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VENOUS ANGIOPLASTY OF SUBCLAVIAN VEIN THROMBOSIS IN PATIENTS WITH FUNCTIONING ARTERIOVENOUS FISTULA FOR HEMODIALYSIS

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Introduction: *Adequate venous outflow is crucial to the proper function of a vascular hemodialysis access for patients with end stage renal disease (ESRD) Stenosis or obstruction of the subclavian vein can significantly compromise this venous outflow.*
Methods: *Vascular access was created in 230 patients with ESRD. Seventy-six patients had their initial AVF before dialysis, 82 had temporary subclavian catheters and 72 have been dialyzed through femoral catheters before or during the maturation of AVF. 138 patients had only one AVF that maintained adequate access for a mean duration of 38.8 months. 62 patients had two AVF with mean duration of function of 23.5 months.*
Results: *Subclavian vein stenosis and obstruction developed in 25 patients. In 19 patients with subclavian vein stenosis, angioplasty was successful in relieving manifestations of venous hypertension whereas jumping graft was used to bypass the obstructed vein in 6 patients.*
Conclusions: *1-Venous angioplasty or bypass is a successful method to relieve venous hypertension and prolong the patency of hemodialysis access. 2- Because hemodialysis catheters in the subclavian position are associated with a high (25%) incidence of central venous stenosis or occlusion, it is wise to limit its use by the nephrologists in the initial period of patients` care.*

Keywords: *angioplasty, subclavian, stenosis, hemodialysis.*

INTRODUCTION

Primary arteriovenous fistulae remain the gold standard for hemodialysis access. With the increasing number of patients with ESRD, surgeons are faced with the task of choosing the best approach for hemodialysis. The ideal access should provide long-term patency and function with the fewest complications[1] Percutaneous catheters in the subclavian vein have been used for temporary hemodialysis in the 1970s.[2-5] The subclavian approach for the temporary dialysis access gained popularity because of the ease of catheter placement. However, this is considered the most common cause of subclavian vein stenosis and thrombosis. It is a recognized complication of percutaneous catheterization in 1 out of every 3 patients receiving central venous catheter, with the thrombosis being symptomatic in 1–5 % of all cases. Subclavian vein stenosis in these patients became apparent only after placement of a permanent vascular access in the ipsilateral extremity[6] Long–term sequelae of subclavian vein stenosis can include reduced vascular access flow, graft thrombosis, and pronounced venous hypertension manifested by arm swelling, pigmentation and even ulceration[7, 8] As subclavian vein stenosis has been shown to have an adverse impact on the efficacy of dialysis, such stenosis or obstruction must be identified and treatment become necessary. Ablation of the access was the usual option,[9,10] but it does not address the underlying disorder and sacrifices the life–sustaining fistula, rendering the extremity unsuitable for future use in hemodialysis. Although neither surgical nor endovascular management resulted in long–term function for the majority of shunts after stenosis, endovascular treatment

can extend the life of dialysis shunts and bypass to decompress vascular graft to the internal jugular vein can improve venous outflow and restore vascular integrity.[11] The aim of the present study is improving the longevity of a functioning AVF by relieving subclavian vein stenosis or obstruction either by venous angioplasty or bypassing the site of obstruction.

PATIENTS AND METHODS

Between May 2001 and March 2004, 230 patients with ESRD, had their primary or secondary AVF created for Haemodialysis purposes at Mansoura International and Mansoura Insurance hospitals, whereas venograms and angioplasty were done at Mansoura University and Mansoura International hospitals. Patient medical records were reviewed. Preoperative clinical venous assessments had been performed for all patients to determine the feasibility and optimal site for fistula formation. Both wrists and antecubital fossae were examined as possible fistula sites. Fistula formation had been considered clinically feasible if the venous return of the cephalic vein was palpable and patent from wrist to antecubital fossa. Allen's test was performed to confirm arterial patency in the radial and ulnar vessels. To obtain missing data, patients were interviewed by telephone and nephrologists were also contacted. The AVF site, anastomosis type, anaesthesia used, and concurrent procedures performed were all recorded. The AVF outcome and any complications were assessed. There were 136 males and 94 females whose ages ranged from 11 to 71 years (mean, 52 years) In 82 patients there was either a history of or an existing, subclavian dialysis catheters whereas 72 patients had been dialyzed through femoral catheters before or during maturation of AVF and the remaining 76 patients had never had a subclavian or femoral catheter. Patients with clinical suspicion of outflow obstacle were investigated initially by Doppler, which is due to the increasing equipment accuracy, able to assess the axillary, subclavian and jugular veins rather well[12, 13] In case of uncertainty or demonstration of an obstacle, venography is carried out with digital subtraction angiography via a large-bore angiocath placed in either a forearm or antecubital vein. Images were acquired with a 40-cm image intensifier at one or two frames per second.

