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Correction of central venous stenoses: Use of angioplasty and vascular Wallstents

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Central venous stenosis: Use of transluminal angioplasty and endovascular Wallstents: Central venous stenoses are a frequent complication in hemodialysis patients. These lesions lead to fistula thromboses, arm swelling, and limit future vascular access. Stenoses are characterized by excellent initial response to transluminal angioplasty but rapid recurrence. Response to angioplasty allows classification of stenoses as elastic or nonelastic. The success of angioplasty alone in 30 patients with central venous stenoses was compared to angioplasty and Wallstent placement in 11 patients with recurrent stenoses. In those who had angioplasty alone, 7% failed angioplasty, 70% had ≥ 50% improvement in the luminal diameter while 23% showed no improvement due to elastic lesions. Subsequently, 81% of those with a successful result restenosed at an average of 7.6 months while 100% of elastic lesions occluded in an average of 2.9 months. In the 10 patients who underwent angioplasty and Wallstent placement, 5 were due to elastic lesions with four recurrences at a mean of 8.6 months. Four of five patients (80%) stented with nonelastic lesions had reappearance of symptoms at a mean of 4.2 months. We conclude that vascular stents should be reserved for those lesions that show elastic recoil after standard angioplasty.

Central vein stenosis is a serious complication in patients receiving maintenance hemodialysis therapy [1–4]. We and others have proposed a link between central vein cannulation and the subsequent development of central venous stenoses [1]. Prior to the development of adequate treatment options, the arm edema associated with this condition often forced removal of the arteriovenous fistula and prevented future ipsilateral fistula placement. We have reported dramatic success with percutaneous transluminal angioplasty (PTA) in the correction of this condition [5] Subsequently, however, we noted a very high recurrence rate for central vein lesions compared with venous stenoses in other locations [6]. Davidson, using intravascular ultrasound to measure intraluminal diameter before and after angioplasty, was able to characterize the histologic appearance of various venous stenoses and found that a significant number of central vein lesions were associated with normal internal morphology but had dramatic elastic recoil post-angioplasty [7]. Knowledge of these characteristics has allowed us to assess elastic recoil by standard angiographic means post-angioplasty.

Recently, placement of intravascular stents has been proposed as a method to prevent restenosis. Various authors have used differing stent designs to perform this function with varing results [8–16] The majority of these studies involve stenoses in the vascular graft or proximal venous outflow tract with few stentings of the central veins. We reasoned that the primary advantage of stents would be in the treatment of recurrent stenoses or elastic lesions that respond poorly to angioplasty. We therefore designed the study to follow consecutive patients focusing on central vein stenoses. In central venous stenoses we have previously demonstrated a disproportionately high rate of recurrence [6, 7]. In this study, we compare results obtained using angioplasty alone with results obtained from the use of Wallstents (Medinvent SA, Lausanne, Switzerland) in patients with hemodialysis associated central vein stenoses which rapidly recurred.

Methods

Phase I

From 1987 through 1991, central venous stenosis was detected in 30 chronic hemodialysis patients. The stenoses occurred in the axillary, subclavian, and inominate veins as well as the superior vena cava. Detection of central stenosis was by a combination of elevated urea recirculation, elevated venous dialysis pressure and arm edema. Twenty-one patients were female, nine were male with a mean age being 56 ± 6 years. A total of 47 transluminal angioplasties were performed on these 30 patients.

Procedure

Upper arm venograms of the arteriovenous fistula and central veins were performed in a standard manner as previously described [5]. Under normal instances, the diagnostic venogram was performed from the hemodialysis fistula. After intravenous heparin (3000 to 5000 units) was given, percutaneous transluminal angioplasty was performed. With a high grade central vein stenosis, the angioplasty approach was via the femoral vein to minimize the size of the puncture in the high pressure fistula circuit and to allow use of oversized balloons. Central venous lesions were dilated with either a 8 mm, 10 mm, 12 mm, 15 mm, or double balloon (6 mm + 6 mm) diameter catheters.

