Surgical management of central venous occlusive disease in hemodialysis patients

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Background
Central venous disease is a common and complex problem that compromises functioning access in patients undergoing hemodialysis which may result in loss of the access. Prior ipsilateral insertion of central venous catheters is a common risk factor. Percutaneous angioplasty with or without stenting is considered the primary method to treat central venous stenosis. However, it carries poor long-term patency rates and require multiple and repetitive interventions. Surgical options could be the choice if endovascular approaches are refractory or impossible.
Aim
The purpose of this retrospective, observational study is to report our experience in the surgical management to maintain hemodialysis access compromised by venous hypertension (VHTN) due to central venous occlusive disease.
Patients and methods
This is a retrospective analysis of 14 patients with existing upper extremity hemodialysis access who underwent extra-anatomic surgical bypass to treat symptomatic VHTN due to central vein occlusive disease after failure of endovascular management.
Results
Technical success was achieved in the 14 (100%) cases while clinical success occurred in 13 (92.6%) cases; 12 (85.7%) patients had performed their hemodialysis sessions via their preexisting access within 24 h postprocedurally. Maximum postoperative hospital stay was 3 days. No in-hospital morbidity or death was recorded. The mean primary and secondary patency were 18.3 and 22.7 months, respectively. Primary patency rates at 6, 12, 18, and 24 months were 85, 78, 64, and 57%, respectively. Secondary patency rates at 6, 12, 18, and 24 months were 92, 85, 71, and 64%, respectively.
Conclusion
Extra-anatomic surgical bypass of central venous obstruction is an effective and safe method to provide symptomatic relief of VHTN and salvage of existing access in hemodialysis patients when endovascular solutions are unfeasible.

Keywords:
central venous disease, hemodialysis access, venous hypertension

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Introduction

Central venous occlusive disease (CVOD) is one of the most common and significant problems in the management of hemodialysis access dysfunction. It has been reported in the literature to be in the range of 25–40% [1]. The access circuit and flow rates during dialysis are disturbed by CVOD when it causes venous hypertension (VHTN) with or without debilitating symptoms [2]. VHTN may present in the form of pain, massive edema, skin breakdown, and disability of the affected extremity that may result in access loss or ligation [3]. The problem turns more complex for patients who have exhausted all conventional sites and who are not candidates for either transplantation or peritoneal dialysis [4]. The most common risk factor for the development of COVD is previous history of central venous catheter where it counts for 27% of cases with a particularly higher incidence (42%) if placed by subclavian access compared with a 10% rate with catheters placed via an internal jugular vein access [5]. The pathophysiology of central vein occlusion is thought to arise from thrombus formation due to direct intimal trauma at the catheter site which in turn leads to neointimal fibroplasia [3]. Stimulation of vessel wall fibrosis may be due to the presence of the catheter as a foreign body in the vein, its sliding movement with respiratory movements together with increased flow and turbulence from its usage in dialysis [6]. At first, COVD is asymptomatic due to the formation of collaterals around the occluded venous segment; however, when an arteriovenous access is created, either a fistula or a

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graft, high flow against venous obstruction can develop significant VHTN [7]. One of the solutions to relieve the symptoms is ligation of the access; however, it does not only terminate a functioning access but also precludes any further arteriovenous reconstructions in that arm [8]. Percutaneous angioplasty and stenting can temporarily manage CVOD regarding elastic and recurring lesions, but multiple interventions, short-term outcome, and inability to recanalize a totally occluded vein may limit the utility of this approach [9]. Surgical bypass of CVOD has the advantage of relieving symptoms together with maintaining the existing dialysis access and preserving the extremity for future access reconstructions [10]. The purpose of this retrospective observational study is to report our experience in the surgical management to maintain hemodialysis access compromised by VHTN due to CVOD.

