Original Article

# Management of venous hypertension following arteriovenous fistula creation for hemodialysis access

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## ABSTRACT

**Introduction:** Venous hypertension (VH) is a distressing complication following the creation of arteriovenous fistula (AVF). The aim of management is to relieve edema with preservation of AVF. Extensive edema increases surgical morbidity with the loss of hemodialysis access. We present our experience in management of VH.

**Methods:** A retrospective study was conducted on 37 patients with VH managed between July 2005 to May 2014. Patient demographics, evaluation, and procedures performed were noted. A successful outcome of management with surgical ligation (SL), angioembolization (AE), balloon dilatation (BD) or endovascular stent (EVS) was defined by immediate disappearance of thrill and murmur with resolution of edema in the next 48–72 h, no demonstrable flow during check angiogram and resolution of edema with preservation of AVF respectively.

**Results:** All 8 distal AVF had peripheral venous stenosis and were managed with SL in 7 and BD in one patient. In 29 proximal AVF, central and peripheral venous stenosis was present in 16 and 13 patients respectively. SL, AE, BD, and BD with EVS were done in 18, 5, 4, and 3 patients, respectively. All patients had a successful outcome. SL was associated with wound related complications in 11 (29.73 %) patients. A total of 7 AVF were salvaged. One had restenosis after BD and was managed with AE. BD, EVS, and AE had no associated morbidity.

**Conclusions:** Management of central and peripheral venous stenosis with VH should be individualized and in selected cases it seems preferable to secure a new access in another limb and close the native AVF in edematous limb for better overall outcome.

**Key words**: Arteriovenous fistula, balloon dilatation, digital subtraction angiography, embolization, hemodialysis, surgical ligation, venous hypertension

## INTRODUCTION

Hemodialysis (HD) access via arteriovenous fistula (AVF) can lead to venous hypertension (VH) in the upper extremity. These complications may occur for anatomical reasons and more frequently due to the increasing utilization of central venous catheters especially subclavian as a vascular access for HD. Most common complications of VH are edema of soft tissues and collateral circulation at the level of the shoulder.[1] When collateral circulation is not able to establish hemodynamic compensation, upper limb edema worsens and evolves toward elephantiasis. The problem may be solved either by means of open surgical and/or percutaneous catheter based techniques. Surgery is difficult to perform due to the extensive edema, thickening of the skin and there is a high risk of bleeding especially when VH is present. Further, the AVF salvage rate is low. Percutaneous treatment of

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VH is emerging as a single time, safer, easier, and minimal invasive procedure for VH. Due to the technological advancements in digital subtraction angiography (DSA), it is now easier and safer to access small vessels of low caliber. Transluminal angioplasty in the form of balloon dilatation (BD) and endovascular stent (EVS) is a safer alternative to surgery with an advantage of preservation of AVF, but still has unimpressive long-term patency rates.[2-7] When salvage options are exhausted, angiographic embolization of the AVF is another minimal invasive modality in the cases complicated by VH.[8] We present our experience in management of VH.

## METHODS

A retrospective observational study was conducted on all end stage renal disease patients who presented with upper limb edema that is, venous hypertension after regular HD via AVF. The study period was from July 2005 to May 2014. Patient demographics, type of AVF from which HD was being done, a procedure performed for VH, and outcomes were noted. Preoperative evaluation was done with duplex and computed tomography (CT) or magnetic resonance angiography in selected cases. Fistula locations were radiocephalic ($n$ = 8), brachiocephalic ($n$ = 25), or brachiobasilic ($n$ = 4). Primary interventions for VH consisted of surgical ligation (SL), BD with or without EVS, and angioembolization (AE) of AVF. Before 2011, primary modality of treatment was SL or AE of the AVF for VH. But in the present time VH is being treated with intent to salvage AVF by BD with or without EVS. BD with or without EVS and AE was done at DSA theater in radiology. Indications for fistula closure by AE included extensive edema making surgical dissection difficult and high risk for surgery, restenosis after BD and EVS failure. Outcome of procedure that is, success was defined as, clinically by immediate disappearance of thrill and murmur on table and resolution of edema in the next 48–72 h and radiologically by no demonstrable flow during check angiogram. In addition the, preservation of AVF was also included in the definition of success in the case of BD or EVS. Regular HD was ensured in all patients through an alternate access. Postprocedural morbidity that is, the complications were noted. Patients were followed up at 4 weeks, 3 months, and 1-year and then yearly. Following are the few examples to highlight different types of procedures performed, viz., BD, EVS, SL, and AE.

### *Case 1*

A 64-year-old male patient had been treated by HD in the last 5 years via right brachiocephalic fistula (BCF). He presented with gradually increasing painful swelling of the right upper limb, a sign of VH. He was evaluated with CT angiography and documented to have right internal jugular vein (IJV) stenosis with extensive collaterals in upper limb [Figure 1].

