Nephrol Dial Transplant (2007) 22: 1468–1470
doi:10.1093/ndt/gfm047
Advance Access publication 17 February 2007

NDT
Nephrology Dialysis Transplantation

Case Report

Nitinol stenting and an unsuccessful surgical operation

Carlo Lomonte[1], Sergio Petronelli[2], Francesco Casucci[1] and Carlo Basile[1]

[1]Division of Nephrology and [2]Interventional Radiology Unit, Miulli General Hospital, Acquaviva delle Fonti, Italy

Keywords: arteriovenous fistula; embolization; haemodialysis; nitinol; stent; venous hypertension

Introduction

Stent implantation in vascular access for haemodialysis has grown up in the last few years. Nine percent of percutaneous transluminal angioplasties (PTA) performed in 2001 on haemodialysis accesses was associated with stent implantation, according to the United States Renal Data System 2003 annual data report [1]. Furthermore, graft longevity is improved when stenoses are treated with stents in selected cases [2,3]. Among several materials, nitinol is one of the most used: it is a non-magnetic alloy of nickel (ni) and titanium (ti) (+ nol, from Naval Ordinary Laboratory, where it was created in 1968) [4].

We report here the case of a haemodialysis patient bearing a native arteriovenous fistula (AVF), in whom nitinol stents behaved as a two-faced Janus: initially, nitinol stent implantation in a stenotic vein enabled the patient to overcome a syndrome of venous hypertension; after 1 year, when surgical ligation of the AVF was decided upon because of the relapse of the syndrome, the same nitinol stents represented an unexpected trap.

Case

A 45-year-old male patient had been affected by chronic uraemia due to nephronophtisis since he was 21 years old; he had been on haemodialysis in the years 1982–96; he was then transplanted, receiving a cadaver kidney; 7 years later, he again suffered from chronic uraemia due to chronic rejection, but refused to start haemodialysis treatment. He was hospitalized in March 2003 because of acute pulmonary oedema; only then was haemodialysis started, after the implantation of a temporary central venous catheter in the right jugular vein (the distal right AVF constructed in 1982 had meanwhile thrombosed).

Construction of a right latero-lateral brachio-basilic AVF in March 2003

Both the physical examination and the Duplex Doppler sonography showed perviousness of the right basilic vein at the arm and forearm; the cephalic vein, which was occluded at the antecubital level, was inhabited again at the middle third of the arm, by the confluence of an accessory vein. By considering the diameter and the hypertrophy of the veins, which had been punctured in the previous period of haemodialysis treatment, and the particular topography of vessels, a right latero-lateral brachio-basilic AVF (just above the elbow) was created in March 2003: the aim was to develop a centrifugal flow in the basilic vein of the forearm (to be used as arterial needle) and a centripetal flow in the cephalic vein (to be used as venous needle). First venipuncture occurred 2 weeks afterwards and the temporary central venous catheter in the right jugular vein was removed at that time.

Implantation of two self-expanding nitinol stents in the stenotic part of the basilic vein in December 2005

Two years and 9 months later, the cephalic vein thrombosed; at the same time, a progressive oedema developed in the hand and forearm. Angiography showed a complete occlusion of the right cephalic venous axis, a stenosis followed by aneurismal dilation of the first part of the basilic vein in the forearm and a tight stenosis of the basilic vein in the middle part of the arm, associated with irregularities and diffuse narrowing of the basilic vein in the distal part of the arm (Figure 1A). A PTA aimed to save the AVF and to reduce venous hypertension was performed in December 2005. Angioplasty was unsuccessful due to immediate elastic recoil; thus, two self-expanding nitinol stents were placed in the stenotic part of the basilic vein (Figure 1B). This procedure was successful, with a rapid resolution of the oedema and a functional restoration of the hand. Venipunctures for routine

Correspondence and offprint requests to: Carlo Basile, MD, Via Battisti 192, 74100 TARANTO, Italy.
Email: basile.miulli@libero.it