Patients and methods

We got the approval of the scientific and ethical committee of Ain Shams University. From December 2013 to January 2019, after the approval of the scientific and ethical committee of Ain Shams University, the medical records of 14 patients with end-stage renal disease on regular hemodialysis who underwent surgical bypass to manage symptomatic VHTN due to CVOD were retrospectively analyzed. Follow-up was done every 6 months for 2 years. Those patients had been referred to our vascular surgery unit for evaluation because of failure to perform their usual hemodialysis due to dysfunction of their upper extremity access. Those patients were known to have previous technically unfeasible endovascular trial to cross an occluded ipsilateral segment of subclavian or innominate veins or at least one previous percutanoues transluminal angioplasty (PTA) and stenting procedure which failed to relieve their debilitating symptoms. This was decided when one or more of the following criteria appeared: increased arm or breast swelling edema, decrease or absence of thrill, difficulty in cannulation, prolonged bleeding time after dialysis, development of collateral veins, and persistent elevation in dynamic venous pressures, unexplained by the needle position or size. We excluded patients with immature access, thrombosed fistulae or AVGs, previous surgical attempts to salvage the access via central venous bypass and patients with accompanied occluded superior vena cava. Patients were evaluated with duplex ultrasound, computed tomography venography, or conventional venography to reveal the segmental occlusion or severe stricture of the central venous territory.

Technique

All procedures were performed at Ain Shams University Hospitals. All patients were provided oral and written consent before angiography. All procedures were performed in a hybrid OR theater under general or regional anesthesia. The decision on the technique and choice of the surgery was planned to reconstruct the shortest possible length of bypass. All patients underwent an extracavitary, extra-anatomic venous bypass of the obstructed subclavian vein segment using an externally reinforced ringed 8-mm polytetrafluoroethylene graft. Two separate incisions were used: the first was an axillary incision to expose either the cephalic or axillary vein or an infraclavicular one to expose a patent segment of the subclavian vein and the second incision was at the lateral neck to expose either the ipsilateral or contralateral internal jugular vein or similar incision to expose the contralateral axillary vein. The graft was sewn to the outflow vein in an end-to-side fashion and was then tunneled either subcutaneously over the clavicle if the draining vein is the cephalic or axillary vein or infraclavicular if it was the subclavian vein, and then was anastomosed to the inflow vein in the same end-to-side fashion. An intraoperative postprocedural completion venography was performed to confirm the patency of the bypass.

Definitions and study endpoints

'Central venous occlusion' was defined in this study as an occluded ipsilateral segment of the central venous system composed of internal jugular, subclavian, or innominate veins. We excluded SVC occlusion.

'Technical success' was defined by getting a functioning bypass from a patent venous segment prior to the centrally occluded vein to another patent outflow vein either ipsilateral or contralateral to the site of the access without major complications that indicate termination of the procedure.

'Clinical success' was defined when the patient can restore normal venous flow to perform successful hemodialysis sessions after the procedure together with relief of venous hypertensive symptoms regarding arm or breast swelling edema, skin breakdown, and collateral veins.

'Primary patency' was defined as the interval following surgery until the need for other intervention, vascular access failure, or study end (after 2 years of follow-up), whichever occurred first. 'Secondary patency' was defined as the interval after surgery till the access was surgically ligated or excluded due to inability to be used regardless of subsequent endovascular or

surgical trials, new access creation, kidney transplantation, loss during the follow-up period, or death.

Statistical analysis

Summaries of the categorical factors were described using frequencies and percentages. The mean and SD were used to summarize continuous measure distributions.

Results

During the study period, 14 patients with dysfunction of upper extremity hemodialysis vascular access due to VHTN resulting from CVOD underwent extra-anatomic bypass surgery to maintain their access function and relieve their disabling symptoms. Patency of the access after our initial surgical procedure was followed every 6 months for 2 years. Regarding the demographics and clinical characteristics of the patients (Table 1), we treated eight (57.1%) men and six (42.9%) women with a mean age of 53±21 years. The most common comorbidities accompanying the patients were hypertension, 13 (92.6%) patients and diabetes, nine (64.3%) patients. During the follow-up, one (7.1%) patient underwent kidney transplantation and one (7.1%) died due to other causes not related to the procedure.