Under all aseptic precautions, right IJV access was secured with 7 Fr sheaths. 5 Fr KMP catheter was used to negotiate across the IJV stenosis over a guide wire. A 10 mm × 40 mm balloon dilator was deployed across the stenosis and dilatation done. 14 mm × 40 mm self-expandable stent was passed across the stenosis. Poststent check angiogram revealed few collaterals still persisting around the stenotic site [Figure 1]. The AVF was cannulated via radial artery and fistulogram done revealing multiple stenosis along the whole length of the cephalic vein which were dilated sequentially from

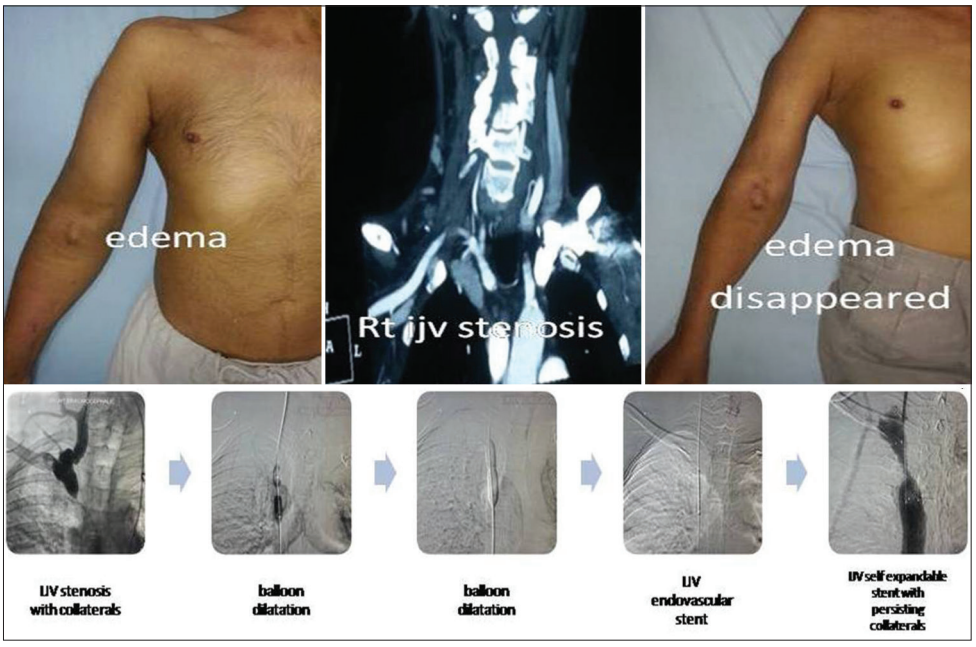


**Figure 1:** Venous hypertension in right upper limb, computerized tomography and digital subtraction angiography documented right internal jugular vein stenosis, balloon dilatation with endovascular stenting done and upper limb edema disappeared in 72 h

central to the peripheral. The venogram revealed persistent stenosis in IJV proximal to the level of the stent already *in situ*. Another 14 mm × 40 mm self-expandable stent was deployed proximal to the first one and final check angiogram revealed good direct flow in central vein [Figure 2]. AE of the peripheral collaterals near the anastomotic site was also done to give a further advantage.

### *Case 2*

A 55-year-old male with left BCF, had VH with extensive edema of upper limb Upper limb DSA revealed left subclavian stenosis. BD with EVS was done and AVF was preserved, and limb edema disappeared in 72 h [Figure 3].

### *Case 3*

A 55-year-old male with left BCF, had VH with extensive edema of upper limb. He was evaluated with upper limb CT angiography and found to have left subclavian thrombosis with central venous stenosis at the junction of IJV and subclavian. SL of left BCF was performed and limb edema disappeared in 72 h [Figure 4].

### *Case 4*

A 34-year-old male patient had been treated by HD in the last 3 years via left brachiocephalic AVF. He presented with gradually increasing painful swelling of the left upper limb, a sign of VH. He was evaluated with CT angiography and documented to have stenosis at IJV and left brachiocephalic vein. Under local anesthesia, the right common femoral artery access was secured with a 5 French sheath. Using 5 French H1 catheter and hydrophilic guide wire, left brachial artery angiogram was performed. The left common femoral venous access secured. However, H1 catheter could not be negotiated into left brachiocephalic vein (the

