Vascular access for haemodialysis : long term results, costs and the effects of percutaneous transluminal angioplasty

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VASCULAR ACCESS FOR HAEMODIALYSIS

Long term results, costs and the effects of
percutaneous transluminal angioplasty

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PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Rijksuniversiteit Limburg te Maastricht,
op gezag van de Rector Magnificus,
Prof. Dr. H. Philipsen,
volgens het besluit van het College
van Dekanen
in het openbaar te verdedigen
op donderdag, 16 juni 1994, om 16.00 uur

door

Hendrik Burger

geboren te Alkmaar

Promotores:

Prof. dr. G. Kootstra

Prof. dr. P.J.E.H.M. Kitslaar

Beoordelingscommissie:

Prof. dr. J.P. van Hooff (voorzitter)

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"We believe to be able to keep patients suffering from uraemia and anuria alive so long as bloodvessels for puncture are available"

W.J. Kolff, 1944

"Although vascular access surgery does not have the drama and glamour of major cardiovascular surgery, for the individual patient, vascular access is a lifeline"

M. Haimov, 1987

"In the last 20 years, the many and most delicate techniques involved in creating and maintaining vascular access have become significant and demanding parts of one of the most rapidly growing specialties, vascular surgery."

W.F. Barker, 1988

Aan de dialyse patiënten, die hebben leren leven met hun kwetsbare toegang tot de bloedbaan.

Aan mijn ouders.

Aan mijn vrouw en kinderen.

De uitgave van dit proefschrift is financieel gesteund door bijdragen van de Nier Stichting Nederland en de Stichting Ontwikkelingsfonds Drechtsteden Ziekenhuis.

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List of abbreviations

A-V	: arteriovenous
CAPD	: continuous ambulant peritoneal dialysis
CCPD	: continuous cyclic peritoneal dialysis
Dfl	: Dutch guilder
ESRD	: end-stage renal disease
n	: number
No	: number
PTA	: percutaneous transluminal angioplasty
PTCA	: percutaneous transluminal coronary angioplasty
PTFE	: (expanded) polytetrafluoroethylene
USD	: United States dollar

Preface

The loss of function of the kidneys, called end-stage renal disease (ESRD), can be treated by haemodialysis, peritoneal dialysis, or kidney transplantation. Haemodialysis was practiced with success for the first time by Kolff [1] on 17 March 1943 at Kampen in the Netherlands. He had constructed an artificial kidney with the technical help of Berk. Access to the circulation proved to be an insurmountable problem after twelve dialyses and for the last five accesses the help of a surgeon was required.

To make long term haemodialysis feasible for a patient, a permanent access to his circulation is needed. This access, which has been called vascular access or angioaccess, is the subject of this thesis.

On 1 January 1992, the Netherlands had a population of 15 129 150, 6447 of whom were on dialysis or living with a functioning transplant (1 out of every 2347 men or women)¹ Out of a group of 3311 patients on dialysis and being treated in 53 centres, including some centres for home dialysis, 2447 were on haemodialysis and 864 on peritoneal dialysis. All patients on haemodialysis require a vascular access. To establish and maintain this vascular access, about 0.8 surgical interventions per patient per year are needed.

After many trials and errors, Quinton et al. succeeded in 1960 [2] in constructing a permanent vascular access, that made it possible to offer prolonged treatment for ESRD. They created a connection between an artery and a vein with Teflon and silicon rubber tubing. This external arteriovenous (A-V) shunt could be used several times a week and remained patent for a longer period. Other and more effective types of vascular access have been found since, especially the A-V fistula developed by Brescia et al. in 1966 [3]. The general term "shunt" is still used for all sorts of accesses in which an artery and a vein are linked together to provide an access to the circulation of the blood. The term includes the subcutaneous kind, which requires skin puncture for each dialysis and the transcutaneous kind, which permanently penetrates through the skin.

Another treatment for ESRD, peritoneal dialysis, was at first only practical for acute dialysis during a limited time period [4]. Later a

¹ Newsletter Registration Renal Replacement Therapy the Netherlands. Foundation RENINE, Rotterdam, 1992.

permanent access to the peritoneal cavity was developed and continuous ambulant peritoneal dialysis (CAPD) and its variants among them continuous cyclic peritoneal dialysis (CCPD), are now practical alternatives [5]. It is estimated that more than a million people all over the world are being kept alive by means of haemodialysis and peritoneal dialysis.

The third and most desirable treatment for ESRD, kidney transplantation, has become a standard procedure and gives the best results with regard to quality of life [6]. Yet, kidneys for transplantation cannot be obtained in sufficient numbers, a compatible kidney is often not available and not all patients are suitable for transplantation. Also, a number of transplanted kidneys are rejected by patients, in spite of modern immunosuppressive medication and patients then have to rely on dialysis again.

The lifetime of an A-V shunt is threatened by several complications, the most serious being stenosis. The diagnosis and treatment of stenosis of shunts is vital for the maintenance of vascular access. Balloon dilatation, percutaneous transluminal angioplasty (PTA), a relatively new vascular intervention technic, has been proven to be quite useful in vascular access for the treatment of stenotic complications.

The present thesis consists of studies about the state of vascular access surgery for haemodialysis and its results in the Netherlands, as well as the influence of PTA on the number of surgical interventions required to maintain vascular access, the survival of shunts and the costs of shunt surgery.

The aims of this study are:

1. To establish the state of vascular access for haemodialysis in the Netherlands.
2. To investigate the long term results of the different types of vascular access and the effect of PTA on the results.
3. To investigate the effects of the routine application of PTA for treatment of stenotic complications in vascular access on the number of surgical interventions needed to maintain an adequate vascular access for haemodialysis.
4. To investigate the costs of vascular access surgery and PTA and the effects of routine application of PTA on the total costs of vascular access.

Patient connected to a dialysis machine by way of an arteriovenous fistula.

Quilley et al. [20] support in the service of hemodialysis was first performed by Kolmer in the region of Kaff on a special table in Europe in the Netherlands. The dialysis and blood circulation is produced by the collective haemodialysis in a median body and well described by Apollon [21] similar to the Dutch blood of area in 1948 [21,22] and

General Introduction

Access to the blood circulation is a precondition for haemodialysis. Vascular access surgery concerns itself with creating and maintaining such an access. It is called a shunt or dialysis shunt; the Index Medicus refers to it as "arteriovenous shunt, surgical". More specifically the word "shunt" is often reserved for the partly external arteriovenous (A-V) shunt. The entirely internal A-V shunt complex is called an A-V fistula. The term blood access also covers the central venous or arterial catheters which can be used for haemodialysis.

Publications about vascular access have appeared in abundance over the years since 1960. Monographs on vascular access surgery have been published, among them the books of Bell and Calman [7], Haimov [8] and Wilson [9], an issue of Current Problems in Surgery by Marx, Landmann and Harder [10] and the atlases of Rubio and Farrell [11] and Ota [12]. In some atlases and handbooks on vascular surgery chapters on vascular access, as well as dialysis contain good overviews by authorities in their field [13, 14]. In the Netherlands, theses by Bast [15], Slooff [16], Zijlstra [17] and Tordoir [18] have highlighted aspects of vascular access.

International congresses on vascular access surgery in 1982 and 1990 in Maastricht [19, 20] have provided a platform for establishing the state of the art and for indicating future developments.

HISTORICAL NOTES

The history of successful surgery for a permanent vascular access for haemodialysis started in 1960 with the construction of an A-V shunt by Quinton et al. [2]. Surgery in the service of haemodialysis was first performed by Kehrer at the request of Kolff on 6 April 1943 at Kampen in the Netherlands. The difficult and fateful endeavors to prolong the first effective haemodialysis in a human being are well described by Kolff in his articles in the Dutch medical press in 1943 [21,22] and

in *Acta Medica Scandinavica* in 1944 [1] as well as in his thesis in 1946 [23].

One is tempted to recall Carrel's first A-V anastomoses in 1902 [24]. He and Guthrie probably did not foresee the use of these anastomoses for a permanent access to the superficial veins, but they certainly did see the possibilities of transplantation surgery and they immediately did some kidney autotransplantations [25]. Brescia et al. were able to build on their experience when they constructed an A-V fistula at the wrist to provide a permanent access to the circulation for haemodialysis in 1966.

The founding of centres for haemodialysis in the sixties and seventies required adequate vascular access surgery and so from modest beginnings the latter has become an established branch of vascular surgery. While in most patients vascular access can be established for long periods without many interventions, a number of patients requires several operations and persistent efforts to sustain an access or create new ones.

VASCULAR ACCESS IN THE NINETIES

Vascular access, defined as a temporary or permanent access to the blood circulation, is an important condition for much diagnostic and therapeutic medical work. It ranges from a simple intravenous infusion or a venous puncture to draw blood for analysis to central venous catheters, access ports for chemotherapy and A-V fistulas and shunts, meant to provide a permanent access for haemodialysis. The last two forms of access usually call for surgical intervention. Surgery that concerns itself with creating and maintaining access to the blood circulation is called vascular access surgery.

Access surgery for haemodialysis has become more sophisticated than it used to be because a wide range of possibilities of gaining and maintaining access to the circulation has become available.

The first choice for a vascular access for haemodialysis is an autogenous distal A-V fistula at the wrist, as described by Brescia et al. [3]. Usually this fistula must ripen for 3-6 weeks before it can be used and, therefore, it is important to make such a fistula in time. When an immediate dialysis is wanted, a central venous catheter is placed. Shaldon pioneered the catheterisation of the femoral vein [26]. Later the subclavian vein became popular and lately the jugular vein is preferred. The alternative acute access, an A-V shunt, preferably in the leg in order to spare the arm vessels, is presently used less frequent but is not obsolete.

— When a primary or first choice access is not possible, other accesses can be constructed that function well [27]. These so-called secondary or second choice accesses include more proximal A-V fistulas, graft A-V fistulas and implantable systems. Second choice accesses can be very useful but they should, indeed, be second choice because they are associated with more complications and their survival is inferior to first choice accesses. The problem is knowing when a first choice access has a good chance functioning well. Still, when the patient and his physician are well motivated, it is worthwhile trying to make a first choice access. The patient may need an access for years and it is wise to conserve more proximal vessels for the future.

Several varieties of the A-V shunt and fistula have proven to be useful in clinical practice.

The A-V shunt

The A-V shunt is based on the simple principle of cannulation of an artery and a vein in a limb connected by tubing that perforates the skin. For dialysis, the tubes are disconnected outside the skin and linked to the artificial kidney. This method, already explored by Kolff and Alwall

Figure 1. The A-V shunt in the leg. The Scribner shunt in the Ramirez variation, with an external bend.

[28], was made practicable by Quinton et al.[2,29] by using Teflon cannulas and Silastic tubing. Ramirez suggested a variation of the Scribner A-V shunt [30] (Fig. 1). The Ramirez shunt does not have a subcutaneous bend for better fixation like the original Scribner shunt, but it has straight subcutaneous tubing with wings for fixation which facilitates the passage of catheters to treat complications [17].

Figure 2. The radiocephalic distal A-V fistula side to side in the arm, the Cimino fistula.

Figure 3. The radiocephalic distal A-V fistula side to end in the arm, the Cimino fistula.

Figure 4. The radiocephalic distal A-V fistula end to end in the arm, a Cimino fistula variation.

The autogenous distal A-V fistula

To create a useful A-V fistula a connection is made between an artery and a superficial vein, which results in perfusion of the veins with a strong blood flow. Under arterial pressure the veins tend to dilate, allowing an easier puncture of the veins. Repeated puncture of the superficial veins is quite possible and provides a flow of blood that is sufficient for regular haemodialysis. However, in the course of time, stenoses do occur in the arteriatised veins. Brescia et al. first reported on the A-V fistula between the radial artery and the cephalic vein at the wrist for vascular access in 1966 [3] (Fig. 2-4). Several variations have been found useful, but essentially this same A-V fistula has proven to be the best access available [31]. Some surgeons have reported good or even better results for a still more distal A-V fistula, the anatomical snuffbox, the "tabatière anatomique" fistula [32].

Figure 5. The autogenous A-V fistula at the elbow between the brachial artery and a cubital vein. A side to side variation.

The proximal A-V fistula

When a distal fistula fails, a more proximal fistula is sometimes possible in the elbow region [33, 34] (Fig. 5). This A-V fistula often supplies a good flow of blood. Whether this second choice A-V fistula is useful depends on whether the superficial veins are sufficient and whether the circulation to the hand is not compromised.

The graft A-V fistula

Whenever there are not enough superficial veins available, a superficially placed graft between an artery and a vein can provide a good access (Fig. 6). The saphenous vein as an autotransplant (May et al. 1969) [35] has been used with good results by a number of surgeons [36]. Others have reported negative results [37] and sufficient veins for grafting may not always be available. In general the saphenous vein is still used, albeit to a limited extent, for A-V graft fistulas. In the late seventies, the bovine artery graft was extensively used [37], but it has since been discarded because there were too many complications [38]. Extended polytetrafluoroethylene (PTFE) grafts have now been in use for more than 10 years and are probably the most popular grafts these days [39,

Figure 6. The graft A-V fistula in the arm. A PTFE loop with anastomoses at the elbow.

40]. The homologous saphenous vein graft, a saphenous vein from another person that has undergone a process of denaturation to prevent immune rejection, seems a reasonable alternative to the autologous vein [41].

Implantable systems

Implantable vascular access systems with a transcutaneous connection, that can easily be attached to the artificial kidney have been used with varying degrees of success (Fig. 7). Most experience has been gained with Biocarbon® [42] and Hemasite systems® [43]. They can function well, but because they perforate the skin they are susceptible to infection. New systems are being tried out, but none is, as yet, regularly employed for clinical haemodialysis.

Figure 7. An external vascular access device (Biocarbon®). The device, fixed on a PTFE graft which is anastomosed with the brachial artery and the cephalic vein, offers access by using a special plug.

Surveillance of vascular access

Good surveillance of vascular access means careful daily monitoring of blood flow by auscultation by the patient or the attending medical staff and observation of signs of infection, abnormal dilatation of veins and signs of ischemia or venous hypertension. During dialysis, blood flow and venous pressure must be monitored. Vacuum suction with a blood flow of more than 300 ml/min and a venous pressure higher than 150 mm Hg during three consecutive dialysis sessions must be regarded as abnormal and is often indicative of stenotic problems within the vascular access [44]. Recirculation of the blood in the shunt may also be indicative of stenoses and a monthly recirculation test is sensible. New dialysis equipment also allows one to measure arterial pressures.

Diagnostic methods to evaluate access surgery

Invasive methods

Angiography of a vascular access is the preferred method for imaging and remains the golden standard [45, 46]. To perform angiography from various angles is not easy. The high-pressure inflow with a low-pressure outflow demands a special technique. To make an angiogram immediately after dialysis obviates a new puncture, but puts a certain amount of pressure on the radiology department. Conventional film techniques are preferred [17], although some report advantages for digital subtraction angiography [47].

Noninvasive methods

Duplex scanning, combining the use of ultrasonic vessel imaging and pulsed Doppler examination, has proven to be useful in diagnosing stenoses in a vascular access [18]. The colour Doppler technique may improve that method by visualizing the direction of the blood flow in colour [48].

Complications of vascular access

From the time it was first used until today, the most serious complications of vascular access have been thrombosis, stenosis and infection [49]. To these must be added prolonged bleeding, decubitus, venous hypertension, aneurysm, steal syndrome, subclavian vein thrombosis [50, 51] and accidental disconnection of an external shunt. Prevention of these complications and, when possible, early treatment may save a vascular

access. Prevention includes performing the operation in a meticulous way, with careful assessment of the blood flow on completion of the anastomosis and after closure of the skin, anticoagulant therapy when needed and prompt reintervention in the case of thrombosis.

Treatment of the most serious complications of vascular access

Thrombosis

Three methods are available to treat thrombosis: surgical thrombectomy, thrombolysis and percutaneous thrombectomy. While postponing treatment for a few hours is acceptable and a thrombectomy can be attempted even after days of occlusion, prompt treatment is the best choice. Thrombolysis of Scribner shunts with streptokinase has been used for a long time and with good results. A Scribner shunt can also be cleared with the help of catheters. Surgical thrombectomy is usually still the method of choice for A-V fistulas. Thrombectomy by percutaneous catheterization is sometimes also successful with A-V fistulas. Percutaneous catheter techniques for thrombolysis, combined with balloon dilatation of stenoses, possibly promise good results and do not require surgical interventions [52].