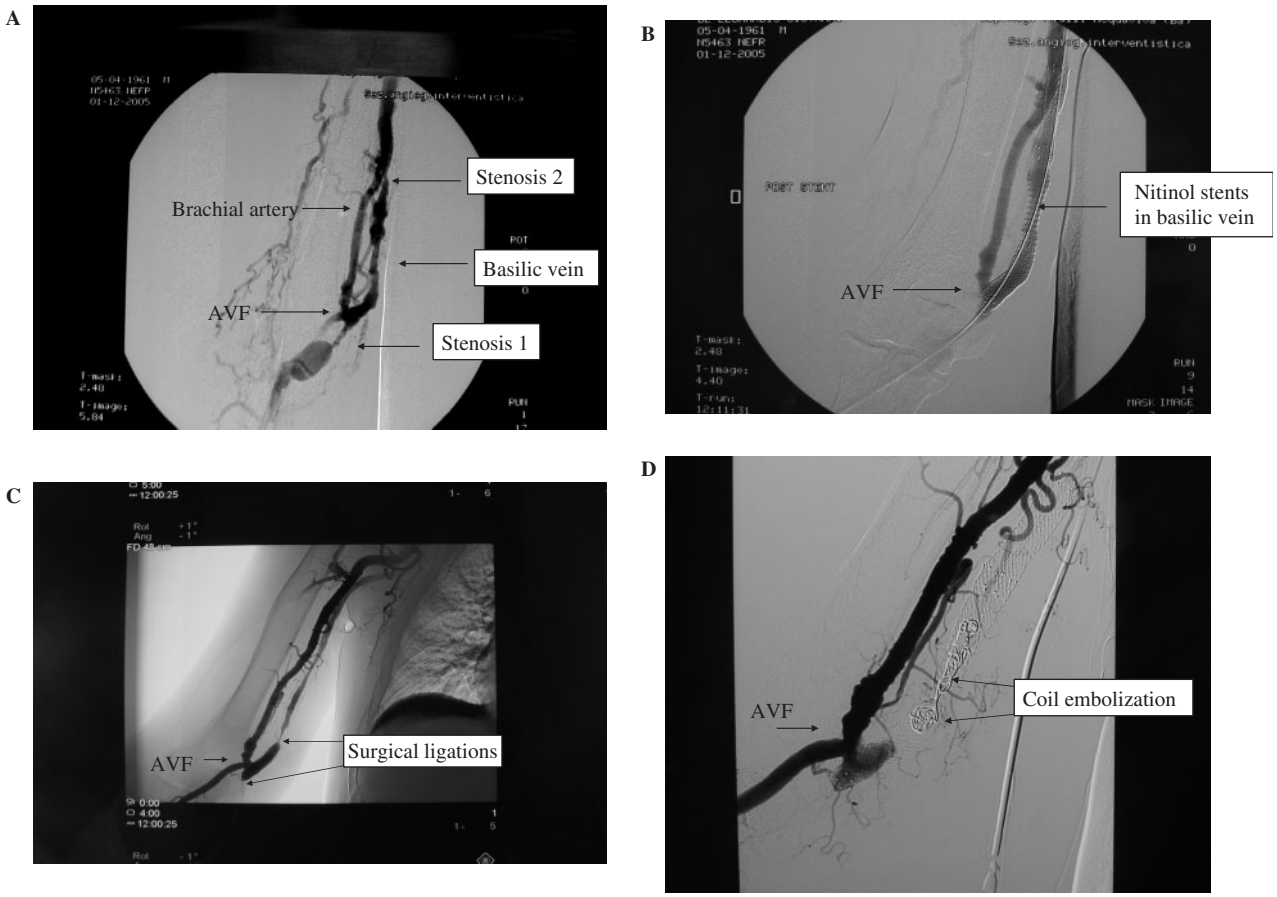

Fig. 1. (**A**) Angiography showed a complete occlusion of the right cephalic venous axis, a stenosis (indicated as stenosis 1) followed by aneurismal dilation of the first part of the basilic vein in the forearm and a tight stenosis (indicated as stenosis 2) of the basilic vein in the middle part of the arm associated with irregularities and diffuse narrowing of the basilic vein in the distal part of the arm. (**B**) Angioplasty was unsuccessful due to immediate elastic recoil; thus, two self-expanding nitinol stents were placed in the stenotic part of the basilic vein. (**C**) A new angiography showed a patent brachio-basilic AVF; the surgical ligation at the distal efferent basilic vein had been effective; however, the efferent proximal vein, hosting the nitinol stents, was pervious at the level of the arm: the vein was stenotic for a long part, the stenosis was very tight and haemodynamically significant (>80%), sufficient, however, to assure the perviousness of the vein. (**D**) Embolization of AVF was performed by inserting nitinol coils.

haemodialysis treatment were not performed in the basilic vein: in fact, it is preferable not to utilize veins hosting stents.