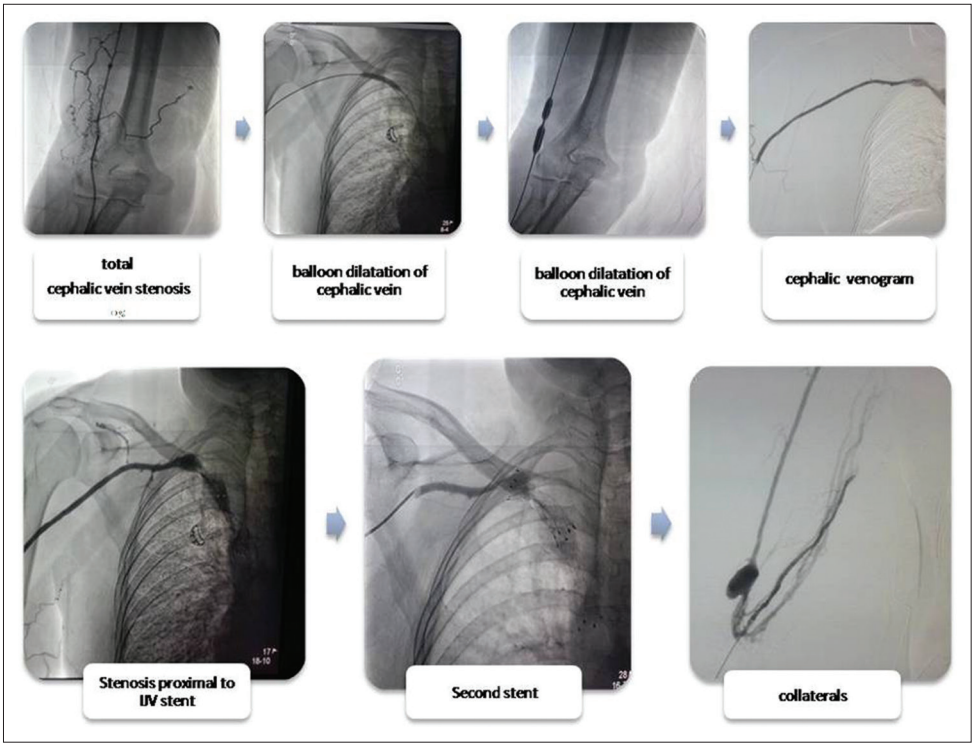


**Figure 2:** Right brachiocephalic fistula with total cephalic vein stenosis, balloon dilatation done, stenosis proximal to internal jugular vein was taken care by putting second stent, persistent peripheral collaterals around anastomosis

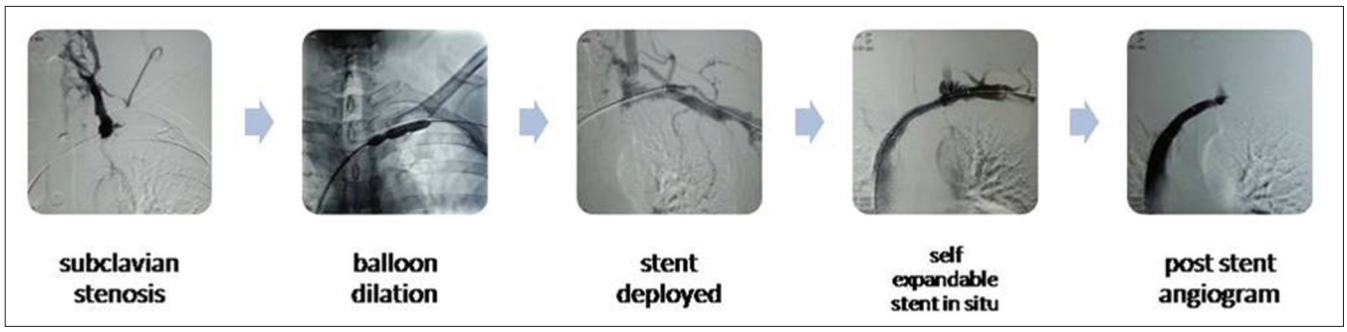


**Figure 3:** Subclavian stenosis treated with balloon dilatation and self expandable stent

angiogram also confirmed the presence of an occlusion in left brachiocephalic vein. Echelon – 10 and traxcess for guide wire was placed within the venous side of AVF. A 6 × 20 microplex 18 coil was placed in the venous side. Subsequently 5 × 15 (GDC – 18) and 4 × 10 (GDC – 10) coils were placed within the venous side of a fistula, followed by introduction of fibrin glue, 1 ml (1:2 dilution). Final check angiogram revealed closure of AVF.Right lower limb was immobilized for 6 h and left upper limb raised. Limb edema disappeared in 48 h [Figure 5].