Lately, the frequency of thrombotic complications in vascular access for end-stage renal disease (ESRD) has risen considerably, maybe because of the use of erythropoietin in dialysis patients. This new medicine not only raises the hemoglobin level but also restores the impaired coagulation of the ESRD patient [53, 54]. A more active thrombosis prophylaxis is warranted for patients receiving erythropoietin.

Although thrombosis may occur without serious endovascular stenosis, it is always wise to search for a stenosis in the event of a shunt thrombosis. Prevention of thrombosis with anticoagulants must also be considered for patients with heterologous grafts, Scribner A-V shunts and high hemoglobin levels, as well as for patients with a manifest disposition for thrombosis. Coumarin derivatives (Sintrom mitis®), acetyl salicylic acid and dipyridamol (Persantin®) [55] can be used; the latter two may be especially helpful when one does not want to risk bleeding.

Stenosis

Stenosis is the most serious complication of vascular access. It is caused by the repeated punctures and by the abnormal bloodflow, which results in hyperplasia of the intima. When caused by the abnormal bloodstream, this intimal hyperplasia typically occurs just proximal of the A-V anastomosis in Cimino fistulas, at the graft-venous anastomosis of graft A-V

fistulas and in the efferent vein of graft A-V fistulas. Repeated puncture of the vessel wall may lead to dilatation and the formation of aneurysms, but most often it leads to stenosis [18].

Two methods of treatment are available: surgical and radio-interventional. The surgical treatment can be a dilatation operation with the help of a patch, such as autologous vein or PTFE. Sometimes a bypass or an interposition is a better solution to the problem of stenosis, utilizing a transplanted vein or a PTFE graft. The radio-interventional method - the balloon dilatation - is still gaining ground, as more radiologists acquire experience and enthusiasm for the method. It is a more patient-friendly method and the results justify continuation [56].

Infection

Infection of a vascular access poses a threat to the access itself and to the patient. The skin-perforating accesses like the Scribner A-V shunt are most prone to infection. The heterologous graft A-V fistulas are also susceptible to infection. Prophylactic and therapeutic use of antibiotics may prevent an infection and save an access [51, 57]. Not only very strict surgical discipline is needed to help to prevent infection but also discipline on the part of the patient and of the haemodialysis department. Infected grafts may have to be taken out. Infected catheters demand a very active antibiotic regimen and often removal of the catheter [58].

Vascular access for acute haemodialysis

Acute haemodialysis demands immediate vascular access. Catheters are used in the femoral vein (Shaldon) [26], the subclavian vein [59], or the internal jugular vein [60] to provide access in acute situations for patients on chronic haemodialysis or for patients with a rapidly developing uremia. The subclavian vein catheter and the internal jugular vein catheter have also been used as a semipermanent or even a permanent access [57]. Their associated complications - notably stenosis, thrombosis and infection of central veins - are more serious than the same complications in more distal veins.

While an A-V shunt of the Scribner type is useful as an acute and semipermanent access, in most dialysis departments the access of choice for acute and semipermanent access is a catheter in the subclavian vein [61]. A catheter in the femoral vein has fewer serious complications, but is far less practical as an access for more than a few days. The internal jugular vein has been used more and more lately as a good access vessel for catheters [62, 63]. Over the past years, there has been a growing

awareness of the complications of upper central venous catheters [57, 64-66], especially thrombosis. An obstruction of the subclavian vein obviates the possibilities for a vascular access in the corresponding arm [67].

Percutaneous transluminal angioplasty (PTA)

The technique of dilating stenoses in blood vessels, often called transluminal angioplasty, was originally developed by Dotter and Judkins [68] and Grüntzig and Hopff [69]. Dilatation can be accomplished during an operation or percutaneously. Percutaneous dilatation is less invasive and tends to be more patient-friendly.

Percutaneous transluminal coronary angioplasty (PTCA), balloon dilatation for arteriosclerotic stenosed coronary arteries, has acquired a wide reputation, making coronary heart surgery sometimes superfluous. In peripheral arteries too balloon dilatation is regularly used with success. The right indications for PTA and PTCA are still a matter of debate, but a consensus is developing [70].

The fibrotic stenoses that tend to develop in the arterialised veins, grafts and anastomoses of A-V fistulas and shunts can also be dilated, often percutaneously. This method is increasingly used for vascular access [17, 54, 71-73].

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A survey of haemodialysis in the Netherlands

H. Burger, G. Kootstra[#], F. de Charro^{*}, P. Leffers⁺

From the Departments of Surgery, Diaconessenhuis Refaja, Dordrecht and [#]the University Hospital Maastricht, ^{*}the Renal Replacement Registry Netherlands Rotterdam and ⁺ the Department of Epidemiology, University of Limburg.

ABSTRACT

After nearly 30 years of access surgery for haemodialysis, a survey of vascular access in a large population seemed relevant in order to analyze the state of the art.

On January 1, 1988, 2195 patients in 52 centres in the Netherlands (population 14 714 900) were on long term haemodialysis and 588 on continuous ambulant peritoneal dialysis (CAPD) for renal insufficiency.

A questionnaire was mailed out, to which there was 100% response. Of all the patients on long term haemodialysis, 70% had a Cimino fistula, 22% a graft fistula and 6% a more proximal arm fistula. The remaining 2% had a Scribner shunt. Of all the graft fistulas, the expanded polytetrafluoroethylene (PTFE) graft was the one most used (58%), followed by the homologous vein graft (25%), the autologous vein graft (13%) and those made of other other materials (4%).

Preference for acute access was recorded; catheterization of the subclavian vein was used almost exclusively in 17 centres, while in 24 centres it was chosen in more than 50% of the cases. The femoral vein was almost always the choice for acute access in 6 centres and it was selected in more than 50% of the cases in 17 centres. Another alternative, the Scribner shunt, was applied in selected cases in 22 of the 52 centres.

Percutaneous transluminal angioplasty (PTA), as a method for treating stenoses in vessels used for vascular access, was applied routinely in 5 centres and occasionally in 19 centres.

INTRODUCTION

Nearly 30 years ago, more than 15 years after the first successful haemodialysis by Kolff in 1943, a useful vascular access was created by Quinton, Scribner and Dillard. Since then, the technique and the results of access surgery for haemodialysis have been the subject of extensive research.

Information about vascular access is needed in order to provide professionals in the field with basic data about the extent of the problem, to provide data for the planning of facilities and to facilitate comparison of the use of different procedures all over the world. Such data about the actual state of vascular access for long term haemodialysis in larger populations turn out to be scarce.

Porter et al. reported on vascular access among haemodialysis patients in an area with over 12 million inhabitants in Ohio, U.S.A. [1]. In 2562 patients, the following types of vascular access were found: autogenous arteriovenous (A-V) fistula (65%), graft fistula (34%) and external Scribner shunt (1%).

In the Netherlands, the centres for haemodialysis and continuous ambulant peritoneal dialysis (CAPD) are regularly surveyed regarding many aspects of dialysis and transplantation by RENINE, the renal replacement registry of the Netherlands. However, until now, vascular access has not received much attention. Only two studies thus far have been carried out in the Netherlands. In its 1978 annual report, the European Dialysis and Transplantation Association (EDTA) [2] gave data about vascular access in 14 European countries and compared them with 1975 data. In 1985, a postal survey about the state of access surgery in the Netherlands was conducted (Tordoir) [3]; however, this has not been published.

To gain a more current insight into vascular access and changes in practice over time, a questionnaire was distributed to all centres for renal replacement in the Netherlands.

MATERIALS AND METHODS

A questionnaire about vascular access on January 1, 1988 was mailed to all the centres for renal replacement therapy in the Netherlands. On that date the population of the Netherlands was 14 714 900 [4].

The data registered included the number of patients with various types of vascular access: A-V fistula (Cimino), A-V shunt (Scribner), primary access (i.e., radiocephalic A-V fistula or first choice A-V shunt) and

secondary access (i.e., all access other than primary access), as well as the number with vascular grafts: autologous vein, homologous vein (Vascogref® = Varivas®, Dardik®, heterologous vessel (bovine), artificial vessel (expanded polytetrafluoroethylene (PTFE)), A-V fistula in the elbow and some other special forms of access. Centres were asked if the single needle method (the method of puncturing the A-V fistula with only one needle instead of the usual two) was used incidentally or routinely. There were also questions about the percentage of cases of long term haemodialysis, in which subclavian vein catheter, femoral vein catheter, A-V shunt (Scribner) or other access methods were used. Another topic was the frequency of application of percutaneous transluminal angioplasty (PTA): routinely, incidentally, or not at all. Finally, there were questions about whether the operating team included one surgeon, some surgeons, all surgeons, or surgical residents.

Permission was requested to allow RENINE to provide information about the age and sex distribution of patients per centre, the number of patients on CAPD, the number of patients who were previously transplanted but who were now back on dialysis and about the number of patients with diabetes mellitus.

RESULTS

All of the questionnaires were filled out and returned. It was found that as of January 1, 1988, 2807 patients (1503 men and 1304 women) were on renal replacement therapy in 52 centres. Of these, 2195 (78%) were on long term haemodialysis. Another 588 patients (20%) were on CAPD, while for 24 the type of treatment was unknown.

The 52 centres included 12 academic dialysis units, 35 dialysis units in general hospitals and 5 other units.

Two centres were for home dialysis only, three centres for hotel dialysis only, three centres for children and one centre for CAPD only. A fourth centre for children was incorporated into the dialysis centre of a university hospital.

There was a wide range in the number of patients in the different centres (3-115, mean 42). There were 13 centres with more than 70 patients and 9 with less than 30 patients.

A total of 2170 patients were found to have a vascular access. The different types of shunts are listed in Table 1. Some 1517 (70%) of the patients had a radiocephalic (Cimino) A-V fistula, 474 (22%) a graft A-V fistula and 139 (6%) an elbow A-V fistula. Thirty-eight (2%) A-V (Scribner) shunts were counted and two Biocarbon® access devices. Among the

graft A-V fistulas with their respective percentage of grafts were: PTFE (58%), autologous vein (13%), homologous vein Varivas® (25%) or Dardik® (1%) and heterologous vein bovine (3%) (Table 2).

Table 1. Distribution of types of access among all patients with a vascular access. Distribution of centres according to prevalence of the specific type of vascular access per centre.

	Number of patients		Proportion of patients per centre with specified type of access				
			0-19%	20-39%	40-59%	60-79%	80-100%
			Number of centres				
A-V fistula (Cimino)	1517	(70%)	1	3	8	26	13
A-V fistula (graft)	474	(22%)	28	18	4	2	0
A-V fistula (elbow)	139	(6%)	49	3	0	3	0
A-V shunt (Scribner)	38	(2%)	52	0	0	0	0
Other shunt Biocarbon	2	(0.1%)	52	0	0	0	0
All types vascular access	2170	(100%)					

Table 2. Graft fistulae, their distribution and the centres where certain types of access were present.

	Number of patients	Proportion of all types of access	Proportion of grafts	Number of centres where graft is used
All grafts	474	22%	100%	47
PTFE	274	13%	58%	35
Autologous vein	63	3%	13%	22
Homologous vein	119	6%	25%	20
Bovine graft	13	0.6%	3%	7
Dardik graft	5	0.2%	1%	2
Other types of vascular access	1696	78%		
All types of vascular access	2170	100%		

The four centres for children, which are all academic, treated a total of 62 patients. They apply an age limit of approximately 16 years (mean age 10 years). Some young children were also treated in centres that are not specifically paediatric. There was a high percentage of A-V fistulae: 86%. CAPD was the dialysis method in 43% of the children.

The percentage of diabetic patients among the whole dialysis population was 7%. The percentage of diabetic patients in the different centres varied widely. Diabetes mellitus was found in a frequency of more than 10% in 13 centres. No correlation was found between a high frequency of diabetes and a certain pattern of vascular access, e.g. more secondary access.

The use of the single needle technique was the first choice in four centres (75%-100% of the patients on single needle technique), while five others (25%-74%) used it as a good alternative. The majority used it only when the two needle technique failed or not at all (Table 3).

Table 3. Single needle technique as routine for access to A-V fistulae in the different centres. Number of patients on single-needle access and percentage of all patients in haemodialysis.

	Number of centres	Number of patients in these centres (percentage of all patients)
Single-needle 95-100% routine	3	85 (4%)
Single-needle 50-94% routine	2	76 (3.5%)
Single-needle 25-49% routine	4	47 (2%)
Single-needle 1-24% routine	24	76 (3.5%)
Single-needle never	19	0
Total	52	284 (13%)

PTA was used routinely in 5 centres, occasionally in 19 centres and never in 28 centres.

Access surgery was done mainly by one surgeon (more than 80% of the operations) in 13 centres, by a group of surgeons in most centres, but rarely by residents. Differences in access were not found in relation to the number of surgeons employed in access surgery.

Acute access methods in long term haemodialysis were analysed. Catheterization of the subclavian vein was the first choice in 17 centres. Twenty-four centres used the subclavian vein in more than 50% of the cases. The femoral vein was used nearly exclusively in 6 centres and in more than 50% of the cases in 17 centres. The Scribner shunt, as an alternative acute access, was in use in 22 centres and in more than 5% of the cases in 11 centres. Jugular vein catheterization was only practiced in two centres.

The number of patients with failed transplants (572 patients) varied very much per centre, from 0% to 75% (on the average 11 patients per centre). In 11 centres more than 30% of the patients had transplants that failed (220 patients). These included 9 of the 12 academic centres, which, in turn, included the centres for children only.

Correlations between types of vascular access and characteristics of the centres were explored. Mean age, percentage of patients 65 years and older, predominance of men or women, percentage of patients with diabetes mellitus, percentage of patients on CAPD, percentage of patients with failed transplants and number of surgeons occupied with vascular access did not correlate with any special type of vascular access or percentage of primary or secondary access.

DISCUSSION

The different types of access call for a close examination.

The Cimino-Brescia A-V fistula and its variations

There is a consensus in the literature that the A-V fistula in the forearm, the radiocephalic fistula, offers the best vascular access when, in fact, it is possible to create such a fistula or a variation of it [5]. Maintaining this sort of access in 61%-80% of the patients is apparently not possible or desirable in 12 centres. On the other hand, in 14 centres, 81% or more of the patients have a Cimino A-V fistula (Table 1). Factors such as intensity of treatment and diagnostics before the stage of terminal renal insufficiency was reached, damaging veins and arteries and, on the other hand, an active policy of sparing vessels, play a role.

The Scribner A-V shunt

The first serviceable vascular access is still in use but in a decreasing number of centres [6]. Only 38 Scribner shunts were registered, the shunt being largely replaced for acute access by semipermanent catheters. In two centres more than 5 shunts, meant as a primary access (first

choice) or secondary access (second choice) were counted. In five centres more than 5% of the patients receiving haemodialysis (6%-15%) had an A-V shunt. There may still be a valid place for the Scribner shunt as a safe and easy access as it has few serious complications when constructed with great care and maintained with the help of percutaneous transluminal angioplasty [7,8].

Primary and secondary access

In the present survey, primary access was defined as an A-V fistula (Cimino) or a first choice A-V shunt (Scribner). We presume that whenever possible a Scribner shunt is replaced by a Cimino fistula, the latter being the best access available.

There was a wide variation (100%-38%) in the percentage of patients with a primary access (Cimino fistula or Scribner shunt as first choice) in the different centres. In some patient populations the state of the vessels may be better than in others, something which makes comparison difficult. On the other hand, some centres seem to prefer a certain form of secondary access (e.g., a homologous venous graft fistula). Many centres strongly prefer an A-V fistula and will spend a good deal of energy trying to create and preserve one. Others choose a graft fistula as a very acceptable alternative for many of their patients.

Vascular grafts

When a primary access is not possible, several choices are available. The most popular option among vascular surgeons nowadays seems to be an artificial graft, the PTFE graft (Goretex® or Impra®). The autologous vein graft has been tried extensively and is still in use. The homologous vein (Varivas®, formerly called Vascogref®), a prepared human vein, is now being used increasingly (Table 2). Several other grafts have been used extensively (bovine, Dardik®) but do not appear to have proved to be satisfactory in most hands. The same is true for implants like the Biocarbon® and Hemasite® devices.

The centres for children

Dialysis in children's centres has different characteristics, especially with regard to the frequent application of CAPD in young children [10]. The pattern of vascular access is also distinctive, with a high percentage of A-V fistulae.

Changes in vascular access patterns

The 1985 questionnaire [3] had a 74% response rate (37 of the then 50 centres), which represented 80% of all patients on renal replacement therapy.

