Introduction

Development of vascular access surgery

historical review

The remarkable achievements in access to venous & arterial circulation have been directly responsible for prolongation or saving the lives of countless patients ***(H. Earl Godon, 2002).***

Chronic access to the circulation finally became a reality in 1960 through the combined talents of an internist, a surgeon and an engineer. Sceibriegs, Dillard, and Quinton introduced the Teflon–Silastic arteriovenous shunt ***(Quinton et al, 1960)***. Many of the disadvantages of this artificial shunt were overcomed through introduction of the subcutaneous AVF by Brescia, Cimino, Appel, and Huwich in 1966. They surgically created A V fistula between the radial artery above the wrist and the largest available vein in close proximity.

Since 1966, this ground–breaking article by Brescia and Cimino revolutionized the creation of the vascular access . Access surgery developed remarkably over the next decade introducing various types and sites of anastomoses and learning how to manage several complications ***(Brscia et al,1966)*** .

Graft materials were introduced during the 1970s including ePTFE (expanded polytetrafluoroethylene). Unfortunately, subsequent wide spread use of PTFE grafts instead of AV fistula occurred because of certain advantages ***(Allan et al, 2002).***

During the following 25 years, access surgery failed to achieve really new technical developments. An increasing use of mainly ePTFE grafts was observed with a well-known high complication rate .

Although the Brescia–Cimino fistula is considered 'the best available form of vascular access'. Modifications and minor innovative procedures only came up in the field of management of complications.

In the early 1980s, percutaneous balloon angioplasty was introduced by interventional radiologists for the treatment of stenoses followed by a series of other non-invasive approaches including thrombolysis, mechanical/ pharmaco-mechanical thrombectomy, endo-vascular stents, and atherectomy techniques

A remarkable geographical difference developed during this time: Europe continued to prefer native arteriovenous Fistulas with a proportion of graft use of 20–30%, whereas in the United States in 70–80% of patients graft material is used ***(Konner,et al 2003).***

Epidemiology of chronic renal failure

The incidence of and prevalence of end stage renal disease (ESRD) have increase enormously since 1990's. On December 31, 1998 there are 319,515 patients receiving treatment for ESRD in U. S. which is more than double the number of patients who were reported in 1989. Approximately 87,000 new patient began treatment for ESRD in 1998, 48% were 65 year or older and 3.7% were 85 year old or older. 53% were male ***(USRDS, 2000).***

In the 1995 to 1998 period, 47.5% of new patients with ESRD with diabetes reported were 65 years or older. This phenomena is of particular importance to the vascular surgeon given the significant vascular pathology that often accompanies long-standing D.M***(USRDS, 2000).***

An important distinction between successful renal transplantation and chronic dialysis is that the former provides natural replacement for both excretory and endocrine functions of the kidney. In contrast, various dialysis modalities primarily replace the excretory function of the kidney which is responsible for the elimination of endogenous metabolic waste products, exogenous drugs and toxins ,hydrogen ions, and surplus water ,minerals ,and electrolytes and for the generation of bicarbonate. Therefore, the use of dialysis therapies can provide a satisfactory control of azotemia, fluid, electrolyte and acid-base disorders but fails to correct deficiencies of major renal hormones. Erythropoietin,an essential factor for erythropoiesis and calcitriol, responsible for calcium homeostasis and bone metabolism , helped to ameliorate ESRD associated anaemia and osteodystrophy. ***(Winearls, 2000).***

Clinical Features: Uraemia negatively affects almost all organ systems:

1. cardiovascular features:

Hypertension, hypervolemia, pulmonary edema, uremic pericarditis, and pericardial temponade. In addition, particularly diabetes is associated with accelerated arteriosclerosis, atherosclerosis, and ischemic cardiovascular disease ***(Levin et al, 2000).***

2. Neurological features:

Brain dysfunction and Peripheral nerves as asymmetrical distal sensory and motor neuropathy that occur earlier and more severe in diabetes than in non diabetics. ***(Moe et al, 1994).***

3. Hematologic abnormalities:

Severe anaemia ,impaired iron utilization, shortened erythrocyte life span ***(Kausz et al, 2000).***

Platelet dysfunction leads to prolonged bleeding time and hemorrhage ***(Weigert et al, 1998).***

4. GastrointestinalAbnormalitiesas:Anorexia,nausea,vomiting,gastritis,peptic ulcer ,stomatittis, enterocolities.***(Etmand, 1998).***

5. Immunologic abnormalities:

Both cell mediated & hurmoral immunity are depressed and account in part to infection ***(Cohen et al, 1999)***.

6. Dermatological abnormalities:

Diffuse brown pigmentation, dryness and scaling lead to infection, etching, and bullous eruptions ***(Schwartz& Iaina, 2000).***

Etiology of ESRD

The most commonly reported cause of ESRD in 1998 was diabetes (40.31) followed by hypertension 21.1%, glomerulonephritis 11.0% ,polycystic kidney, analgesic nephropathy ,hereditary nephropathy ,vascular nephropathy ,urological diseases systemic diseases and other unknown categories 27.6% (combined). The reported incidence of D M leading to

ESRD has increased significantly from 33% in 1989 to 40.3% in 1998(*USRDS, 2000).*

Diabetic patient with ESRD:

This category of patients have certain characteristics that need a special attention to be discussed in detail.

In many countries, diabetic renal disease has become, or will soon become, the single most common cause of end-stage renal disease (ESRD). End-stage renal failure (ESRF) in type-2 diabetic patients is increasing worldwide. Incidence of ESRF caused by diabetic nephropathy (DN) in 1996 in the USA was 41.7% and prevalence was 32.4%. Assessment and treatment of a diabetic with ESRD must be highly individualized. Hemodialysis (HD) has emerged as the most common treatment for all forms of renal failure including diabetic nephropathy. In diabetic patients with ESRD, dialysis is started early at creatinine clearance as high as 15-20 ml/min, at serum creatinine levels as low as 3-5 mg/dl.*(Polenakovic, 2004).*

The first choice of HD access in diabetics is an autologous AF fistula of the Cimino-Brescia type. The AV fistula should be created several months before starting HD when creatinine clearance is above 20-25 ml/min.

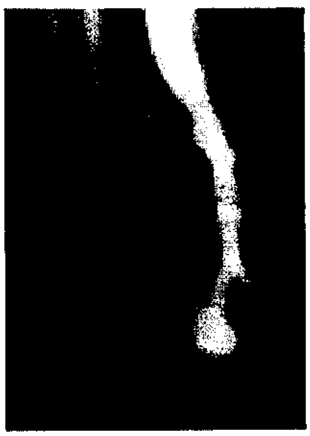
Cardiovascular disease and serious infections are the major causes of death in haemodialysed diabetics. Despite recent improvement, rehabilitation of HD diabetics continues to be inferior to that of non-diabetics. Improvement of survival is a matter of reduction of cardiovascular death and infection. *(Prilozi, 2004).*

During the late 1970s, diabetic patients with end-stage renal failure were increasingly accepted for maintenance chronic haemodialysis. This concerned mainly younger patients suffering from insulin-dependent diabetes mellitus type 1. At that time the strategies for creating vascular access in diabetic patients were not different from those in non-diabetic patients: absolute priority was given to an anastomosis located at the wrist, despite occasional technical problems in suturing the vein to a calcified artery. This strategy, well established and accepted in non-diabetic patients, caused a high failure rate, especially early thromboses and low arteriovenous fistula blood flow.

In an effort to improve the results in diabetic patients, two clinical observations that had been made in non-diabetic patients gave new directions for interventional strategies in diabetic patients:

(i) During revision of arteriovenous Fistulas, it was noted that the feeding radial artery had dilated from approximately 2 mm to 4 or 5 mm, and this was confirmed by angiographic findings (Figure 1).

(ii) Intraoperative and native X-ray findings revealed that arterial calcification was less pronounced in the elbow than in the wrist region. ***(Konner et al 2000)***.



(Fig. 1) Angiogram showing dilatation of the feeding radial artery.

These observations shifted the focus of attention from the veins to the arteries, particularly to the quality of the arterial wall and the diameter of the arterial lumen. The conclusion was that an atherosclerotic and calcified radial artery narrowed at the level of the wrist will deliver only a limited blood flow rate and will not undergo adaptive flow-mediated dilatation to deliver sufficient fistula blood volume-the prerequisite for venous dilatation and satisfactory blood flow.

This consideration led us to the idea of using the proximal radial artery or the brachial artery in the region of the elbow or the upper arm when constructing a first Av fistula in the diabetic patient. The same proposal was subsequently also made by ***(Adams et al.1986).***

The choice between either the wrist/forearm or the elbow region was made after assessment of a variety of clinical parameters:

(i)Medical history with regard to diabetes mellitus, peripheral ischaemia, hypertension, stroke, amputation, and other factors.

(ii)Blood pressure measurements in both arms.

(iii)Careful search for a suitable vein.

(iv)Quality of the arterial pulses along the radial, ulnar, and brachial arteries.

(v)Phlebography in some obese patients.

(vi)Native X-ray of the arms to detect arterial calcifications.

(vii)Ultrasonographic evaluation of the arterial and venous system in both arms including arterial blood flow rates.

Doppler/duplex investigation has recently become an essential part of the preoperative diagnostic procedure, providing information on diameter and wall structure of the blood vessels as well as arterial blood flow rates, ***(Silvia etal 2001).***

These patients may present special problems for several reasons:

1. The distal vessels are likely to be occluded or severely stenotic, rendering them unusable .
2. The use of the larger proximal vessels (brachial or axillary) is associated with a higher incidence of vascular steal . ***(Matalon et al, 1971).*** In addition to the decreased number of vessels available for access, the systemic nature of the disease makes occlusion of any access site more common, and long term patency rates are poor. Steal in these patients tend to be severely symptomatic and may precipitate digital gangrene because of poor small vessels and inadequate collateralization ***(Adams et al, 1986)***.
3. An episode of arterial thrombosis or embolization that has only a minor clinical effect in the normal limb may precipitate to severe distal ischemia in the presence of arterial disease. There is no accurate method of predicting steal although the application of clinical testing of collateral supply via the palmar arterial arches is recommended for this patient group. Angiography or venography is rarely required but may help in a particularly challenging patients with advanced peripheral vascular disease ***(Connoly et al, 1984).***

Surgical anatomy for vascular access:

Accurate incision placement and atraumatic dissection help to protect adjacent arterial or neural structures and to ensure long term patency of the vein and /or artery chosen for the angioaccess.

