malfunction 18 (16.8%): 14 of them (77.7%) had Access flow < 800 ml/min, resolved by: 14 PTA, 4 news. X PTA increasing since 454.46 ± 351 until 799.53 ± 433 ml/min getting on in all of them.

Conclusions: 1. The prevalence of autologous VA is higher than that of PTFE grafts in our population; however, grafts appear more frequently in females lower than 65 years. 2. Comparing autologous and PTFE grafts, we found differences in the % of malfunction in 9 months of follow-up. 3. The PTA appeared a good option to resolve malfunction VA. 4. 600 ml/min in autologous and 800 ml/min in PTFE grafts appear as a pronostic factors.

In Vitro and Numerical Modeling of a Straight and Tapered Loop Graft

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Stenosis and thrombosis are common problems at the venous anastomosis of a PTFE-graft. Hemodynamic factors initiate the processes leading to intimal hyperplasia development.

A realistic in vitro model of a loop graft in the elbow region is built. Compliant silicon tubes simulate brachial artery and vein having 4% relative distensibility, tested with compliance measurements. Pulse pressure at the artery inlet is 60 mmHg. Two conditions are considered – control condition: MAP is 100 mmHg; low resistance condition: mean venous outlet pressure is 20 mmHg. Flow rate varies between 500 and 1,500 ml/min. Pressure is measured with a fluid filled catheter, velocity is measured with an ultrasound machine and flow is measured volumetrically. The flow through the graft model is analyzed in more detail in a numerical flow simulation package Fluent.

Pressure loss at the arterial anastomosis of the tapered graft is nearly three times greater than in the straight graft. Pressure losses over the grafts are about equal. Mean pressure and pulse pressure are lower in the vein in the low resistance condition. Difference between maximum and minimum velocity is smaller in the low resistance condition. Wall shear stresses up to 15 Pa appear at the toe of the venous anastomosis. Vortices exist in the venous anastomosis region and transition to turbulent flow is observed.

Pressure drop and velocity patterns are similar along both graft types, the only difference is the greater pressure drop at the arterial anastomosis.

Functional Evaluation of Preventive Vascular Access (VA) Intervention

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We prospectively monitored the blood flow rate (Q_A) of 86 VA (arteriovenous fistula AVF 82.6% or graft AVG 17.4%; mean VA duration 25.53 ± 44.09 months) during hemodialysis (HD) in 78 ESRD (mean age 63.48 ± 12.63 yr; mean time on HD 33.76 ± 47.79 months; 17.4% diabetes) patients (pts) over 2 yr period. Q_A was measured at least every 4 months by the ultrafiltration (UF) method (Yarar et al., *Kidney Int* 1999;56:1129) using the Crit Line III Monitor (overall mean Q_A $1,175.63 \pm 483.54$ ml/min). The mean arterial pressure MAP (diastolic plus 1/3 pulse pressure) and Kt/V (Daugirdas' second generation, single-pool) were measured simultaneous with Q_A . Twenty-three VA (23/78, 29.5%) met criteria of positive evaluation PE (absolute $Q_A < 700$ ml/min 69.6%, Q_A decreased $>20\%$ from baseline 30.4%). The angiography AG was performed in most PE pts (22/23, 95.6%) and all of them showed VA stenosis $\geq 50\%$. Six explored PE pts (6/22, 27.3%) were lost to follow-up (4 death, 2 transplantation) and most of the remaining 16 explored PE pts (11/16, 68.7%) were referred for corrective VA intervention (int).

