Endovascular treatment of immature, dysfunctional and thrombosed forearm autogenous ulnar-basilic and radial-basilic fistulas for haemodialysis

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Abstract

Background. Forearm basilic fistulas are rarely used as vascular accesses for haemodialysis but they represent a valuable option when autogenous radial-cephalic fistulas cannot be performed. There is no information in the literature to date about the outcome of direct ulnar-basilic or transposed radial-basilic forearm autogenous fistulas after endovascular treatment of stenosis or thrombosis.

Methods. This retrospective study included 78 consecutive patients from eight dialysis units who were referred to a single interventional radiology centre for endovascular treatment of delayed maturation (n = 30), dysfunction (n = 35) or thrombosis (n = 13) of their autogenous forearm ulnar-basilic (n = 62) or radial-basilic fistulas (n = 16). The male/female ratio was 54/24, mean age was 64.7 years, 26% had diabetes, 83% were treated for hypertension and the mean body mass index was 24 kg/m². Immature and dysfunctional fistulas were treated by dilation and thrombosed fistulas by aspiration thrombectomy. Clinical success was defined as the perception of a continuous palpable thrill and the ability to perform dialysis. Fistula patency rates were calculated with the Kaplan–Meier method.

Results. Overall primary patency rates were 51% and 44% at 1 and 2 years, respectively. These rates were lower for immature and thrombosed fistulas compared to dysfunctional mature fistulas. Secondary patency rates were 96% and 91% at 1 and 4 years, respectively. Immediate overall clinical success was 97%. The two failures occurred with an immature and a thrombosed fistula. Immediate complications included two transient dilation-induced ruptures treated by prolonged balloon inflation. One case of subsequent hand ischaemia was successfully treated by distal artery ligation.

Conclusions. Endovascular treatment plays a major role in the maturation process, maintenance and salvage of radial and ulnar-basilic fistulas. The preservation of upper arm veins for the future, with low risk of hand ischaemia or hyperflow, might encourage nephrologists and surgeons to consider forearm basilic fistulas systematically in their strategy of vascular access creation.

Keywords: endovascular treatment; haemodialysis; transposed radial-basilic fistula; ulnar-basilic fistula; vascular access patency

Introduction

When the time arrives for creation of an arteriovenous access for long-term dialysis, current recommendations indicate that native veins should be preferred over prosthetic material and that the arteriovenous communication should be performed as distally as possible [1,2]. The reasons are that long-term patency of native fistulas is better than that of grafts, and that the venous capital of patients must be preserved.

It is usually possible to create an upper arm fistula after failure of a forearm fistula, whereas it is usually impossible to create a forearm fistula after failure of an upper arm access, since the elbow or upper arm outflow of forearm veins has often been destroyed.

The construction of a functional radial-cephalic fistula can be challenging, and high initial failure rates have been reported in many publications [3,4]. On the other hand, a significant number of patients may have poor cephalic veins in both forearms but have preserved basilic veins. This is the reason why as early as 1967 some surgeons reported the possibility of creating an arteriovenous fistula (AVF) between the ulnar or radial artery and the basilic vein in the lower third of the forearm [5].
Endovascular treatment of forearm basilic fistulas

Since then distal direct ulnar-basilic or transposed radial-basilic fistulas have been routinely created and used in some countries, but few series have been reported since the initial articles of Hanson and Kinnaert in 1967 and 1977 [5,6]. Unfortunately, initial failure rates appeared higher and primary patency rates poorer than those achieved with radial-cephalic fistulas [6–8]. This is probably the reason why this anatomic type of AVF is not mentioned in the European or American guidelines [1,2]. However, small series with more encouraging results have since been published [9,10], and the recent clinical practice guidelines of the American Society for Vascular Surgery (SVS) state that ‘when the forearm cephalic vein is not considered adequate for an autogenous AV access, the forearm basilic vein is the preferred alternative’ [11].

Meanwhile, several publications have emphasized the increasing value of endovascular techniques in the salvage of immature, dysfunctional mature and thrombosed autogenous fistulas [12–21]. However, there is no report in the literature to date about the outcome of direct ulnar-basilic or transposed radial-basilic autogenous fistulas after endovascular treatment of stenosis or thrombosis.

The purpose of this study is to report the outcome of forearm autogenous distal basilic fistulas after endovascular treatment. Our fairly positive experience in this field leads us to believe that interventional techniques considerably improve the outcome of these forearm basilic fistulas and that they deserve to be included in future official guidelines.