At wrist:

An incision made between palpable radial artery and the cephalic vein affords access to both vessels. In the soft tissue between the vessels lies the superficial branch of the radial nerve which supplies the skin of the dorsum of the thumb and the radial two and one – half digits. The nerve must be protected during this exposure because the loss of this skin innervation can be particularly annoying . Incision of the deep fascia lateral to the tendon of flexor carpi radialis muscle exposes the radial artery which have numerous small branches at this level ***(Jeffrey, 2002).***

The radial artery is usually chosen as the arterial source for a chronic dialysis fistula in forearm because it is subcutaneous and non dominant compared to the ulnar artery. Use of this artery is less likely to cause arterial steal syndrome of the hand ***(Sparks et al, 1997).***

The forearm:& **Anatomy of antecubital fossa**:

The venous circulation of the forearm involves two major veins. The cephalic vein begins in the vicinity of the anatomic Snuff-box on the posterolateral aspect of the wrist. Gradually swings around the forearm as it ascends to become the lateral vein of the forearm at the apex of the antecubital fossa. The median cubital vein courses variably and medially .

The cephalic vein continues up to the anterolateral aspect of the arm and courses through the deltopectoral groove before it empties into the axillary vein.

The basilic vein begins on the posterior aspect of the forearm, course upward then serving around the proximal forearm, and ascends into the medial aspect of the distal arm before it pierces the deep fascia. At the lower border of the teres major muscle, it joins the brachial veins in the arm to form the axillary vein lateral to the pectoralis major muscle.

The median cubital vein is a continuation of the cephalic vein of the forearm. It courses from the apex of the triangle in a medial course to join the basilic vein in the distal arm.

The forearm cephalic vein travels laterally through the antecubital fossa and ascends through the anterlateral aspect of the arm.

The bicepital aponeurosis covers the brachial artery. The median nerve lies medial to the brachial artery ***(Sparks et al, 1997).***

<u>Vascular Anatomy Of The Arm:</u>

The brachial artery begins at the lower border of teres major muscle and terminates approximately 2.5cm below the transverse skin crease of the elbow. The two terminal branches are the radial and ulnar artery. The latter is the larger branch.

The medial cutaenous nerve and ulnar nerve lies on the medial side of brachial artery and separate the artery from basilica vein. The radial nerve lies posterior to the brachial artery. The median nerve closely related to the brachial artery and crosses from lateral to medial aspect in the middle of the arm to reach the posterior componet***(James, 1978).***

Anaesthesia for vascular accessing:

These patients present a significant Anaesthesia risks. Rational anesthetic management in these patients requires a thorough understanding of the functional changes that are characteristic of chronic renal failure. These can be listed as:

1. Chronic anemia: hemoglobin <8gm/dl, Hct <24%.
2. Coagulopathies (platelet dysfunction): the presence of bleeding tendency.
3. Increased susceptibility to infection: due to protein caloric malnutrition, cutaneous anergy and functional abnormalities of neutrophils, monocytes and macrophages.
4. Cardiovascular abnormalities: pericardial effusion, tamponade.
5. Hypertension.
6. Unpredictable intravascular fluid volume.
7. Electrolyte disturbances: hyperkalemia, hypermagnesemia, hypocalcemia
8. Metabolic acidosis
9. Nervous system abnormalities: autonomic dysfunction, encephalopathy.

Gastrointestinal abnormalities: delayed gastric emptying time, increased acid production ***(Watson et al, 1988)***

All these increase anesthetic risk and influence the selection of the techniques and monitoring require a skilled anesthesiologist and a close working relationship between anesthesiologist and surgeon. Most of the cases are having brachial plexus blockade or local infiltration anesthesia.

One has three Anaesthesia options: local Anaesthesia (infiltration), regional Anaesthesia (brachial plexus block), or general Anaesthesia ***(Hovagim et al, 1989)***

Local anaesthesia:

One percent xylocaine without epinephrine is infiltrated. This offer greater intraoperative hemodynamic stability than general anaesthesia and so associated with higher blood flows in newly created AV Fistula than are general or local techniques. Local Anaesthesia is simple, usually very satisfactory and commonly well tolerated, but it has the disadvantage of causing local edema thus, increasing the risk of infection. Furthermore, arterial and venous spasms are more common and more severe than with regional or general anesthesia.***(Beduregard et al, 1987)***

Regional anesthesia:

The infiltration of the brachial or axillary plexus has the advantage of significantly reducing the frequency of vascular spasms and promotes vasodilatation. It also allows easy surgery-site change, *e.g.* from wrist to elbow. The disadvantage is that an experienced anesthesiologist is required***(Hovagim et al, 1989)***

General Anaesthesia :

In an uncooperative patient or a child general Anaesthesia will be required to allow careful and meticulous dissection and anastomosis.If the patient is on dialysis, a small, temporary fluid infusion may facilitate function of the new fistula. It is essential to avoid hypotension because this may initiate fistula thrombosis***(Hovagim et al, 1989)***

It is also required when time-consuming operations in more proximal parts of the arm are anticipated or when patients have severe co morbid conditions ***(Hovagim et al, 1989)***

Preoperative use of antibiotics:

Most of the surgeons advise against routine preoperative use of antibiotics. In diabetic patients and other patients at high risk of bacterial infection, however, a single dose of an antibiotic, with dose adjustment for renal failure, is advisable. Preoperative administration of antibiotics is obviously necessary if an infected fistula or graft is operated upon ***(Chiruchill, et al, 1992), (Lowine, et al, 1973).***

Planning and patient assessment for vascular access surgery

One of the primary determinants of successful vascular access surgery is the preoperative planning process which must be based on a thorough assessment of the patient and on knowledgeable selection of the appropriate access technique. Because the age, prevalence, and long-term survival of patients who received dialysis for end-stage renal failure are all increasing, the requirements for multiple access procedures over many years is common ***(Scribner, 1982)***.

It is thus advantageous to not only consider the first procedure but to also have in mind a long term plan that includes stepwise, multiple access procedures. Early failures of the access site can be minimized by careful procedure choice of the inflow and outflow vessels. Patients should not be submitted to an exploration of various vessels in an attempt to decide on a procedure at the time of the surgery. In addition, patient comfort during hemodialysis can be greatly improved by correct positioning of the access site in the extremity ***(Gotch & Velinger, 1991)***.

GUIDELINES FOR VASCULAR ACCESS

Vascular access recommendations were outlined and enumerated by Vascular access work group, **(NKF-DOQI 2001)** as following:

I. Patient Evaluation Prior to Access Placement:

GUIDELINE 1: Patient History and Physical Examination Prior to Permanent Access Selection.

GUIDELINE 2: Diagnostic Evaluation Prior to Permanent Access Selection.

GUIDELINE 3: Selection of Permanent Vascular Access and Order of Preference for Placement of AV Fistulas.

GUIDELINE 4: Preservation of Veins for AV Access.

GUIDELINE 5: Timing of Access Placement.

GUIDELINE 6: Access Maturation.

GUIDELINE 1: patient history and physical examination prior to permanent access selection.

To determine the type of access most suitable for an ESRD patient, a history must be taken and physical examination of the patient's venous, arterial, and cardiopulmonary systems must be performed. Diagnostic evaluation should be performed when indicated based on patient history or physical examination.

Table -1. Patient Evaluation Prior to Access Placement

Consideration	Relevance
1-Patient History	
History of previous central venous catheter	Previous placement of a central venous catheter is associated with central venous stenosis.
Dominant arm	To minimize negative impact on quality of life, use of the nondominant arm is preferred.
History of pacemaker use	There is a correlation between pacemaker use and central venous stenosis.
History of severe congestive heart failure	Accesses may alter hemodynamics and cardiac output.
History of arterial or venous peripheral catheter	Previous placement of an arterial or venous peripheral catheter may have damaged target vasculature.
History of diabetes mellitus	Diabetes mellitus is associated with damage to vasculature necessary for internal accesses.
History of anticoagulant therapy or any coagulation disorder	Abnormal coagulation may cause clotting or problems with hemostasis of accesses.
Presence of comorbid conditions, such as malignancy or coronary artery disease, that limit patient's life expectancy	Morbidity associated with placement and maintenance of certain accesses may not justify their use in some patients.

History of vascular access	Previously failed vascular accesses will limit available sites for accesses; the cause of a previous failure may influence planned access if the cause is still present.
History of heart valve disease or prosthesis	Rate of infection associated with specific access types should be considered.
History of previous arm, neck, or chest surgery/trauma	Vascular damage associated with previous surgery or trauma may limit viable access sites.
Anticipated renal transplant from living donor	Temporary access may be sufficient.
2-Physical Examination	
Physical examination of arterial system	
Character of peripheral pulses, supplemented by hand-held doppler evaluation when indicated	An adequate arterial system is needed for access; the quality of the arterial system will influence the choice of access site.
Results of Allen test	Abnormal arterial flow pattern to the hand may contraindicate the creation of a radial-cephalic fistula.
Bilateral upper extremity blood pressures	Pressures determine suitability of arterial access in upper extremities.
Physical examination of venous system	
Evaluation for edema .	Edema indicates venous outflow problems that may limit usefulness of the associated potential access site or extremity for access placement
Assessment of arm size comparability	Differential arm size may indicate inadequate veins or venous obstruction which should influence choice of access site.
Examination for collateral veins	Collateral veins are indicative of venous obstruction.
Tourniquet venous palpation with vein mapping	Palpation and mapping allow selection of ideal veins for access.