During the last 10 years, the percentage of patients with an A-V fistula of the forearm (Cimino), generally accepted as the first choice for vascular access, has not changed substantially (Table 4). However, there has been a significant change in the frequency of other types of access. The Scribner shunt is used much less. Among the grafts, the use of PTFE and the homologous vein (Varivas®) is steadily increasing and the use of the autologous vein is decreasing (Fig. 1).

Diabetes mellitus

There is no simple explanation for the fact that only 7% of the patients on dialysis had diabetes mellitus. The prevalence of diabetes mellitus in the population of the Netherlands is estimated at 2.3% (0.3% type I and 2% type II). This is not much different from the overall situation in the US (prevalence estimated at 2.6%), although there are considerable variations between the different states. The prevalence of diabetes mellitus in Europe varies greatly. In the Nordic countries there is a large population of young type I diabetes mellitus, while in the south there is a preponderance of elderly type II patients. Acceptance policies for elderly diabetics may differ.

Percutaneous transluminal angioplasty

Results of PTA of vascular access were not asked for in the questionnaire. In a recent study [8] an immediate success rate of 90% of PTA was recorded. An extended longevity for Scribner shunts of 9 weeks and for A-V fistulae of 10 months for each PTA was computed, early failures not excluded [8].

The varying patterns of vascular access in the different centres seem to be influenced primarily by the choice of the vascular surgeon, the nephrologist and the nursing staff of the dialysis centres. None of the recorded characteristics of the centres correlated with a particular type of vascular access.

The quality of vascular access should have a high priority in the care of patients who need haemodialysis. In the Netherlands a working group for access surgery was established in 1989 to advance that specialty.

This survey of vascular access among more than 2000 patients, reflects the choices presently available to surgeons who seek to establish and

Figure 1. Distribution of types of vascular access, excluding the autogenous A-V fistula, in 1978, 1985 and 1988.

maintain the lifeline for patients on haemodialysis. Research in controlled, multicentre studies (e.g., comparing the results of the autologous vein graft, the homologous vein graft and the PTFE graft) may lead to more consensus about secondary vascular access.

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Percutaneous Transluminal Angioplasty Improves Longevity of Arteriovenous Shunts and Fistulas for Haemodialysis

H. Burger, J.J. Zijlstra*, S.A. Kluchert#, A.P. Scholten#
and G. Kootstra+

From the Departments of Surgery, *Radiology and #Nephrology, Diakonessenhuis Refaja, Dordrecht and the +Department of Surgery of the University Hospital, Maastricht, the Netherlands.

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ABSTRACT

Percutaneous transluminal angioplasty (PTA) has proved to be an effective method for dilating stenoses in veins and arteries used for vascular access in haemodialysis. Not only can stenoses of arteriovenous fistulas (Cimino and other types) be treated, but stenoses of arteriovenous shunts (Scribner) can also be successfully dilated.

Over a period of 3 years, PTA was applied 94 times in a haemodialysis population of about 50 patients. It reduced the number of surgical interventions required to maintain permanent vascular access by 30%. The longevity of external and internal shunts was increased by nearly 2 months and 1 year, respectively, with a PTA. Repeated PTA's were often possible.

During the 3 years that PTA was practiced routinely, there was a 50% reduction in the number of operations with stenosis as indication as compared to the 3 preceding years.

INTRODUCTION

Percutaneous transluminal angioplasty (PTA), developed by Dotter in 1964 [1], was introduced in the early 1980's for dilatation of stenoses occurring after the development of arteriovenous (A-V) fistulas. Most authors report satisfying results [2-9], although one observed an increase in costs and a shorter patency [10]. Extensive experience has been gathered concerning the dilatation of stenoses caused by degenerative lesions in the coronary and peripheral arteries. It has also been established that good results can be obtained when PTA is used for vascular access. The fibrous stenoses that most often result from repeated punctures and changed bloodstream characteristics can be dilated successfully.

While initially only stenoses of A-V fistulas were treated, it later became evident that the well-known stenoses at the end of an implanted vessel tip of an external A-V shunt (i.e., the Scribner shunt) could also be treated with PTA. The Scribner shunt plays a reduced role in vascular access. It comprises now only 2% of all forms of access in the Netherlands [13]. It still has a place in selected patients and as an acute access or a semipermanent secondary access. The technique of using PTA for the Scribner shunt was developed by Zijlstra et al. [11, 12]. They employed modified catheters for internal and external shunts, which are now commercially available (Schneider Europe AG Zurich, Switzerland). The Ramirez variation of the Scribner shunt, which has a straight subcutaneous tubing and an optional external bend, is recommended for easier catheterization. Stenosis may recur after a dilatation, but dilatations can be repeated successfully. [9, 11, 12]

Although Brooks et al. [10] report an increase in costs, we have calculated that the cost of a PTA on an out-patient basis is considerably lower than the costs of an operation plus an average of several days in the hospital [12]. Of course some surgical interventions may take only one or two days in hospital, but others require an extended hospitalization. A PTA has to be repeated more often than a treatment of stenosis by surgical means, but on a yearly basis the cost of a PTA is still lower.

PATIENTS AND METHODS

From January 1983 until January 1989, an average of 50 patients were treated with chronic haemodialysis in the Department of Nephrology of the Refaja Hospital in Dordrecht, The Netherlands. Characteristics of the group of patients were the following: Mean number of patients 49

(range 46-54), mean age 51 years (range 48- 56), mean duration of haemodialysis 5.1 years (range 4.7-5.4).

During the study period, most of the operations and PTA's were carried out by the same surgeon (HB) and radiologist (JJZ).

The effect of PTA on the number of interventions for stenosis of the artery or vein involved in the access was analyzed by counting all the interventions before and after the application of PTA. Except for the first access operation, all operations were counted as reinterventions. In order to gain a fair insight into the effect of PTA, the assumption was made that any malfunctioning of a vascular access could be related to a stenosis.

Since March 1986, PTA has been used more and more often in the Refaja Hospital and since 1987 it has been the treatment of choice for all stenoses. Rising venous pressure or diminished arterial pressure during haemodialysis requires angiography and when a potentially dilatable stenosis is found, a PTA is done. As mentioned earlier, the technique of using PTA has already been described elsewhere [11, 12], but will also be summarised here.

For dilatation of a Cimino fistula, a 5 French catheter, 50 cm in length, with a balloon length of 4 cm and diameter, when inflated, of 6 or 8 mm, is used (Fig.1). A straight wire with a floppy tip is used. The

Fig.1. Cimino A-V fistula. (1) Side hole to flush both sides of the stenosis during the procedure. (2) Low profile balloon of 6-8 mm. (3) Most common site of stenosis in Cimino fistulas. (4) 5 French catheter, 50 cm in length.

wire is 100 cm in length and has a diameter of 0.020 in. The balloon catheter is inserted cranially to the anastomosis of the Cimino fistula through a puncture of the venous limb using the Seldinger technique. The veins have thick walls and may be difficult to enter. They often require prolonged compression in order to achieve hemostasis after the procedure.

For dilatation of a Scribner shunt, a 4.3 French catheter with a balloon length of 2 cm and diameter, when inflated, of 3.7 or 4.3 mm is used. The diameter of the concomitant guide wire with a short floppy tip is 0.012 in. The way in which the Scribner balloon catheter is introduced is shown in Fig.2. The Teflon silastic tube of a Scribner shunt is curved. The resistance inside this curve can be diminished by lubricating the tube with radiodiagnostic contrast media. The diameter of the connection between blood vessels and silastic tube the vessel tip is the real limiting factor for catheter introduction. A 4.3 French catheter with a 3.7 mm balloon can be introduced even when the diameter of the connection is 1.6 mm.

Fig.2. Scribner A-V shunt. (1) Side hole to flush both sides of the stenosis. (2) Super low profile balloon, circumference 3.7-4.2 mm. (3) Venous limb of a Quinton-Scribner shunt, variant according to Ramirez. (4) Teflon vessel tip, circumference 1.6-2.8 mm. (5) Most common site of stenotic area in Scribner shunts. (6) 4.3 French catheter, length 50 cm.

In both procedures, the super low-profile balloon catheters (Schneider Europe AG, Switzerland) are flushed with a heparin solution during dilatation by withdrawing the feeder from the short catheter. A special feature of the catheters used in both procedures are the side holes just a few millimeters proximal to the balloon. During balloon inflation, both sides of the fistula or shunt can be flushed simultaneously, thus preventing clotting during occlusion.

Occlusion time can be as long as 30 min. The procedure is terminated when no deformity of the balloon can be visualised. Inflation times of up to 30 min are often necessary.

In the present study, PTA was considered a success when the stenosis was dilated and the procedure resulted in a functioning shunt with decreased venous pressure or increased arterial pressure. An early failure implied the opposite. Thus, the number of failures was kept to a minimum. The early failures (i.e., those occurring within 4 days) are included in the results.

RESULTS

Over the course of the study period, a reduction in the number of surgical interventions and an increase in the number of PTA's was observed. Surgical interventions for stenosis decreased by 50%. This decrease was more manifest with external shunts than with internal shunts, as illustrated in Table 1. There was an overall 30% decrease in the number of surgical interventions needed to maintain vascular access.

During the study period, the number of shunts fluctuated. In order to achieve a better understanding of the effects of PTA, the ratio between the number of shunts and the number of interventions with the indication of stenosis was calculated.

The number of PTA's and surgical interventions are illustrated in Tables 1 and 2. A success rate of 90% was attained in the first 95 PTA's.

The mean longevity after a PTA (including the 10% that failed) was 310 days for an arteriovenous fistula and 54 days for an external shunt. When correcting for early failures (those in the first 4 days), the mean longevity was 347 days for an arteriovenous fistula and 59 days for an external shunt.

There were five complications with the PTA technique. In 95 PTA's, leakage of contrast from a ruptured vein was seen three times, but only the first time an operation was performed. Conservative treatment (i.e., light compression) later on sufficed. In one case, the tip of a Scribner shunt had to be surgically attached after a dilatation and in another

Table 1. Surgical reinterventions for internal and external shunts and PTA from 1983 to 1988

Year	1983	1984	1985	1986	1987	1988
Total number of patients	46	49	47	45	54	53
All internal shunts (all types A-V fistulae)	32	31	32	33	45	46
External shunts (Scribner-Ramirez shunts)	13	16	14	10	8	6
Biocarbon shunt	1	1	1	1	1	1
Reinterventions stenosis internal shunts	14	20	13	10	10	14
Reinterventions stenosis external shunts	26	24	16	11	6	2
Reinterventions other indications	3	4	10	3	12	11
All interventions	43	48	39	24	28	31
PTA stenosis internal shunts	-	-	1	5	13	20
PTA stenosis external shunts	-	-	-	13	20	23
All PTA				18	33	43

Table 2. The ratio between the number of surgical reinterventions needed to maintain vascular access and the number of arteriovenous shunts of a certain type from 1983 to 1988

Year	1983	1984	1985	1986	1987	1988
Total number of patients as of June 30th	46	49	47	45	54	53
Ratio all interventions/all shunts	0.93	0.98	0.83	0.53	0.52	0.57
Ratio reinterv. stenosis int. shunts/int. shunts	0.44	0.64	0.40	0.30	0.22	0.30
Ratio reinterv. stenosis ext. shunts/ext. shunts	2.00	1.50	1.42	1.10	0.75	0.33
Ratio all reinterv. stenosis/all shunts	0.87	0.90	0.62	0.47	0.30	0.30

case desobstruction was needed after dilatation of an anastomosis of a Biocarbon shunt followed by thrombosis.

DISCUSSION

Our group of patients was no different from a standard haemodialysis centre population [13]. During the 6 years of the study, the number of A-V fistulas increased, while the number of external shunts (Scribner) decreased, a trend which is apparent elsewhere [14]. We want to stress that a maximum effort to make the best possible A-V fistula or shunt at the start is the basis for a good access.

In the literature and also in our series, the arteriovenous fistulas need relatively few reinterventions, but with the application of PTA, the reintervention ratio for fistulas decreased even more. It is unlikely that the results were biased by interperson variation or change in policy. During the 6-year study period, 90% of all access surgery was done by one and the same surgeon and the indication to create a certain type of vascular access was established by two experienced nephrologists, together with this surgeon. It therefore seems reasonable to attribute the better results to the use of PTA.

The use of PTA has had a significant impact on the number of surgical interventions indicated for treatment of vascular stenosis in access surgery. PTA promises to be a real innovation in the management of vascular access and it positively affects the quality of life for the patient. An intervention on an out-patient basis or during a short hospital stay is appreciated by patients much more than surgery, which comes at a higher cost. Surgical reinterventions can be performed without the need of hospital admission sometimes, but more extended surgery and the whole surgical procedure often require a stay in the hospital.

The fact that the access is available the next day, which after surgery cannot always be the case, is an improvement in the quality of haemodialysis. Elaborate procedures, such as temporary haemodialysis by catheters, can be avoided.

Surgical intervention for stenosis in a vein or artery of an A-V fistula usually means a venous or expanded polytetrafluoroethylene (P.T.F.E) patch, a transluminal angioplasty, or eventually a bypass procedure. In an external shunt, the vessel tip has to be reimplanted more proximally, which means loss of a venous or an arterial access site. All these disadvantages can be avoided using PTA.

PTA increases the longevity of an internal shunt by 310 days (347 days excluding early failure). In the present study, an external shunt

had an increased longevity of 54 days (59 days excluding early failure).

Complications of PTA, such as thrombosis or the rupture of a blood vessel, do occur but can be managed without serious problems as they are usually diagnosed immediately by angiography [6, 12]. The latter can often be treated conservatively. Three times we operated for a complication. Slight leakage is not an indication for operation anymore.

In a recent survey of access surgery in all centres in The Netherlands [13], it was found that PTA was never carried out in 28 centres, occasionally carried out in 19 centres and regularly carried out in only 5 centres.

The application of PTA means a very substantial reduction in both cost and the use of vessels for access. Moreover, it improves the quality of life of patients dependent upon haemodialysis.

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Chapter 3

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Survival of vascular access for haemodialysis

H. Burger, S.A. Kluchert*, G. Kootstra#,
P.J.E.H.M. Kitslaar#, D.Th. Ubbink#.

From the Departments of Surgery and *Nephrology, Drechtsteden Ziekenhuis, Dordrecht and #the Department of Surgery of the University Hospital, Maastricht.

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STRUCTURED ABSTRACT

Objective – To formulate a standard for assessing functional patency of vascular access and to present long-term results of vascular access in a group undergoing dialysis, in particular the effects of percutaneous transluminal angioplasty (PTA).

Design – Retrospective study 1971-1980. Prospective study 1981-1991.

Setting – A unit for haemodialysis in a regional hospital.

Subjects – All 259 patients treated from 1971 to 1991 in a programme for chronic haemodialysis.

Interventions – All interventions, surgical and radiological, needed to maintain vascular access.

Main outcome measures – Intervention free periods, patency of access, life expectancy of access, and early failure rate (within 4 days). Patency of access before and after PTA.

Results – A total of 1179 interventions were made. 407 Arteriovenous (A-V) fistulas and shunts were constructed, and there were 519 surgical reoperations and 253 PTAs. The secondary cumulative patency rate for the autogenous distal A-V fistulas (Cimino) was 79% at one year, 68% at two years and 59% at three years. Routine use of PTA from 1986 onwards resulted in a rise in secondary cumulative patency for Cimino A-V fistulas after two years from 65% to 80% ($p>0.05$)

Conclusions – To describe and assess vascular access the patency rate alone is not sufficient; intervention free periods and life expectancy must also be given. Routine use of PTA with the Cimino A-V fistula resulted in an appreciable but not significant increase patency at two years.

INTRODUCTION

Adequate vascular access is the lifeline for a patient on haemodialysis. Access to the bloodstream can be obtained by surgically created arteriovenous (A-V) fistulas or by shunts. For practical reasons, in this paper we will use the general term "shunt" when we refer to both A-V fistulas and shunts. As is well known, shunts are susceptible to complications that threaten their function. Adequate function must be estimated and that means measuring it in several ways. Measuring only patency is not enough.

In general vascular surgery successful attempts have been made to standardise the reporting of results [16,17], but comparable standardisation has yet to be established in vascular access surgery. Such reporting is needed to reach a consensus about the right methods in vascular access surgery. Two international congresses on access surgery have advanced the development of such a consensus [9,19].

As any criterion of the survival of a shunt has its limitations [16,17,2], a truer picture of the results of access surgery is obtained when more than one criterion is used [1,12,14,18]. The intervention-free intervals for access shunts are important for patients because they influence their well-being. They also reflect the complication rate. The cumulative patency rate of a particular group of shunts, including the salvage operations, is relevant because it accentuates the possibilities of maintaining vascular access, so sparing other locations. The life expectancy of a group of shunts, assumed to be equivalent to its median secondary survival, might be used to emphasise the potential survival of a shunt.