Subjects and methods

Once the strategic decision for creation of an ulnar-basilic fistula had been taken, our surgeons constructed a side-to-end anastomosis between the ulnar artery and the basilic vein in the lower forearm, close to the wrist (the then deep location of the artery makes it impossible to create such an anastomosis in the mid or upper forearm). At 6–8 weeks’ follow-up, the surgeons considered two indications for transposition of the basilic vein to the radial artery: a short juxta-anastomotic stenosis of the vein associated with a non-enlarged ulnar artery, and deep location of the vein that required concomitant superficialization. In such cases, the ulnar anastomosis was closed, and the basilic vein was transposed beneath the skin on the volar (anterior) aspect of the forearm in order to be anastomosed to the radial artery at the junction of the mid and lower third of the forearm. The radial artery had usually gained in diameter because for several weeks it had contributed to the feeding of the ulnar-basilic fistula via the palmar arches that provided retrograde flow to the ulnar artery distal to the anastomosis. An additional interval of 6–8 weeks was then required before routine cannulation of the vein could be contemplated.

This retrospective cohort study includes 78 consecutive patients who underwent percutaneous dilatation or thrombectomy of a forearm autogenous distal ulnar-basilic (n = 62) or radial-basilic (n = 16) fistula between April 1997 and September 2008. The proportions of ulnar-basilic and radial-basilic fistulas in participating dialysis centres are 2.5% in incident and 4.7% in prevalent patients.

The patient characteristics are set out in Table 1. Dialysis had already been commenced in all patients except for one case of immature fistula. The 29 other cases of immature fistulas were dialyzed either via the recently created fistula with difficulty (n = 16), a previous vascular access (n = 11) or via a central catheter (n = 2). Iodine diluted to 90% was used in the non-dialyzed patient [22]. The risk of renal deterioration after using diluted iodine was very low according to the article by Kian and this also reflects our previous experience in this field. A gadolinium-based contrast agent (Gadoterate meglumine) was used in two patients with severe history of allergy to iodine. No case of nephrogenic systemic fibrosis has ever been described to date after injection of this very stable molecule.

Indications for endovascular treatment were delayed maturation (n = 30), acute thrombosis (n = 13) and dysfunction of a mature fistula (n = 35). The latter group comprised low flow (n = 15), difficulties in cannulation (n = 5), increased venous pressure (n = 9), increased compression times (n = 2), recirculation (n = 3) and arm oedema (n = 1).

The endovascular techniques used were those described by Turnel-Rodrigues and co-workers [13,15]. Immature fistulas were defined as all fistulas of < 3 months and in some cases fistulas of >3 months but used in dialysis for < 1 month with major difficulties. In the latter cases, the diagnosis of non-maturation was recognized only when the time had come for actual use of the fistula. Diagnostic angiography was performed by retrograde puncture of the brachial artery at the elbow level only in patent fistulas of >4 weeks. An underlying stenosis was diagnosed in all cases and these were dilated using a venous antegrade or retrograde approach. Balloon diameters ranged from 4 mm (arterial or anastomotic stenoses) to 6 mm (outflow vein stenoses). The dilation balloons used were the Powerflex Extreme (Cordis®, Crawley, UK). The Powerflex and the Blue Max were inflated up to 25 atm and the Conquest up to 30 atm. The highest inflation pressure accepted by each balloon was systematically used in order to warrant the better dilation process. A flexed elbow position was required in most cases to allow easy cannulation of the vein and pushing of wires and catheters (Figure 1). No side-branch was embolized or ligated. Thrombosed immature fistulas not used successfully at least once were considered to be a contraindication for any endovascular treatment.

Thrombosed fistulas were treated by manual aspiration thrombectomy after placement of two 7F–9F introducers, depending on the vein diameter and estimated clot burden [16]. In five cases, the small clot volume was aspirated with a 7F catheter. In the eight cases with high clot burden filling an aneurysmal vein, 8F and 9F aspiration catheters were used. Underlying stenoses were then dilated. Balloon diameter ranged from 4 mm (anastomotic stenosis) to 12 mm (outflow stenosis of an aneurysmal fistula). The flexed elbow position was necessary when the vein was small, although well-developed veins were accessible from the usual and more convenient supine rest position. The aneurysmal degeneration of the vein was the cause of fistula abandonment at 3 years’ follow-up in one case. In cases of dysfunctional mature fistulas, diagnostic angiography was performed through a puncture of the brachial artery in cases of low flow or difficulties in cannulation. In cases of venous hypertension, direct antegrade cannulation of the vein was performed close to the anastomosis. In all cases, dilation balloons, the same as for immature fistulas, were then pushed from a venous (antegrade or retrograde) approach.