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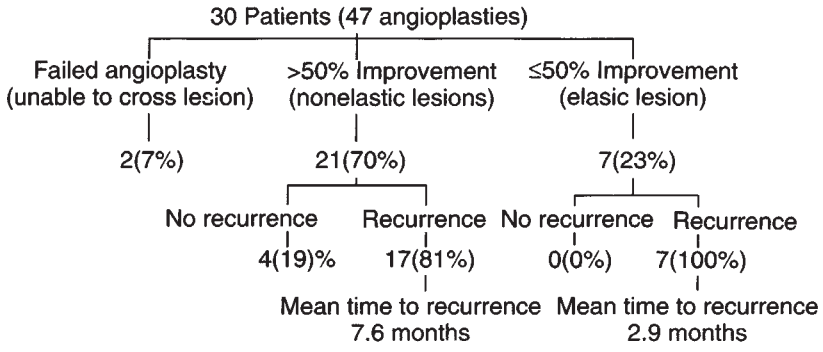

Fig. 1. *Outcomes of patients undergoing angioplasty alone.*

Table 1. Characteristics of stented patients

Groups	Males	Females	Mean age *years*	Symptoms: Swelling	Symptoms: Poor graft function	Symptoms: Unknown
Total	8	2	62.9	5	4	1
Recurrent stenosis	4	1	53.2	2	2	1
Elastic lesions	4	1	72.6	3	2	0

The balloon diameter was determined by generally accepted angiographic/angioplasty practices. The diameter of the balloon utilized for dilatation of the venous lesion was determined by the diameter of the normal reference segment of the vein. This was obtained via direct measurement from the angiogram. Since the angiogram includes some magnification, this results in modest overdilatation of the venous lesion (approximately 20%). Thus, the range of 8 to 15 mm diameter balloon utilization. Contrast cineangiography was obtained before and after the PTA with either hand or power injection of nonionic contrast agents. Angiographic images were analyzed with a previously validated, commercially-available edge detection algorithm. Percent diameter stenosis was obtained before and after PTA. Additionally, a total of 18 central veins were imaged pre- and post-angioplasty by intravascular ultrasound as previously described [7]. Perforation of guidewires outside the central venous system occurred on two occasions without any significant clinical complication. In both instances the patients were observed overnight prior to being dismissed.

Phase II

From 1991 through 1993, patients with elastic lesions which showed > 50% elastic recoil with reconstitution of the vessel diameter to ≤ 50% after angioplasty underwent endovascular Wallstent placement. In addition, patients with a recurrence of the same central venous stenoses within six months of a previous angioplasty also underwent placement of an endovascular stent. Thus patients with poor technical results to angioplasty due to elastic recoil (50% reconstitution of the lumen) and patients with a documented recurrence were selected for stent placement. A total of 10 patients underwent placement of the endovascular stent with greater than six months of follow up available on each patient. Due to the significant findings, the trial was terminated and only elastic lesions were subsequently considered for stent placement.

Procedures

Angiographic documentation of the stenotic vessel was initially performed. For stent placement, heparin (3000 to 5000 units) was administered intravenously and the stenosis or occlusion negotiated with a catheter/guidewire combination. An angioplasty was performed with the appropriate sized balloon. Following angioplasty, the Wallstent was manipulated into position and deployed in the desired location within the stenosis or occlusion. After successful deployment, the Wallstent was dilated to 10 mm and an angiogram performed to document the final result. Post-angiography, the catheter was removed and pressure maintained on the puncture site for hemostasis.

All patients were followed long-term either in the Duke University dialysis centers or by frequent communication with the patient's personal nephrologist. Detailed follow-up was performed to assure the absence of fistula thrombosis, arm edema, normal urea recirculation and normal venous dialysis pressure. If any of these criteria became abnormal, a repeat fistulogram was performed. Follow-up was terminated if restenosis was documented or upon the death of the patient.

Statistics

Data are reported as mean ± standard deviation. Comparisons between groups were done with unpaired Student's *t*-test.