AVF surgical ligation in October 2006

Ten months later (October 2006), the patient presented ulcerative lesions of the skin at the venipuncture sites and a progressive oedema of the arm. At the same time, we observed a prolonged bleeding time after removal of the needles at the end of dialysis and an increased pulsation originating from the arteriovenous anastomosis. A temporary central venous catheter was inserted in the right femoral vein. AVF surgical ligation was decided upon, owing to the high bleeding risk and in order to definitively solve the problem of venous hypertension. The access to the AVF anastomosis was impossible; however, the two efferent veins were detected, the proximal one (hosting the nitinol stents) and the distal one; they were ligated by means of two robust strings of silk. The thrill of the AVF disappeared and a rapid resolution of the oedema was demonstrated by the possibility of clenching the fist in the immediate post-operative period.

Embolization of AVF by means of nitinol coils in October 2006

However, 24 h later, the patient presented the same difficulty in clenching the fist and the thrill was present at the level of the AVF anastomosis. A new angiography showed a patent brachio-basilic AVF; the surgical ligation at the distal efferent basilic vein had been effective; however, the efferent proximal vein, hosting the nitinol stents, was pervious at the level of the arm: the vein was stenotic for a long part, the stenosis was very tight and haemodynamically significant (>80%), sufficient, however, to assure the perviousness of the vein (Figure 1C). Embolization of the AVF was then performed by inserting nitinol

coils [5] (Figure 1D). A rapid disappearance of the oedema and of the venous hypertension occurred.

Construction of a left latero-terminal brachio-basilic AVF with vein transposition in October 2006

A left latero-terminal brachio-basilic AVF with vein transposition was created on 26 October 2006 and punctured for the first time on 10 December 2006.

Discussion

Two issues emerge from the present case report: firstly, was stenting of the AVF (step 2 of the case report) appropriate? secondly, why did surgical procedure (step 3 of the case report) fail?

As far as the first issue is concerned, stents should be reserved to stenoses which are not accessible by surgical operation and in which a PTA procedure has failed, according to the consensus NKF K/DOQI guidelines [6,7]. Furthermore, the quality improvement guidelines of the Interventional Radiology Society do recommend stenting of a haemodialysis access in particular cases [8]:

(a) peripheral lesions in which PTA has failed and surgical access is difficult, surgery is contra-indicated or there are limited remaining access sites;
(b) central venous lesions after failure of PTA or that recur within 3 months after initially successful PTA;
(c) rupture of an outflow vein after PTA.

The indication for AVF stenting in our case derived from the first recommendation: failure of PTA due to a rapid elastic recoil and difficult surgical approach due to venous hypertension.

As far as the second issue is concerned, surgical ligation of the efferent vein hosting the nitinol stents was unsuccessful, even though performed by an experienced surgeon. Blood flow was initially stopped, as documented by the early thrill disappearance and oedema reduction; however, the ligation procedure was unable to totally occlude the lumen of the vein because of four alternative (or probably concurrent) reasons, at least three of them due to the physico-chemical properties of nitinol: it has a crystal structure with two temperature-dependent forms: when temperature is $>30^{\circ}$C it expands up to a predetermined diameter and increases its rigidity. Nitinol is a very elastic and easily deformed material, which restores its original configuration when the operating forces are removed. It resists to radial forces of hundreds of kilograms per square centimetre [9].

The four causes of the unsuccessful surgical ligation could be:

(a) nitinol induced an enormous resistance to the radial forces;
(b) nitinol progressively dilated in the hours following the operation because of an increase in temperature: this dilation was able to restore blood flow in the vein;
(c) stent is made of a self-expanding net, whose rest position (corresponding to a complete lock) corresponds to a dead point of a given diameter, which may have allowed the maintenance of flow in the lumen;
(d) heparin administered to the patient may have avoided the complete occlusion of the stenotic vessel, even though stenosis was haemodynamically significant (>80%).

In conclusion, the lesson of the present case report is the following: when an AVF hosts stents in its context, the safest and simplest way of occluding it is by embolization, by inserting, for example, nitinol coils; otherwise, if the surgical option (AVF ligation) is preferred, the stent must be removed surgically.

Conflict of interest statement. None declared.

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Received for publication: 27.12.06
Accepted in revised form: 16.1.07