Examination for evidence of previous central or peripheral venous catheterization	Use of central venous catheters is associated with central venous stenosis; previous placement of venous catheters may have damaged target vasculature necessary for access.
Examination for evidence of arm, chest, or neck surgery/trauma	Vascular damage associated with previous surgery or trauma may limit access sites.
Cardiovascular evaluation	
Examination for evidence of heart failure	Accesses may alter cardiac output.

Characteristics of the patient's arterial, venous and cardiopulmonary systems will influence which access type and location are most desirable for the patient The patient life expectancy and planned duration of ESRD therapy also can influence the type and location of the access ***(Palder et al, 1985).***

GUIDELINE 2: Diagnostic evaluation prior to permanent access selection

A. Venography prior to placement of access is indicated in patients with the following:

1. Edema in the extremity in which an access site is planned.
2. Collateral vein development in any planned access site.
3. Differential extremity size, if that extremity is contemplated as an access site.
4. Current or previous subclavian catheter placement of any type in venous drainage of planned access .
5. Current or previous transvenous pacemaker in venous drainage of planned access .
6. Previous arm, neck, or chest trauma or surgery in venous drainage of planned access .
7. Multiple previous accesses in an extremity planned as an access site .

B. Imaging techniques are indicated in selected cases where multiple previous vascular accesses have been placed or when residual kidney function makes contrast studies undesirable. Appropriate techniques include:

1. Doppler ultrasound .
2. Magnetic Resonance Imaging .

C. Arteriography or Doppler examination is indicated when arterial pulses in the desired access location are markedly diminished

Venography allows identification of veins suitable for attempted access creation and can be used to exclude sites no longer suitable for access creation. Each of the conditions listed above is associated with vein impairment; each may render a site unsuitable for creating access. Specific factors are as follows:

Extremity edema, collateral vein development, or differential extremity size may indicate inadequate venous drainage or central vein obstruction. ***(Tordoir et al, 1990)*** Detection of the underlying anatomical defect(s) should be attempted by venography. Such defects should be corrected prior to access placement; the site should not be used for access creation if the anatomical defect(s) cannot be detected and corrected.

Subclavian vein cannulation and transvenous pacemaker placement are associated with central vein stenosis and thrombosis ***(Bolz et al, 1995)***Thus, access should never be placed on the same side as an existing transvenous pacemaker or an existing subclavian catheter unless other options have been exhausted. An extremity should not be used for access creation if catheter-induced central vein stenosis or thrombosis on the same side cannot be corrected.

Arm, neck, and chest surgery and trauma are associated with central vein stenosis and obliteration of central veins. Thus, a history of these findings may affect access site choice. Multiple previous access placements may likewise limit availability of veins suitable for access placement. ***(Harland, 1994).***

Doppler studies may be used in lieu of venography at facilities where this modality is available and reliable for venous assessment ***(Sands, 1996).***

However, this method is less accurate than venography for evaluation of central vein structures ***(Middleton et al, 1989).***

Doppler studies or magnetic resonance imaging may be preferred to venography and arteriography in patients with reduced kidney function in whom contrast agents should be avoided.

Arteriography is useful to avoid extremity ischemia in patients with diminished pulses in whom access in the extremity is still desired. However, the Work Group concluded that arteriography is only rarely required.

<u>GUIDELINE 3:</u> Selection of permanent vascular access and order of preference for placement of AV Fistulas

A. The order of preference for placement of AV Fistulas in patients with kidney failure who will become hemodialysis dependent is:

1. A wrist (radial-cephalic) primary AV fistula.
2. An elbow (brachial-cephalic) primary AV fistula

B. If it is not possible to establish either of these types of fistula, access may be established using:

1. An arteriovenous graft of synthetic material (eg, PTF) or
2. A transposed brachial basilic vein fistula .

C. Cuffed tunneled central venous catheters should be discouraged as permanent vascular access.

Wrist (radial-cephalic) and elbow (brachial-cephalic) primary Fistulas are the preferred types of access because of the following characteristics:

A. Excellent patency once established ***(Harland, 1994).***

B. Lower complication rates compared to other access options, ***(Albers, 1994)*** including lower incidence of conduit stenosis, infection, and vascular steal phenomenon

C. Lower morbidity associated with their creation

D. Improved performance (ie, flow) over time

The Work Group concluded that the advantages of wrist and elbow primary AV Fistulas, listed above, outweigh the following potential disadvantages:

A. The vein may fail to enlarge and increase blood flow to satisfactory levels (ie, fail to mature) ***(Albers, 1994)***

B. Comparatively long maturation times–1 to 4 months–must elapse following creation of these Fistulas before they can be used. Thus, the access must be created several months in advance of the anticipated need for dialysis or an alternative temporary method of vascular access must be used while the fistula matures.

C. In some individuals, the vein may be more difficult to cannulate than an AV graft.

D. The enlarged vein may be visible in the forearm and perceived as cosmetically unattractive.

The wrist fistula is the first choice of access type because of the following advantages:

A. It is simple to create.

B. It preserves more proximal vessels for future access placement ***(Albers, 1994).***

C. It has few complications. Specifically, the incidence of vascular steal is low, and in mature Fistulas, thrombosis and infection rates are low ***(Kherlakian et al, 1986)*** **.**

The only major disadvantage of the wrist (radial-cephalic) fistula is a lower blood flow rate compared to other fistula types. If adequate flow to support the hemodialysis prescription is not achieved within 4 months with a radial-cephalic fistula, then another type of access should be established.

The elbow (brachial-cephalic) primary arteriovenous fistula is the second choice for initial placement of an access. Its advantages include ***(Nazzal et al, 1990).***

A. It has a higher blood flow compared to the wrist fistula.

B. The cephalic vein in the upper arm is easy to cannulate and is easily covered, providing a potential cosmetic benefit.

The disadvantages of the elbow (brachial-cephalic) primary AV fistula include:

A. It is slightly more difficult to create surgically than a radial-cephalic fistula.

B. It may result in more arm swelling than a radial-cephalic fistula.

C. It is associated with an increased incidence of steal compared to a radial-cephalic fistula.

If a wrist or elbow fistula cannot be created, a dialysis AV graft using synthetic materials (PTFE or others) or a transposed brachial-basilic fistula is the next choice

Transposed brachial-basilic Fistulas have several disadvantages:

A. The transposition proceedure may create sigificant arm swelling and patient pain.

B. They have a higher incidence of steal and arm swelling than other fistula types.

GUIDELINE 4: Preservation of Veins for AV Access

A. Arm veins suitable for placement of vascular access should be preserved, regardless of arm dominance. Arm veins, particularly the cephalic veins of the nondominant arm, should not be used for venipuncture or intravenous catheters. The dorsum of the hand should be used for intravenous lines in patients with chronic kidney disease. When venipuncture of the arm veins is necessary, sites should be rotated.

B. Instruct hospital staff, patients with progressive kidney disease (creatinine >3 mg/dL), and all patients with conditions likely to lead to ESRD to protect the arms from venipuncture and intravenous catheters. A medic alert bracelet should be worn to inform hospital staff to avoid IV cannulation of essential veins.

C. Subclavian vein catheterization should be avoided for temporary access in all patients with kidney failure due to the risk of central venous stenosis.

Venipuncture complications of veins potentially available for vascular access may render such vein sites unsuitable for construction of a primary AV fistula.

Patients and healthcare professionals should be educated about the need to preserve veins to avoid loss of potential access sites in the arms and to maximize chances for successful AV fistula placement and maturation. Subclavian vein catheterization is associated with central venous stenosis ***(Barrett et al, 1988).***

Significant subclavian vein stenosis will generally preclude the use of the entire ipsilateral arm for vascular access. Thus, subclavian vein catheterization should be avoided for temporary access in patients with kidney failure.

Surgical Creation of an Autologous AVF

Creation of an AV fistula is an interdisciplinary task. In several countries, the task of coordination is delegated to a "fistula manager" who integrates the activities of the nephrologist, the ultrasonographer, the surgeon, or the interventional radiologist ***(Munda et al, 1983).***

The creation of Fistulas should be delegated to a restricted number of dedicated surgeons, because good results are only achieved by surgeons with considerable expertise.

AV fistula is to be preferred in the choice of primary vascular access for chronic Hemodialysis patients. It should be created early enough before the beginning of the treatment (when serum creatinine reaches 6 to 7 mg/dL). This planning avoids central venous catheter placement, preserves vessels and the choice of the best surgical option thus resulting in a better fistula survival.***(Baldrati etal 2003).***

Surgical technique

The Prerequisites

The first step is to select a suitable 'healthy' artery and vein. Before surgery, a thorough examination of the limbs should be carried out.. This can be done by clinical and ultrasonographic investigation. The patient is kept warm. Careful palpation of the arterial pulses should be done throughout both arms. A sphygmomanometer cuff is applied to the upper arm and inflated to a pressure below the systolic pressure, allowing the veins to be studied should there be any difficulty in visualization of veins. Doppler ultrasound may be used to determine their patency and diameter. It is preferably to use the non dominant arm. An anatomic prerequisite is that the chosen vein should have a continous prograde run. Any obstruction to flow will initiate retrograde flow with distal congestion. Once the choice of the anastomosis has been made, the veins and their tributaries are marked along their length. This practice simplifies the planning of an adequate incision, and should the fistula fail at surgery, the location of another anastomotic site is facilitated.

Surgeon should be comfortably seated with adequate lightening, magnifying glasses are may helpful for a precise vein to artery anastomosis ***(Bourquelot et al, 1990).***

Skin incisions:

The first potential mistake concerns the incision: (and the scar that develops) must never cross the 'arterialized' vein, particularly not close to the anastomosis. Transverse skin incisions do not permit exploration of more cephalad segments and cause unnecessary destruction of lymphatic vessels. Consequently,most of the surgeons favour longitudinal incisions and use this approach even in the elbow region.

Formation of post-operative haematoma must be avoided and this requires an extremely 'clean' preparation of tissues and vessels using bi-polar electrocoagulation.

The goal of atraumatic closure of the skin can be achieved by using a few, but well adapted, subcutaneous sutures and sterile adhesive strips. To achieve high quality surgery, microsurgical instruments, magnification glasses, or a microscope are indispensable. ***(Bourquelot et al, 1990).***

Types of the AVF according to the anatomical site

1. Radio cephalic fistula:

An oblique or longitudinal incision is made overlying the selected anastomotic site.