Table 1 Patients' demographic and clinical characteristics

Characteristics	*N*=14
Age (years)	58±23
Sex [*n* (%)]	
Male	8 (57.1)
Female	6 (42.9)
Comorbidity [*n* (%)]	
Diabetes	9 (64.3)
Hypertension	13 (92.6)
Coronary artery disease	3 (21.4)
Follow-up [*n* (%)]	
Kidney transplant	1 (7.1)
Patient death	1 (7.1)

Table 2 Access characteristics

Characteristics	*N*=14
Right side [*n* (%)]	6 (42.9)
Left side [*n* (%)]	8 (57.1)
Age of fistula (months)	16.4 ±7.9
Type of fistula [*n* (%)]	
Brachioaxillary AVG	7 (50)
Brachiocephalic	5 (35.7)
Brachiobasilic	2 (14.3)
Previous ipsilateral placement of central venous catheter [*n* (%)]	14 (100)

AVG, arteriovenous graft.

The mean age of the access included in the study since their creation was 16.4±7.9 months, most of them were brachioaxillary AVGs (seven patients, 50%), while we operated upon five (35.7%) patients with brachiocephalic fistulas. Brachiobasilic fistulas showed to be the least to be affected in two (14.3%) patients. The majority were in the left side in eight (57.1%) cases. All the patients gave a previous history of one or more ipsilateral placement of central venous catheter via internal jugular, subclavian vein or both. Characteristics of the access are reported in Table 2.

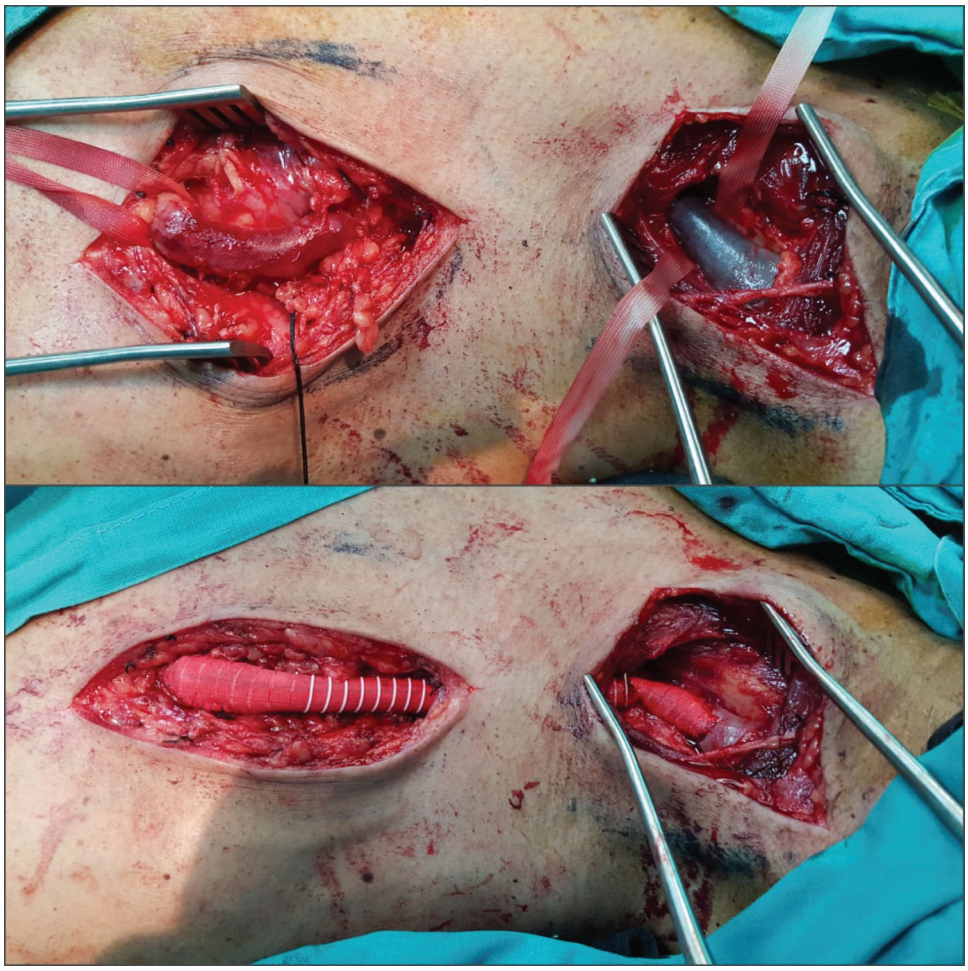
All patients had previously undergone at least one failed endovascular attempt to recanalize their occluded central veins. Percutaneous interventions in the form of balloon angioplasty for either subclavian or innominate veins were recorded in the medical history of six (42.9%) patients while two (14.3%) patients had a history of deployment of venous stents that were occluded afterwards. All the patients had a history of frequent hospital admissions for catheter-related issues.