Results

Thirty patients developed central vein stenosis during the first phase of the study. A total of 47 percutaneous transvenous angioplasties were performed in this group of patients. In two patients (7%) the lesions were not able to be crossed by the catheter and no therapy was attempted. Twenty-one patients (70%) had > 50% improvement in the stenosis following angioplasty as judged by post-angioplasty venogram or by intravenous ultrasound (Fig. 1). Mean follow-up for the group was 16 months. Of these, four patients (19%) had no recurrence of symptoms during the follow up period. In contrast, 17 (81%) patients from the group with successful angioplasty had recurrence at a mean of 7.6 months following the procedure and patency rate (defined as time without recurrence of symptoms) of 13.1 months. Seven patients (23%) had an unsatisfactory result (≤ 50% improvement in the lesion) due to elastic recoil of the vessel wall. All of these patients had loss of fistula function by a mean of 2.9 months. This result was significant when compared to the angioplasty patency rate in nonelastic lesions ($P < 0.05$).

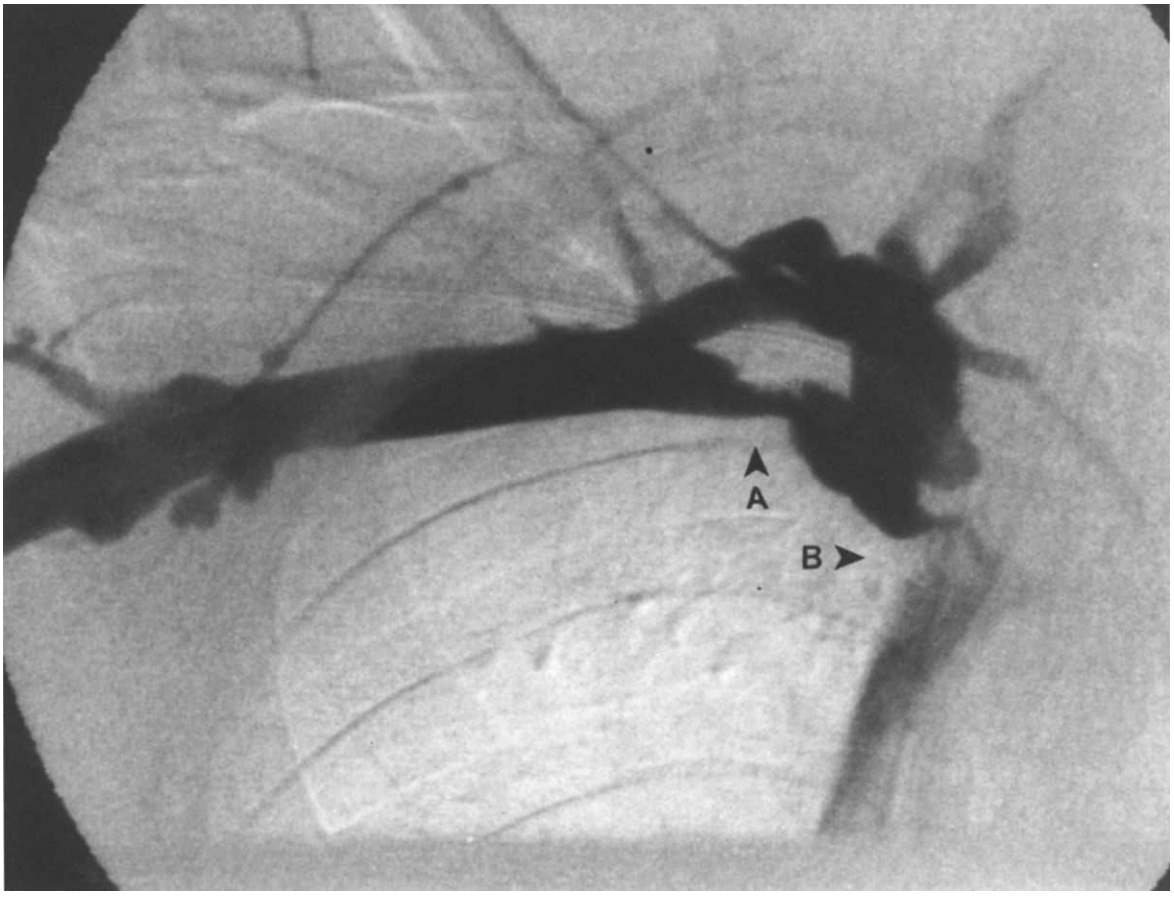

Fig. 2. *Pre-stent angiogram of an elastic central vein lesions.* **A.** Subclavian stenosis and **(B).** stenosis at the junction of the subclavian vein and superior vena cava.