Usually two or three separate injections of 10-15 ml of contrast material were performed for the extremity, with imaging over the appropriate location. In all studies, we evaluated the venous drainage of the upper arm, the axillary and subclavian veins, the brachiocephalic vein and the superior vena cava. All pertinent images were reviewed by experienced vascular radiologist without knowledge of the patient's history of subclavian vein access. The subclavian vein was classified as normal, less then 50% stenotic, greater then 50% stenotic, or occluded.

Technique of angioplasty

Angioplasty was preformed after preparation of the skin around the elbow after 5ml local xylocaine 2% infiltration . A suitable vein proximal to the AVF was punctured with an angiographic entry needle, and a 0.035-in diameter floppy tipped guide wire was advanced antegrade under fluoroscopy into the subclavian vein. A 5F angiographic access sheath was advanced over the guide wire. Venography was performed through the sidearm of the sheath. Images were enhanced with the placement of the image intensifier close to the surface of the area of interest and with beam filters. The guide wire was advanced through the subclavian vein lesion by means of fluoroscopy. A 6-mm balloon angioplasty catheter was advanced over the guide wire, through the sheath and into the lesion. The balloon was brought to full profile with fluoroscopic visualization. Completion venography was performed through the sidearm of the sheath. Contrast required for the procedure ranged from 25 to 50ml. When completion venography demonstrated a significant residual lesion, the 5F sheath was exchanged for a 7F sheath and an 8-mm balloon angioplasty catheter was advanced to further dilate the residual lesion. After a satisfactory completion venography was obtained, the guide wire and sheath were removed and the puncture site of the vein was compressed for 10 minutes.

Axillary-jugular vein bypass

All the procedures were done under general anesthesia. An incision was made in the infraclavicular or the upper axillary region, and multiple subcutaneous accessory venous collateral vessels were encountered and preserved during dissection of the axillary vein, which was dilated and had a water hammer pulse. A second incision was made along the anterior border of sternomastoid muscle. The facial vein was divided and the internal jugular vein was generously mobilized. A subcutaneous tunnel was created between the two incisions. A 6 mm PTFE graft or reversed saphenous vein graft was anastomosed as end-to-side between the axillary and internal jugular veins (Fig. 1). An excellent pulse and thrill were immediately palpable in the interposed graft along. The arteriovenous fistula in the arm promptly developed a more prolonged thrill, and the upper limb began to visibly decompress immediately.

RESULTS

The detailed causes of ESRD in the study group are shown in Table 1. The most common cause of ESRD was glomerulonephritis whereas collagen disease was the least known cause. Three patients with polycystic disease of the kidney were of the same family.. Comorbid conditions such as coronary artery disease, diabetes mellitus, previous cerebrovascular strokes, and peripheral vascular disease were present in 149 patients (64.7%) of the 230 patients.

Table 2. Summarizes the number, the types and the side of fistulae done per case. Most of the fistulae performed were radiocephalic (129/230; 56%), 64 (27.8%) were antecubital brachiocephalic, 23 (10%) were brachiobasilic followed by transposition, and 14 (6%) were AV graft due to unsuitability of upper limb veins. Most fistulae (134; 58.2%) were formed on the non-dominant left side. The types of anastomoses used were side of vein to side of artery (142; 61.7%), end of vein to side of artery (79; 34.3%) and anastomoses using polytetrafluoro-ethylene grafts (9; 3.9%). In side-to-side anastomoses, the vein distal to the anastomosis was usually ligated to prevent venous hypertension in the hand and encourage the development of the fistula in a proximal direction. The procedures were performed using general anaesthesia in 37 (16%) patients, nerve block in 4 (1.7%) patients, and local anaesthesia in 189 (82%) patients. Sixty percent (138/230) of patients had only one AVF in their history of venous access for hemodialysis and maintained adequate function for a mean duration of 38.8 months, 62 (26.9%) patients had two AVFs with mean duration of function for 23.5 months, 23 (10%) patients had three AVFs with a mean duration of satisfactory access for 13.2 months, and seven patients had four AVFs that remained for average duration of 5 months. The two year primary patency of radiocephalic AVF was 88% whereas that of brachiocephalic was 62%. Thirty-four percent of fistulae had been used but use had been abandoned for various reasons. On the other hand, 16 AVFs had never been used. The causes for abandoned use and non-use are shown in Table 3.