We performed 14 extracavitary, extra-anatomic bypass surgeries: cephalic to ipsilateral internal jugular vein bypass was performed in three (21.4%) patients (Figs 1 and 2), four (28.6%) axillary to ipsilateral internal jugular vein bypass grafts, five (35.8%) subclavian to ipsilateral internal jugular bypasses (Fig. 3), one (7.1%) bypass between left subclavian vein and right internal jugular vein and lastly, one (7.1%) patient underwent right axillary to left axillary vein bypass (Figs 4, 5).

Technical success was achieved in 14 (100%) cases while clinical success occurred in 13 (92.6%) cases. Improvement of venous flow rates occurred immediately postoperatively while complete resolution of symptoms occurred within 2 weeks after the procedure; 12 (85.7%) patients had performed their hemodialysis sessions via their preexisting access within 24 h postprocedurally. Postoperative hospital stay did not exceed 3 days for all cases. The surgeries were performed without in-hospital morbidity or death. Wound hematoma occurred in one patient only which was conservatively managed.

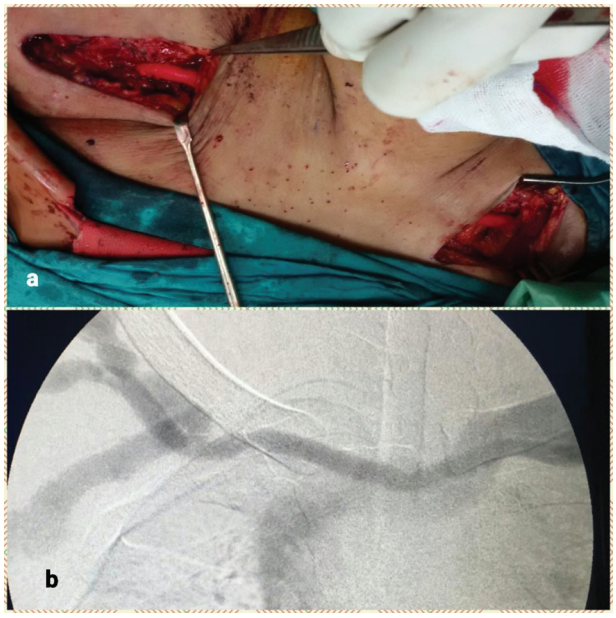
The mean primary and secondary patency were 18.3 and 22.7 months, respectively. Primary patency rates

Figure 1



(a) Conventional venography showing occluded left subclavian vein, (b) patent left IJV and innominate vein, (c) left cephalic vein to left IJV bypass.