### *Case 5*

A 63-year-old male patient had been treated by HD in the last 5 years via left brachiobasilic AVF. He presented with gradually increasing painful swelling of the left upper limb, a sign of VH. CT angiography documented left brachiobasilic vein stenosis with extensive collaterals in the upper limb. Under local anesthesia, the right common femoral artery access was obtained with 8 french arterial sheath. This was followed by 5 french micro venous sheaths in left basilic vein, distal to stenosis site via left common femoral venous access. Then a Swan-Ganz catheter was placed in the left brachial artery just proximal to fistula site, followed by inflation of the balloon, check angiogram showed patent fistula site with stenosis of basilic vein. Through dilator of 5 French sheath – 6, 8 cm × 5 cm pushable coils were placed in venous side just distal to fistula, followed by introduction of fibrin glue, 1 ml (1:2). Final check angiogram documented successful embolization. Also, in this case, a rapid disappearance of the edema occurred with a progressive resolution of the elephantiasis [Figure 6].

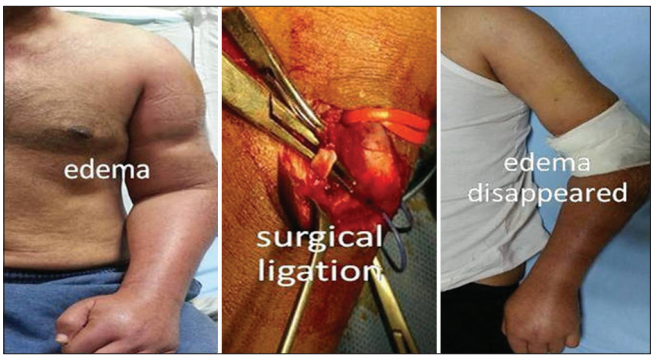


**Figure 4:** Surgical ligation of brachiocephalic fistula for venous hypertension

## RESULTS

Thirty-seven referred consecutive patients of VH from July 2005 to May 2014 were included. All were maintained on regular HD via AVF ranging from 6 months to 5 years with a history of central venous catheter insertion. Out of 37 patients, 8 (21.62%) had distal that is, radiocephalic fistula (RCF) and 29 had (78.37%) proximal, with 25 (67.56%) BCF and 4 (10.81%) brachiobasilic fistula (BBF). Total 17 patients had a history of insertion of the ipsilateral central catheter as HD access and majority were in the subclavian vein. All were

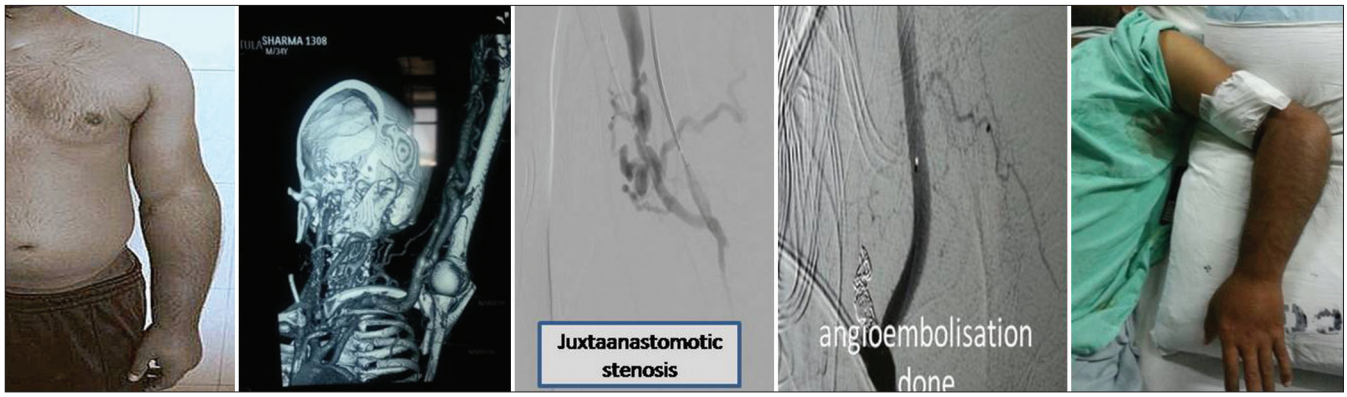


**Figure 5:** Venous hypertension in left upper limb with extensive collaterals over shoulder, computerized tomography documented stenosis at left internal jugular vein and brachiocephalic vein, digital subtraction angiography documented a well-functioning side to end brachiocephalic fistula with extensive collaterals at the elbow, angioembolisation done and check angiogram revealed closure of arteriovenous fistula and upper limb edema disappeared in 48 h