Almost one quarter (57; 24.7%) of all patients had complications secondary to their AVF Table 5. The most common complications were thrombosis and stenosis. Less frequent complications included aneurysm formation, infection, venous hypertension, ischemia and steal. Thrombosis developed in the vein used for dialysis, the subclavian vein or the superior vena cava. Surgical technique or small, diseased vessels were the most common reason for early thrombosis. Other factors contributing to early failure were related to hemodialysis. These include hypotension, hemoconcentration, platelet activation, needle placement, wound hematoma, and post-dialysis needle site compression. Diabetes mellitus, old age, and inadequate vein or artery size have been associated with early failure. Most often, late thrombosis was caused by fibrosis of the vein and stenosis secondary to repeated vein punctures, with arterial stenosis accounting for only a small fraction of the thromboses.

In peripheral vein thrombosis, when techniqual problem was rulled out, simple balloon thrombectomy was effective in restoring patency. Streptokinase infusion was successful in reestablishing patency in 46% of the tried cases. Success rate was higher when a short segment of the vein is still pulsating distal to the thrombosed site as cannulation of this pulsating segment helps in pushing the thrombolytic agent and fragmentation of the thrombus. On the other band, the results were poor in case of cannulation of a totally thrombosed vein or graft. No patient in whom this was done had any symptoms or findings of pulmonary embolism. In addition to short-term streptokinase, heparin therapy for 24 to 72 hours may help to maintain patency, and was used in 50% of the occlusion successes. Any stenosis on the venous limb of AVF is then dilated with an angioplasty balloon. Often a high-pressure balloon is needed to treat the venous outflow stenosis, which may be resistant to dilatation. Any residual thrombus left within the graft is subsequently macerated with short duration (10-seconds) expansion of the angioplasty balloon at the location of the clot.

Occlusion of the subclavian vein (stenosis or thrombosis) is relatively common after indwelling catheters have been used. Subclavian vein stenosis developed in 19 patients whereas obstruction developed in 6 patients. This represents 10.8% of the whole series but 30.4% of those having subclavian catheter inserted at a time during the course of dialysis. These cases were clinically silent. The consequences of creating a high-flow AVF in the same arm are immediate fistula failure or rapid, massive arm swelling (Fig. 2) accompanied by dilated veins on the chest wall or the forearm, or it may be associated with pigmentation and cyanosis (Fig. 3) Duplex was successful in diagnosis of 95% of cases even if the patient's habitus precludes confident interrogation of the subclavian vein. Venography was conclusive in 5% of the cases when the clinical evaluation and duplex were inadequate. In 19 patients with subclavian vein stenosis, venous angioplasty was done using 8 F high-pressure balloon (Fig. 4) resulting in adequate flow in the vein (Fig. 5) and even reflux of the dye in the internal jugular vein and subsequent amelioration of edema in 17 patients (Fig. 6) One of the two failures involved an intimal flap at the angioplasty site and became restenosed 2 days later. The other failure involved multiple stenoses and became reoccluded within 2 months. The results of the venous stenosis are summarized in Table 4. The two longest patencies were still functioning at 16 and 18 months. The average patency was 9.2 months. In the course of venous angioplasty, one patient had chest pain and transient electrocardiographic changes and the procedure was aborted. After a 3-day wait to determine that a myocardial infarction had not occurred, the procedure was completed. There were two moderate sized hematomas at the vein puncture sites. One patient had cellulitis at the puncture site that cleared rapidly with antibiotics. One patient had a small full thickness slough at a site of contrast material extravasation in the forearm that healed completely. Five patients developed proximal vein stenosis at an average distance of 7 cm form the site of AVF. Angioplasty was successful in 4 of them. In case of complete obstruction of the subclavian vein, angioplasty is