Early failure is a standardised concept in general vascular surgery, and means failure within the first days (up to a month) of a vascular operation. In access surgery, it is possible to be exact about failure. An access is used at intervals of no more than four days and each time the function is established beyond any doubt. It is, therefore, reasonable to define the upper limit for early failure as four days from the intervention. Because of its superficial position, function of the access can be monitored better than most other vascular interventions.

We report the results of access surgery in one centre for haemodialysis in a regional hospital over a period of 20 years during which time the same surgeon did most of the access surgery. From the beginning all relevant data about the procedures as well as the follow-up information were stored in prospectively and a standard way in a structured data base. The following changes in practice occurred in the course of the study period: after a period in which the arteriovenous shunt (Scribner)

was the first choice access, there was a period when most accesses were converted to A-V fistulas -1974-. Graft fistulas were then introduced (in this department the autogenous vein graft - 1976 - and the expanded polytetrafluoroethylene (PTFE) graft - 1978 -), and extended the possibilities of second choice access. Finally, percutaneous transluminal angioplasty (PTA) [4,6,7] was introduced as routine treatment for stenoses in arteries, veins and anastomoses of all shunts - 1985 - and this started a new era. These changes in policy over time have been taken into consideration in the analysis of our results.

The aim of this study was to propose standards for reporting on vascular access surgery, and to report our results of vascular access surgery over a 20 year period using these standards.

PATIENTS AND METHODS

Patients

All patients, who had been enrolled in the programme for chronic haemodialysis in the department of dialysis of the Drechtsteden Ziekenhuis in Dordrecht from 1971 to 1991 were registered and each intervention for vascular access was recorded. All shunts were included in the study (Table 1). The mean age rose from 35 years in the early 1970s to 44 years in 1980 and 56 years in 1990. Within the group of

Table 1. Details of the 290 patients entered in the study, 1 March 1971 - 1 November 1991. Figures are number (%) unless otherwise stated.

Variable	No (%)
Sex: Male	123
Female	97
Mean age at start of dialysis (years)	46
Range	7 - 80
Causes of end stage renal disease:	
Chronic glomerulonephritis	51 (23)
Polycystic kidney disease	29 (13)
Chronic interstitial nephritis	18 (8)
Diabetes mellitus	16 (7)
Glomerulosclerosis	16 (7)
Chronic pyelonephritis	14 (6)
Other	76 (35)
Mean duration of chronic haemodialysis (years)	4.5

patients on chronic haemodialysis, 82 renal transplantations were done during this time.

The centre

The Department for Dialysis is a regional centre, that serves 354 000 people and it includes a centre for home dialysis. Since 1990 we have had a growing number of patients who were treated with continuous ambulatory peritoneal dialysis (CAPD). The number of patients on haemodialysis rose steadily to 40 around 1980 and to 60 around 1990.

Definitions

Primary survival: the time between the construction of a vascular access and its first failure.

Secondary survival: the time between the construction of a vascular access and its ultimate failure, all interim interventions included.

Patency: confirmed blood flow with sufficient function of the vascular access.

Cumulative primary patency: the percentage of shunts, that were functioning without salvage interventions of the total number of shunts at risk at any one time.

Cumulative secondary patency: the percentage of shunts, that were functioning with all salvage interventions included of the number of shunts at risk at any one time.

Failure: function of a vascular access inadequate.

Early failure: failure of a vascular access within four days (called also "initial failure") [2].

Intervention: any type of operation to create or maintain vascular access including percutaneous transluminal angioplasty.

Intervention-free period: the time between an intervention or reintervention and its failure.

Life expectancy: median value of secondary survival.

First choice access: a distal autogenous radiocephalic A-V fistula (for example a Cimino-Brescia fistula) or an A-V shunt (for example a Scribner shunt) when it was the surgeons first choice and not chosen because a Cimino fistula was impossible (sometimes also called "primary access").

Second choice access: all those accesses constructed when the first choice access was impossible. These accesses include the graft A-V fistulas, the proximal autogenous A-V fistulas and the A-V shunts made as a second choice (also sometimes called "secondary access").

Revision: all those procedures that do not essentially change the type of a shunt.

Revision of shunt or new shunt

An access is generally regarded as having the same continuing function when it has been opened up without an operation (for example opening up a Scribner shunt) or treated with PTA; a simple thrombectomy does not change the status of an access. An operative transluminal angioplasty or a patch graft for stenosis also leaves the shunt in much the same state. A step further is a new anastomosis in an A-V fistula while the veins that are punctured remain the same. There is no real difference between a patch graft for a short stenosis and a small bypass when the bypass is not meant to be punctured for access. The line between a revision and a new shunt is drawn when the bypass itself is meant to be punctured.

Statistical methods

Calculations about the survival of the shunts were made with the help of a database for vascular access created by one of the authors (SAK) together with the Statistical Package for the Social Sciences (SPSS) [13]. Because it was likely that the distribution of the shunt survival was skewed, median values are presented. As mean values were used in some cases, these have been added in parentheses. The cumulative patency rate was calculated by Kaplan-Meyer survival analysis. From these data we used monthly intervals for the first year and yearly intervals thereafter. For the statistical analysis of the difference between median values of the different shunt groups and the patency rates we used the Mann Whitney test.

The survival of a shunt ends at the moment that occlusion or another stenotic complication prevents its use. After successful transplantation, or death of the patient, the shunt does not count any more. Transplantation, death and discontinuing dialysis with a functioning shunt implies that the patients were censored - that is, that they were regarded as no longer at risk - and so they were excluded from the study from that date.

Percutaneous transluminal angioplasty

Primary and secondary shunt survival, before and after the start of routine PTA, are presented separately. The influence of the availability of PTA on primary and secondary survival of each type of fistula or shunt was assessed by comparing the survival of the fistulas created in the last two six-year periods of the study. During the first period, (1980 - 1985), PTA was not available. In the second period (1986 - october 1991) PTA was an additional means of dealing with serious stenosis

of a fistula. The indications for intervention in both periods were assumed to be equal. Venous pressure and arterial flow measured during haemodialysis, were routinely followed. Bloodflow of less than 300 ml/min and venous pressure of more than 150 mm Hg was regarded as abnormal. When abnormal values persisted an angiography was done followed by an intervention. A PTA was always attempted in a case of a stenosis. Fistulas created during the first period that required PTA during its follow-up period were excluded from the comparison, so, 262 PTAs were done in 65 patients, who had had 72 A-V fistulas or shunts. Early failure was calculated for the different shunt groups and also for the reinterventions.

No lifetable values are given if the SE was 10% or more.

RESULTS

Over a period of 20 years, 220 first A-V fistulas and shunts and 187 subsequent ones were created in 220 patients. In total, 1179 interventions and reinterventions were done, including 262 PTAs.

A total of 208 autogenous Cimino-Brescia A-V fistulas at the wrist were constructed: 107 side to side, 96 end-to-side and 5 end-to-end. The 133 Scribner shunts were made with the Ramirez variation with an external bend. There were 46 graft A-V fistulas, among them 26 PTFE loop grafts, and 17 saphenous vein grafts (Table 2).

The primary cumulative patency rate for all shunts was 45% at one year, 29% at two years, 22% at three years, 19% at four years and 17% at five years (Figs 1 and 2). For the Cimino A-V fistula, these figures were 53%, 36%, 24%, 18% and 14%; for the graft A-V fistula 37%, 21%, 17% and 16%; and for the Scribner A-V shunt for the first two years 18% and 6% respectively.

Table 2. Primary and secondary survival between 1971 and 1991 of A-V fistulas and shunts. Results are expressed as median (mean).

Shunt	Number	Primary survival (days)	Secondary survival (days)
Cimino A-V fistula	208	364 (669)	630 (1027)
Scribner A-V fistula	133	78 (178)	231 (531)
Graft A-V fistula	6	238 (436)	457 (888)
Total	387		

Numbers

Cimino	208	161	148	139	133	128	121	118	116	111	107	103	101
Scribner	133	91	72	58	48	42	39	36	32	31	28	26	23
Graft	46	32	28	27	25	23	23	22	20	20	18	18	17

Figure 1. One year cumulative primary patency of A-V Cimino and graft fistulas and A-V Scribner shunts.

Number

Cimino	208	101	64	41	28	21	15	12	11	10	5	5	3	3	2	1
Scribner	133	23	7	2	1											
Graft	46	17	9	4	4	4	1

Figure 2. Long term cumulative primary patency of A-V Cimino and graft fistulas and A-V Scribner shunts.

Figure 3. Long term cumulative secondary patency of A-V Cimino and graft fistulas and A-V Scribner shunts.

The secondary cumulative patency rate for all shunts, including early failures, was 69% at one year, 58% at two years, 48% at three years, 43% at four years and 39% at five years. There was a 28% survival rate at 10 years (Fig 3). For the Cimino A-V fistula, the secondary cumulative patency was 79% at one year, 68% at two years, 59% at three years, 55% at four years and 52% at five years, respectively. For the graft A-V fistula, these figures were 61%, 60%, 54%, 32% and 31% and for the Scribner A-V shunt 47%, 46%, 28%, 13% and 9%.

The median intervention-free period for all shunts during the whole observation period, including every single intervention, was 80 days (mean 287, range 0-5701). For surgical interventions only, the value was 99 days (mean 335, range 0-5701).

The median secondary patency of the Cimino A-V fistulas was 836 days (mean 1044, range 0-6025), of Scribner shunts 262 days (mean 517, range 0-2827), of saphenous vein graft fistulas 510 days (mean 963, range 0-3264) and of PTFE graft fistulas 506 days (mean 839, range 0-3041). The median primary and secondary patency of all types of shunts is given in Table 3.

Complications that required reinterventions are listed in Table 4. Stenosis in the shunt vein was the most common complication, and

Table 3. All 407 shunts constructed between March 1971 and December 1991.

Type of shunt	No (%) of shunts	Median secondary survival (days)	Mean, (range) of survival (days)
Cimino S to S A-V fistula	107 (26)	478	927 (0-5780)
Cimino E to S A-V fistula	96 (24)	867	1159 (0-6025)
Cimino E to E A-V fistula	5 (1)	96	754 (3-2480)
Scribner A-V shunt	133 (33)	231	513 (0-2824)
PTFE loop A-V fistula	26 (6)	506	839 (0-3041)
PTFE straight A-V fistula	2 (0.5)	344	318 and 370
Saphenous vein A-V fistula	17 (4)	510	963 (0-3264)
Proximal arm A-V fistula	12 (3)	185	568 (50-4583)
Biocarbon® or Hemasite® A-V shunt	4 (1.0)	135	691 (25-2469)
Basilical vein transposition A-V fistula	4 (1.0)	82	374 (12-1029)
Varivas® A-V fistula	1 (0.2)	2051	2051
Total	407 (100)	465	827 (0-6025)

Table 4. Complications of vascular access surgery that required intervention between 1971 and 1991.

Complication	No of interventions	Incidence (%)
Stenosis shunt vein	257	29.8
Thrombosis of unknown cause	178	28.2
Stenosis anastomosis	47	5.5
Venous hypertension	7	0.8
Steal syndrom	4	0.5
Aneurysm	7	0.8
Infection	8	0.9
Bleeding	15	1.7
Ulcer	23	2.7
Stenosis venous outflow Scribner A-V shunt	243	28.2
Stenosis arterial inflow Scribner A-V shunt	69	8.0
Disconnection Scribner A-V shunt	3	0.3

in the Scribner A-V shunts, stenosis at the vessel tip was common. Thrombosis without a known cause was the second most frequent complication. Infection was a rare indication for operation.

The early failure rate for all new shunts was 4.9%, for Cimino fistulas 6.3% and for Scribner shunts 1.7%. That for surgical reinterventions was 27% and for PTAs was 13%.

After introduction of routine PTA the two year cumulative secondary patency rate rose from 65% to 80% for the Cimino A-V fistulas ($p > 0.05$). Primary patency was shorter after PTA was started ($p < 0.05$; Table 5). Comparison of experience before and after PTA was introduced for the other shunts was not useful, because the numbers were too small (the graft fistulas) or there had been changes in indications over time (the Scribner shunts).

Table 5. Primary and secondary cumulative patency of the Cimino A-V fistula before and after routine application of PTA.

Cimino A-V fistula (n = 152)	1980-1985	1986-1991
No of fistulas	67	
No (%) treated by PTA	0	85 22 (28)
Primary cumulative patency %		
At 1 year	57	50
At 2 years	45	39
Secondary cumulative patency %		
At 1 year	79	85
At 2 years	65	80
At 3 years	63	67

DISCUSSION

Survival of vascular access for haemodialysis, expressed as its functional patency, can be judged with certainty as long as the access is in use. Calculation of the patency of a vascular access for haemodialysis is more accurate than that of other vascular reconstructions, because the regular use of fistulas and shunts establishes beyond any doubt their patency and function.

Our definition of "a new shunt" is clear, but is open for discussion. A partial replacement of a shunt vein by an implant, which can be punctured for access, means a new shunt. This situation is common after a long period of puncturing the vein, which has caused stenosis

and if PTA has been used to treat the stenosis, after repeated dilatations. Partial substitution of a shunt vein by a graft (more a renovation than a totally new shunt, as it can be used immediately by puncturing the preserved part of the shunt vein), can mean satisfactory access. According to our definition it must be recorded as a new shunt.

Complications of vascular access surgery had been reported to be mainly stenosis, thrombosis and infection. A strict aseptic regimen and treatment with an antibiotic if infection developed resulted in few surgical interventions for infection.

In publications about the Scribner shunt, its survival is supposed to end when reimplantation is required [8]. Usually this involves the venous cannula, although of course the whole shunt can be lost. It has been said that the survival of a Scribner shunt is equivalent to its primary patency. We propose that reimplantations in the same veins and arteries be regarded as revisions, just as dilating a stenosis in an arteriovenous fistula by a patch graft is a revision. To make a comparison with other studies about the Scribner shunt possible, one must realize that in most reports secondary patency has not been distinguished from primary patency.

The relatively common use of the Scribner A-V shunt in this series requires comment. The arguments for using the Scribner shunt as a semipermanent access when there is, as yet, no A-V fistula available, are that it is a dependable access that can nearly always be constructed with a low early failure rate (1.7%); it can be used immediately and can function for a number of months, if needed, without the risk of compromising an upper central vein; and if well cared for, it poses few problems and, with the help of PTA for stenoses at the vessel tip, it can survive while a long term access is created. We recommend the Ramirez variation with straight subcutaneous tubing and, near a joint, an extracutaneous bend. It makes catheterisation (for example for a PTA) much easier. The risk of problems with central veins in a patient, who may be dependent for years on an access in one arm makes us reluctant to catheterise a subclavian or jugular vein for vascular access haemodialysis [5]. Femoral vein catheterisation (Shaldon) [20] can be used but only for short periods.

A comparison of the results of different periods when a certain policy was in force (for example, using autogenous saphenous vein as a first choice interposition graft) is of limited value because of the small number of shunts involved, the length of the periods and the number of other variables. The effect of changing policies has its limits and makes comparison difficult.

The reason that primary shunt survival was lower after the start of routine PTA is that stenoses were treated earlier by PTA. Secondary shunt survival of the whole group of A-V fistulas was longer after 1986 but not significantly so), although there was no other change in treatment. Whenever a stenosis was diagnosed, a PTA was attempted and this resulted in treatment of 28% of all A-V fistulas by PTA. It seems probable that the combination of operation and PTA is more effective in prolonging the survival of A-V fistulas than operation alone, and our results are similar to those of a recent study from an experienced group in France [21]. They calculated patency after radiological interventions only. For the Scribner A-V shunt the primary and secondary survival rates were significantly lower during the last six years. There has been a change in the use of these shunts in that they are now used for a shorter time, so one should not conclude that PTA for Scribner A-V shunts results in shorter survival. The data have been given, to show a complete picture of our recent results including the Scribner shunts.

Table 6. Survey of cumulative secondary patency rates (in percentages) of the autogenous distal A-V fistula reported by other authors. Patency at 4 weeks is given in parentheses. * Snuff box A-V fistula. ** Some authors probably, after having reported early failure, report patencies of the remaining group of fistulas. *** Routine PTA used when indicated (1986-1991).

