ENDOVASCULAR DEEP VEIN RECANALIZATION

Houman Jalaie • Rukiye Derin Atabey

Endovascular deep vein recanalization is a minimally invasive technique designed to restore deep venous flow in patients with symptomatic chronic venous occlusion (CVO), including post-thrombotic syndrome (PTS).

Chronic venous occlusion, particularly involving the iliofemoral segment and inferior vena cava (IVC) is associated with significant morbidity in the lower extremities, including pain, swelling, venous claudication and ulceration. Conventional therapies, such as anticoagulation and compression therapy, often fail to resolve these obstructions due to the transformation of thrombotic material into fibrotic tissue, which tightly adheres to the vein walls and obstructs the venous outflow. Therefore, endovascular recanalization techniques with stenting have been developed to restore patency and function of the affected veins. Venous recanalization is indicated in CVO patients with significant

Figure 21.1. Standard position, preparation, and draping for venous recanalization.

morbidity and symptomatic venous hypertension, who have already exhausted the conservative therapy. Compared to traditional open surgical procedures, the endovascular technique offers an effective solution with much less morbidity and complications. It has been associated with significant reductions in venous clinical severity scores and improvements in quality of life of patients. Recent studies have reported one-year primary and secondary patency rates of 81% and 89.5%, respectively.

This chapter discusses endovascular techniques for venous revascularization in the treatment of patients with severe CVO.

SURGICAL TECHNIQUE

Preoperative preparation, anesthesia, and positioning

A thorough evaluation of preoperative diagnostic findings (i.e., physical examination, duplex ultrasound, computed tomography venography or magnetic resonance venography) is crucial to plan endovascular venous recanalization. In certain cases, endophlebectomy may be used in adjunction to endovascular techniques to restore the venous flow. The procedure is performed under general anesthesia, while the patient is in the supine position. Regular positioning, prepping and draping is shown in Figure 21.1. Sterile preparation of the right side of the neck is essential for possible need to use jugular vein access.

ENDOVASCULAR RECANALIZATION

Traversing the occlusion: The ipsilateral common femoral vein (CFV), femoral vein (FV), popliteal vein (PV), right internal jugular vein and contralateral CFV can be used to gain access. The great saphenous vein (GSV), the small saphenous vein (SSV), lower leg veins, and deep femoral vein (DFV) can be used to obtain access as a last resort (Figure 21.2). The ipsilateral FV between the mid and proximal third is the preferred puncture site in a patient with iliofemoral CVO. After ultrasound-guided puncture of the vein, a medium sized sheath is introduced using the Seldinger technique and an initial phlebography is performed (Figure 21.3). Therapeutic anticoagulation is not discontinued preoperatively and 5,000 IU heparin is administered as the sheaths are placed. Surgery is performed under regular monitoring of the activated clotting time (ACT) to be ≥200 sec. Consequently, a stiff 0.035" hydrophilic guidewire, supported by a vertebral catheter, is advanced to recanalize the occluded vein segment. The smooth hydrophilic

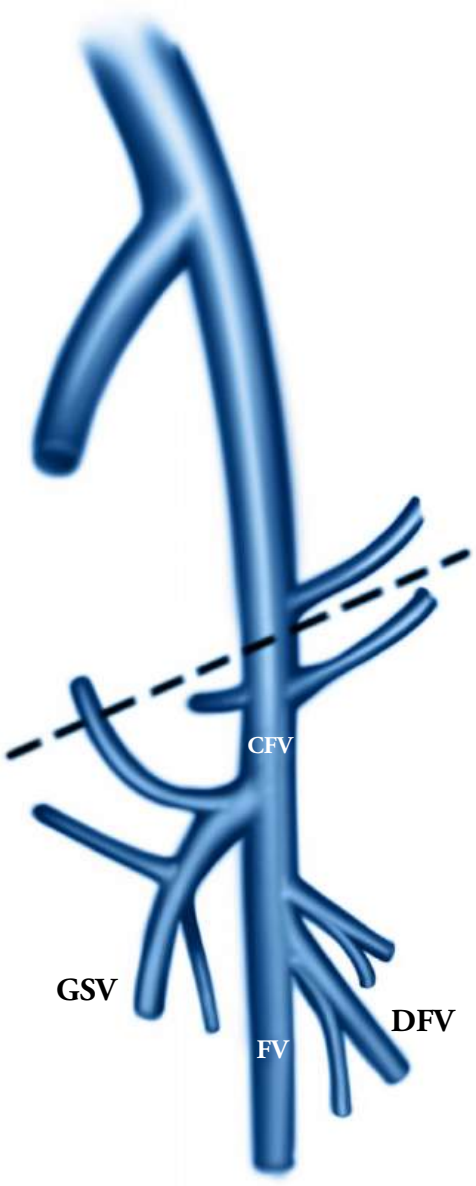

Figure 21.2. Anatomy of the venous systemin the inguinal region.

CFV: Common femoral vein; GSV: Great saphenous vein; FV: Femoral vein; DFV: Deep femoral vein.