Eleven EP pts (mean age 67.64 ± 10.11 yr; mean time on HD 15.45 ± 20.52 months; 27.3% diabetes) underwent elective VA (radial AVF 90.9% and femoral AVG 9.1%; mean VA duration 15.36 ± 25.77 months) int (angioplasty PTA 36.4%, revision surgery SUR 63.6%). PE causes: $Q_A < 700$ ml/min 72.7%, Q_A decreased $>20\%$ from baseline 27.3%. Mean percentage of VA stenosis: 79.2%. One PTA pt (9.1%) thrombosed VA 3 months after int. Mean time between int and the first Q_A post-int: 14.56 days. Mean Q_A increased from 544.27 ± 85.06 ml/min before int (Q_A pre) to 967.64 ± 289.82 ml/min after int (Q_A post) (mean $\Delta Q_A = 423.36 \pm 281.47$ ml/min) ($p = 0.001$). No difference was found when the highest recorded mean Q_A before int (820.55 ± 407.57 ml/min) and mean Q_A post were compared ($p = 0.124$). Mean MAP remained stable after int (90.15 ± 13.63 mmHg vs. 95.61 ± 11.97 mmHg, $p = 0.082$). Mean Kt/V improved from 1.36 ± 0.17 just before int to 1.44 ± 0.18 just after int without any change in dialyzer type or HD duration ($p = 0.020$). Mean ΔQ_A did not differ for diabetic pts vs. nondiabetic pts ($p = 0.31$), for young pts (age < 65 yr) vs. older pts (age ≥ 65 yr) ($p = 0.63$) and for PTA pts vs. SUR pts ($p = 0.18$). We found an inverse correlation between mean ΔQ_A and mean Q_A pre for PTA pts ($r = -0.963$, $p = 0.037$) and a positive correlation between mean ΔQ_A and mean Q_A post for SUR pts ($r = 0.985$, $p = 0.001$).

We conclude that 1. Monitoring Q_A by the UF method is useful to assess the hemodynamic response to preventive VA int 2. Mean Q_A post was similar to the highest recorded mean Q_A before int. 3. The HD effectiveness (Kt/V) improves after int. 4. Mean ΔQ_A is related to mean Q_A pre for PTA pts and mean Q_A post for SUR pts.

Early Arteriovenous Fistula Construction: Maturation in Time and Delayed Deterioration of Renal Function?

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Introduction: Placement and adequate maturation of an arteriovenous fistula (AVF) for hemodialysis means adequate blood flow for chronic hemodialysis treatment when needed. It was noticed that deterioration of renal function was slower in chronic renal patients with AVF constructed at serum creatinine level between 450 and 500 $\mu\text{mol/l}$.

Aim: Aim of this prospective study was to find out the influence of AVF on the renal function.

Methods and Results: Patients (pts) were randomised in two groups. In group A of 10 chronic renal pts, 6 males and 4 females, mean age 62 ± 7.3 yrs (range from 56 to 79 yrs), primary cause of kidney failure was in 5 pts glomerulonephritis, in 2 APKD, in 2 hypertension and in 1 other, mean serum creatinine level 463 ± 34 $\mu\text{mol/l}$ (range from 430 to 498 $\mu\text{mol/l}$), mean creatinine clearance 26.7 ± 3.8 ml/min, daily diuresis mean 1,680 ml (range from 1,340 to 2,120 ml) native forearm AVF was constructed. Group B of 10 pts, 5 males and 5 females, mean age 60.8 ± 6.2 yrs (range from 52 to 81 yrs), primary cause of kidney failure was in 4 glomerulonephritis, 1 APKD, 2 hypertension, and in 2 other, mean serum creatinine level 492.4 ± 62.2 $\mu\text{mol/l}$ (range from 463 to 512 $\mu\text{mol/l}$), mean creatinine clearance 25.1 ± 6.2 ml/min, daily diuresis 1,230 ml/min (range from 980 to 2,110 ml) was followed without AVF construction. Patients in both groups were followed every two months. After 1 year in group A 1/10 pts (10%) started with hemodialysis (HD) (8 months after AVF construction). In 9 pts mean serum creatinine level was 560 ± 43 $\mu\text{mol/l}$ (range from 490 to 593 $\mu\text{mol/l}$), creatinine clearance 19.3 ± 4.2 ml/min, no difference in diuresis, mean arterial blood pressure (MAP) was 102 mmHg, mean AVF blood flow 879 ± 123 ml/min, no signs of cardiac insufficiency was found. In group B 5/10 (50%) ($p < 0.001$) started with HD (from 6 to 11 months), central vein catheter was used as a vascular access. In rest of 5 pts mean serum creatinine level was 794 ± 62 $\mu\text{mol/l}$ ($p < 0.01$), creatinine clearance 11.2 ± 2.3 ml/min ($p < 0.001$), MAP was 112 mm Hg (NS).

Conclusions: Beside well matured AVF, useful for adequate HD treatment when needed. Results of this prospective study indicates benefit of early AVF construction on progression of renal insufficiency. One of the reasons could be increased cardiac output because of increased cardiac pre-load and the consequences could be increased perfusion of the kidneys, but further study of renal perfusion by duplex sonography are planned.

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