doomed to failure, so bypass surgery between the axillary vein and the internal jugular vein is the reasonable alternative that had been used in 6 patients with restoration of thrill over the vein rather than pulsation and resolution of edema. One patient developed hematoma in the neck that needed evacuation without interference of the suture line at the internal jugular vein. Graft patency was maintained for the follow up period in all but one patient who used the bypass graft as a hemodialysis access leading to thrombosis after 8 months and recurrence of arm edema that needed declotting with restoration of graft thrill and amelioration of venous hypertension.

Hematoma, seroma, abscess or phlegmon are all recorded complications in the present study. True aneurysms of the vein from repeated vein punctures developed in 3.5% of the cases and were managed conservatively. In one case, a mural thrombus leads to an embolic event. In five cases there was atrophy of the overlying skin, ulceration and impending rupture. Treatment included ligation of the aneurysm and moving the fistula proximally. Arterial steal syndrome developed in 1.7% of wrist fistula and 3.5% of elbow fistula. Symptoms included hand pain, coldness, parasthesias, and deficiencies of motor function. Compression of fistula yields symptomatic improvement. The treatment was ligation of the radial artery distal to the fistula, provided there is adequate flow to the hand through the ulnar artery or ligation of the brachial artery distal to the fistula and bypassing the fistula site. Carpal tunnel syndrome developed in 1.7% of cases. This typically presented with pain and parasthesia in the median nerve distribution, with some patients complaining of exacerbation during dialysis. Motor dysfunction and thenar atrophy was observed in one patient.

Table 1: Causes of end-stage renal disease in the study group

Diagnosis	Patients, n = 230	
	No	(%)
Glomerulonephritis	58	(25.21)
Hypertension	38	(16.50)
Chronic pyelonephritis	37	(16.08)
Analgesic nephropathy	26	(11.30)
Diabetes mellitus	25	(10.86)
Polycystic kidney disease	10	(4.34)
Renovascular disease	8	(3.47)
Collagen disease	4	(1.73)
Unknown	22	(9.56)
Others	2	(0.86)

Table 2: The number, type and side of individual AVFs

Type of op	One op		Two op		Three op		Four op		Total	
	138		62		23		7			
Radio cephalic	90		27		9		3		129	
Side	Lt 63	Rt 27	Lt 16	Rt 11	Lt 4	Rt 5	Lt 0	Rt 3	Lt 83	Rt 46
Brachiocephalic	30		26		7		1		64	
Side	Lt 19	Rt 11	Lt 11	Rt 15	Lt 3	Rt 4	Lt 0	Rt 1	Lt 33	Rt 31
Brachiobasilic	12		5		4		2		23	
Side	Lt 6	Rt 6	Lt 3	Rt 2	Lt 1	Rt 3	Lt 0	Rt 2	Lt 10	Rt 13
AV Graft (Bridge)	6		4		3		1		14	
Side	Lt 6	Rt 0	Lt 2	Rt 2	Lt 0	Rt 3	Lt 0	Rt 1	Lt 8	Rt 6

Table 3: Causes of abandoned arteriovenous fistula use and non-use

Cause	Patients	
	No	(%)
Abandoned use		
Fistula failure	67	(29.13)
Fistula complication	5	(2.17)
Renal transplantation	3	(1.30)
Renal recovery	2	(0.86)
Death	2	(0.86)
Non-use		
Fistula failure	7	(3.04)
Fistula complication	6	(2.60)
Renal recovery	2	(0.86)
Renal transplantation	1	(0.43)

Table 4. Summary of stenosis

Location	No	Successes	Failures
Subclavian vein	19	17	2
Low proximal vein	5	4	1

Table 5: Complications of the AVF in the study group

complication	Patients (n=57)
Stenosis	24
Thrombosis	21
Impending rupture	5
Steal	3
True aneurysm	2
Thenar muscle atrophy	1
Carpal tunnel syndrome	1

Fig 1. Saphenous vein graft inserted as end-to-side between the axillary and subclavian veins.