Anatomic, haemodynamic or clinical success was defined in agreement with the reporting standards of the (American) Society of Interventional Radiology (SIR) [23]. For thrombosed fistulas, success was defined by the simple ability to perform at least one dialysis session. For dysfunctional or immature fistulas, anatomic success was defined as a < 30% residual
stenosis, although it was occasionally difficult to define the reference diameter in immature fistulas. Haemodynamic success was defined as the recovery of normal flow or normalization of venous pressures. Clinical success was defined as the perception of a continuous palpable thrill and the disappearance of initial clinical abnormalities. For immature fistulas, this meant overall the possibility of using the fistula for at least three successful dialysis treatments.

Follow-up was based on clinical surveillance by nephrologists in dialysis units. Recurrence of low flow, difficulties in cannulation, increased venous pressure, increased haemostasis time, arm oedema or hand pain led to new angiography with subsequent dilation. The flow rate monitoring using a transonic device or ultrasound examinations was available in five out of the eight referring dialysis centres. A raw flow rate < 500 mL/min or a flow rate < 1 L/min resulting from a 25% decrease between measurements led to angiography with subsequent redilation of underlying stenoses. Any further thrombosis or rethrombosis was treated by endovascular means.

**Statistical analysis**

Descriptive statistics were produced regarding the study population. The number of endovascular interventions per patient/year was determined. Differences in primary and secondary patency rates were assessed in survival analysis. *Primary patency* was defined as the interval from the time of the endovascular intervention until any reintervention on the fistula or until the time of measurement of patency. *Secondary patency* was defined as the interval from the time of the endovascular intervention until access abandonment or the time of patency measurement, including any new endovascular manipulation designed to reestablish functionality in a thrombosed access.

Fistula primary patency rate at 1 and 2 years and secondary patency at 1, 2 and 4 years was estimated using the Kaplan–Meier method and compared using the log-rank test according to the indications for endovascular treatment. Fistula patency rates are reported on an ‘intention-to-treat’ basis, which means that initial failures were included in agreement with the reporting standards of the SIR and SVS [23,24].

Analyses were conducted using SPSS 15.0 for Windows. A *P*-value ≤ 0.05 was considered statistically significant.

**Results**

**Stenosis location**

As for radial-cephalic fistulas, the main underlying stenosis was located in the anastomotic area (Figure 2).

**Immediate success**

Immediate overall clinical success rate was 97% (thrombosed fistulas 92%, mature dysfunctional fistulas 100% and immature fistulas 97%). The only failure with thrombosed fistulas was due to early rethrombosis before any dialysis treatment and was eventually treated by surgical revision of the anastomosis. The only failure with immature fistulas was the inability to cross a chronic occlusion of the outflow vein at the elbow. All other immature fistulas were cannulated for dialysis within 15 days of dilation. Mean vascular access flow rate increased from 424 mL/min to 952 mL/min for the nine dysfunctional fistulas where both measurements were available.

**Complications**

One patient died within 1 month of intervention but the nephrologists considered that it was not linked to the
Endovascular treatment of forearm basilic fistulas 535

Fig. 2. Distribution of stenosis treated with angioplasty during the follow-up period according to fistula type: ulnar-basilic (A) and transposed radial-basilic (B).

endovascular treatment. Two transient dilation-induced ruptures of the vein were treated by simple balloon tamponade. No significant haematoma occurred requiring any specific treatment. One case of subsequent hand ischaemia in a radial-basilic fistula was easily treated by Distal Radial Artery Ligation (DRAL) that suppressed steal of the fistula from the arterial hand supply.

Self-expandable stents (‘Wallstent’, Boston Scientific®, USA, or ‘Fluency’, Bard®, USA) were placed in five patients for rupture control (n = 1) or elastic recoil (n = 4) after maintenance redilations, at the anastomosis (n = 1), in the elbow vein (n = 2), in the upper arm basilic vein (n = 1) and in the subclavian vein (n = 1), respectively. No stent was placed in cannulation areas.

Follow-up

During the follow-up period, 8 patients underwent renal transplantation and 27 died. The number of endovascular interventions for salvage or maintenance of all fistulas was 1.03 per patient/year.

Patency rates

The fistula patency rates and the survival curves are presented in Tables 2 and 3 and in Figure 3.

Discussion

The results of this study show that, despite high initial success rates, 1-year primary patency rates after percutaneous treatment of immature or thrombosed forearm basilic fistulas were relatively low, i.e. around 35%. However, much better results were achieved in mature fistulas (around 70%).