End to side, vein to artery is the preferred anastomosis by most of the surgeon.

A double armed monofilament 6-0 polypropylene is used. Classical anastomosis is done avoiding tension, kinking or rotation of the vessels. Ensuring that there is a palpable thrill at the end of the operation and no proximal vein obstruction. Distal radial pulse must be felt. After operation, elevation of the hand and light pressure dressing is done. Cannulation 4-5 weeks is allowed if sufficient dilations occurred.

2, Brachio cephalic:AV Fistula:

Anastomosis of the brachial artery to the cephalic vein immediately proximal to the antecubital crease can provide satisfactory access.

Transverse incision is made proximal to antecubital fossa. The brachial artery is mobilized until it reaches the bifurcation at level of biceps tendon. It is often necessary to partially divide the biceptal aponeurosis. Median nerve lies medial and posterior to the artery and should be carefully protected. The anastomosis is end to side type but the venotomy and arteriotomy should be limited to 5mm to minimize the incidence of steal syndrome. There is often a communicating branch between the confluence of the elbow veins and the venae commitantes. This branch should be divided to avoid increasing flow to the deep veins.***(Samuel, 2002).***

3.Basilic vein to hrachial artery fistula(Basilic vein transposition):

Incision is made along the course of the vein from the elbow to the level of pectoralis muscle. The cutaneous nerve of the forearm lies close to the vein and is preserved. Tributaries are legated and divided. The vein is divided distally and mobilized deep to the cutaneous nerve. Its patency is established by passage of small catheter or by injection of heparinized saline. A further incision is made in the antecubital fossa and the brachial artery is located just proximal to its bifurcation. A subcutaneous tunnel is created between the antecubital fossa and axilla using a bakes dilators.

The vein is brought through this subcutaneous tunnel after filling it with heparinized saline. Care to avoid spiral rotation or angulation. The anastomosis is performed between the end of the basilic vein and the anterior aspect of the brachial artery after spatulation of the vein. A bruit or palpable thrill should be felt at completion of the procedure.: Brachio basilic fistula with superficialization is an acceptable access for dialysis with a good success rate and fewer complications compared to brachio axillary Gortex graft ***(Dahduli, 2002).***

Types of Anastomosis in AVF Creation

Today, the most frequently used technique of anastomosis is the (artery) side to (vein) end technique (in the following, the sequence is always artery to vein). Historically, the first anastomoses used, were side-to-side***(Brscia et al,1966)***; later on, the end-to-end technique was introduced, but today the side-to-end technique is the most commonly used approach. All three techniques have advantages and disadvantages***(Konner etal 2003).***

1.Artery-side-to-vein-side anastomosis:

When an artery-side-to-vein-side anastomosis is created, the arterial and venous incision should be made exactly on the lateral aspect of the vessels. If vessels that cross each other must be anastomosed, the incisions should be located on the top and the bottom of the respective vessel. In performing these incisions, there is a great risk of causing lesions to the posterior wall. If this occurs, immediate and meticulous repair is mandatory, otherwise there is a risk of late aneurysm formation and/or perforation.

If a stiff arterial vessel has to be operated upon, it is advisable to excise some tissue at the site of the arteriotomy, otherwise turbulences will develop and interfere with the arterial inflow into the vein. The lumen and the distensibility of the vein should be tested by gently compressing the vein and watching the filling of the vessel. The use of a Fogarty catheter for these procedures should be avoided because of the risk of injury to the intima. It is indispensable to test the venous run-offas described because optimal function of the anastomosis requires, among other things, optimal venous drainage.

2.Artery-side-to-vein-end anastomosis

It is more demanding to create an artery side-to-vein-end anastomosis. This type of anastomosis requires much more care, experience, and power of imagination, i.e. three-dimensional visualization of the final result. With this technique the stump of the vein is isolated and has to be approximated to the artery across a certain distance. Unavoidably, the angle between artery and vein at the site of the anastomosis will differ from case to case. Each angle requires an individual length of the arteriotomy and venotomy.*(**Konner, 1999)***.Another point requires attention, as the vein approaches the artery it is necessary to avoid rotation or kinking of the vein .

3.End-to-end anastomoses

In the past, end-to-end anastomoses had been fashionable. This has several disadvantages. The diameters of the artery and the vein differ, and this has to be overcome by inserting a rhombus-like vein patch into the suture. The suture itself is performed in three independent sections without any connection of the closing knots. The main objections arise from the fact that one has to sever the distal radial artery. This procedure is dangerous in diabetic and elderly patients who constitute the majority of the patients that are seen to date. As an initial vascular access procedure this technique should be abandoned today.

Handling of the vein

The vein must be mobilized and adapted to the artery. It is important, however, to limit the length of the mobilized vein to an absolute minimum.

Mobilization implies trauma to and devascularization of the venous wall secondary to interruption of vasa vasorum and removal of the adventitia. Obviously this increases the long-term risk of scar formation of the damaged venous wall. This is particularly true since after creation of the anastomosis, high-flow rates and high pressure further increase the risk of scar formation and, in addition, aggravate the risk of torsion and kinking For the same reason, other types of 'venous transposition' should be avoided whenever possible. More favourable conditions are found when a pre-dilated basilic vein in the upper arm will be placed in a subcutaneous position ('superficialization').

It is an error to clamp the thin-walled vein during the procedure. Clamping causes injury and oedema, particularly to the intimal layer. This carries the long-term risk of stenosis. Instead of clamping one should prevent venous backflow during suturing by gently applying proximal digital pressure.

A known complication is arterial as well as venous spasm. Should this occur we advise to rinse the vessel from the outside using warmed 0.9% saline with or without addition of papaverine or nitroglycerine. If this alone is not effective, mechanical tricks such as proximal venous compression or, if everything fails, introduction (with utmost caution) of a Fogarty catheter or olives can be successful. It is wrong to suture the skin without making sure that vascular spasm is absent. Even a high blood-flow rate alone will not be able to overcome and resolve venous spasm.

The suture

A standard technique should allow the placing of any needle stick to be extremely well controlled. The technique of Tellis ***(Tellis, 1971)*** is very advantageous and this is true even for the very small vessels of paediatric patients; the suture starts in the centre of the back wall of the arteriotomy and venotomy. Suturing is continued passing the corners with excellent visualization throughout the procedure as shown in Figure (2). This variant can be used in artery-side-to-vein as well as side-to-side anastomoses.

(Fig. 2): Illustration of the surgical technique to create a side-to-side AV anastomosis according to Tellis

The suturing material:

No reliable information is available on which suturing material is best: polypropylene, polytetrafluoroethylene and others are currently in use; some authors recommend absorbable material. Reliable studies are not available to compare the different types of suture material and therefore the selection has to be based on individual experience. ***(Konner et al 2002)***.

Technical errors:

Transverse cutaneous incisions should be avoided, and we recommend longitudinal incisions if possible.

Whenever the arterial or venous vessels are pulled and stretched, the mechanical trauma will chronically lead to long segment stenosis.

Whenever the length of the venous segment is excessive, there is a risk of kinking. The risk is compounded by the fact that during maturation of the

AVF, the vein will further elongate secondary to the increase in blood flow rate and vascular remodelling.

Technical Points Determining Success:

An AV fistula transforms a vein into a high-flow vessel. It is obvious that obstacles to flow must be avoided, *e.g.*, kinking, acute angles, torque etc. They create turbulence, damage endothelial cells, and increase the risk of stenosis formation.

It has been recommended that veins should be mobilized so that they can be more easily adapted to the artery. This maneuver removes adventitial layer and vasa vasorum, thus predisposing to sclerosis and stenosis. There is no doubt that veins occasionally have to be used for transposition or superficialization, but this should not be done at the time of the first surgical intervention, when veins are still thin-walled. During a second procedure, when veins have matured and remodeled, they can be used. For this purpose, one can even create a temporary AV anastomosis; not to obtain a fistula for puncturing, but to create a vein suitable for later transposition or superficialization. ***(Konner et al. 2003).***

Endothelial cell damage from clamping thin-walled veins should be avoided to prevent late stenoses. Digital compression is safe for interruption of blood flow. Instead of forcefully dilating a spastic venous segment, *e.g.*, with a Fogarty catheter, we enter a venous catheter from the distal limb of the veins and gently dilate the vein by injecting warm saline. If this is not sufficient, papavarin and nitroglycerin are administered locally.

It is not advisable to ligate run-off veins at the time of first fistula surgery, because it is impossible to predict the future function of the fistula. Venous tissue may be extremely useful later on, *e.g.*, for patches, grafts etc. If venous hypertension develops, veins can then be ligated in a targeted fashion.

An anastomosis at the level of the wrist is only sensible if both artery and vein are able to dilate ***(Matalon et al, 1971) (Wedgwood, 1984)*** so as to accommodate an increase in blood flow by a factor of 20 to 100. Therefore the ultrasonographer and later the surgeon must evaluate the quality of the vessels, particularly of the artery. This is increasingly important because of the rising proportion of elderly and diabetic patients with sclerosed or calcified radial arteries. It is of interest that, in contrast to the carotid and coronary arteries, the radial artery rarely develops atherosclerotic plaques. When evaluating the arteries and veins during surgery, it is useful to do this with the aid of magnification glasses or even a microscope.

At the level of the wrist, the cephalic vein divides into a smaller branch that lies closer to the radial artery and a larger branch running across the dorsum of the hand. The smaller branch usually has a valve impeding venous run-off, and the lumen of the vessel is often unable to accommodate high flow rates. In view of such anatomy, it is often wise to select a more proximal site for anastomosis.