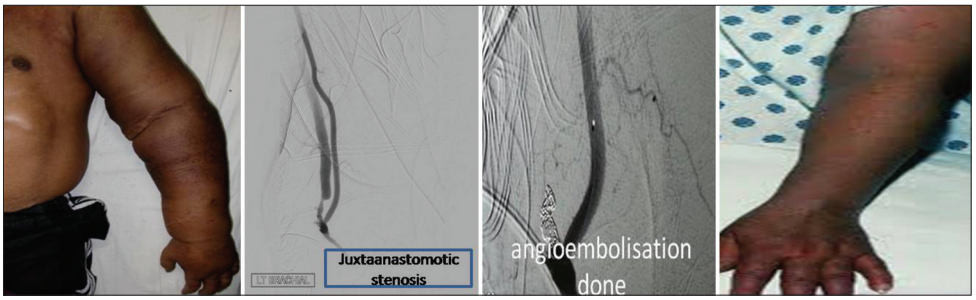


**Figure 6:** Venous hypertension in left upper limb, angiography documented a well-functioning left side to end Brachiobasilic AVF with juxtaanastomotic stenosis of basilic vein, angioembolisation done and edema disappeared in 72 h

an end to side fistula that is, end of vein anastomosed to the side of the artery. The cause of VH was the venous stenosis either central or peripheral, with or without collaterals. In all distal AVF cause of VH was peripheral venous stenosis and edema was limited to hand. Out of 29 proximal AVF, 16 patients (15 BCF and 1 BBF) had central venous stenosis and rest, 13 patients (10 BCF and 3 BBF) had peripheral venous stenosis as the cause of VH.

Out of 8, seven distal AVF that is, the radiocephalic having peripheral venous stenosis were managed with SL. One RCF was salvaged with BD. In proximal AV fistula, total 29 (25 BCF and 4 BBF), 18 cases (1 BBF and 17 BCF) were managed with SL in the initial years. AE of AVF was done in 5 patients (1 BBF and 4 BCF) with extensive edema making surgical dissection difficult and high risk for surgery including one with restenosis.

Four BCF and 2 BBF with venous stenosis were managed with BD with or without EVS. Endovascular self-expandable wall stent was placed in three patients (2 BCF, 1 BBF) having central venous stenosis. Rest four (1 RCF, 2 BCF, 1 BBF) having juxta-anastomotic that is, the peripheral venous stenosis were managed with BD only. Total seven AVF were salvaged. Out of 4 BCF, one with peripheral venous stenosis developed restenosis after BD and presented with VH after 14 months and was managed with AE of AVF [Figure 7]. Others, 1 RCF, 3 BCF, and 2 BBF are doing well till recent follow-up.

All patients had a successful outcome. Wound related complications occurred in 11 (29.73%) patients in whom SL was performed, postoperative wound infection in 5, and delayed wound healing in 3 and other 3 had lymphorrhea [Figure 8]. No significant complications other than postembolization fever in 2 in whom AE was performed [Figure 8]. In all patients with SL and AE alternate dialysis access in the form of either AVF in contra lateral limb or continuous ambulatory, peritoneal dialysis catheter was secured. All these patients were followed up clinically and till now, all the patients with SL and AE are on regular HD via alternate access. All except one who had BD are undergoing HD via native AVF.

## DISCUSSION

VH in AVF bearing upper limb is one of the distressing complication of the HD access. This may occur due to various anatomical and physiological reasons and more frequently due to the more and more utilization of central venous catheters especially subclavian as a vascular access for HD.[9] There is also an increased predilection for the left-sided access for catheter placement because of tortuous course of the central vein.[10] A suggested mechanism for stenosis includes central venous catheter-induced trauma to the venous endothelium and secondary inflammatory damage within the vessel wall at the time of insertion. Turbulent blood flow has been shown to incite an inflammatory response and stimulate intimal hyperplasia. A central venous stenosis may, unfortunately, be clinically asymptomatic before the creation of vascular access and become symptomatic only when flow is increased across the stenosis. If a critical stenosis is unable to accommodate increased flow rates, it becomes functionally significant stenosis and results in edema and gradually bluish discoloration of the whole of the upper limb with formation of collaterals on the shoulder and chest wall. When collateral circulation is not able to establish hemodynamic compensation, upper limb edema worsens and evolves towards elephantiasis. Alternatively, it may manifest itself as a vascular access thrombosis, sometimes with elephantiasis of the arm with bluish discoloration and pigmentation of the skin and, in more severe cases; finger tips ulcers, neuralgias and functional loss of the limb.[1] Less frequently, this may happen due to venous stenosis