Figure 2



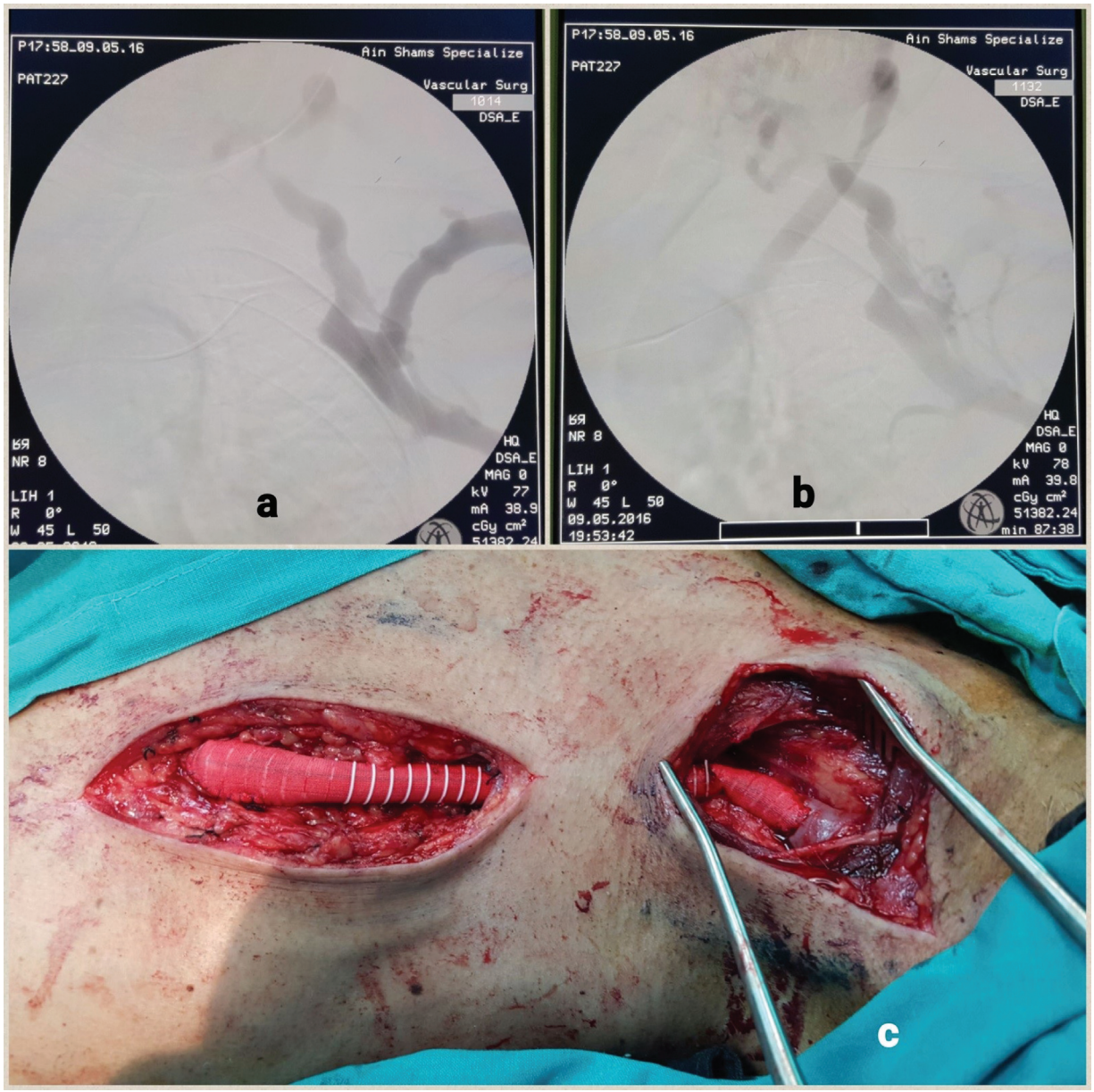
Left cephalic vein and left IJV dissection with AVG bypass between them.

at 6, 12, 18, and 24 months were 85, 78, 64, and 57%, respectively. Secondary patency rates at 6, 12, 18, and 24 months were 92, 85, 71, and 64%, respectively.

Discussion

The increase of population of people with end-stage renal disease and improvement of their life expectancy on dialysis made the issue of vascular access creation and preservation of great importance [7]. VHTN due to CVOD (especially subclavian vein thrombosis and subsequent occlusion) is one of the most serious complications that affect the long-term usage of upper extremity vascular access. It has been reported that 50% of cases with CVOD had a history of prior replacement of central venous catheters and 50% of them had these catheters inserted via subclavian vein access [11]. Early referral of patients, kidney transplantation, creation of vascular access before the onset of dialysis, and avoiding the usage of temporary

Figure 3



(a) CT venography showing occluded proximal segment of right subclavian vein; (b) and (c) failure of endovascular crossing of the lesion; (d) right subclavian to right IJV bypass; (e, f) comparison between arm circumference, preoperatively and & postoperatively.