First author	Reference No	Patent at four days	Time (years)				
			1	2	3	4	5
Bonalumi (n = 177) *	3	88.8	83.1	78	70		52.5
Reilly (n = 145)	15	(90)	80	75	72	65	
Palder (n = 99)	14	(76)	60		42		
Ota (n = 865)	13	97					76.5
Landmann (n = 148)	10		65		60		
Landmann (n = 216) *	10		74		64		
Wehrli (n = 181) **	29	(88.8)	88.7		60.2		36.6
Marx (n = 1476)	11		65				
Present study (n = 208)		93.7	79	68	59	55	52
Present study (n = 85) ***		93.8	85	80	67		

We define early failure as failure within four days. Others have defined it as failure within four weeks. It can be argued that four weeks is a reasonable period to decide whether an A-V fistula will function, but it is an arbitrary choice because many fistulas need a longer time to ripen and may still be used. We have analysed the time of failure of shunts and have shown that in our series a certain, steady percentage of A-V fistulas failed, after a larger number during the first days. The early failure rate can be kept low when little risk is taken with the shunt veins. On the other hand, trying to establish an A-V fistula with a doubtful prognosis can cause real harm to a patient. The high early failure rate for surgical reinterventions (27%) may reflect poor selection, because in the case of stenoses PTA is attempted first; it also, however, reflects the wellknown problems of salvage operations.

Reported results are not easy to compare, but they do give some indication of the figures involved. Even the first choice access, the radiocephalic A-V fistula (Cimino- Brescia), regarded by every author as the best one, is not easy to compare. A survey of survival data is offered (Table 6), that shows the difficulty in comparing different studies [3,10-12,14,22] and puts our results in perspective. There are interesting differences in the patency rates reported in the various studies. They may be related to the patient group, the surgeons, or the users of the shunts, but the patency rates are of the same order; this suggests that the results can reasonably be achieved.

CONCLUSIONS

We have proposed a standardised way of reporting vascular access surgery and have tested it on actual figures in our practice. We can draw the following conclusions: The radiocephalic A-V fistula has, over many years, consistently proved to be the vascular access with the best survival. PTA seemed to improve secondary survival rates of the radiocephalic A-V fistula, but not statistically so. The fact that in only 28% of the Cimino A-V fistulas the indication for a PTA arose, means that beneficial effects can only become significant when a large group is studied for a longer period. The A-V shunt (Scribner) has a place as a semipermanent vascular access with a reasonable secondary survival when treated with PTA as soon as clinically important stenoses occur.

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Cost Analysis of Vascular Access for Haemodialysis

H. Burger, C. van Halem⁺, P. Heesters[#], F.Th. de Charro^{*}

From the Departments of Surgery and [#]Economics of the Drechtsteden Ziekenhuis, Dordrecht, ⁺the Faculty of Economics of the Free University of Amsterdam and ^{*}the Centre of Health Policy and Law of the Erasmus University of Rotterdam.

Submitted

ABSTRACT

The costs of vascular access surgery make up a considerable part of the total costs of renal replacement therapy. For that reason they are the subject of the present study.

A permanent vascular access is needed for haemodialysis. In this report, the costs of access surgery as well as those of specific interventions are calculated per patient per year.

The method of percutaneous transluminal angioplasty (PTA) has increasingly become a useful adjuvant in the treatment of stenoses in arteriovenous fistulas and shunts. The costs of establishing and maintaining vascular access before and after the routine application of PTA are analysed by comparing two periods: 1980-1985 and 1986-1991. PTA, when routinely used, carries with it added costs, in particular for secondary access procedures. Then again, secondary access, with its higher costs and complications rates, may be postponed or even averted by using PTA. Overall costs per patient per year for creating and maintaining vascular access, surgery and PTA were about USD 3640* (Dfl 6500), or 7.9% of the costs of haemodialysis during the period 1986-1991. For Cimino A-V fistulas alone these overall costs amounted to USD 1600 (Dfl 2850) per patient per year over the last 6 years. Yet, for less than USD 785 (Dfl 1400) extra per patient per year, the Cimino A-V fistulas prolonged cumulative survival of the access by 7% in the first year and by 15% in the second year when PTA was used as an adjuvant to surgery.

* 1 United States Dollar (USD) = 1.8 Dutch guilders (Dfl); 1 Dfl = 0.56 USD

INTRODUCTION

A precondition for haemodialysis is the presence of a long term or permanent vascular access that will allow an adequate supply of blood to flow through the artificial kidney. Scribner et al. were in 1960, the first to make a permanent vascular access by implanting Teflon vessel tips in an artery and a vein and linking the two outside the skin with silicon rubber tubing, the arteriovenous (A-V) shunt. In 1966, Cimino et al. devised the subcutaneous A-V fistula between the radial artery and the cephalic vein at the wrist as an effective vascular access. The superficial arterialised venous net could be punctured frequently for a long time, providing a sufficient flow of blood through the artificial kidney. This Cimino A-V fistula is still widely regarded as the best and probably the least expensive vascular access. When it is not possible to make an A-V fistula at the wrist, other possibilities are available, among them an A-V fistula that is more proximal, often at the elbow, or an A-V fistula with interpositioning of a graft, when suitable superficial veins are absent. Several graft materials have been tried, a transplanted vein of the patient, a transplanted vein of another person (homologous vein) or animal (heterologous vein or artery), or an artificial blood vessel e.g., extended polytetrafluoroethylene (PTFE). At the moment, the most frequently used graft material for a vascular access for haemodialysis is PTFE.

Treatment for end-stage renal disease (ESRD) presently includes haemodialysis, peritoneal dialysis, or kidney transplantation. On 1 January 1992 3318 people in the Netherlands (population at the time 15 102 231) were on dialysis: 2454 on haemodialysis and 864 on peritoneal dialysis. Chronic haemodialysis is an important part of the treatment for ESRD and the costs for treating ESRD have been the subject of substantial research. As chronic haemodialysis requires a permanent vascular access, an analysis of the costs of vascular access surgery is appropriate.

A cost-effectiveness analysis of treatment for ESRD in the Netherlands was carried out by De Charro in 1988 [1]. In that study the costs of centre haemodialysis (passive or active) were estimated as being USD 59 475 (Dfl 106 206) per patient per year, based on "billing" figures, i.e., costs based on the reimbursement rates. The costs to society referred to later as "total costs" or "full costs" for active centre haemodialysis were calculated as being USD 43 020 (Dfl 76 830) per patient per year and those for passive centre haemodialysis as USD 49 240 (87 930) per patient per year. Home haemodialysis costs amounted to USD 36 590

(65 340) per patient per year after an initial training period that cost of USD 49 450 (Dfl 88 300) for the first year.

Some studies on the costs of ESRD have taken the role of access surgery into account [2-6]. Chapman et al. [5] published the results of a cost analysis of vascular and peritoneal access for ESRD in a community hospital. Their estimates, based mainly on reimbursement rates, were USD 19 600 for haemodialysis per patient per year, with USD 18 000 representing the approximate reimbursement rate per patient per year for dialysis, and USD 1600 the rate for vascular and peritoneal access. The costs of continuous ambulatory peritoneal dialysis (CAPD) were not lower than the costs of haemodialysis, owing to more complications in the CAPD group. The costs for the associated hospital care were most likely not included in the costs for access procedures but in the non-specified costs for dialysis. Chapman et al. concluded that an initial access procedure of any sort carried a price tag of USD 2500 and that maintenance procedures cost about the same. The differences in costs per year for the different types of access were determined by the number of maintenance procedures and the survival rate of an access. In the thesis of Zijlstra [6], describing a cohort of patients on haemodialysis in a regional hospital, the costs of treating a stenosis in a dialysis shunt were calculated on the basis of direct costs, i.e., those directly attributable to personnel, material and doctor's fees. He then added the cost of the associated hospital stay, i.e., the average cost per bed per day, computed as the total hospital costs per year, divided by the product of 365 and the number of beds. The price of an operation for a stenosis in the vessels of an A-V fistula (including a 5 day stay in the hospital) was $\text{USD } 720 + (5 \times \text{USD } 336) = \text{USD } 2400$ (Dfl 4290). For an A-V shunt, the price was $\text{USD } 680 + (5 \times \text{USD } 336) = \text{USD } 2360$ (Dfl 4220).

In the medical literature, costs are frequently based on reimbursement rates. Economists are used to expressing the costs in terms of the value of the resources involved [1-5].

As costs can be attributed to specific procedures in various ways, there is a need to clearly define concepts involved in the calculation of costs. While medical economists have, of course, always been well aware of the pitfalls of cost analysis, their conclusions are often open to different interpretations. We will try to present different approaches in order to minimise prejudice.

As normally all hospital costs are included in the calculation of the cost per day of a hospital bed, the costs of hospital stays associated with vascular access operations are often exaggerated. Being able to separate the direct costs for the patient in a hospital bed from the costs

allocated to the hospital bed is essential. The direct costs for a patient undergoing a relatively simple operation are fairly low. For a patient on dialysis or a patient who is being prepared for dialysis, there may be a number of reasons for prolonging the stay in the hospital that will most likely affect the costs incurred. Diagnostic tests, consultations with other specialists and special care in connection with ESRD generate additional hospital costs that are difficult to separate from the hospital costs incurred for the operation alone.

The use of percutaneous transluminal angioplasty (PTA) as an adjuvant to vascular surgery in treating vascular stenoses by balloon dilatation has signified the beginning of a new era in access surgery with beneficial effects for the patients [6-8]. Vascular accesses have a longer survival and require fewer surgical interventions thanks to PTA, which can nearly always be done on an outpatient basis. No length of blood vessel has to be sacrificed and PTA increases the quality of life for the patients on haemodialysis [6,7,9]. While the costs of treatment of coronary insufficiency by surgery and PTA have been compared [9], only a few publications make the comparison for surgery and PTA for access surgery. Brooks [11] calculated higher costs for PTA while Zijlstra [7] suggested cost savings. One of the aims of the present study was to further analyse data in order to confirm some of these earlier findings.

METHODS AND MATERIALS

The costs of access procedures for haemodialysis were calculated in a regional centre for dialysis - the Department for Dialysis of the Drechtsteden Ziekenhuis in Dordrecht - over the 12-year period, from 1980 until 1991. Calculations were made on the basis of direct costs and total costs. Two periods - 1980-1985 and 1986-1991 - were compared to determine the effect of routine use of PTA on costs.

The costs of a stay in a hospital bed were calculated on the basis of the real costs, not of the reimbursement rate. The costs of the surgeon and the anaesthesiologist are always difficult to assess. While Dutch law sets fixed rates for doctors, these rates do not always adequately reflect services rendered. Yet, they are probably the best estimate available and include indirect costs. It should be noted that doctor's fees for a state-insured patient are lower than those for a privately insured patient. Fees are averaged, making allowances for the ratio of privately versus state-insured patients, which is now 33% versus 66%. The costs of specific procedures, as well as the costs per patient per year, are calculated.

Amounts of money totalling more than USD 100 are rounded off to the nearest USD 10.

The centre

In the course of 10 years, an evolution of the population of the centre took place. The number of patients on haemodialysis rose from 45 to 56. At the end of 1991, six patients were on CAPD. The average age rose from 46.6 to 56.5 years. The average treatment period remained fairly constant, ranging from 4 to 5.5 years. The duration of a hospital stay was calculated by taking the total period of hospitalization associated with the vascular access surgery and subtracting the period not attributable to surgery. All hospital stays in connection with access surgery were reviewed by the surgeon and, when in doubt, they were reconsidered by the nephrologists.

Patients in this department are normally dialysed three times a week or, in other words, 156 times per year. The costs per year per dialysis are well known, so the share of the costs attributed to access surgery can easily be calculated.

Definitions

Total cost (also called "full cost"): the sum of the direct costs and the indirect costs.

Costs based on reimbursement rates or "billing figures": the costs that the health care institutions that provide the funding pay to health care providers, according to the agreements that exist between the financing institutions and the health care providers.

Direct costs (also called "variable costs"): costs directly attributable to procedures.

Indirect costs: those not directly attributable or traceable to procedures. Indirect costs can be allocated to procedures by means of different costing models.

Mark-up refers to the amount obtained by multiplying the direct costs by a certain percentage required to calculate the indirect costs. This percentage is different for each department and differs from year to year.

First choice access: a distal autogenous radiocephalic A-V fistula (for example a Cimino-Brescia fistula) or an A-V shunt (for example a Scribner shunt) when it was the surgeons first choice and not chosen because a Cimino fistula was impossible (sometimes also called "primary access").

Second choice access: all those accesses constructed when the first choice access was impossible. These accesses include the graft A-V fistulas, the proximal autogenous A-V fistulas and the A-V shunts made as a second choice (also sometimes called "secondary access").

A-V shunt: generally means any type of vascular access (in the Index Medicus: arteriovenous shunt, surgical) in which an artery is linked to a vein and, in particular, a Scribner A-V shunt.

RESULTS

The costs of vascular access surgery were reported for two periods, 1980-1985 and 1986-1991. The number and type of all interventions, surgical

Table 1. The number of first and subsequent shunts, the number of surgical reinterventions, the number of PTA's on A-V fistulas and A-V shunts (Scribner), the total number of interventions, and the number of patients treated by haemodialysis in the Department for Dialysis of the Drechtsteden Ziekenhuis Dordrecht from 1980 until 1992.

Year	First shunts	Subsequent shunts	Reinterventions surgical	PTA's A-V fistula	PTA's A-V shunt	All interventions incl. PTA, excl. first shunts	Number of patients on dialysis
1980	6	12	25	0	0	37	39
1981	12	14	35	0	0	49	41
1982	8	15	45	0	0	60	45
1983	11	11	37	0	0	48	46
1984	8	9	40	0	0	49	49
1985	12	6	36	0	0	42	47
1986	13	11	23	5	13	52	45
1987	16	6	27	13	20	66	54
1988	12	7	24	20	23	74	54
1989	13	9	27	23	20	79	55
1990	12	8	40	36	34	123	50
1991	20	19	44	39	38	140	56

Table 2. Average duration of hospital stay in days for reinterventions - surgery and percutaneous transluminal angioplasty (PTA) - in vascular access (Cimino A-V fistula) in two periods: 1980-1985 and 1986-1991.

Period	1980-1985		1986-1991	
Type of intervention	Surgery	PTA	Surgery	PTA and Surgery
Days in hospital, average	3.79	0.19	3.36	1.54
Days in hospital, minimum-maximum	0-60	0-2	0-15	0-15

Table 3. Total costs of creating and maintaining vascular access for hemodialysis (incl. stay in hospital) in the periods 1980-1985 and 1986-1991, taking into account the effects of routine adjuvant application of percutaneous transluminal angioplasty (PTA). Price level 1991.

	1980-1985	1986-1991
Number of surgical interventions	342	331
Number of PTA's	0	286
Number of all interventions	342	617
Average number of patients	44.5	52.3
Sum of total costs of all access interventions	Dfl 944 340	Dfl 2 031 830
Average total costs of any intervention	Dfl 2 760	Dfl 3 290
Sum of total costs of surgical interventions	Dfl 944 340	Dfl 881 580
Average total costs of a surgical intervention	Dfl 2 760	Dfl 2 660
Sum of total costs of PTA	-	Dfl 1 150 250
Average total costs of a PTA	-	Dfl 4 020
Costs per patient per year (surgery only)	Dfl 3 540	Dfl 2 810
Costs per patient per year (PTA only)	-	Dfl 3 670
Costs per patient per year (surgery and PTA)	Dfl 3 540	Dfl 6 480

Table 4. Costs of percutaneous transluminal angioplasty of A-V fistulas and Scribner A-V shunts. Price level 1991.

	PTA A-V fistula (Dfl)	PTA Scribner shunt (Dfl)
Schneider balloon catheter and guide wire	1400	1890
Disposables	100	140
All materials	1500	2030
Personnel radiology	60	60
Personnel dialysis	80	80
All personnel	140	140
Fee radiologist	390	390
All direct costs (excl. doctor's fee)	1600	2170
All direct costs (incl. doctor's fee)	2030	2560
Mark up indirect costs personnel, 52.7%	70	70
Mark up indirect costs materials, 111.3%	1670	2250
All hospital costs indirect and direct (excl. doctor's fee)	3380	4490
Total costs (incl. doctor's fee)	3770	4880

and radiological, were determined per year (Table 1). In the first period, 57 first shunts were created and 218 surgical reinterventions were needed for an average of 44.5 patients in the centre. In the second period, 86 first shunts were created and, 185 surgical reinterventions were done for an average of 52.3 patients. In addition, 266 PTA's (136 for A-V fistulas and 148 for Scribner A-V shunts) were carried out in the second period. The average associated hospital stay for surgery was 3.79 days in the first period and 3.36 days in the second period. PTA's were usually carried out on an outpatient basis and required an average hospital stay of 0.19 days (Table 2). The total costs of a stay in the hospital in the nephrology ward were USD 130 (Dfl 230) per day in 1991, operations, dialysis and special treatments excluded. The total costs for a surgical intervention were slightly lower in the second period: USD 1600 (Dfl 2860) in the

Table 5. Costs of creating new Cimino A-V fistulas, Scribner A-V shunts, autologous saphenous vein (VSM loop), and PTFE graft A-V fistulas. Price level 1991.