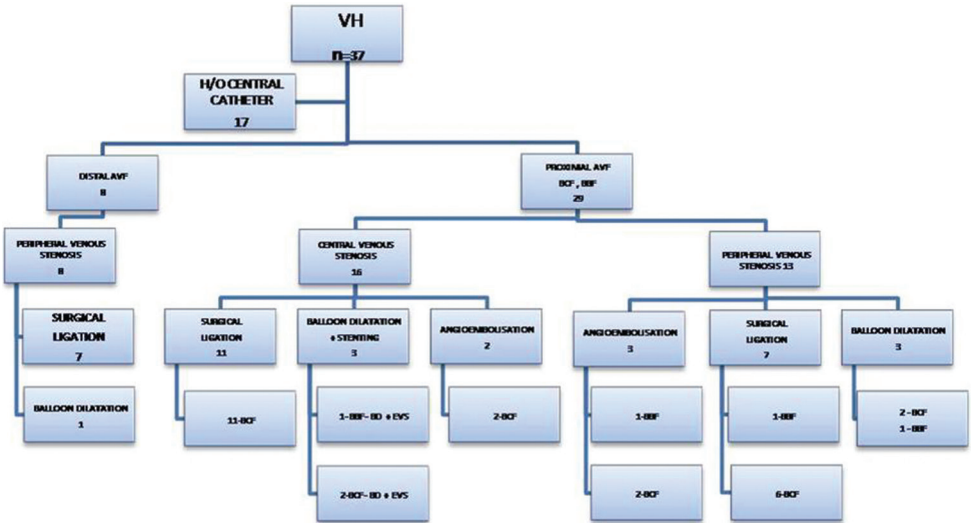


**Figure 7:** Methods and results of the present study. AVF, Arteriovenous fistula, BBF, Brachiobasilic fistula, BCF, brachiocephalic fistula

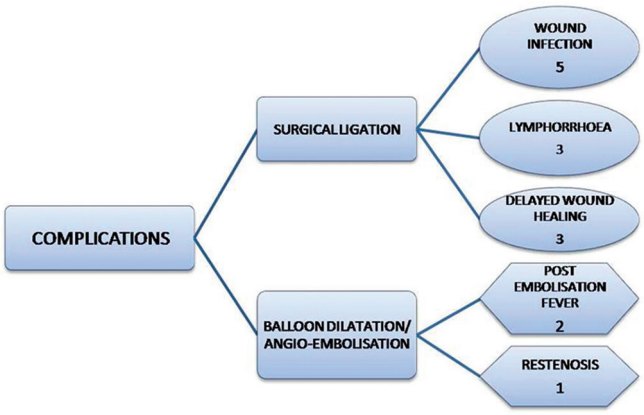


**Figure 8:** Post procedural complications

in the draining vein that is, peripheral venous stenosis, and most frequently at the juxta-anastomotic site with the development of collaterals. This leads to edema which is mainly distributed below the fistula site. This is more common in distal AVF that is, RCF. Rarely, in case the venous anastomosis is made side to side, the flow may be diverted retrograde in the draining vein leading to edema of the hand distal to the site of the anastomosis. The main aim of therapy is to reduce edema by means of open surgical or percutaneous catheter based techniques.[2,3,8]

Recently, with the emergence of percutaneous catheter based methods as BD and EVS, VH is being treated with intent to salvage AVF. Percutaneous management of complications of HD access that is, AVF has been suggested as a treatment alternative to a surgical method. An integral part of this procedure includes the performance of angiography of the fistula and its arterial inflow and venography of the draining veins to the level of the superior vena cava-right atrial junction to locate the level of the stenosis whether peripheral or central, thrombosis, and collateral anatomy.[11] Stenosis can be treated with percutaneous transluminal angioplasty (PTA) involving balloon dilation with or without EVSs to restore the luminal diameter to a functional state with variable primary and secondary patency rates. Results of these interventions also vary with the location of stenosis that is, peripheral or central. Bakken *et al*. in 2007 evaluated the patency rates with BD in 47 patients and demonstrated a technical success rate of 77%. The primary and secondary patency rates at 3/6/12 months were 58/45/29% and 76/62/53% respectively.[4] It was observed that the subgroup of VH patients with elastic lesions were unresponsive to BD and required repeated interventions to maintain the patency over the long-term. Endovascular bare metal stents (BMS) have been proposed and are being used widely to overcome this problem, but the primary and secondary patency rates at 1 and 2 years are not encouraging. Haage *et al*. in 1999 retrospectively analyzed results of BMS in 50 patients and demonstrated 6/12-month primary and secondary patency rates of 84/56% and 97%, respectively, but these results were not found in subsequent studies.[5] In 2007 Bakken *et al*. compared BD and BMS and found no significant difference in primary and secondary patency. Covered stents (CSs), also known as peripheral endografts, have been proposed as a treatment option for central venous stenosis with VH. They are relatively inert and provide a stable intravascular matrix for endothelialization while providing the mechanical advantages of a BMS. This could potentially reduce the intimal hyperplastic response, causing restenosis after BD or BMS. But the long-term results are still awaited.