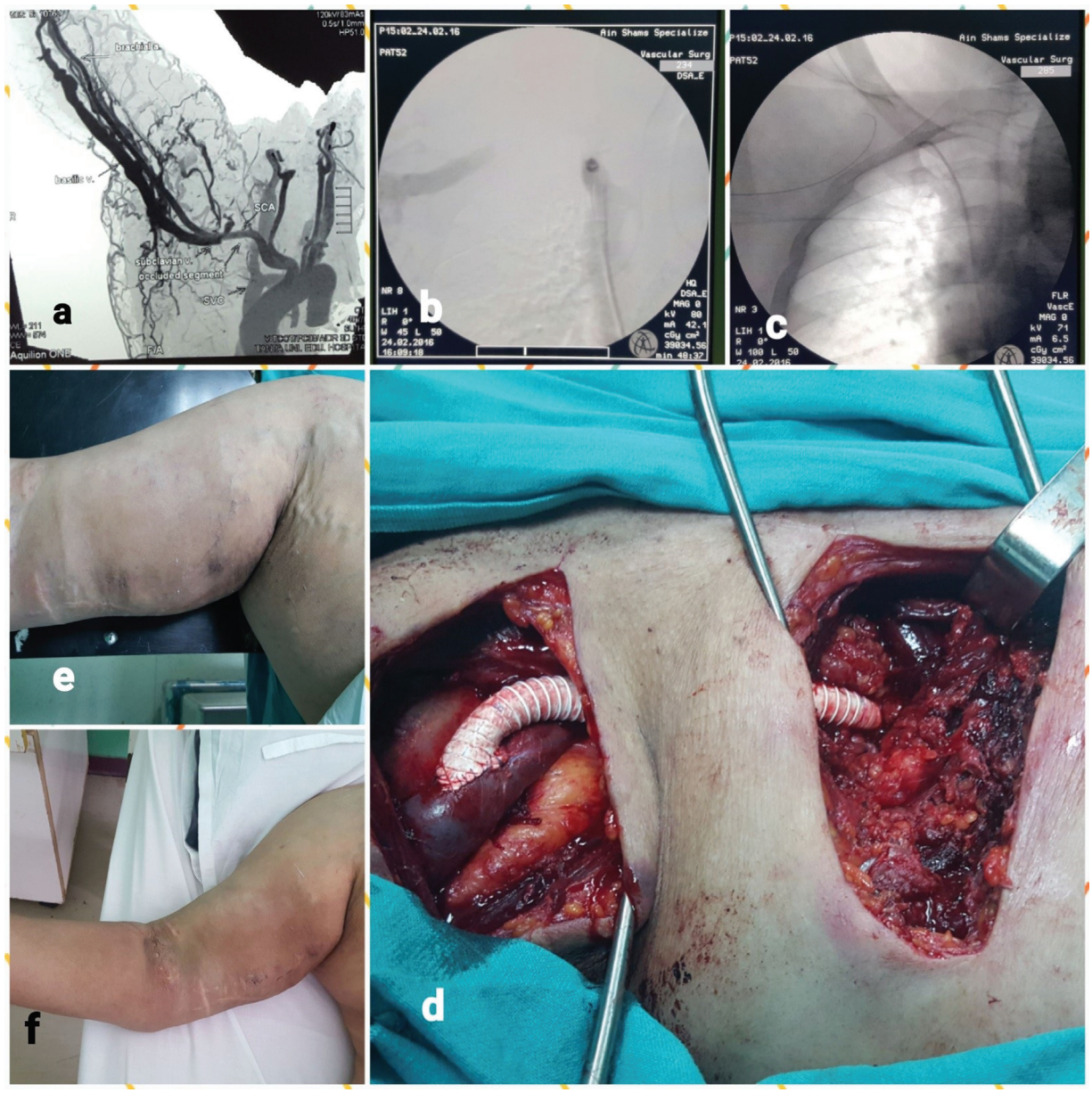
central catheters will prevent the development of CVOD in most cases [12].