When closing the skin, it is important to consider that the uremic patient, particularly the diabetic uremic patient, is at high risk of infection. We avoid sutures that act as a wick, use only subcutaneous sutures, and close the skin incision by adapting the edges with tapes***(konner et al 2003).***

Post-Operative monitoring of the fistula:

Staff should be trained to recognize fistula problems and to pay attention to a progressive increase of venous inflow pressure and post-puncture bleeding time. Regular "fistula visits" are advisable, *i.e.*, inspection and physical examination of the fistula every 6 or 8 wk. The main purpose is to detect development and progression of stenoses in time to prevent eventual thrombosis, so that one is not forced to surgically correct an established thrombosis ***(Connolly et al,1984) (De Marchi et al, 1996).***

Alternative Surgical Approaches:

An increasingly higher proportion of patients requires approaches other than the classical Cimino fistula at the level of the wrist ***(Brscia et al,1966)*** because an increasing proportion of diabetic and elderly patients are unable to achieve high flow rates for optimal fistula function when the radial artery is used for anastomosis. The solution may be anastomosis at a more proximal level.

Many nephrologists are hesitant to use the brachial artery for primary anastomosis out of fear of provoking hypercirculation and cardiac decompensation. This risk can be minimized if one adopts the policy of keeping the anastmosis size of about 5 mm. Because of flow limitation, the risk of a steal phenomenon and peripheral ischemia is reduced as well. In obese patients, the cephalic vein (or even a mobilized basilic vein) has to be brought up often in a second step into a subcutaneous position.

The first superficial segment of the basilic vein in the region of the elbow is too short in many patients, providing only a short stretch of the vessel for cannulation. Here again the subcutaneous superficialisation of the basilic vein along the medial aspect of the upper arm can yield satisfactory longterm results. It is important to leave the proximal third of the basilic vein untouched to allow venous drainage during later surgical corrections, *e.g.*, PTFE bridge grafts. ***(Konner et al,2000).***

Physiology of the arteriovenous fistula

The physiologic effects of AV Fistulas can be separated into: Primary effects due to hemodynamic changes ,local or systemic and secondary effects on tissue metabolism due to local or systemic changes. Because the caliber of the AV access vessels increases for several weeks after surgical construction

We discuss both the immediate hemodynamic consequences of opening an AV Fistula and the chronic effects that are evident once a fistula has matured ***(Wong et al, 1996).***

I. Hemodynamic:

(A) Local hemodynamic effects of AVF:

The effect of creating a fistula on the PA(proximal artery) is like making a hole in a dike. The minimal pressure gradient that normally exists between neighboring segments of an artery and vein is changed at the fistula connection because of the large difference in pressure between arteries and veins. Flow in the PA increases dramatically in response to the sudden decrease in out flow pressure afforded by the fistula.

The direction of flow in the PA remains antegrade away from the heart when an AV fistula is acutely opened but increases dramatically with forearm AV fistulas...Brachial artery flow increases5 to 10 fold compared with flow before communication ***(Wedgood et al, 1984).***

The situation in DA(distal artery) is more complex. With small fistula, flow is maintained antegrade away from the heart. With ↑ fistula size, however, DA Flow ↓ until it reaches a standstill when the anastomotic length is about the same as the PA diameter. At this point, circusmotion develops. Antegrade flow toward the PVB(peripheral vascular bed) during systole is matched by retrograde flow during diastole through the fistula into the venous limbs.

As the anastomotic length of the fistula communication ↑ further, above the diameter of the artery, reversed flow in the DA ↑until it exceeds antegrade DA flow ***(Reilly et al,1982).*** Of note, clinical studies of radiocephalic fistulas indicate that retrograde DA Flow is evident at the time of surgical construction in 75% to 80% of cases ***(Sivanesan et al, 1998).***

All flow through the fistula is directly toward the heart via the PV(proximal vein).

Retrograde Flow into the DV is prevented or minimized by competent venous valves.

Effect on pressure:

Immediate: after opening of the fistula, there is small decrement in PA pressure near the anastomosis and a larger decrease in neighboring DA pressure which may fall to 50% of PA pressure.

The pressure in the PV is highest just at the anastomosis but it rapidly falls in the PV with movement toward the heart to base values, reflecting the large capacitance of the venous circulation.

Factors affect the magnitude of the flow are:

1. Proximity to the heart
2. The anastomotic length: until the anastomotic diameter exceeds 20% of PA diameter, fistula flow is low. At 20% to 75% of the PA diameter the total fistula flow rapidly rises. Above 75% of the PA diameter, further modest increases in total fistula flow access due to increasing retrograde DA flow into the fistula.
3. Arterial blood pressure: affects flow in the AV fistula in a linear fashion ***(Reilly et al,1982)*** with the diameter of the veins and arteries carrying the AV flow: Clinical data show that with small veins (≤3mm in diameter) significantly lower flows are observed immediately after

the construction of radiocephalic AV fistulas. Similarly when either the artery or vein is less than 1.6 mm in diameter, significantly lower flow and ↑ risk of early access failure are found ***(Sir anesans et al 1998).***

4. Blood viscosity influence blood flow***(Reilly et al,1982)***:

Normal brachial artery flow mean value 85ml/min, opening an AV fistula, multiplies brachial artery flow by a factor of 5 to 10 ***(Wedgood et al, 1984).*** Flow rates measured in operating room may not accurately predict subsequent flows of the vessels in spasm and do not reflect the increased flows that normally result from vessel dilation as fistula mature . Intraoperative flow measurements obtained immediately after AV access construction show mean flow to be about 300ml/min for radiocephalic fistula ***(Johnson et al,1998)*** and about 700 to 1000 ml/min for brachial or femoral arteries based on fistula.

Flow usually ↑ by 50% to 100% over few weeks as vessels dilate ***(Bosman et al, 1996).*** Desirable flow rates for hemodialysis are 350ml/min or higher, otherwise the efficiency of dialysis is reduced by recirculation within the fistula dialysis-dialysis machine circuit ***(Windus et al, 1990).***

Reversed flow in the DA leads to diversion of flow from the distal vascular bed ,for example ,the hand in radiocephalic fistulas. This phenomenon underlies the rationale for ligating the DA or constructing end artery-to-vein radiocephalic fistula to prevent retrograde DA flow .Steal tends to develop in all side artery-to-vein construction with large communications ,but local anatomy will influence the severity. When fistulas are based on the brachial artery, reversal of the flow may be created in both the radial and ulnar arteries ,leading to a higher risk of severe steal than for radial artery based accesses,where ulnar flow is maintained antegrade into the palmer arch, which in turn feeds retrograde radial flow ***(Lin et al, 1997).***

(B)Systemic hemodynamic effects that result from AVF:

The immediate effect of opening a fistula is to divert blood flow away from the rest of the peripheral circulation and into a special low resistance path directly connecting the left side to the right side of the heart. Cardiac output increases acutely via increased rate and stroke volume to provide this flow, but paradoxically diversion of flow into this parasitic circulation depletes the volume in the remainder of the vascular system. Arterial blood pressure falls and heart rate increases, these changes are minimal with low flow fistulas, and increases with increasing fistula flow.

Patient with renal failure can not be relied to compensate for the hypovolaemic state, created by opening the fistula. through the rennin-angiotensin-aldosterone axis and thought must be given to expanding intravascular volume as an adjuvant to surgery, particularly if high flow fistulas in the brachial or femoral system are being constructed ***(Mandin, 1973).***

II.Secondary effects on tissues&Metabolism

(A) Local Effects:

In small fistulas, the anastomotic communication tends to become obstructed by the accumulation of platelets and fibrin. Subsequent myointimal proliferation leads to thrombosis and closure. In fistulas that remains patent, the PA, PV and DV all tend to elongate and dilate to accommodate the increased blood flow.

The PV undergoes arterializatiion with hypertrophy of sub-intimal smooth muscle and elastin and increased collagen and fibrous tissue content. The DV undergoes similar changes when incompetent valves allow retrograde flow ***(Smith et al,1976).*** Other changes that frequently occur in AV fistula include atherosclerotic degeneration or myointimal hyperplasia.

Clinical measurement of fistula flow in hemodialysis patients during hand exercise (which decreases resistance in the hand) have confirmed that exercise does not increase fistula flow although it may promote arterial collateral formation ***(Moran et al, 1984) (Moran et al, 1985).*** One of the striking differences between acute and chronic fistula is the collateral arterial supply to the DA. In side to side AV fistula, retrograde flow through the DA usually increases with time over several months. At the same time, peripheral vascular bed perfusion returns close to the level that existed before shunt construction.

As in acute setting, retrograde flow through the DA in mature fistula 1/3rd may supply as much as one 1/3rd of total flow, with time flow increases in both proximal and distal arteries ***(Anderson et al, 1977)*.**

The incidence of steal is highest inside to side radial fistulas when the ulnar artery is obstructed.

It appears that a good strategy when constructing AV access is to avoid ligation of the distal radial artery unless preoperative studies suggest compromise of the ulnar artery.

In the rare case, in which steal develops with the presence of side of artery to vein fistulas, ligation of the fistula and restoration of distal flow always represent the safest course ***(Patel et al, 1992).(Flanigan, 1994).***

Edema of the upper extremity after access construction generally is a consequence of obstruction in the lymphatic or venous drainage of the limb and is unlikely to result from the hemodynamic impact of AVF function alone. In the mature fistula, repeated puncture may cause strictures and increased resistance in the PV, diverting flow into the retrograde vein and collaterals which often are not accessible for hemodialysis. After ligation of DV, flow rates via the accessible PV may be more satisfactory for dialysis.

Similarly, branches of the PV that communicate with deeper veins may divert flow away from easily accessed superficial vein segments. In these cases, ligation of distal tributaries of the PV near the fistula can salvage a fistula with inadequate flow ***(Beathard, 1999).***

Studies of flow in hemodialysis AV Fistula indicates that flows tend to ↑ with time but not invariably. Increased flow is promoted by dilatation of the PA and the outflow veins, which expand to the degree allowed by their anatomic properties, limited by the caliber of the fistula communication and the pressure gradient. Collateral flow around the fistula also increases with much of this being diverted retrograde with DA into the fistula.