In the second phase of the study, 10 patients (8 men and 2 women) underwent endovascular stent placement for their central vein stenosis (Table 1, Figs. 2 and 3). Their mean age was 63 years ± 16 years. Five were due to recurrent lesions and five were secondary to elastic lesions that did not respond to angioplasty. Signs and symptoms included poor blood flow with elevated venous dialysis pressures in four, and arm edema in association with elevented venous dialysis pressures in five and was undocumented in one patient. The mean follow-up for the group was 7.5 months with a median of 7.2 months (Fig. 4).

Four of five elastic lesions recurred in a mean time of 8.6 ± 4.1 months following stenting. Total mean follow-up time for this subgroup was 9.8 months with a median of 11.7 months. Four of the five patients stented for recurrent nonelastic stenoses also had recurrence of symptoms. The mean follow-up was 5.2 months with a median of 4.4 months and the mean time to first recurrence was 4.2 ± 1.8 months. Two patients had stenoses at the edge of the stent that responded to angioplasty. Two had intimal hyperplasia in the stent, one of which responded to angioplasty while the other required a second stent (Fig. 4). The mean patency time was significantly greater in the stented patients with elastic lesions compared to those with nonelastic lesions (9.8 ± 4.5 months vs. 5.2 ± 2.8 months; $P < 0.05$; Fig. 5). There was also a significant improvement of patency rate of stented elastic lesions compared to similar lesions undergoing angioplasty alone and in the patency rate of nonelastic lesions undergoing angioplasty alone versus stent placement. Because of the substantially worse outcomes in stented, nonelastic, recurrent central vein stenoses, the trial of stents in this patient group was terminated.

Discussion

Hemodialysis-associated central vein stenosis is emerging as a serious vascular access complication. We initially described this condition in 1987 and postulated that the causative factors included previous central vein cannulation and subsequent placement of a ipsilateral fistula with associated rapid blood flows [1]. We theorized that the nidus of fibrosis created by the catheter insertion expanded, driven by the turbulence created by the increased blood flow of the downstream fistula, and subsequently demonstrated that these lesions, in general, responded well to percutaneous transluminal angioplasty [5]. The importance of these lesions is that, if left untreated, they result in ipsilateral arm swelling, preventing the use of affected extremity for vascular access.

Despite the initial success of angioplasty, long-term follow-up from our institution showed a rapid recurrence of central venous stenoses compared with peripheral venous stenoses [6].

Fig. 3. *Post-stent angiogram of vessel in Figure 2.* Wallstent (arrow) placed to overlap both areas of stenosis with excellent blood flow post-procedure.

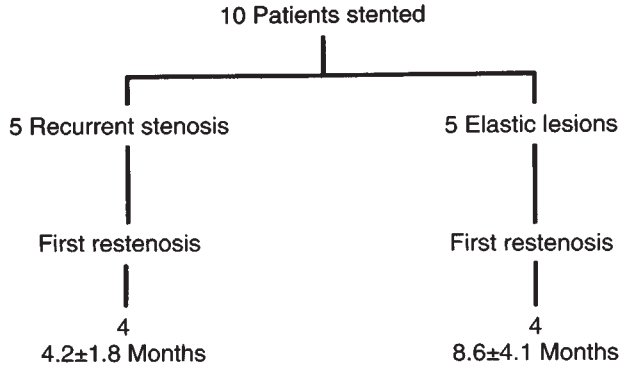

Fig. 4. *Outcomes of patients undergoing venous stent placement.*

Davidson, evaluating the mechanisms by which transluminal angioplasty corrects venous stenoses, noted that vessel stretch and dissection were the mechanisms associated with successful angioplasty. He also noted that vessel stretch followed by >50% elastic recoil was more frequent and severe in central venous lesions and often led to unsatisfactory angioplasty results [7]. Neither increasing the atmospheres of pressure nor expanding the diameter of the balloon improved the angioplasty results in these elastic lesions. He speculated that other potential catheter-based interventions, such as stent placement, might be beneficial.