When occlusion is significant, the patient may present with access malfunction, pain, massive edema, and skin breakdown up to ulceration. Criado *et al.* [13] found that 36% of arteriovenous graft (AVG) malfunctions were secondary to subclavian vein stenosis. The question then is how to salvage both the access and the limb. Ligation of the access improves the symptoms but has obvious consequence of abolishing an otherwise functioning access together with loss of chance to use that limb for another future access [14].

PTA with or without stenting is considered the first line of treatment for subclavian stenosis. It is considered minimally invasive, can be repeated in case of restenosis, and has low morbidity rates. However, it is ineffective in complete occlusions and has low patency rates and significant high restenosis rates. Stent complications reported in the literature are thrombosis, in-stent stenosis, and fracture secondary to compression [3].

Failure of endovascular treatment together with exhaustion of all other available limb solutions may progress to long-term dependence on tunneled dialysis catheters in unconventional locations. These catheters

Figure 4



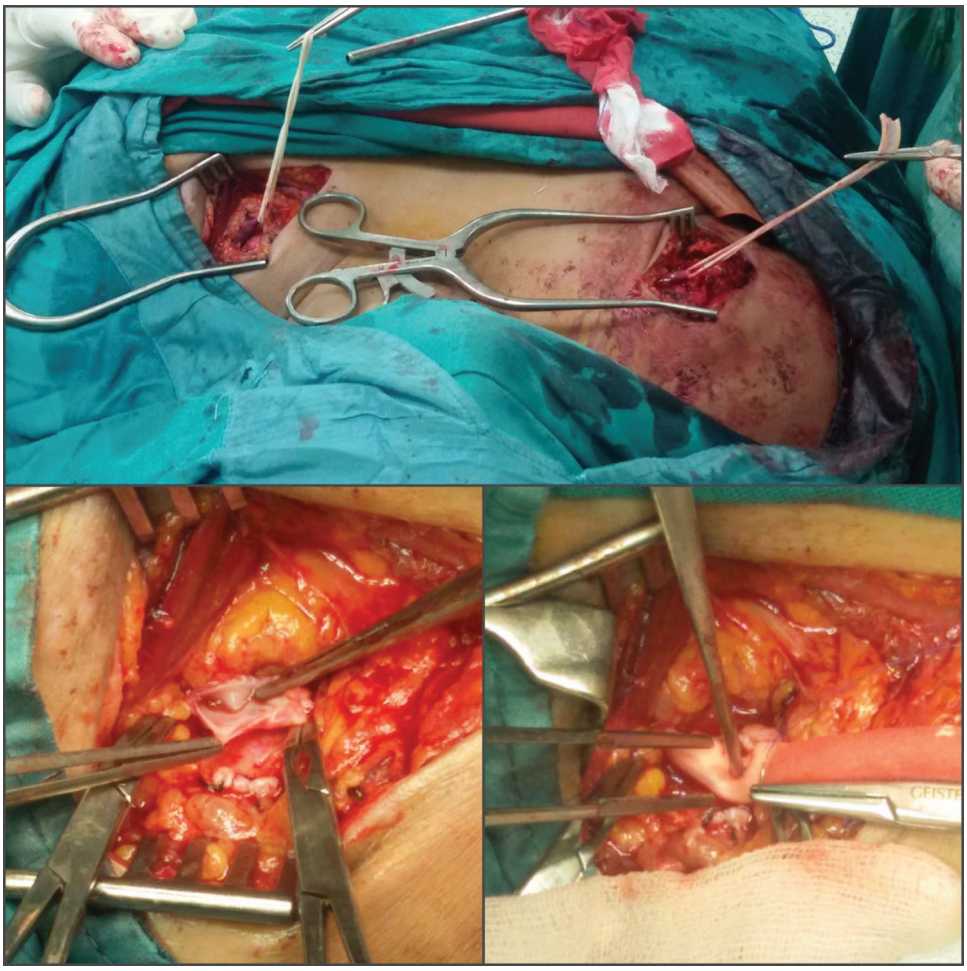
(a) Right axillary to left axillary vein bypass and (b) intraoperative completion angiography showing patent graft.

have higher rates of infections, thrombosis, and necessitate multiple exchanges [4].