The other significant result was that repeated endovascular interventions led to very high and lasting secondary patency rates since there was little difference between 1- and 4-year rates, as illustrated by the slow decrease from 96% to 83%.

These results are comparable with those published for radial-cephalic fistulas. After dilation of dysfunctional radial-cephalic fistulas, Lay, Manninen, Rajan and Turmel-Rodrigues [12,13,17,18] reported 1-year primary patency rates ranging from 44% to 64% (70% in this series), and secondary patency rates ranging from 81% to 86% (92% in this series).

For thrombosed fistulas, our 1-year primary patency rate of 37% for forearm basilic fistulas falls in the 9–49% range.
of those reported in the series of > 25 radial cephalic fistulas [13,14,19]. The 92% secondary patency looks even better than the 51–81% in the same series, but our sample of 13 patients was small, thus with a large standard error.

From this series of 78 cases, it can be concluded that forearm basilic fistulas share the advantages (and also the drawbacks) of radial-cephalic fistulas. Excluding initial surgical failures and once they have matured, they offer the best long-term outcomes because, compared to prosthetic grafts, they are much less prone to infection and to early recurring episodes of acute thrombosis that may become impossible to solve.

In addition, location in the forearm is associated with a lower risk of hand ischaemia or hyperflow. For example, only one case of hand ischaemia occurred in this series of 78 patients and it was easily solved by DRAL.

This very low incidence of hand ischaemia merits attention, especially in view of the high rates reported with other elbow accesses. A recent prospective study performed by Keuter reported that 28% of elbow accesses (autogenous and prosthetic) developed some kind of ischemic symptoms, although only 10% required additional surgical treatment [25]. The low incidence of ischaemia with ulnar-basilic fistulas is easy to understand since the main forearm artery, the radial artery, does not provide any direct flow to the fistula and retains its entire capacity to supply the hand.

Similarly, the small ulnar artery is much less prone than the brachial or even the radial artery to developing excessive fistula flow with time. This is a significant argument in favor of forearm fistulas, in line with the recent publication by Basile reporting an increased risk of cardiac failure in patients with access flow above 2 L/min [26]. However, McMillan reported in 1968 that he was obliged to ligate an ulnar-basilic fistula in a young patient because of access-related congestive heart failure [27].

Forearm basilic fistulas also share the drawbacks of radial-cephalic fistulas. The initially smaller diameter of the ulnar artery and forearm basilic vein compared to elbow or upper arm vessels means an increased technical challenge in the construction of the anastomosis, a higher risk of immediate technical failure and a longer maturation period, including fistulas that never mature spontaneously. This key-point after surgical creation is very well demonstrated in the surgical series reported by Bourquelot (in children) and Cetto (in adults), with low 1-year patency rates of 24% and 47%, respectively [7,8]. In contrast, the problem is almost ignored by Salgado and Weyde [9,10].
probably because they were extremely demanding about the initial quality and diameters of arteries and veins prior to the construction of the anastomosis, yielding high primary patency rates of 70% at 1 year. Unfortunately, initial arterial and venous diameters are never mentioned in their articles, whereas using microsurgery, our surgeons regularly create anastomoses between an artery of 1 mm and a vein of 2 mm as long as pre-operative imaging rules out any evidence of a focal stenosis or outflow occlusion. Our opinion is that diabetes and calcified arteries are not a contraindication but an incentive for creation of such distal fistulas in view of the high risk of hand ischaemia if elbow fistulas were created.

With regard to non-maturation resulting from initially small size vessels, our endovascular series of 30 immature fistulas confirms for ulnar-basilic fistulas what has been published for radial-cephalic fistulas, i.e. that the vast majority of non-maturing fistulas can become usable after dilatation of underlying stenoses, with excellent secondary patency despite poor primary patency rates. When compared only to published series that have included initial failures in the calculation of patency rates, our 1-year primary patency rate of 37% with forearm basilic fistulas is in perfect agreement with the rates of 34–39% reported after endovascular salvage of non-maturing radial-cephalic fistulas [15,20,21]. Surgeons working in close cooperation with experienced interventionists can therefore be less demanding about pre-operative diameters of arteries and veins before construction of ulnar-basilic fistulas.