Today, angioplasty has emerged as an essential procedure in the treatment of central venous stenoses, especially as surgical options in this intrathoracic area are severely limited. When lesions are detected early, prior to, and even after total occlusion, initial successful correction of the stenosis is the rule [17].

In this study, 70% of the cases had a greater than 50% improvement in vessel diameter following angioplasty alone. Of these patients, 19% were long-term successes with no recurrence. Unfortunately, 81% of these lesions recurred with a mean time to recurrence of 7.6 months. In almost all instances, repeat angioplasty was again successful. Stent placement in patients with recurrent nonelastic lesions yielded a significantly worse patency rate. Restenosis in these patients occurred in a mean of 4.2 months versus 7.6 months in patients who underwent repetitive angioplasty. Endothelial proliferation appears to be the primary problem. Thus, patients with nonelastic stenoses do not benefit from stent placement. Until new stent materials are developed that do not lead endothelial proliferation stent placement should be avoided in patients with this type of stenosis.

Twenty-three percent of the total lesions in this study were

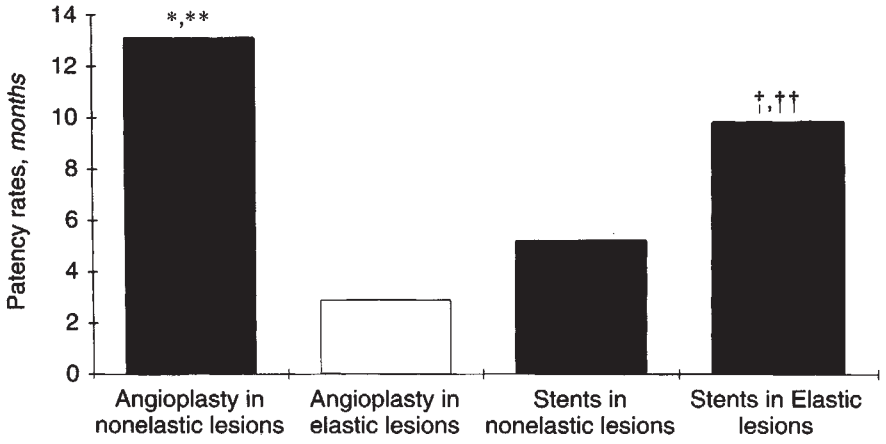

Fig. 5. *Patency rates of angioplasty and stent placement in elastic and nonelastic lesions.* *,** $P < 0.05$ vs. angioplasty in elastic lesions and stents in nonelastic lesions. †,†† $P < 0.05$ vs. angioplasty in elastic lesions and stents in nonelastic lesion.

markedly elastic with less than 50% improvement following angioplasty. One hundred percent of these stenoses recurred in less than three months when treated with angioplasty alone. When these patients were treated with Wallstent placement, significant improvements in patency occurred. Patency with endovascular stents was also significantly better with elastic lesions compared to nonelastic ones. Four patients with elastic venous lesions showed recurrent stenosis on average in 8.6 months during a mean follow-up period of 9.8 months.

Beathard [18] recently showed poor results of Gianturco stents in vein graft stenoses. Our results support his findings. However, our data demonstrate that there are at least two different histiologic types of central venous stenoses and that these types respond differently to interventions. Nonelastic lesions such as those caused by intimal hyperplasia or fibrosis, which also characterize vein-fistula stenoses respond poorly to endovascular stent placement. Elastic lesions such as those occurring in central and proximal veins are probably histiologically different based on intravascular ultrasonographic appearance and respond favorably to stent placement.

Interpretation of these findings suggests that elastic central venous lesions are readily detectable at the time of angioplasty. These lesions recur rapidly unless some sort of permanent indwelling stent is placed. When an indwelling stent is placed, the mean patency period increases dramatically over angioplasty alone. In contrast, nonelastic lesions do not respond to intravascular stent placement compared to angioplasty alone.

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