	New Cimino fistula (Dfl)	New Scribner shunt (Dfl)	New VSM- loop A-V fistula (Dfl)	New PTFE- loop A-V fistula (Dfl)
Disposables	190	190	190	190
Scribner-Ramirez shunt		230		1270
All materials	190	420	190	1460
Personnel surgery and anesthesia	540	540	880	680
All personnel	540	540	880	680
Fee surgeon and anesthesiologist	640	430	1100	1110
All direct costs (excl. doctor's fee)	730	960	1070	2140
All direct costs (incl. doctor's fee)	1360	1390	2170	3240
Mark-up indirect costs personnel, 52.7%	280	280	460	360
Mark-up indirect costs materials, 111.3%	210	470	210	1630
All hospital costs, direct and indirect (excl. doctor's fee)	1230	1710	1740	4120
Total costs (incl. doctor's fee)	1860	2150	2840	5220

second period versus USD 1650 (Dfl 2940) in the first period. The total costs per patient per year for vascular access in the second period, including hospital stay and PTA if needed, were USD 3620 (Dfl 6470) (Table 3).

Direct and indirect costs were computed for PTA's for A-V fistulas and for Scribner A-V shunts (Table 4). The same was done for the different surgical interventions used to reconstruct failing fistulas and shunts. Table 5 presents these calculations for the Cimino A-V fistulas, the Scribner A-V shunts, the autologous saphenous vein and the PTFE graft A-V fistulas. A summing up of the calculations of all types of surgical interventions performed to create or maintain dialysis accesses is presented in Table 6.

Table 6. Direct (excl. doctor's fee) and total costs (indirect and direct costs, incl. doctor's fee) of all surgical interventions for vascular access. Doctor's fee for surgeon and anesthesiologist. Price level 1991.

	Direct costs (Dfl)	Total costs (Dfl)
A-V fistula Cimino	730	1860
A V fistula elbow	800	1950
A-V shunt Scribner	960	2150
A-V fistula PTFE loop graft	2140	5220
A V fistula saphenous vein loop graft	1070	2840
A-V fistula PTFE straight graft	2050	4960
Biocarbon® or Hemasite® access device	2870	6760
Desobstruction	730	1860
New A-V anastomosis	730	1870
New arterial implant Scribner A-V shunt	780	1220
New venous implant Scribner A-V shunt	710	1700
Skin plasty	360	880
Adhesiolysis	460	1130
Patch PTFE	900	2640
Patch venous	870	2530
Bypass PTFE	1270	3380
Bypass venous	930	2630
Surgical balloon dilatation	1210	2880
Aneurysm resection	830	2540
Basilical vein transposition	730	2320
Ligature of a vein	360	840

Table 7. Costs per year per patient of maintaining Cimino A-V fistulas and second choice access in two periods: 1980-1985 and 1986-1991, and average number of patients with second choice vascular access. Price level 1991.

	1980-1985	1986-1991
Surgical reinterventions for Cimino A-V fistulas	Dfl 1480	Dfl 1110
PTA's for Cimino A-V fistulas	—	Dfl 1740
Total costs for Cimino A-V fistulas	Dfl 1480	Dfl 2850
Average number of patients with second choice access and percentage of all patients	15.7 (35%)	11.2 (21%)
Surgical interventions for second choice vascular access	Dfl 4950	Dfl 4870
PTA's for second choice vascular access		Dfl 8600
Total costs for second choice vascular access	Dfl 4950	Dfl 13470

For the Cimino A-V fistula, a detailed cost analysis resulted in a cost of USD 830 (Dfl 1480) per patient per year for revisions in the first period (1980-1985) and of USD 1600 (Dfl 2860) (PTA included) for the second period (1986-1991) (Table 7). From the calculations it is evident that for an extra USD 770 (Dfl 1370) per patient per year, routine PTA can be carried out, resulting in prolonged survival of the Cimino A-V fistula.

The costs of second choice access surgery were also computed (Table 7). In the first period (1980-1985), 140 interventions were done at a cost of USD 2780 (Dfl 4950) per patient per year. In that same period, 35% of the patients had a second choice access. In the second period, 101 surgical interventions were done at a cost per patient per year of USD 2730 (Dfl 4870). In addition to that, 120 PTAs were carried out, the majority on Scribner shunts, at a cost of USD 4820 (Dfl 8600) per patient per year. Creating and maintaining the second choice access carried a price tag of USD 7540 (Dfl 13 470) per patient per year for an average of 11 patients, or 21% of the whole group of patients on haemodialysis.

DISCUSSION

Cost analysis of vascular access for haemodialysis should be considered in decisions involving the appropriate approach to the treatment of ESRD. As expected, first choice access surgery is less expensive than second choice access surgery. Second choice access surgery tends to be more difficult, may require an expensive vascular prosthesis and is associated with a longer stay in the hospital.

The duration of the hospital stay for vascular surgery cannot easily be calculated. One needs to take the recorded hospital stay associated with the period in which access surgery was carried out and then subtract the period not attributed to the vascular surgery. Thus, the surgeon must give serious thought to each case.

The evolution of the population in centres for dialysis in the Netherlands differs from one centre to the next but, in general, the tendency is towards older patients and those with a more compromised general health [10].

We determined that the patency rate for Cimino A-V fistulas increased by 7% in the first year and by 15 % after two years with the use of PTA as a routine adjuvant procedure in the maintenance of fistula function [12]. However this increase in survival was not significant in a group of all 85 Cimino A-V fistulas during the period 1986-1991 compared with the period 1980-1985. Of these fistulas 28% was treated with PTA. Probably the numbers were still too small for significance. The extra costs incurred in order to achieve this improvement in fistula function were Dfl 1370 per patient per year.

While we conclude that routine application of PTA carries with it an extra cost of nearly Dfl 1400, we must also bear in mind that if no simple new Cimino A-V fistula could be created, a second choice access would have to be made and this would cost considerably more. Besides second choice access has a shorter survival time. Therefore the high costs incurred by the routine use of PTA are at least partly offset by the higher costs of second choice access surgery. Maintaining a reduced number of second choice accesses in the second period (35% of the accesses in the first period were second choice versus 21% in the second) was more costly when PTA was routinely used (Table 7) and these high costs were largely generated by repeated PTA's for second choice semipermanent Scribner shunts for only a few patients. These shunts, which could otherwise only be replaced by semipermanent catheters, were maintained with few complications other than stenosis. The repeated PTA's were carried out on an outpatient basis. The overall costs

of maintaining second choice vascular access, surgery and PTA amounted to USD 7560 (Dfl 13 500) per patient per year, or 16% of the costs of haemodialysis (USD 49 or Dfl 87 per dialysis).

Under the circumstances of acute need at the start of haemodialysis the costs of the Scribner A-V shunt as a semipermanent shunt would appear to be acceptable. For use in complicated situations during haemodialysis the shunt is helpful but the costs are relatively high when repeated PTAs are necessary to maintain its function.

As the PTFE graft A-V fistula is now probably the most popular second choice access procedure and may be the best according to literature with a good survival time [13], its costs, though higher than any first choice access, can still be considered acceptable. The cheaper autologous saphenous vein graft fistula is not often constructed, mainly because of limited availability of an adequate vein and of good patency rates only in the hands of some surgeons.

CONCLUSIONS

The costs per patient per year for vascular access are about USD 3640 (Dfl 6500), or 7.9% of the costs of haemodialysis per year (USD 24 or Dfl 42 per dialysis).

The added costs of routine PTA as an adjuvant to maintain Cimino A-V fistulas are, on the average, USD 770 (Dfl 1370) per patient per year. For these fistulas PTA may mean a savings since an expensive second choice access is not needed or can be postponed.

With PTA as an adjuvant to second choice access surgery, something which results in an improvement in the quality of life of the patients, costs incurred are higher, up to 16% of the cost of haemodialysis. Seeing as how other procedures are also expensive, in a limited number of cases a more costly but safe and reliable, method to maintain vascular access would still appear to be acceptable.

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GENERAL DISCUSSION AND CONCLUSIONS

INTRODUCTION

Vascular access for haemodialysis has developed from its modest beginnings in the sixties to a specialised form of surgery. We have investigated the state of vascular access in the Netherlands, the impact of the use of the new technique of PTA and its overall effects on the survival of shunts. The costs of vascular access as a part of all the costs of the treatment of end-stage renal disease and the cost effects of percutaneous transluminal angioplasty in particular have been investigated.

PRIMARY AND SECONDARY ACCESS

There is an informal consensus that the autogenous radiocephalic (Cimino) A-V fistula should be the first choice for a good, long term vascular access [1]. Our study confirms this view.

Often, extensive medical treatment preceding dialysis results in a high percentage of patients with peripheral veins that are of insufficient quality for vascular access. In such cases, some surgeons will nevertheless try their utmost to create a Cimino A-V fistula. Others will choose a graft fistula when there is any doubt about the quality of the peripheral veins or arteries. In such cases, it is always difficult to prove that trying to create an A-V fistula is better than creating a graft fistula. Good overall results from clinics performing a high percentage of autogenous A-V fistulas suggest that in less favorable cases it is also worthwhile trying to create a distal A-V fistula [2]. On the other hand, graft fistulas may function for a long time [3]. They are often easier to puncture and can be reconstructed by PTA or surgery if the need arises.

The right choice of graft material for a second choice A-V fistula has not yet been clearly established. Over the past years, there has been a steadily growing worldwide acceptance of PTFE as the graft material of choice [4]. Homologous vein grafts have not been used on a wide scale, but good long term results have been reported [5]. An autologous

vein transplant makes for a very acceptable graft when the quality of the vein is good; however its application has become limited.

Our survey of the actual state of vascular access in the Netherlands supports the view that the choice of access is strongly influenced by personal preferences. No objective arguments can clarify the observed differences in choice for access.

A consensus about the right choices for vascular access and the correct techniques for the establishment and maintenance of vascular access is important. A working group for access surgery has been active in the Netherlands since 1990. This group takes an active part in organizing congresses and symposia to promote the quality of access surgery. Plans for a national registration of vascular access are being prepared with a view to promoting high standards for access surgery. Surgeons, nephrologists, radiologists and dialysis nursing staff all take part in this working group.

STANDARDISED REPORTING ON THE RESULTS OF VASCULAR ACCESS

A proposal for standardised reporting on vascular access surgery has been put forth and has been tested in a concrete situation. Comparing reports on the results of access surgery has been difficult, because of a lack of consensus about minimum requirements in reporting results. A report on the results of vascular access surgery must present data on cumulative patency rates, including and excluding salvage procedures. Furthermore intervention free periods and life expectancy of shunts must be reported. Definitions of the various terms are given.

EARLY FAILURE OF VASCULAR ACCESS

We have defined early failure as failure within 4 days. A vascular access that is used for dialysis will always be examined within this period. Others have defined early failure of newly constructed A-V fistulas as failure within 4 weeks. It can be argued that 4 weeks is a reasonable period to decide whether an A-V fistula will function. Yet, it is an arbitrary choice because many fistulas need a longer time to ripen and may still be utilised. We analysed the time of failure of shunts and were able to prove, in our material, that a certain, steady percentage of A-V fistulas failed after an accelerated failure rate in the first few days. The early failure rate can be kept low when little risk is taken with regard to the quality of veins and arteries to be used for the shunt. But also the avoidance of technical pitfalls, learned through experience, will protect

the access from early failure. The high early failure rate for surgical reinterventions in our study (27%) may reflect a negative selection since, in the case of stenoses, a PTA is attempted first; however, it also reflects the well-known problems of salvage in access surgery.

CHANGES IN VASCULAR ACCESS PATTERNS

During the last 10 years, the percentage of patients with an A-V fistula of the forearm (Cimino), generally accepted as the first choice for vascular access, has not changed substantially. There has however, been a significant change in the frequency of use of other types of access. The Scribner shunt is used much less. Among the grafts, the use of PTFE and the homologous vein (Varivas®) is steadily increasing and the use of the autologous vein is decreasing.

THE COSTS OF VASCULAR ACCESS SURGERY

Cost analysis of vascular access for haemodialysis should be considered when making decisions involving the appropriate approach to the treatment of end stage renal disease. As expected, first choice access surgery is less expensive than second choice access surgery. Second choice access surgery tends to be more difficult, may require an expensive vascular graft and is associated with a longer stay in the hospital.

The evolution of the population in centres for dialysis in the Netherlands differs from one centre to the other. In general, the tendency towards the treatment of older patients and patients in poorer health will make the construction of vascular access more difficult in the future. In our studies, no calculations were made for the different age groups.

We determined that the patency rate for Cimino A-V fistulas increased by 7% in the first year and by 15 % after 2 years with the use of PTA as a routine adjuvant procedure in the maintenance of fistula function [13]. The extra costs incurred in order to achieve this improvement in fistula function were Dfl 1380 (USD 775) per patient per year. While we conclude that routine application of PTA carries with it an extra cost of nearly Dfl 1400, we must also bear in mind that if no simple new Cimino A-V fistula can be created, a second choice access will have to be constructed with a considerable increase in the costs.

Under the circumstances of acute need at the start of haemodialysis, the costs of the Scribner A-V shunt as a semipermanent shunt are fairly low. For use in complicated situations during haemodialysis, the shunt is helpful but the costs are relatively high when repeated PTA's are necessary to maintain its function.

Since the PTFE graft A-V fistula is now probably the most popular second choice access procedure and may be the best according to the literature, with a good survival rate [14], its costs, though higher than any first choice access, can still be considered acceptable. The cheaper autologous saphenous vein graft fistula is not often constructed, mainly because of the limited availability of an adequate vein and of the good patency rates in the hands of some surgeons only.

The costs per patient per year for vascular access are about USD 3640 (Dfl 6500), or 7.9% of the costs of haemodialysis per year (USD 24 or Dfl 42 per dialysis).

The added costs of routine PTA as an adjuvant to maintain Cimino A-V fistulas are, on the average, USD 785 (Dfl 1400) per patient per year. For these fistulas, PTA may mean a saving since an expensive second choice access is not needed or can be postponed.

With PTA as an adjuvant to second choice access surgery, something which results in an improvement in the quality of life of the patients, costs incurred are higher, up to 16% of the cost of haemodialysis. In a limited number of cases, a more costly, but safe and reliable, method to maintain vascular access would still appear to be acceptable.

Acute access

Central venous catheters provide a relatively easy and rapid vascular access. These catheters, however, can cause serious trouble. Complications of central venous catheters include subclavian vein thrombosis, stenosis and sepsis [5,6]. Recent reports show fewer complications with jugular vein catheters [7,8]. The Scribner shunt, as a means of acute access, needs to be reconsidered. It can be used when acute haemodialysis is indicated as a semi-permanent first choice access. It should be placed distally in a leg to spare arm vessels for an A-V fistula. Dubious arterial circulation of the legs makes a Scribner shunt in a leg undesirable because a distal artery has to be sacrificed. A Scribner shunt, preferably the Ramirez variation without a subcutaneous bend, which allows easier treatment for thrombosis and access for transluminal angioplasty, can serve well for many months without any serious complication. Twardowski [10] foresees greater use of the transcutaneous vascular access, especially the intravenous catheters. Perhaps we may even see a revival of Scribner shunt varieties or better implantable transcutaneous vascular accesses.

Percutaneous transluminal angioplasty

The routine application of PTA in the treatment of stenoses and, hence, in the maintenance of vascular access influences the number of operations

required, the primary and secondary survival of fistulas and shunts and the costs of vascular access.

The conditions that are necessary for a successful routine application of PTA have to be agreed upon, because they fall outside the normal routine. They demand that nephrologists, surgeons and dialysis staff adopt a special attitude and that radio-interventionalists and vascular access surgeons especially be readily available. These conditions also include the accurate and timely diagnosis of stenoses in a vascular access. The problem is that all A-V fistulas have stenoses and that the functionally relevant stenoses must be detected. Monitoring and reporting of the arterial and venous pressures during dialysis provide an opportunity for that detection [9]. In the case of poor dialysis parameters, dilatation without delay is essential, as are the proper technical skills and sufficient care during the intervention. That involves training of personnel and monitoring of results. The new technique of PTA is effective and inexpensive for the maintenance of Cimino A-V fistulas. Graft A-V fistulas can also be treated well with PTA when stenoses occur.