Fig 2. Unilateral edema of the left upper limb due to subclavian vein stenosis.

Fig 3. Venous hypertension presented with pigmentation of the left forearm and hand

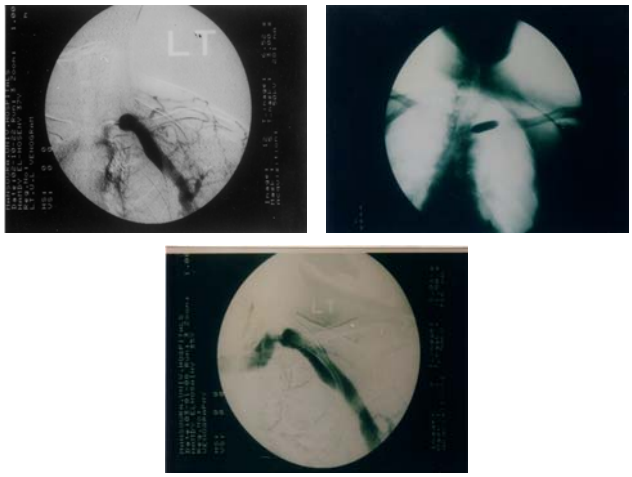

Fig 4a. Venography of the left subclavian vein showing stenosis at the costoclavicular junction with inadequate flow beyond the stenosis. b. Full dilatation of the balloon at the stenotic site for 30 seconds. c. Postdilatation venography of the left subclavian vein showing adequate flow in the proximal segment of the vein.

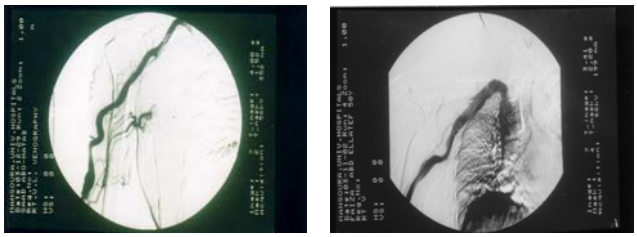

Fig 5a. Right subclavian vein stenosis.
b. Postdilatation adequate flow in the proximal segment of the vein.

Fig 6a. A case of subclavian vein stenosis with edema of the left upper limb and pulsating AVF.
b. Resolution of edema and restoration of thrilling fistula following PTA of the subclavian vein.

DISCUSSION

Non-tunneled central venous catheter allow for immediate and effective vascular access in patients in need for urgent hemodialysis. The high frequency of early and late complications, however, should be sufficient reason for the exercise of great care with respect to indication, implantation and surveillance. The frequency of catheter-associated central venous stenosis and occlusion is as high as 40-50% after cannulation of the subclavian vein[13-16] and may reach 75% once the subclavian catheter has been infected[17] Most of these obstructions do not cause symptoms because they develop slowly and venous collaterals have time to develop. However, when an arteriovenous access is created at a site distal to the obstruction, the collateral transport capacity will be overloaded and the arm will swell. Typical clinical findings in subclavian vein obstruction are arm swellings and development of wide spread subcutaneous venous collaterals around the shoulder and upper thoracic aperture. Especially when the draining vein of a functioning AVF is stenosed, massive venous hypertension with pain and peripheral ulceration may develop[36] Strictures of the central subclavian or innominate vein may cause additional unilateral swelling of breast, face, and neck[37] Central venous access has been shown to be the most important independent risk factor for infection in patients on hemodialysis. The relative risk of bacteremia is more than seven fold higher in catheter patients than in fistula patients[18] Furthermore a peripheral arteriovenous access has been shown to be more reliable than central catheter in terms of recirculation and flow rates achieved[19] Unassisted 1-year survival of tunneled, cuffed catheters has rarely been reported but may be as low as 9%.[20] Secondary 1-year survival rates were reported to vary between 25 and 93%.[21,22]

The classical AVF (Brescia–Cimino) remains the gold standard for vascular access in chronic hemodialysis. Neither its favorable primary and assisted patency rates nor its low complication rates have ever been reached by any other type of access. Patency rates for all radiocephalic fistulas are 80-90% at 2 years.[23] The basilic vein to brachial artery fistula, introduced by Dagher et al[24] has received increased attention over the past few years. In the most extensive study, a patency rate of 70% at 8 years was found in this type of fistula[25] in addition to complication rates much lower than polytetrafluoro ethylene (PTFE) grafts.[26,27]