Unfortunately, there is no agreement on standard method for measuring AV access flow, leading to a high degree of variability in measured flows. Although a threshold value for access flow that should trigger prophylactic interventions has not been reliably established, it appears clear from the literature that low flow correlates with decreased patency especially when serial measurements show falling flow rates ***(Neyra et al, 1998).***

Fistula in the extremities increase skin temperatures. The temperature gradient may be as high as 3° C between the two upper extremities in chronic hemodialysis patients. This effect is due to warming from increased flow of arterial blood through the extremity directly into the superficial veins.

In acute response the distal aspect of the extremity may be cold due to decreased peripheral flow; but as arterial collaterals develop, distal temperature will rise, although they may remain permanently low compared with the contra lateral extremities ***(Wallace & Jameson, 1978).***

Wounds near AVF have been reported to demonstrate enhanced healing although the effect is not seen distally on involved extremities ***(Matsubayashi, 1974).***

(B)General Effects:

All AV fistula ↑ cardiac output and as flow ↑ with chronicity, so does total cardiac output. In general, the percentage of the cardiac output donated to the remainder of the peripheral circulation other than the fistula circuit fall as modestly after opening the fistula (5-10%) depending on the organ need but with time, the percentage returns close to original levels. Studies in chronic hemodialysis patients show that the average, temporary occlusion of forearm AVF and shunt lowers cardiac output by (8-13%) indicating that a comparable proportion of cardiac output passes through the access. Patient with high flow brachial and femoral shunts where flows can exceed 2L/min, have a greater risk of cardiac complications. ***(Chandraratna, 1984)*** .

Guidelines for access maturation:

A. A primary AV fistula is mature and suitable for use when the vein's diameter is sufficient to allow successful cannulation, but not sooner than 1 month (and preferably 3 to 4 months after construction).

B. The following procedures may enhance maturation of AV Fistulas:

1. Fistula hand-arm exercise (eg, squeezing a rubber ball with or without a lightly applied tourniquet) will increase blood flow and speed maturation of a new native AV fistula.
2. Selective obliteration of major venous side branches will speed maturation of a slowly maturing AV fistula.
3. When a new native AV fistula is infiltrated (ie, presence of hematoma with associated induration and edema), it should be rested until swelling is resolved

III. Vascular Remodeling and Adaptation to High Flow

Wedgewood ***(Wedgewood et al, 1984)*** measured flow rates in the radial artery before and immediately subsequent to the creation of an end-to-side fistula. Flow increased from 21.6 ± 20.8 ml/min to 208 ± 175 ml/min immediately after operation. In well-developed Fistulas, flow rates may ultimately reach values of 600 to 1200 ml/min.

Flow increases as a result of both vasodilatation and vascular remodeling. The latter has been studied using echo-tracking techniques***(Corpataux et al, 2002).***

It was found that the diameter of the proximal antecubital vein increased progressively while the intima media thickness remained unchanged. Venous dilatation caused reduction of mean shear stress, which had returned to normal values by 3 months. The venous limb of the AV fistula underwent excentric hypertrophy as documented by increased wall cross-sectional area. In parallel, remodeling of the radial artery was seen without arterial hypertrophy, despite a marked increase in diameter and blood flow ***(Girard et al, 1996).***

The changes in blood flow after creation of an AV fistula initiate compensatory responses that have been elegantly elucidated in experimental models .When extremely high shear stress was induced, it required up to 6 months, for example in the monkey iliac artery subjected to a 10-fold increase of flow, to return back to normal values. ***(Zarins et al, 1987).***

Endothelial cells play a central role in adaptive remodeling ***(Ballermann et al, 1998).***

The crucial importance of endothelial cells is illustrated by the observation that de-endothelialization eliminates the dilation resulting from an increase of flow***(Tohda et al, 1992).***

The first step of remodeling involves controlled removal of preexistent vessel wall constituents. The arterial wall of an AV fistula exhibits early tears and fragmentation of the internal elastic lamina ***(Jones & Stehbens, 1995)***and enlarged fenestrae (***Jones et al, 1994***), increasing arterial distensibility. The loss of the internal elastic lamina results from degradation by metalloproteinases, which are released from endothelial cells ***(Tronc et al, 2000).***

Platelet deposition on extracellular matrix, which had been synthesized in the presence of uremic serum, is also increased. Interestingly an antibody to human tissue factor prevented the increase in platelet deposition observed on "uremic" extracellular matrix, a finding potentially relevant for the genesis of fistula stenoses. Against this background, it is remarkable that remodeling is largely appropriate in uremic patients ***(Corpataux et al, 2002).***

Although not directly related to uremia, the processes underlying the development of stenoses in coronary saphenous vein grafts are of interest for understanding the development of fistula stenoses. It is thought that the changes provoking delayed stenoses are initiated during surgery and consist of denudation of the surface endothelial cells and insudation of granulocytes and monocytes with deposition of fibrin and thrombocyte-containing thrombi***(Vlodaver & Edwards, 1971).***

One important aspect in the evolution of the AV fistula of uremic patients is iatrogenic remodeling resulting from puncture of the AV fistula ***(Krönung, 1984).***

Puncture displaces tissue, and the defect caused by the cannulation is replaced by a thrombus causing a slight increase in tissue mass. Even after healing, the edges of the puncture hole stay apart as shown by applying tattoo marks. This causes cumulative and progressive enlargement of the fistula depending on the number of punctures per unit area. This holds true if the cannula does not punch out tissue, but rather displaces tissue as seen with anti-coring cannulas, in which only the anterior half of such cannulas makes sharp cuts.

Use of platlet inhibitors:

Despite the bleeding tendency of chronic Hemodialysis patients, vascular access thrombosis is a frequent complication. Hypercoagulability is one of the causes contributing to the high frequency of access thrombosis. The hypercoagulable state can be explained by platelet and coagulation factor abnormalities. Unfortunately, few randomized placebo-controlled trials have been conducted using antiplatelet or oral anticoagulation therapy. Therefore, no evidence-based consensus has been established regarding pharmacological prevention of access thrombosis.

It still needs to be determined whether the potential benefits of anticoagulation and antiplatelet therapy outweigh the risk of adverse events. In the meantime it seems reasonable to give some form of anticoagulant therapy based on pathophysiological considerations and the high incidence of thrombotic complications. Our group recently demonstrated that graft flow measurements could effectively predict thrombotic vascular access events. Risk tables that take into account such parameters as well as plasma markers of hypercoagulability may help to develop rationally designed trials and guidelines ***(Blankestijn & Rabelink, 2000).***

Complications

The lack of an adequate AVF at the start of Hemodialysis decreases survival significantly-even if patients are not diabetic. They should be referred to the nephrologist early and planned Hemodialysis is initiated. It also increases the cost of each prevented death.

The most common omplications of AVF are:

1. Failure or thrombosis
2. Infection
3. Aneurysm
4. Ischemic changes
5. Venous hypertension
6. Neuropathy
7. Cardiovascular Complications

1- Failure or thrombosis

The average patient who begins Hemodialysis today has diabetes mellitus as the cause of renal disease and is older than 65y. These risk factors taken together with the propensity of access routes clot, tax the ingenuity of the surgeon in maintaining a route for long term haemodialysis. The most common treatment for CRF, Hemodialysis is used for 58% with end – stage renal failure disease.

The number of renal transplants continues to be limited by lack of available donors, thus it is likely that Hemodialysis will remain the mainstay for the treatment of CRF in the foreseeable future. Almost 20% of all dialysis patient admissions are related to vascular access problems and the most frequent cause of access failure is thrombosis.

The pathophysiology of thrombosis is the underlying stenosis formation. Stenosis result from turbulence of blood flow, which activates platelets and endothelial cells. In this context, a particular role has been postulated for platelet-derived growth factor (PDGF) ***(De Marchi et al, 1996).***

The final trigger causing thrombosis is a critical reduction of fistula blood flow. Many studies document that low fistula flow is the best predictor of thrombosis. The critical flow rate is different in PTFE grafts and in AV Fistulas. For the latter, we found that all Fistulas thrombosed in which the flow rate was < 200 ml/min. This is of course far less than what is required for optimal blood flow during dialysis. As a result of low blood flow, dialysis will become ineffective and recirculation will occur, but measurements of recirculation are considerably less sensitive to predict fistula malfunction and thromboses than direct measurements of fistula flow rates ***(Tonelli et al, 2002).*** The time course is more important than the absolute values.

Table 2. Critical shunt flow volume in dialysis access

Av fistule
• Minimum flow rate: 350 to 400 ml/min
<300 ml/min recirculation problems
<200 ml/min clotting problems
PTFE graft
• Minimum flow rate: 800 to 1000 ml/min
<600 ml/min clotting problems

A number of indicators and predictors of fistula thrombosis have been discussed in the literature, such as, lipid abnormalities, and homocysteine, but nothing has emerged which would be helpful for routine monitoring.

Several procedures help recognition of critically low blood flow rates and impending stenoses at the bedside:

- Auscultation (high frequency bruits at the site of stenosis)
- Hand elevation test (collapse of the post-stenotic venous segment and persisting congestion of the pre-stenotic segment)
- Prolonged bleeding after removal of the needle from the puncture site
- Elevated venous inflow pressure during hemodialysis sessions, particularly progressively increasing venous inflow pressures during consecutive dialysis sessions

Once a critically low fistula flow and stenosis have been documented, one has two alternatives: interventional radiology or corrective surgery.

Although this is still controversial ,our results after surgical intervention are more favorable, and reconstruction of the lumen is usually also curative ***(Konner, 2000).***

Certainly, the foremost complication to be anticipated in the construction of AVF is clotting of fistula. Patency rates are often reported as primary and secondary

Primary patency refers to the useful duration of the AVF function until the first thrombosis occurs.

Secondary patency refers to the total period of time until the access site is abandoned. Usually, several thrombosis reversions and/or angioplasties have been performed within the time defined as secondary patency. The likelihood of thrombosis depends on multiple factors including the anatomic configuration of shunt or fistula constructed, site of a AV anastomosis, intrinsic clotting ability, and adequacy of the patient's veins and arteries.