Similarly, there are studies conducted for the success of BD with or without EVS in peripheral venous stenosis and have demonstrated almost same primary and secondary patency rates. Farber *et al*. in 1999 treated peripheral venous lesions with a Dacron CS in five AV fistula dialysis patients. The primary and secondary patency rates were 57% and 83%, respectively, at 6 months, and 29% and 53%, respectively, at the end of the 1st year.[6] Ozkan *et al*. in 2013 have used metallic stent to treat peripheral venous stenosis in 21 patients with peripheral venous stenosis with VH and demonstrated 1/2-year primary and secondary patency rates of 57.5/40.8% and 76.2%/65.5%, respectively, and these results were comparable to those after balloon angioplasty and surgical shunt revision.[7]

We have managed five patients of venous stenosis, one peripheral and 4 central venous stenosis with transluminal angioplasty with BD. EVS was placed in one patient with central venous stenosis after BD. Our center experience with BD and EVS is preliminary and long-term data on long-term patency rates is not available yet. One patient with central venous stenosis had restenosis after 14 months of follow-up and was managed with AE of AV access. Thrombosis, a less common cause of VH and access failure, can be treated with thrombolysis, suction thrombectomy, mechanical thrombectomy or balloon thrombectomy, or stenting.[12-14] Maya and Allon prospectively evaluated 14 patients with thrombosed arteriovenous access with VH and compared outcomes of EVS and angioplasty and concluded that, Stent placement may be a useful treatment modality in a subset of patients with thrombosed A-V grafts and stenosis at the venous anastomosis and has higher patency rates as compared to thrombectomy alone.[15] We have not come across any patient with access thrombosis as a cause of VH yet.

Surgical correction involves a simple reduction procedure or some rarely described procedures as an extra-anatomic bypass, including jugular vein turn down procedures, subclavian vein to external or IJV bypass, or axillary to femoral vein bypass. The latter interventions involve major surgery and carry a considerable surgical risk with significant morbidity and low long-term patency rates and are therefore

less desirable options.[16,17] Surgically one therapeutic option is to ligate the draining vein and use the other arm for HD access after appropriate imaging to exclude bilateral stenosis. SL although appeared to be a simple technique but associated with some technical problems on an arm affected by edema such as the difficulty in obtaining a good local anesthesia and is associated with inherent morbidity, with more chances of bleeding, wound related complications, as delayed healing and lymphorrhea. We managed 8 distal and 18 proximal AVF having peripheral or central venous stenosis with SL. Wound related complications as wound infection, delayed wound healing and lymphorrhea, were found in 11 (30.55%) patients.

AE offers a minimally invasive treatment for lesions that have traditionally been considered inoperable, in view extensive edema and are associated with high morbidity of surgery. Lomonte *et al*. in 2004 conducted a feasibility study for AE of arteriovenous access complicated by VH and concluded that embolization offers a minimally invasive treatment for lesions that have traditionally been considered inoperable, as well as those requiring extensive surgical resections and/or reconstructions that are associated with high morbidity.[18] At our center, we did AE for VH in 5 patients, including one with restenosis, who were having extensive edema and were high risk for surgery.

The majority of our patients had a history of insertion of the ipsilateral subclavian central catheter as HD access. All were an end to side fistula that is, end of vein anastomosed to the side of the artery. The cause of VH was the venous stenosis either central or peripheral, with or without collaterals. Our experience with percutaneous methods is preliminary and we are now managing VH with BD, EVSs with a goal of preservation AVF and AE in selected cases. All patients had a resolution of edema within 48–72 h. Total seven AVF with venous stenosis were salvaged with BD, with or without EVS and one had restenosis after BD, which was managed with AE.

The percutaneous catheter based methods are the initial procedures of choice for central or peripheral venous stenosis with VH with an advantage of preservation of AVF. The procedure is usually performed on an outpatient basis with the patient being able to return immediately home or to the dialysis unit for treatment. Percutaneous management results in reduced morbidity as compared to standard surgical therapy with reduced postprocedure pain and wound complications. But considering the above literature with variable primary and secondary patency rates, the treatment decisions are difficult and it has to be individualized.[19-21] In the Indian scenario, where the patient can avail above treatment options only at a tertiary referral center and considering various other factors such as morbidity associated with edema, need of alternate HD access and chances of subsequent contralateral venous stenosis, frequent hospital visits, loss of school or work days, cost of the overall treatment, associated disappointment, delay in renal transplant, and decreased quality of life, it is better to individualize the treatment options. Hence, in selected cases it still seems preferable and if feasible to secure a new access in another limb and close the native AVF in an edematous limb for a better outcome.

## CONCLUSIONS

Percutaneous methods as PTA, BD, and EVS for treating central or peripheral venous stenosis with VH are safe, effective, and are not associated with morbidity with an advantage of AVF preservation but are prone to recurrence, requiring multiple repeated interventions to maintain patency. The closure of AVF with SL or preferably AE should be done only after above options are exhausted or are not feasible. Therefore, the treatment has to be individualized and in selected cases it seems preferable to secure a new access in another limb and close the native AVF in an edematous limb for a better outcome. Central dialysis catheters, especially subclavian, are a risk factor for venous stenosis; their use should be restricted in the patients at risk or with existing renal dysfunction.