Surveillance of vascular access

Prevention of complications starts with creating a shunt of the best possible quality. The right puncture technique of the shunt, avoidance of infection and careful compression after removing the needle or cannula from the shunt after dialysis comes next. And then an adequate surveillance of the shunt must lead to a timely intervention in case of a threat to good function.

A method to organise or improve surveillance is to record details of performance of the access during each dialysis on a special chart on which interventions on the shunt are noted also with a drawing of the actual configuration of the access (Appendix 1).

These studies give an insight in vascular access and its development. Comparing subsequent periods of course cannot provide scientific proof such as a randomised trial might offer. However, some conclusions can be drawn.

CONCLUSIONS

1. Vascular access surgery in the Netherlands is developing into a branch of general vascular surgery. Further development must be stimulated as is done by the Working group for Access surgery, which promotes training and research.

2. The long term results of vascular access surgery in the Drechtsteden Ziekenhuis Dordrecht of the different types of vascular access are in short: Before the application of PTA a 2-year secondary cumulative patency of 65% autogenous distal A-V fistula, of 52% for the graft A-V fistula and of 37% for the Scribner shunt was noted. After routine application of PTA an increased survival of a 2-year secondary cumulative patency of 80% for the autogenous distal A-V fistulas was found, which was not statistically significant. Less surgical interventions were needed. For graft fistulas no increased survival was noted, but less surgical interventions were required. The Scribner shunts were successfully treated with PTA and needed far less surgical revisions. Their survival as a group could not be compared validly with an earlier period, because their use was limited for the majority of the patients, more so during the last ten years than before.
3. Since the distal autogenous Cimino A-V fistula is the first choice access, considerable efforts to establish such a fistula are justified. For patients who may have to be dialysed, attempts must be made to save the veins of at least one arm from puncture for diagnosis and intravenous infusions.
4. There may still be a valid place for the Scribner shunt, in the Ramirez variation with an external bend, as a safe and easy access since it is associated with few serious complications when constructed with great care and maintained with the help of PTA [7,8].
5. Structured, disciplined monitoring of vascular access is more relevant when a relatively moderate intervention (PTA) can cure the problem. Monitoring must include regular measurement and evaluation of venous and arterial pressure, blood flow and clinical signs and symptoms. Timely interventions – medical, surgical or radio-interventional – not only save shunts but probably also greatly contribute to the welfare of the patient. This has to be investigated.
6. Routine application of PTA leads to less vascular surgery and good survival for shunts. The use of PTA has had a distinct impact on the number of surgical interventions indicated for the treatment of vascular stenosis in access surgery. A PTA increases the longevity of an internal shunt by 310 days (347 days excluding early failure). In the present study, an external shunt had an increased longevity of 54 days (59 days excluding early failure).

7. PTA may be an improvement in the management of vascular access and it positively affects the quality of life for the patient. Such an intervention which can be performed on an out-patient basis or during a short hospital stay, is appreciated by patients much more than surgery.
8. A statistically significant increased survival for an entire group of shunts of a certain type, when PTA is routinely applied, has not yet been proven. It may very well be possible to demonstrate a significant increase in survival of vascular access for an entire group when more patients have been treated.
9. Complications of PTA, such as thrombosis or the rupture of a blood vessel, do occur but can be managed without serious problems because the bloodvessels are superficial. They are usually diagnosed immediately as angiography is part of the PTA procedure. Ruptures can often be treated conservatively.
10. The costs of vascular access for haemodialysis vary from 3.5% of the total costs of haemodialysis for the most simple access to 16% for the more complicated types of access. The extra costs for routine application of PTA for the first choice access are low. The increased survival of first choice access may even mean a netto saving. The costs for second choice access have been higher after application of PTA. Whether they are justified, as more difficult treatments can be avoided, should be the subject of further investigations.

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SUMMARY

In this thesis vascular access for haemodialysis is investigated. Fifty years ago the first successful haemodialysis was carried out by Kolff at Kampen in the Netherlands. After twelve dialyses in nearly six weeks this treatment had to be terminated because of a lack of vascular access.

Only in 1960 Quinton, Scribner and associates succeeded in constructing a permanent vascular access, the arteriovenous (A-V) shunt. From that time onwards a growing number of patients, now hundreds of thousands around the world, can live with the help of an artificial kidney. Some years later Brescia, Cimino and associates succeeded in constructing a better vascular access, an A-V fistula. By such a fistula the superficial veins are filled with arterial blood. In this way the opportunity is given to let many litres of blood pass through the artificial kidney by puncturing the arteriatised veins.

Apart from haemodialysis, two other treatment modalities are available for end stage renal disease, continuous ambulant peritoneal dialysis (CAPD) and renal transplantation, the most desirable treatment.

The aims of this thesis were:

1. To establish the state of vascular access for haemodialysis in the Netherlands.
2. To investigate the long term results of the different types of vascular access and the effect of percutaneous transluminal angioplasty (PTA) on the results.
3. To investigate the effects of the routine application of PTA for treatment of stenotic complications in vascular access on the number of surgical interventions needed to maintain an adequate vascular access for haemodialysis.
4. To investigate the costs of vascular access surgery and PTA and the effects of routine application of PTA on the total costs of vascular access.

In **Chapter 1** a survey of the more recent general literature on vascular access for haemodialysis is given and the Dutch theses on the subject are mentioned. A few historical remarks are made. Quinton, Scribner and associates succeeded in 1960 to construct a permanent vascular access that functioned well. From that year onward chronic haemodialysis was possible. The vascular anastomosis already pioneered by Carrel in the beginning of the century proved effective in providing a ready vascular access.

Vascular access surgery has developed from modest beginnings to a subspeciality, because a wide range of possibilities to gain and maintain vascular access are available.

Foremost is the A-V fistula developed in 1966 by Brescia, Cimino and associates. This vascular access is still the most effective because of its lower rate of complications and longer overall survival.

Reviewing the most available possibilities for a vascular access also are mentioned the proximal A-V fistula, the graft fistula and implantable systems. A number of graft materials, biological grafts and allografts have been tested. Some, especially the homologous vein graft give good results, but over the last years there is a clear preference for expanded polytetrafluoroethylene (PTFE).

The importance of a good surveillance of the vascular access for early detection of complications is stressed. The diagnostic methods, invasive (angiography) and non invasive (duplex scanning) play a role. The complications of vascular access, thrombosis, stenosis and infection and a number of less frequent ones with emphasis on their treatment is given.

Acute vascular access demands immediate usability and a different approach. While at first the A-V shunt (Scribner) was the self-evident choice, central venous catheters became a much easier and also preferred solution because no vessels had to be sacrificed, or so it seemed. However, the complications of central venous catheters, especially subclavian vein thrombosis, can obviate an access in the same arm. Jugular vein catheterization may turn out to be superior to the use of the subclavian vein.

The introduction is concluded by calling attention to the emergence of percutaneous transluminal angioplasty (PTA) for vascular access. The technique of dilating stenoses in bloodvessels called transluminal angioplasty or Dotter technique after its originator Dotter, has been quite useful for the treatment of stenoses in vascular access. It can often be carried out percutaneously, i.e., without an operation. Over the last seven years experience has been obtained in Dordrecht with routine application

of PTA for all stenoses in vascular access. In this study on vascular access the effects of this method are analysed.

In **Chapter 2** the results are offered of a survey of vascular access for haemodialysis in the Netherlands. On 1 January 1988, 2195 patient in 52 centres were on long term haemodialysis and 588 on CAPD. Of all the patients on haemodialysis 70% had a Cimino fistula, 22% a graft fistula, 6% a proximal arm fistula and 2% had a Scribner shunt. As graft material 58% had a PTFE graft, 25% homologous vein graft, 13% a autologous vein graft and 4% a graft of other materials.

For acute access 46% of the centres positively preferred the subclavian vein catheter, 33% preferred femoral vein catheters. The Scribner shunt was applied only in selected cases in 22% of the centres.

In 1987 routine use of PTA was limited to a few centres.

In **Chapter 3** the effects of PTA on longevity of fistulas and shunts for haemodialysis and the number of surgical interventions needed to maintain vascular access are described. During three years PTA was applied 94 times in a haemodialysis population of about 50 patients. A reduction of surgical reinterventions of 30% was achieved, as compared to the three preceding years. There was a 50% reduction in surgical interventions with stenosis as indication. Longevity of A-V shunts was increased with 2 months and of A-V fistulas with 1 year for every PTA.

In **Chapter 4** a standard for assessing functional patency of vascular access is formulated and long term results of vascular access in a dialysis population, in particular the effects of PTA are presented. Primary and secondary patency of an access, as well as intervention-free periods are reported. The life expectancy of a group of A-V shunts or fistulas is assumed to be equivalent to the median secondary survival.

During a period of 20 years 407 A-V fistulas and shunts were constructed for 259 patients on chronic haemodialysis. In total 1179 interventions were performed, including 519 surgical reinterventions and 253 PTA's. The overall secondary cumulative patency rate for the autogenous distal A-V fistulas (Cimino) was 79% for one year, 68% for two years and 59% for three years. Routine application of PTA from 1986 onward resulted in a rise of secondary cumulative patency for Cimino A-V fistulas after two years from 65% in the 1980-1985 period till to 80% in the 1985-1991 period.

In **Chapter 5** a cost analysis of vascular access for haemodialysis is presented. The costs of haemodialysis make up a considerable part of renal replacement therapy. These costs amounted to DFL 106 000 reimbursable costs and to DFL 81 000 full costs. Calculation of the costs of access surgery, as well as the costs for special interventions per patient per year, has been carried out.

As PTA has increasingly become a useful adjuvant in the treatment of stenoses in vascular access comparing of the costs before and after application of was done. Two periods: 1980-1985 and 1986-1991 were contrasted. The higher quality of life that results when PTA is routinely used, carries with it added costs, especially for secondary access procedures. Overall costs per patient per year for creating and maintaining vascular access, surgery and PTA were about Dfl 6500*, or 7.9% of the costs of haemodialysis during the period 1986-1991. For Cimino A-V fistulas these costs amounted to Dfl 2850 per patient per year. Yet for Dfl 1400 extra per patient per year, the Cimino A-V fistula had a prolonged survival of the access of 7% in the first year and 15% in the second year when PTA was used as an adjuvant to surgery. PTA increases the costs of access surgery to a modest extent, while clearly improving the patients quality of life.

In **Chapter 6** the investigations are discussed and conclusions are reached. Attention is paid to the fact that these studies provide no scientific proof but that an insight in vascular access is provided.

SAMENVATTING

In dit proefschrift wordt de toegang tot de bloedbaan voor hemodialyse onderzocht. Vijftig jaar geleden werd de eerste geslaagde hemodialyse uitgevoerd in Nederland te Kampen door Kolff. Na twaalf dialyses in bijna zes weken moest deze behandeling worden beëindigd bij gebrek aan een goede toegang tot de bloedbaan.

Pas in 1960 gelukte het Quinton, Scribner c.s. een voor een langere tijd bruikbare toegang tot de bloedbaan te maken, de arterioveneuze shunt. Vanaf die tijd kan een groeiend aantal patiënten, nu honderdduizenden over de gehele wereld, leven met hulp van een kunstnier. Enkele jaren later, in 1967 gelukte het Brescia en Cimino c.s. een betere toegang tot de bloedbaan te maken in de vorm van een arterio-veneuze fistel bij de pols. Door deze fistel worden de oppervlakkige aderen met arteriële bloed gevuld, hetgeen de mogelijkheid geeft meer malen per week d.m.v. venepunctie van de gearterialiseerde venen vele liters bloed door de kunstnier te laten stromen.

Naast hemodialyse bestaan er nog twee behandelingswijzen voor ernstige nierinsufficiëntie: peritoneaal dialyse en de meest gewenste behandeling, niertransplantatie.

De doelen van dit proefschrift zijn:

1. Vaststelling van de toestand van de vasculaire toegangschirurgie in Nederland.
2. Onderzoek van de lange termijn resultaten van de verschillende types van vasculaire toegang en het effect van percutane transluminale angioplastiek (PTA) op de resultaten.
3. Onderzoek van de effecten van routinematige toepassing van PTA op de behandeling van stenoses (vernauwingen) in vasculaire toegangen op het aantal chirurgische ingrepen, dat nodig is voor het onderhouden van adequate vasculaire toegang voor hemodialyse.
4. Onderzoek van de kosten van vasculaire toegangschirurgie en PTA en de effecten van routinematige toepassing van PTA op de totale kosten van vasculaire toegangen.

In Hoofdstuk 1 wordt een overzicht van de meer recente literatuur over toegang tot de bloedbaan gegeven en de Nederlandse proefschriften over dit onderwerp worden genoemd. Enkele historische opmerkingen worden gemaakt. Quinton, Scribner en medewerkers gelukte het in 1960 een toegang tot de bloedbaan te maken, die goed functioneerde. Vanaf die tijd was chronische dialyse mogelijk. De A-V anastomose waarvoor het pionierswerk al in het begin van de eeuw door Carrel werd verricht, bleek effectief om een goed bruikbare toegang tot de bloedbaan te verkrijgen.

Van groot belang is de A-V fistel in 1966 ontwikkeld door Brescia, Cimino en medewerkers. Deze toegang tot de bloedbaan is nog steeds de meest effectieve, omdat hij het laagste aantal complicaties heeft en de langste levensduur. De meeste beschikbare toegangen tot de bloedbaan overziend worden ook genoemd de proximale A-V fistel, de transplantaat A-V fistel en de implanteerbare systemen. Gedurende de laatste jaren is er een duidelijke voorkeur voor geëxpandeerde polytetrafluoroethyleen (PTFE) transplantaten, maar sommige andere transplantaten, speciaal de homologe venetransplantaten geven ook goede resultaten.

Het belang van een goed bewaking van toegangen tot de bloedbaan om complicaties vroeg te kunnen ontdekken wordt benadrukt. De diagnostische methoden, de invasieve (angiografie) en de niet invasieve (duplex scanning) spelen een belangrijke rol. De complicaties van toegangen tot de bloedbaan, thrombose, stenose en infectie en een aantal minder frequente complicaties met een nadruk op hun behandeling worden gegeven.

Acute toegang tot de bloedbaan vraagt onmiddellijke bruikbaarheid en een andere benadering. Terwijl aanvankelijk de A-V shunt (Scribner) de vanzelf sprekende keuze was, werden later centraal veneuze catheters de eerste keus, aangezien geen vaten hoefden te worden opgeofferd, tenminste dat leek zo. Echter, de complicaties van centraal-veneuze catheters, speciaal thrombose van de vena subclavia, kunnen een toegang tot de bloedbaan in de betreffende arm onmogelijk maken. Catheterisatie van de vena jugularis lijkt beter te zijn dan het gebruik van de vena subclavia.

Tenslotte wordt de introductie besloten met een bijzondere aandacht voor de percutane transluminale angioplastiek (PTA) voor toegang tot de bloedbaan. De techniek van het verwijden van stenoses (vernauwingen) in bloedvaten, ook wel dotteren genoemd naar de initiator Dotter, is gebleken een zeer bruikbare behandeling te zijn bij stenoses in A-V fistels en shunts. De methode kan vaak worden uitgevoerd d.m.v. een punctie van een shunt bloedvat, d.w.z. zonder operatie. Gedurende de

laatste zeven jaar is te Dordrecht veel ervaring opgedaan met de routinematige toepassing van PTA voor alle stenosen in toegangen tot de bloedbaan. In dit proefschrift worden de effecten van deze methode geanalyseerd.

In **Hoofdstuk 2** worden de resultaten van een gegeven van een overzicht van toegang tot de bloedbaan voor hemodialyse in Nederland. Op 1 januari 1988, waren 2195 patiënten in 52 centra in chronische hemodialyse en 588 werden met CAPD behandeld. Van alle patiënten in hemodialyse had 70% een Cimino fistel, 22% een transplantaat fistel, 6% een proximale A-V fistel in de arm en 2% een Scribner shunt. Als transplantatie materiaal had 58% een PTFE transplantaat, 25% een homoloog vene transplantaat, 13% een autoloog venetransplantaat.

Voor acute toegang prefereerde 46% van de centra duidelijk de v. subclavia catheter, 33% prefereerde de v. femoralis catheter. De Scribner A-V shunt werd slechts toegepast in geselecteerde gevallen in 21% van de centra. In 1987 was het routinegewijs toepassen van PTA beperkt tot slecht enkele centra.