The autogenous radiocephalic AVF is associated with a fairly high early failure rate of 10% to 15% ***(Ehnenfield et al, 1972)*** failure may be caused by small vessels, excessive dehydration in a debilitated patient, or venous outflow obstruction. Once successfully constructed, the autogenous radiocephalic AV Fistula has an excellent long term patency rate, reported as high as 78% at 3 years. A longterm patency of 66% at 2 years for radiocephalic AVF as report by ***(Mandel et al, 1977)*** may be the more generally achieved result.

Perhaps the most definitive data to date on patency rate are those from the USRDS, Morbidity & mortality study by Gibson and colleagues ***(Gibson et al, 2000)*** at 2 years autogenous fistulas has a primary patency rate of 43% and secondary patency of 64%. Vein transposition demonstrated a 1ry patency rate of 31% and secondary patency rate of 64.2% at 2 years.

The anatomic site chosen for placement of the AV fistula also has important bearing on the duration of function before a complicating thrombosis. Thrombosis of shunts may occur soon after surgery or in the follow up period.

Early thrombosis, defined as occurring within the first month of the placement, is often caused by technical factors, whereas late thrombosis occurs from 1 month on and is generally caused by venous run-off stenosis (neo-intimal hyperplasis), continued trauma for hemodialysis, external pressure on the fistula, hypotension or central venous thrombosis.

Early thrombosis:

Clotting of a vascular access construction may be noted in the operating room soon after completion of the last anastomosis. It is recognized by the absence of a pulse and no palpable thrill. Thrombosis of the radiocephalic Brescia Cimino fistula is most frequently due to selection of an inadequate vein.

Rohr et al recommended that the vein be at least 3 mm in diameter and open beyond the antecubital fossa. This condition can be ensured by passing a small Fogarty embolectomy catheter into the vein proximally to just beyond the elbow. Gentle dilation of the cephalic vein immediately proximal to the site of anostomosis with coronary dilators overcomes spasm & ensures wide AV communication. Topical papaverene is also useful ***(Rohr et al, 1978).***

In some elderly patients and diabetics the radial artery is involved with atherosclerotic disease and may not have sufficient pressure to sustain a fistula. Ideally, the patient with a poor radial pulse should have Doppler systolic pressure measurement of at least 100mmHg confirmed in the radial artery before coming to surgery***(Rohr et al, 1978).***

Compression of the radial artery at the wrist should not result in blanching of the hand, and the collateral capability of the ulnar artery should be confirmed before surgery (Allen test).

Plethysmographic recording of finger pulse volume or digital Doppler pressure and the response to compression of the radial and ulnar arteries provide an objective evaluation if there is any doubt as to the adequacy of collateral circulation ***(Fronek, 1985).***

Thrombosis of the fistula during surgery may be caused by inadequate anticoagulation. Remember that patency of all the vascular access sites depends on part on the coagulopathy of end stage renal disease. In most patients, a Brescia–Cimino radiocephalic fistula can be easily accomplished without heparinization. Taking advantage of the already diminished platelet function of the patient with chronic renal failure and short occlusion time necessary for the procedure.

Technical factors are often responsible for thrombosis of the newly placed fistula. In particular, one must be careful not to narrow the lumen of

In the early post operative period, thrombosis may be caused by external compression of the fistula by a tight extremity bandage.

Late Thrombosis:

Clotting of the autogenous radiocephalic fistula after the frist 3 months of successful use is caused by repeated trauma from needle punctures, with subsequent fibrosis and narrowing of the arterialized vein. Repetitive puncture of the fistula in the same area, extravasation of blood with local fibrosis and cellulites of the fistula all lead to fibrosis and stenosis. Anastomotic intimal hyperplasia that causes venous stenosis in AV Fistulas has been attributed to mechanical endothelial damage. The shearing effect of blood flow and the high-pressure, pulsatile nature of arterial flow in the venous system.

Venous stenosis also may be caused by mechanical factors such as angulations and stretching of the vein. There are no methods that are clinically approved to reduce the myointimal hyperplasia that causes venous run off stenosis, although research on irradiation, photodynamic therapy and biochemical methods is ongoing.

Early detection of the impending AVF thrombosis depends on the recognition of decreased flow of the fistula, increased pressure in the venous return lines, recirculation or decreased dialysis efficiency(often reported by the dialysis nurse or technician) . All these signs should prompt the surgeon to investigate and correct the stenosis before clotting. Color flow Doppler imaging a useful non-invasive technique for the detection of the fistula stenosis., these stenosis can be treated successfully with fistula revision before development of thrombosis.

Balloon catheter dilation of stenotic area in patients with falling AV fistula may be successful in carfully selected cases ***(Lawrence et al, 1981).***

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In general the application of this technique results in shorter patency than does surgical revision. Dilation of autogenous veins may result in rupture of the vein. The interventional radiologist and surgeon should work together to select the best approach for the individual patient rather than to apply one method to all.

Table 3. Possible causes of vascular access thrombosis

Low access blood flow
Intimal hyperplasia
Hypotension
Hypovolaemia
External compression
Hypercoagulability

Table 4. Factors contributing to an increased thrombotic tendency in patients on chronic Hemodialysis *(Blankestijn, 2000)*

Platelet factors
Blood–artificial surface interaction
Treatment with recombinant human erythropoietin
Increased platelet count
Platelet activation due to high shear stress in the vascular access
Plasma factor abnormalities
Increased levels of vWF
Hyperfibrinogenaemia
Increased thrombin formation
Reduced levels of protein C anticoagulant activity
High levels of factor VIII procoagulant
Decreased levels and reduced activity of antithrombin III
Impaired release of plasminogen activator

Increased levels of antiphospholipid antibodies
Increased levels of homocysteine

Non-surgical causes of early clotting

It is beyond the scope of this brief report to discuss the non-surgical causes of early AVF failure: Systemic clotting disorders, hypotensive episodes (particularly during Hemodialysis sessions secondary to excessive ultrafiltration), or haematoma formation. The latter may be due to bleeding after over-heparinization or following very early cannulation with injury to the vessel wall or following inappropriate compression after withdrawal of the cannula ***(Konner etal 2003)***

2- Infection in vascular access procedures:

Vascular access is the Achilles heel of the dialysis patient in part because of the consequences of access site infection, which remains a major source of complication and even death. Infection is the most common complication of vascular access surgery after thrombosis and is a frequent cause of hospitalization of hemodialysis patients ***(Kjellstrand, 1978)*** .

Infection of surgical sites may prematurely end the function of the AV Fistula and threatens life, through hemorrhage or systemic sepsis and jeopardizes limb, through disruption of arterial supply . The indications for hemodialysis have been progressively broadened, so that access procedures are now increasingly performed in elderly, diabetic or medically compromised patients ***(Padberg, 1992).***

These complications, such as infection, are frequently encountered in patients with multisystem disease and little reserve to counter infection or endure surgical treatment. These patients constitute a major challenge to the vascular access surgeon, who must recognize and treat infection expeditiously and effectively if morbidity and mortality risks to be minimized.

Pathogenesis:

The overall risk of infection is increased in CRF.Uremia has a suppressive effect on many elements of immunity. Localization of infection to hemodialysis sites is enhanced by increased bacterial access to tissues through multiple diagnostic and therapeutic procedures, chronic indwelling cannulas and repeated needle punctures. The altered bacterial flora of uremic patients also predisposes to infection.

Altered immune response: uremia has been called "nature's immunosuppressant" because of its modulating effects on immune responses which result in an increased incidence of infection & neoplasia, pulmonary, urinary, GIT, wound infection, T.B., peritonities and septicemia are more common ***(Montgomrie et al, 1968).***

Polymorph nuclear granulocytes (PMG):

Functions including chemotaxis, phagocytosis and adherence are impaired particularly in haemodialysed patients for more than three months.

Neutrophil function is also impaired by metabolic abnormalities. Clinically, deficient cell-mediated immunity is exposed as impaired cutaneous hypersensitivity.

Humoral immunity appears less affected by uremia and immunoglobulin levels had to be normal or increased.

Altered Natural Barriers:

The medical management of HD patient is characterized by multiple invasive procedures which result in direct bacterial inoculation occurring in operating room or needle punctures resulting in cannulation sepsis.

Alteration in mucosal barrier function occur in uremia, and enhanced intestinal permeability and transmural bacterial migration provide the most common source of bacteria when access sites are excluded ***(Kinnaert et al, 1977).***

Altered bacterial flora:

In virtually all reported series of vascular access sepsis, S. aureus is the most predominant organism and because phage typing reveals autocolonization, mostly infections result from staphylococcus already carried by the patients. (60-70%) have the organism in the nose, throat, and skin, compared with (10-14%) in control populations ***(Yu VL, 1986).***

Dialysis Unit employees have an intermediate carrier incidence of 30% but most phage typing studies do not indicate staff – patient cross colonization.

Access type and site:

Infection rates for autologous fistulas continue to be acceptable (2-3%) ***(Zibari et al,1988).*** Forearm AVF is less liable to infection than AVF in lower limb.

Bacteriology:

S. Aureus predominates as a causative organism being responsible for more than 90% of fistula infection, resistant to methicillin. In one series, 54% of infections were due to organism other than S. Aureus. 29% of organism were streptococci eg. streptococci viridans, enterococcus faecalis and 25% were gram-ve bacilli including 2 cases of pseudomonas areogenosa. ***(Kherlakin et al, 1986).***

The natural nosocomial infection surveillance system collected data showing the rates of resistance of S. aureus to semsynthetic penicillin to have increased from approximately 28% in 1994 to 55% in 1999, accordingly

Single organism is responsible for 80% of cases & 15% for 2 organisms. In 5% of cases no bacterial growth obtained in spite of clinical evidence of infection. This relates to prior antibiotic treatment.

Clinical Features:

Localized warmth in the overlying tissues, with erythema, swelling, pain and tenderness are early signs.

In other stages of infection: Abcess formation with eventual skin breakdown and chronic discharge of pus may occur. Autologous fistula infection are rare but superficial cellulitic wound infections after fistula formation are common.