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Nil.

### *Conflicts of interest*
There are no conflicts of interest.

## REFERENCES

1. Neville RF, Abularrage CJ, White PW, Sidawy AN. Venous hypertension associated with arteriovenous hemodialysis access. Semin Vasc Surg 2004;17:50-6.
2. Aytekin C, Boyvat F, Yagmurdur MC, Moray G, Haberal M. Endovascular stent placement in the treatment of upper extremity central venous obstruction in hemodialysis patients. Eur J Radiol 2004;49:81-5.
3. Quinn SF, Kim J, Sheley RC. Transluminally placed endovascular grafts for venous lesions in patients on hemodialysis. Cardiovasc Intervent Radiol 2003;26:365-9.
4. Bakken AM, Protack CD, Saad WE, Lee DE, Waldman DL, Davies MG. Long-term outcomes of primary angioplasty and primary stenting of central venous stenosis in hemodialysis patients. J Vasc Surg 2007;45:776-83.
5. Haage P, Vorwerk D, Piroth W, Schuermann K, Guenther RW. Treatment of hemodialysis-related central venous stenosis or occlusion: Results of primary Wallstent placement and follow-up in 50 patients. Radiology 1999;212:175-80.
6. Farber A, Barbey MM, Grunert JH, Gmelin E. Access-related venous stenoses and occlusions: Treatment with percutaneous transluminal angioplasty and Dacron-covered stents. Cardiovasc Intervent Radiol 1999;22:214-8.
7. Ozkan B, Güngör D, Yildirim UM, Harman A, Ozen O, Aytekin C. Endovascular stent placement of juxtaanastomotic stenosis in native

arteriovenous fistula after unsuccessful balloon angioplasty. Iran J Radiol 2013;10:133-9.
8. Lookstein RA, Guller J. Embolization of complex vascular lesions. Mt Sinai J Med 2004;71:17-28.
9. Cimochowski GE, Worley E, Rutherford WE, Sartain J, Blondin J, Harter H. Superiority of the internal jugular over the subclavian access for temporary dialysis. Nephron 1990;54:154-61.
10. Salgado OJ, Urdaneta B, Colmenares B, García R, Flores C. Right versus left internal jugular vein catheterization for hemodialysis: Complications and impact on ipsilateral access creation. Artif Organs 2004;28:728-33.
11. Picus D, van Breda A, Katzen BT, Steinberg DL. Use of digital subtraction angiography for evaluation of vascular access for hemodialysis. Cardiovasc Intervent Radiol 1987;10:210-4.
12. Cohen MA, Kumpe DA, Durham JD, Zwerdlinger SC. Improved treatment of thrombosed hemodialysis access sites with thrombolysis and angioplasty. Kidney Int 1994;46:1375-80.
13. Schwartz CI, McBrayer CV, Sloan JH, Meneses P, Ennis WJ. Thrombosed dialysis grafts: Comparison of treatment with transluminal angioplasty and surgical revision. Radiology 1995;194:337-41.
14. Gray RJ, Dolmatch BL, Buick MK. Directional atherectomy treatment for hemodialysis access: Early results. J Vasc Interv Radiol 1992;3:497-503.
15. Maya ID, Allon M. Outcomes of thrombosed arteriovenous grafts: Comparison of stents vs angioplasty. Kidney Int 2006;69:934-7.
16. Gradman WS, Bressman P, Sernaque JD. Subclavian vein repair in patients with an ipsilateral arteriovenous fistula. Ann Vasc Surg 1994;8:549-56.
17. Chandler NM, Mistry BM, Garvin PJ. Surgical bypass for subclavian vein occlusion in hemodialysis patients. J Am Coll Surg 2002;194:416-21.
18. Lomonte C, Petronelli S, Antonelli M, Prudenzano R, Giammaria B, Marchio G, *et al*. Embolization of haemodialysis arteriovenous fistulas complicated by venous hypertension: A feasibility study. Nephrol Dial Transplant 2005;20:199-202.
19. Sugimoto K, Higashino T, Kuwata Y, Imanaka K, Hirota S, Sugimura K. Percutaneous transluminal angioplasty of malfunctioning Brescia-Cimino arteriovenous fistula: Analysis of factors adversely affecting long-term patency. Eur Radiol 2003;13:1615-9.
20. Tapping CR, Mallinson PI, Scott PM, Robinson GJ, Lakshminarayan R, Ettles DF. Clinical outcomes following endovascular treatment of the malfunctioning autologous dialysis fistula. J Med Imaging Radiat Oncol 2010;54:534-40.
21. Clark TW, Hirsch DA, Jindal KJ, Veugelers PJ, LeBlanc J. Outcome and prognostic factors of restenosis after percutaneous treatment of native hemodialysis fistulas. J Vasc Interv Radiol 2002;13:51-9.