In selected patients, several surgical techniques have been described to direct reconstruct or bypass the occluded central venous segment, alleviate the symptoms of VHTN while preserving the functioning distal arteriovenous access. These surgical options include the following: direct bypass to either the SVC or right atrium, ipsilateral and contralateral cephalic or axillary or subclavian to jugular vein bypass, internal jugular vein turndown, axillary to femoral bypass. Other surgical nonvenous options include an all-arterial graft, such as axillary axillary arterial–arterial loop graft [15,16].

Bypass to the right atrium and innominate veins is quite morbid for high-risk patients and necessitates sternotomy [3]. Internal jugular vein turndown is another surgical technique, where the ipsilateral internal jugular vein (IJV) is divided high in the neck and anastomosed to the subclavian or axillary veins. It has many drawbacks. The IJV must be ligated and transected, so it cannot be used for future catheter placement. Adequate length and prevention of kink need extensive dissection. Moreover, it is not feasible in contralateral cases [10]. Grimm *et al.* [17] presented their initial results of a series of axillary vein-to-femoral vein bypass after failure of endovascular therapy with median assisted-

Figure 5



Dissection of both axillary veins, venotomy, and AVG anastomosis.

primary patency reaching 197 days but with quite high rate of lower extremity swelling.

In our study, we operated upon patients who experienced failure of endovascular attempts to cross the occluded lesion or had recurrent symptoms despite multiple interventions. Our decision and choice of approach was taken after performing bilateral venography either by computed tomography or through the conventional one. All our procedures were extra-anatomic and extracavitary. This technique has minimal morbidity, does not necessitate sternotomy, and could be done through two small incisions. Usage of synthetic polytetrafluoroethylene graft gives unlimited length to reach the contralateral side if needed. Ringed external reinforcement of these grafts allows to either tunnel it subcutaneously or even behind the clavicle with no fear of compression or kink. It also preserves IJV for further interventions.

Technically, our approach was 100% successful and clinically, almost all our patients had immediate improvement of symptoms and had performed their usual hemodialysis sessions through their preexisting access within 24 h postprocedurally. The maximum hospital stay postoperatively was 3 days. No procedure-related mortality was recorded.

Comparing our patency rates to the literature, Chandler and colleagues had a series of 12 patients with a mean follow-up of 16 months. They demonstrated rates of salvaged hemodialysis (HD) access reaching 100% at 1 month, 80% at 1 year, 60% at 2 years, and 25% at 3 years [3]. Mickley observed in his review of COVD in hemodialysis patients 80–100% 1-year primary patency rate with surgical management [8]. Our cumulative patency rates at 6, 12, 18, and 24 months were 92, 85, 71, and 64%, respectively.Regarding endovascular management, previous reports have documented a variable technical success rate of PTA ranging from 70 to 90%. Overall, PTA 6-month primary patency rates are 23–63% and cumulative patency rates range from 29 to 100%. As for 12-month primary patency rates,

they count for 12–50% and cumulative patency rates ranging about 13–100%. Stent deployment to mere balloon angioplasty has added little to long-term patency rates. At 3 months, primary patency rates are 63–100% and cumulative patency rates are 72–100%; the respective rates are 42–89% and 55–100% at 6 months and 14–73% and 31–91% at 12 months [18–20].

Recently, Maturi and colleagues studied the effect of covered stent placement (Viabahn and Covera) to treat CVHTN. They found that primary patency at 1, 6, 12, 18, and 24 months was 100, 88, 71, 63, and 58%, respectively. Primary assisted patency and secondary patency have been evaluated: 72 and 74%, respectively [21].

By comparing these results, we can say that long-term patency of surgical bypass is comparable with the assisted patency rates of PTA and stenting. This conclusion may support that one surgical bypass could be equal to multiple endovascular reinterventions with likely equal rates of morbidity and mortality.

Conclusion

Extra-anatomic surgical bypass of central venous obstruction is an effective and safe method to provide symptomatic relief of VHTN and salvage of existing access in hemodialysis patients when endovascular solutions are unfeasible.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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