The most common complication of AVF is thrombosis, which accounts for nearly 90% of the complications[28,29] Published results of thrombolysis of clotted hemodialysis accesses show resumption of dialysis in 75% of patients, success rates comparable with those of surgical revascularization (70% to 90%)[30,31] Valji, et al[32] reported technical success of 90% in patients treated with pulse spray with a mean time to lysis of 46 minutes. Poulain et al[33] treated thrombosed AVF with retrograde injection of urokinase followed by aspiration of residual thrombus. Diabetes mellitus seems to exert a major impact not only on the kidney function but also on the peripheral vessels and limits its suitability for AVF. This observation was true since all the seven patients who underwent 4 operations of AVFs were diabetic.

Venous stenosis with internal AVF generally occurs at or within a few centimeters of the anastomotic site. They may be related to surgical trauma. The turbulence and shear stresses of arterial blood flowing into a low-resistance vein may act as the initiating event in the deposition of platelets and fibrin, resulting in mural thrombus and eventual fibrosis[34] Stehbens and Karmody suggest that venous atherosclerosis is accelerated in association with AVF.[35] Venous stenosis may occasionally occur far from the anastomotic site and may be seen as far proximally as the axillary or subclavian vein.

There are severel options for the treatment of venous hypertension due to outflow obstruction of functioning hemodialysis access. Fistula ligation[36] is the least invasive as well as the most frustrating operation as the vascular

pathology causing the patients problem is not corrected. The respective extremity is thus rendered unsuitable for further shunt operations.[37] PTA of central venous stenosis in hemodialysis patients has been reported since the early 1980s[38] Because of frequent restenosis and occlusions, however, one year primary patency of PTA alone is less than 40 %. To reduce the number of reinterventions, stent implantation was added to PTA by different investigators.[39]

Our results of initial patency rate (89.4 %) after PTA, are comparable to those of Beathard[40] who reported an initial patency success of 91 % at 3 months but higher than that of Glanz[38] with patency rate of 35 % at 1 year. Recurrence of the stenosis can be treated with repeat angioplasty. The efficacy of repeat PTA is not yet quantified. Kanterman et al[41] reported decreasing patency rates with repeated angioplasty of hemodialysis grafts. Adjunctive measures including stent placement have been suggested to increase the patency rates of angioplasty sites and to allow percutaneous treatment of sites that have failed angioplasty. Turmel–Rodrigues et al[42] reported increased restenosis intervals from 3.6 months after angioplasty to 15.2 months after stent placement. Conversely, Quinn et al[43] found no benefit of stent placement over angioplasty for outflow stenoses in the arm.

Several surgical approaches have been reported in the management of subclavian venous thrombosis. Among these have been direct exploration of the vein with repair of a traumatic internal flap, and a variety of venous bypass techniques, including subclavian vein – superior vena cava bypass,[44] cephalic vein crossover bypass, and axillary vein – internal jugular vein bypass with saphenous vein interposition graft.[45] In the absence of an ipsilateral AVF, venovenous anastomoses have historically had poor patency rates. As demonstrated experimentally,[46] creation of a temporary AVF distal to the venovenous anastomosis may increase flow sufficiently to dramatically improve patency rates. The present study suggests that the presence of an ipsilateral AVF compounds the morbidity of subclavian vein thrombosis but contributes to the success of a venovenous bypass in treating this disorder.

Surveillance of access site function by a variety of means, with prophylactic correction of flow–limiting stenosis before thrombosis occurs, has been shown to increase access site longevity and decrease the rate of access replacement. The treatment of venous hypertension is complicated and measures must be taken to prevent this complication from occurring. It is recommended that the central venous access system must be through the internal jugular vein by means of silicon catheters at the time of creating of AVF and its regular monitoring for proper function and treatment prior to its closure. Surgery and PTA are complementary techniques. Surgical revision usually requires further correction with PTA. On the other hand, site that fail angioplasty should be considered for surgical revision. This combination of percutaneous and surgical therapies will allow physicians to maximize the longevity of each dialysis access site for the best interests of the patient.

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