The less serious drawback of forearm basilic fistulas is that routine cannulation of the basilic vein can initially prove difficult, especially in countries where cannulation is not mandatorily performed by dedicated nurses. The posterior location of the vein is the main reason why the basilic vein is often the only preserved vein in both forearms. During a patient’s pre-dialysis lifetime, this hidden vein is usually ignored by nurses in search of venous access for blood sampling or perfusion, simply because it is not visible in the usual supine position. Cannulation of the basilic vein, before or after arterIALIZATION, is usually feasible only when the patient adopts a flexed elbow position, which is initially disquieting for many nurses and patients. However, the elbow can be stretched back to its spontaneous resting position for the duration of any dialysis treatment once access is gained and needles secured to the skin. When the arterialized vein becomes well developed with time, cannulation in supination becomes feasible for most patients. Transposed radial-basilic fistulas are easier to cannulate but the surgeons push forward several reasons for avoiding to transpose the basilic vein whenever possible: the ulnar artery and the basilic vein are very close to each other at the wrist and the making of the anastomosis is very easy, thus less time-consuming, with few mobilizations of the vein. Systematic transposition of the vein is felt to be at risk of damaging the vein and creating twists or kinks. In addition, this is usually a second-stage procedure that delays the use of the fistula for dialysis since surgeons know from their experience with upper arm basilic veins that it is much easier to transpose a vein that has been dilated by a few weeks of arterIALIZATION. Overall, the surgeons feel that it is better to preserve the entire flow of the radial artery for the feeding of the hand.

The ultimate aim of this article should be to encourage nephrologists and surgeons to consider the ulnar-basilic fistula systematically in their strategy of vascular access creation and maintenance and to help to determine the place of the ulnar-basilic fistula in the currently recommended algorithms for access creation. It is clear that the radial-cephalic fistula remains the access of choice. It is usually easier to construct since the radial artery and the forearm cephalic vein are usually larger than the ulnar artery and basilic vein. Cannulation is also easier to perform since it does not require a transient flexed elbow position.

With regard to the autogenous brachial-cephalic fistula, which comes second after the radial-cephalic fistula in current recommendations, the usually longer maturation time of the ulnar-basilic fistula and the significant risk of initial surgical failure, which is not graded in this series starting from the first endovascular intervention, should be taken into account. The four advantages of the ulnar-basilic fistula, i.e. preservation of upper arm veins for the future, low risk of hand ischaemia, low risk of hyperflow with time and easy to perform maintenance reinterventions, must be weighed by nephrologists against the risk of having to manage a patient with no usable arteriovenous access 3 months after initial surgery.

In pre-dialysis patients, the ulnar-basilic fistula might be preferable to a brachial-cephalic fistula whenever the nephrologists consider that the scheduled date for initiation of dialysis leaves sufficient time for maturation of this distal fistula or creation of a new access in cases of early failure. In patients currently dialyzed via a temporary central line, the brachial-cephalic fistula might be preferred in order to shorten the time that the central catheter is needed. It is even more true that the failure of an ipsilateral brachial-cephalic fistula does not preclude future creation of an ulnar-basilic fistula as long as the upper arm basilic and axillary venous outflow is not compromised, for example by further inappropriate stent placement in the cephalic arch protruding into the subclavian vein or by stenosis resulting from surgical transposition of the cephalic vein into the axillary vein. The ulnar-basilic fistula can be then reconsidered as soon as the brachial-cephalic fistula needs repeated maintenance reinterventions, leading to predictable abandonment.

In conclusion, endovascular treatment plays a major role in the salvage of immature, dysfunctional and thrombosed forearm basilic fistulas. A lack of local knowledge or expertise in percutaneous treatments will automatically force nephrologists and surgeons to maintain the ulnar-basilic fistula at its current status of marginal or overlooked alternative.

Acknowledgement. The authors thank Doreen Raine for editing the English language.

Conflict of interest statement. None declared.

References

Guided optimization of fluid status in haemodialysis patients

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Abstract

Background. Achieving normohydration remains a non-trivial issue in haemodialysis therapy. Guiding the haemodialysis patient on the path between fluid overload and dehydration should be the clinical target, although it can be difficult to achieve this target in practice. Objective and clinically applicable methods for the determination of the normohydration status on an individual basis are needed to help in the identification of an appropriate target weight.

Methods. The aim of this prospective trial was to guide the patient population of a complete dialysis centre towards normohydration over the course of approximately 1 year. Fluid status was assessed frequently (at least monthly) in haemodialysis patients (n = 52) with the body composition monitor (BCM), which is based on whole body

Received for publication: 9.1.09. Accepted in revised form: 17.8.09

doi: 10.1093/ndt/gfp487
Advance Access publication 30 September 2009