Repeated needle puncture may cause hematoma formation with subsequent infection and the typical signs of inflammation which may proceed to abcess formation if neglected. If anastomotic infection develops disruption of the anastomosis and pseudoaneurysm formation may occur .About 10% mortality rates due to the effects of overwhelming sepsis ***(Bourquelot et al, 1990).***

Management:

Prevention:

The mainsty of prevention of in vascular access surgery is strict adherence to aseptic technique. This is good surgical practice during any operation, but it is mandatory for vascular procedures.

Correct skin preparation before needle puncture must become an obsess ional requirements.

Preoperative antibiotics: contradictory with some studies suggesting that infection rates can be decreased ***(Yu VL, 1986)*** and others falling to corroborate such findings:***(Taylor et al, 1993)***. Vancomycin is often administered for one dose perioperatively.

corroborate such findings:*(Taylor et al, 1993)*. Vancomycin is often administered for one dose perioperatively.

Treatment:

Commenced promptly and appropriate balance between medical and surgical management is critical In most infection: Antibiotic therapy plays an important role that complements rather than replaces surgical treatment. Antibiotic selection based on bacterial growth and sensitiveness obtained from wound & blood but while sensitivty results are awaited in mild & moderate cases. Vancomycin is usually the drug of choice for patients and should commence immediately,usually excreted by the kidney & 80% -90% of the dose eliminated in 24 hours.

Add a gram-ve agent such as a 3rd generation cephalosporin, aminoglycoside or carbapenem when there are severe local signs or evidence of systemic infection. If successful antibiotics may be needed for several weeks, drug levels should be measured, conversion to oral preparation depends on individual patient ***(Brodly et al, 1987)***.

Whenever a poor response to antibiotics is observed, surgical treatment must be considered.

Infected perifistula hematoma require incision & drainage which may allow preservation of fistula function. Post operation wound infections with deep collections, larger puncture infections where skin cover has been lost, and rare anastomotic infections of autologous fistula are usually intractable problems that require ligation of the fistula and removal of anastomotic suture material ***(Taylor et al, 1993)***.

Formation of a more proximal fistula through a clean surgical field and using the same vessels can often provide an early return of the fistula function ***(Padberg, 1992)***.

3- Aneurysm:

Aneurysms of the AV fistula are usually the result of destruction of the vessel wall and replacement by biophysically inferior collagenous tissue. Once aneurysms have formed, the law of Laplace predicts that there is a tendency to progress spontaneously, because wall stress becomes greater with increasing diameter of the aneurysm.

Aneurysm formation is favored by replacement of the vessel wall by scar tissue after repetitive puncture of the same vessel segment. A precondition for formation of an aneurysm is usually a stenosis and a pre-stenotic rise of outflow pressure.

Major complications are rupture, infection (which is favored by intra-aneurysmatic thrombi), and in rare cases orthograde or retrograde embolism. Before intervention, adequate imaging using ultrasonography is absolutely indispensable for identification of thrombi, assessment of the degree of outflow stenosis, and evaluation of the surrounding tissue. The surgical correction includes partial or complete resection of the aneurysmatic sac, correction of accompanying stenoses, and reconstruction of an adequate lumen ***(Konner etal 2003***).

Today numerous rescue operations are available for stenoses, fistula thrombosis, aneurysms, etc. The type of intervention should be based on pathophysiologic considerations. Two examples illustrate that limited reconstruction, if necessary with the use of a short PTFE interposition graft, allows preservation of a fistula and avoids fistula abandonment ***(Mickley, 2003).***

It was observed that pseudoaneurysms most commonly at needle puncture sites. Large aneurysmal dilatations frequently occur in the run off veins of an AVF after some years of use. If the overlying skin is thinning or eroding, these should be repaired with local measures such as excision or inter position of prosthetic material.

4-Steal Phenomenon:

In recent years, ischemic lesions resulting from an arterial steal phenomenon have become more frequent in the population of highly comorbid elderly patients with vascular disease and diabetes mellitus. Concerning the interventional strategies, it is important to distinguish two varieties:

First, high-flow steal, *i.e.*, when Fistulas with very low resistance "suck-off" blood flow from the palmar arc and the opposite ulnar artery, thus creating critical ischemia of the fingers. In theory, this type of lesion should be relatively easy to correct by limiting the size of the anastomosis and reducing fistula flow ***(Burrows et al, 1979).***

Because the resistance goes with the 4th power of the radius according to Poiseuille's law, only drastic reduction of the fistula's lumen will be effective. To create an effective yet safe lumen is tricky, however, and poses the risk of low flow and thrombosis.

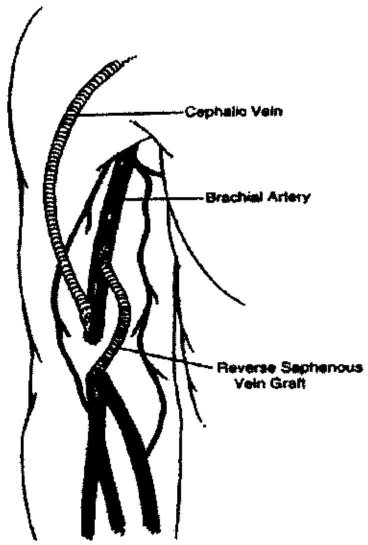
Second,more difficult, but unfortunately increasing in frequency, is the steal phenomenon in patients with low fistula flow. It is primarily the result of stenosed peripheral arteries so that even normal blood flow in the fistula will create critical ischemia in distal vascular beds.

Preoperative monitoring helps to predict the risk of low-flow steal from the limited vasodilation of the palmar arc arteries

There are only a few therapeutic options. One is to close the fistula and use a central catheter. An alternative procedure has originally been proposed by Schanzer ***(Schanzer et al, 1988)*** and recently renamed DRIL (distal revascularization–interval ligation) ***(Knox et al, 2002).***

The principle is illustrated in (Figure3). The artery distal to the anastomosis is ligated so that the fistula no longer sucks blood off from peripheral vessels. In a second step, the peripheral artery is fed via an interposed segment of saphenous vein or PTFE graft to raise the perfusion pressure. The DRIL technique is the most effective procedure for treatment of angioaccess-induced hand ischemia. This technique can be used to achieve persistent relief of symptoms with continued access patency. The DRIL artery bypass improves vascularization of the hand, and ligature of the artery stops the vascular steal without affecting hemodialysis access. The DRIL technique should be proposed as first-line treatment for hand ischemia due to AVF for Hemodialysis ***(Sessa et al, 2004).***

An unresolved issue is whether for such patients, in analogy to hemodilution in patients with peripheral arterial disease, moderately low hematocrit values should be aimed at to avoid rouleaux formation and microcirculatory stasis or, conversely, whether high hematocrit values are beneficial by raising pO_2 and tissue oxygenation. Calcium channel blockers may be contra-productive by increasing the run-off from ischemic tissue into adequately vasodilating parts of the circulation



(Fig 3) The DRIL technique (distal revascularization–interval ligation). Diagram of an upper arm brachiocephalic fistula and brachial artery bypass with interval brachial artery ligation. In this case, the brachial artery was divided below the origin of the fistula. A distal end-to-end anastomosis between vein bypass graft and distal brachial artery was performed. ***(Schillinger et al, 1991).***

5-Venous hypertention

The function of an arteriovenous (AV) fistula for Hemodialysis may be complicated by manifestation of peripheral venous hypertension, which results from the arterial blood flow through the venous system into the periphery of the upper extremity. Its development is most typically caused by a proximal forearm AV-fistula, as, in addition to the desirable arterialisation of the subcutaneous venous system of the arm, arterialization of the venous system of the forearm and the hand may occur and possibly promote the development of venous hypertension, which may in the extreme result in gangrene of the fingers.

Awareness of these problems as well as of the necessity of their surgical solution is essential for doctors dealing with Hemodialysis ***(Smith et al, 1976).*** This is caused by a stenosis or occlusion affecting the central venous system (central venous hypertension) or the so-called peripheral form of venous hypertension occurs, resulting from blood flow into the peripheral venous branch of the fistula.

Peripheral venous hypertension is now less frequent than in the 1970s and 1980s, when it occurred as a complication connected with the radiocephalic side-to-side fistula and was caused by a technical mistake in the construction of anastomosis, resulting in stenosis or thrombosis of the central discharge branch of the fistula and inflow of blood into the peripheral venous branch of the fistula.

This complication was more frequent as a delayed complication, characterised by the development of a typical stenosis of the central vein approximately 2–3 cm after the anastomosis due to haemodynamic factors. This results in a reversed blood flow, alteration of venous valves and filling of the veins of the periphery of the upper extremity.

This type of fistula is now used only rarely, and an end-to-side fistula is preferred. Only central flow is thus allowed, and the occurrence of complications has been considerably reduced. This complication is currently encountered after the creation of a proximal forearm AV-fistula. The fistula is created according to Gracz or one of its modifications. This causes possible arterialisation of the subcutaneous forearm venous system, manifested by venous hypertension. Complications occur not only in the event of an obstruction in the venous system of the arm, with the blood flow seeking for easier passage ways and with distal .flow being developed after the valves are altered, but also in the case of normal flow in the subcutaneous venous system of the arm with simultaneous filling of the forearm venous system.

Peripheral venous hypertension is manifested by finger and hand oedema, their limited motility, with the advanced stages being characterised by livid swollen .fingers and even the development of venous gangrene. In most cases, therapy is of surgical nature if conservative measures as elevation failed ***(Patel et al, 1992).***

6-Congestive Heart Failure

One advantage of the native AV fistula is that hypercirculation and congestive heart failure from high fistula flow are very rare indeed, in contrast with what is seen with PTFE grafts ***(O'Regan et al, 1978).*** Hypercirculation ensues if outflow resistance is too low; in other words, when the anastomosis is too wide. This problem is more common with PTFE grafts and brachial artery Fistulas. The only reliable diagnostic measure is to quantitate fistula flow. Banding procedures, *i.e.*, artificial narrowing of the anastomosis have been recommended, but the result is very unpredictable. Apart from the desperate act of ligating the fistula, the best intervention is to recreate a narrower anastomosis. The results of narrowing are often unsatisfactory for reasons explained above ***(Konner et al. 2003).***