In **Hoofdstuk 3** worden de effecten beschreven van PTA op de levensduur van fistels en shunts en het aantal chirurgische ingrepen nodig om de toegang tot de bloedbaan in stand te houden. PTA werd in een periode van drie jaar 94 keer toegepast in een groep van 50 hemodialyse patiënten. Er werd een afname van chirurgische ingrepen van 30% gezien, vergeleken met de drie voorafgaande jaren. De chirurgische ingrepen met stenose als indicatie namen af met 50%. De levensduur van A-V shunts nam gemiddeld toe met twee maanden en die van A-V fistels met één jaar na elke PTA.

In **Hoofdstuk 4** wordt de levensduur van A-V fistels en shunts voor hemodialyse behandeld en de behoefte aan gestandariseerde rapportage van de resultaten. Primaire en secundaire functionele (bruikbare) door-gankelijkheid van een toegang, zowel als de interventie-vrije perioden moeten worden gerapporteerd. De levensverwachting van een groep A-V shunts of fistels wordt geacht equivalent te zijn aan hun mediane secundaire overleving.

Gedurende een periode van 20 jaar, van 1971 tot 1991, werden voor 259 patiënten in chronische hemodialyse 407 A-V fistels en shunts aangelegd. In totaal werden 1179 interventies uitgevoerd, waaronder 519 chirurgische reïnterventies en 253 PTAs. De cumulatieve door-gankelijkheid voor de gehele periode voor de autogene distale A-V fistels (Cimino)

was 79% na één jaar, 68% na twee jaar en 59% na drie jaar. Routine toepassing van PTA vanaf 1986 resulteerde in een stijging van de secundaire cumulatieve functionele doorgankelijkheid van Cimino A-V fistels na twee jaar van 65% in de periode 1980-1985 tot 80% in de periode 1986-1991.

In Hoofdstuk 5 wordt een kostenanalyse van vasculaire toegangschirurgie in het Drechtsteden Ziekenhuis beschreven. De kosten van hemodialyse zijn een aanzienlijk deel van niervervangingstherapie. Deze kosten bedroegen in 1988 ongeveer Fl 106 000 in declarabele kosten en Fl 81 000 in werkelijke kosten per patiënt per jaar. De kosten van vasculaire toegangschirurgie in Nederland zijn tot nu toe niet uitgerekend of althans niet gepubliceerd. Berekening van deze kosten, zowel als de kosten voor de verschillende interventies per patiënt per jaar zijn uitgevoerd.

Aangezien PTA in toenemende mate een bruikbare methode is geweest voor de behandeling van stenoses van toegangen tot de bloedbaan is een vergelijkend onderzoek gedaan naar de kosten voor en na toepassing van PTA. Twee perioden: 1980-1985 en 1986-1991 werden tegenover elkaar gezet. De hogere kwaliteit van leven die resulteert als PTA routinematig wordt toegepast geeft hogere kosten, speciaal voor secundaire toegangs procedures. De globale kosten per patiënt per jaar voor het maken en onderhouden van een toegang tot de bloedbaan, chirurgie en PTA, waren ongeveer Fl 6500, of 7,9% van de kosten van hemodialyse gedurende de periode 1986-1991. Voor de Cimino A-V fistel bedroegen deze kosten Fl 2850 per patiënt per jaar. Voor Fl 1400 extra per patiënt per jaar hadden de Cimino A-V fistels een toegenomen levensduur van 7% in het eerste jaar en 15% in het tweede jaar, toen PTA als steun bij het onderhoud van de vasculaire toegang werd gebruikt. PTA doet de kosten van vasculaire toegangschirurgie matig toenemen, terwijl het de kwaliteit van leven van de patiënten verbetert.

In Hoofdstuk 6 worden de onderzoeken besproken en worden conclusies getrokken. Deze onderzoeken geven een inzicht in de vasculaire toegangschirurgie. De vergelijking van opvolgende periodes levert natuurlijk geen wetenschappelijk bewijs, zoals een "randomised trial" zou leveren. Echter enige conclusies kunnen worden getrokken:

1. Vasculaire toegangschirurgie in Nederland ontwikkelt zich tot een tak van algemene vaatchirurgie. Verdere ontwikkeling moet worden gestimuleerd zoals wordt gedaan door de Werkgroep voor Toegangschirurgie, die training en onderzoek bevordert.

2. De lange-termijn resultaten van chirurgie voor de toegang tot de bloedbaan zijn in het kort de volgende: Vóór de toepassing van PTA een 2-jaars secundaire "patency" van 65% voor de autogene distale A-V fistel, van 52% voor de transplantaat A-V fistel en van 37% voor de Scribner shunt.

Na routine toepassing van PTA was er een toename van de cumulatieve secundaire "patency" tot 80% voor de Cimino A-V fistel, welke toename toch niet significant was. Minder chirurgische ingrepen waren nodig. Voor transplantaat A-V fistels werd geen toegenomen "patency" opgemerkt, maar minder chirurgische ingrepen waren nodig. De Scribner shunts werden met succes behandeld met PTA en hadden veel minder chirurgische ingrepen nodig. Hun overleving als groep kon niet zinvol worden vergeleken met een eerdere periode, omdat hun toepassing beperkt was voor de meeste patiënten, in de laatste tien jaar nog meer dan vroeger.

3. Omdat de distale autogene Cimino A-V fistel de eerste keus voor toegang tot de bloedbaan voor hemodialyse is, zijn aanzienlijke inspanningen gerechtvaardigd om te zorgen dat zo'n fistel gemaakt wordt. Het sparen van de venen van tenminste één arm met vermijden van diagnostische puncties en intraveneuze infusen moet nadrukkelijk worden nagestreefd voor patiënten die mogelijk zullen moeten worden gedialyseerd.
4. Er is waarschijnlijk nog steeds een nuttige plaats voor de Scribner shunt, in de Ramirez variatie met uitwendige bocht, als een veilige en relatief gemakkelijke toegang tot de bloedbaan met zeer weinig ernstige complicaties, wanneer hij gemaakt wordt met grote zorg. Wanneer de stenoses bij de vaattip worden behandeld met PTA kan het aantal operatieve interventies om de shunt in stand te houden laag zijn.
5. Een gestructureerde gedisciplineerde controle van vasculaire toegangen is nog zinvoller nu een relatief lichte ingreep het probleem van stenosering mogelijk kan oplossen. De controle moet mede inhouden regelmatige meting van de veneuze drukken en de bloedstroom en beoordeling van de klinische verschijnselen en symptomen. De controle spaart niet alleen shunts door tijdige nefrologische, chirurgische of radio-interventionele ingrepen, maar hij draagt waarschijnlijk in hoge mate bij aan het welbevinden van de patiënt. Dit moet nader onderzocht worden.
6. Routinematige toepassing van PTA leidt tot minder vaatoperaties en een waarschijnlijk verhoogde secundaire overleving van A-V fistels en shunts. Gemiddeld geeft een PTA een toename van de overleving

van een inwendige shunt van 310 dagen (347 dagen excl. vroege mislukking). Voor de uitwendige shunt werd een toegenomen levensduur van 54 dagen (59 dagen excl. vroege mislukking) gevonden.

7. PTA kan een verbetering zijn bij het beheer van de toegangen tot de bloedbaan en beïnvloedt de kwaliteit van leven positief. Een poliklinische interventie of één met een opname van een dag wordt door de patiënten bijna altijd verkozen boven een chirurgische ingreep.
8. Een statistisch significant toegenomen levensduur voor de hele groep van shunts van enig type, als PTA routinematig wordt toegepast, is nog niet bewezen. Het zou heel wel mogelijk kunnen zijn een dergelijk significante toename aan te tonen, als meer patiënten behandeld zijn.
9. Complicaties van PTA, zoals thrombose en ruptuur van een bloedvat komen voor maar kunnen relatief gemakkelijk behandeld worden omdat de vaten oppervlakkig liggen. Zij worden gewoonlijk onmiddellijk ontdekt omdat angiografie deel van de PTA procedure is. Een ruptuur kan meestal conservatief worden behandeld.
10. De kosten van een toegang tot de bloedbaan variëren van 3,5% van de totale kosten voor hemodialyse voor de eenvoudigste toegang tot 16% van de totale kosten voor de meer gecompliceerde soorten toegangen. De extra kosten voor routine toepassing van PTA voor de eerste keus toegang zijn laag. De toegenomen levensduur van eerste keus toegangen zou zelfs een netto besparing kunnen betekenen. De kosten van tweede keus toegangschirurgie zijn hoger geworden na toepassing van PTA. Of deze kosten gerechtvaardigd zijn, omdat moeilijker behandelingen kunnen worden vermeden zou nader onderzocht moeten worden.

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Voor de nefrologen was het vanzelfsprekend dat toegangschirurgie in de nauwste samenwerking tussen nefroloog en chirurg en later ook radioloog plaats zou vinden. Deze samenwerking werd gekenmerkt door wederzijdse aanmoediging en zelden door verwijten.

Dr. Zijlstra, beste Jan, je inventiviteit bij het dilateren van shunts en je onvermoeide inzet, die al uitmondde in een voortreffelijk proefschrift over de percutane transluminale angioplastiek bij de toegang tot de bloedbaan voor hemodialysis heeft het beschrijven van de resultaten van de toegangschirurgie in ons ziekenhuis zinvol gemaakt. Een consequent toegepaste nieuwe methode kon vergeleken worden met de algemeen gangbare methode. Zonder de goede en vriendschappelijk verhoudingen die wij daarbij hadden was dat waarschijnlijk niet gelukt.

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Ook wil ik wel de patiënten noemen, die vaak met grote moed het leven met nierfunctievervanging dragen en daarbij de zorgen om hun shunt. Geen dialyse is denkbaar zonder de bijzondere verpleging, die daarbij hoort. De verpleegkundigen van de dialyseafdeling en allen die werken op de operatieafdeling, die zo'n grote rol spelen bij de zorg voor de shunts, verdienen een ereplaats in dit dankwoord.

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CURRICULUM VITAE

De schrijver van dit proefschrift werd geboren op 2 augustus 1934 te Alkmaar. Hij was leerling van het Stedelijk Gymnasium te Utrecht, waar hij in 1952 eindexamen gymnasium 8 deed. In 1961 legde hij het artsexamen af aan de Rijksuniversiteit te Leiden. Zijn opleiding in de chirurgie kreeg hij op de chirurgische afdeling van het Gemeente Ziekenhuis aan de Bergweg te Rotterdam (opleider dr. M.W. van Weel). Na zijn registratie als chirurg in 1967 was hij chef de clinique in hetzelfde ziekenhuis tot hij zich in 1970 vestigde te Dordrecht in het Diaconessenhuis Refaja. Nu werkt hij in dat zelfde, inmiddels door fusie vergrote ziekenhuis, het Drechtsteden Ziekenhuis, in maatschapsverband met W.F. Blom, dr. W.L.E.M. Hesp, dr. C. Mahabier, M. de Mos, dr. B. van Ooijen, L. Stam en dr. O.C.M. Varin.

ENQUETE NAAR DE TOESTAND VAN DE ACCESS-CHIRURGIE IN DE NEDERLANDSE CENTRA VOOR CHRONISCHE HEMODIALYSE OP 31 DECEMBER 1987.

Codenummer centrum

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Hoofd Dialyse afdeling

[illegible]

Naam van de invuller van de enquête

[illegible]

1. Hoeveel patiënten zijn er met nierfunctievervangende behandeling op Uw afdeling?
HOEFT NIET BEANTWOORD TE WORDEN. (RENINE-ENQUETE)

2. Hoeveel patiënten met nierinsufficiëntie worden met hemodialyse behandeld op de peildatum?
HOEFT NIET BEANTWOORD TE WORDEN. (RENINE-ENQUETE)

3. Hoeveel patiënten hebben een arterio-veneuze fistel (A-V fistel) volgens Cimino?
Toelichting
 Bij patiënten met meer functionerende shunts
 Alle A-V shunts tellen.

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- 4 Hoeveel patiënten hebben een A-V shunt volgens Scribner?

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5. Hoeveel patiënten hebben een primaire toegang tot de bloedbaan?
(zie toelichting)

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Toelichting

Onder primaire toegang wordt verstaan een A-V fistel volgens Cimino en een A-V shunt volgens Scribner, tenzij de laatste wordt aangelegd omdat de primaire toegangen gefaald hebben, of onmogelijk zijn.

6. Hoeveel patiënten hebben een secundaire toegang tot de bloedbaan? (zie toelichting)

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Toelichting

Onder secundaire toegang wordt verstaan de toegangschirurgie vermeld onder vraag 7.

7. Hoeveel patiënten met een secundaire toegang tot de bloedbaan hebben

- 1 Vaattransplantaten
- 1a Autologe venen
 - 1b Homologe venen
 - 1b1 Vascogref
 - 1b2 Dardik
 - 1b3 overige
 - 1c Heterologe vaten
 - 1c1 Bovine
 - 1c2 overige
- PTFE

[illegible]

Appendix I

<p>2. A-V fistels in de elleboogholte</p> <p>3. Scribner shunts (secundaire d.w.z. omdat andere shunts faalden)</p> <p>4. Bijzondere vormen?</p> <p>4a Biocarbon</p> <p>4b Hemasite</p> <p>4c overige</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> </table>																				
<p>8. Hoeveel patiënten worden met de single needle methode behandeld</p> <p>1. Incidenteel</p> <p>2. Als routine voor een langere periode?</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> <tr><td></td><td></td></tr> </table>																				
<p>9. Voor welke toegangsweg(en) wordt gekozen wanneer iemand gedialyseerd moet worden terwijl de permanente toegang tot de bloedbaan uitgevallen is of er nog geen permanente toegang is? (geschatte percentages)</p> <p>1. Subclavia catheter</p> <p>2. Shaldon (lies)catheter</p> <p>3. Scribner shunt</p> <p>4. Andere methode</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> </table>			%			%			%			%								
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<p>10. Wordt bij stenoses bij A-V fistels en shunts de percutane transluminale angioplastiek (P.T.A.), de techniek volgens Dotter, toegepast?</p> <p>1. Incidenteel</p> <p>2. Regelmatig</p> <p>3. Nooit</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td>ja / nee</td></tr> <tr><td>ja / nee</td></tr> <tr><td>ja / nee</td></tr> </table>	ja / nee	ja / nee	ja / nee																	
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<p>11. Wordt de toegangschirurgie uitgevoerd door (geschatte percentages)</p> <p>1. één chirurg</p> <p>2. enkele vaste chirurgen</p> <p>3. ieder van de chirurgen</p> <p>4. assistenten</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> <tr><td></td><td></td><td style="text-align: right;">%</td></tr> </table>			%			%			%			%								
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<p>12. Is het mogelijk het aantal operatieve interventies voor access-chirurgie voor alle patiënten per jaar op te leveren zonder veel moeite?</p> <p>Zo ja, hoe groot is dat getal</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td>ja / nee</td></tr> <tr><td></td><td></td><td></td></tr> </table>	ja / nee																			
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<p>13. Stemt U toe in het door de Stichting Renine aan ons ter beschikking stellen van de hierboven en hieronder met name genoemde gegevens? Wij vestigen er de aandacht op dat de gegevens anoniem gemaakt worden per patiënt en per centrum.</p>	<table border="1" style="width: 100px; height: 100px; border-collapse: collapse;"> <tr><td>ja / nee</td></tr> </table>	ja / nee																			
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.....

handtekening

stempel of naam in blokletters

.....

Van ieder van de patiënten zijn de volgende gegevens van belang: leeftijd, geslacht, aantal doorgemaakte transplantaties en de vraag of zij aan diabetes mellitus lijden. Het aantal patiënten in thuisdialyse wordt gevraagd. Deze gegevens zijn door de Stichting RENINE verzameld en zouden wij graag bij het onderzoek gebruiken.

De gegevens worden zowel per patiënt als per centrum anoniem gemaakt.

Shuntcontrole

Naam:		Soort shunt: _____															
_____		_____															
_____		_____															
Pompstand:	d.d.	d.d.		d.d.		d.d.		d.d.		d.d.		d.d.		d.d.			
	Art.	Ven.	Art.	Ven.	Art.	Ven.	Art.	Ven.	Art.	Ven.	Art.	Ven.	Art.	Ven.	Art.	Ven.	
	200 ml/min																
	350 ml/min																
	ml/min																
Plaats naalden		Arterieel		Arterieel		Arterieel		Arterieel		Arterieel		Arterieel		Arterieel		Arterieel	
Shunt tekening																	
		Veneus		Veneus		Veneus		Veneus		Veneus		Veneus		Veneus		Veneus	
Bijzonderheden																	
Behandeld door:																	

COLOFON

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