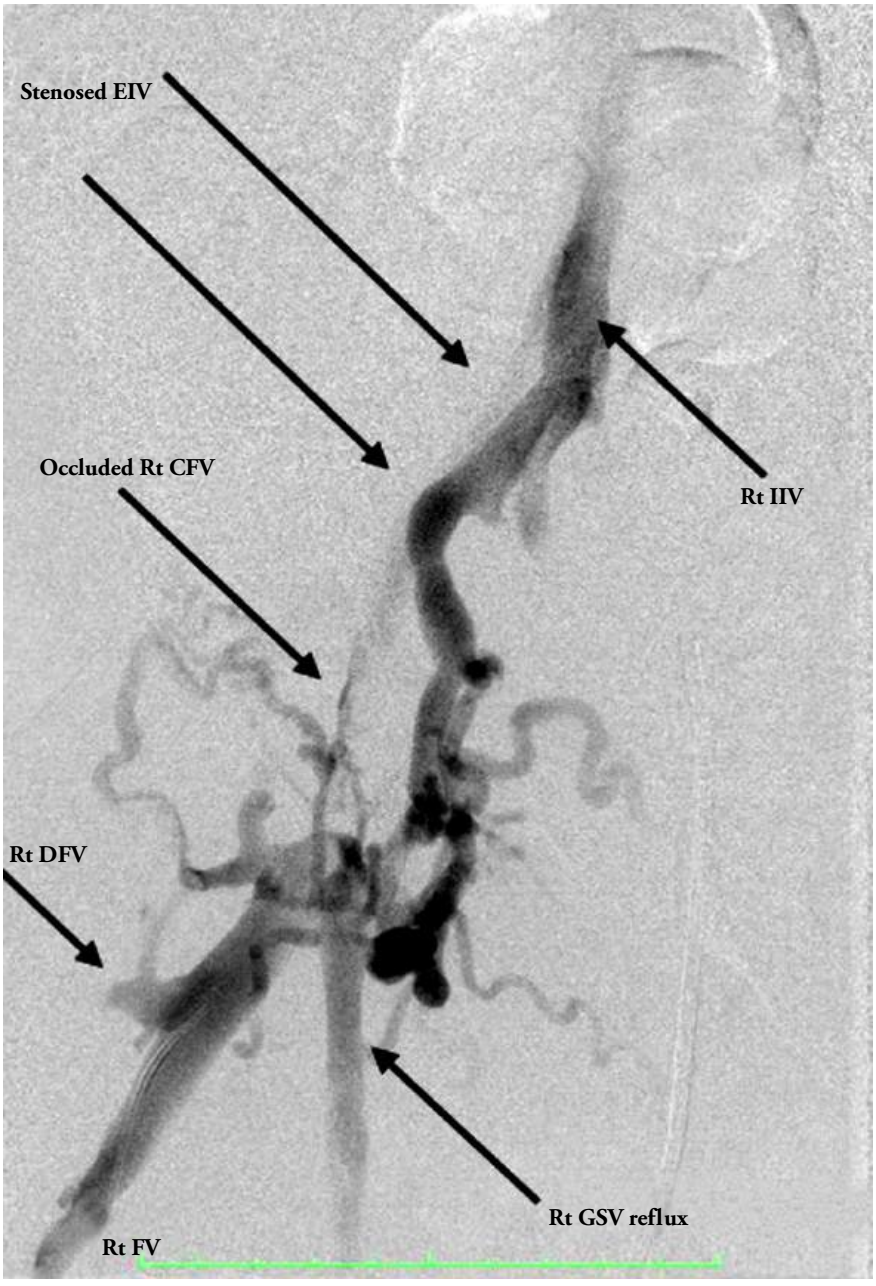

Figure 21.3. Initial phlebogram showing chronic occlusion of right CFV and EIV with extensive collaterals and reflux in GSV and IIV.

EIV: External iliac vein; CFV: Common femoral vein; DFV: Deep femoral vein; FV: Femoral vein; GSV: Great saphenous vein; IIV: Internal iliac vein.

surface of the guidewire allows better navigation through the occluded segment. Alternative access through the jugular vein can be used in cases of very dense or complex occlusion. Once the pathology has been traversed, the hydrophilic wire should be changed to a more stable super stiff wire.

Balloon angioplasty: After successful recanalization, balloon venoplasty should be performed to predilate the occluded or diseased venous segments. Predilation should be performed to at least the diameter of the planned stent (Figure 21.4). Non-compliant balloons of various

sizes (typically 14 to 16 mm for iliofemoral tract and >20 mm for IVC) are used to ensure adequate dilation and prepare the vessel for stenting. Of note, they provide more forceful and directed expansion of the post-thrombotic lesions, as opposed to compliant balloons, which conform to the shape of the vessel and may not exert enough force where it is most needed.

Stent placement: Implantation of dedicated venous stents is crucial following recanalization and balloon angioplasty to prevent recoil or collapse of the recanalized segment and to maintain patency. Dedicated venous stents are needed to have large diameter and be highly flexible to adapt to the anatomical course of the vein even during hip flexion and to have a high radial force to resist the recoil inertia of scarred veins. Therefore, self-expanding nitinol stents are typically used due to their flexibility and compatibility with the dynamic environment of venous system. Stents should be carefully sized with approximately 10% oversized in diameter to ensure adequate wall apposition and prevent

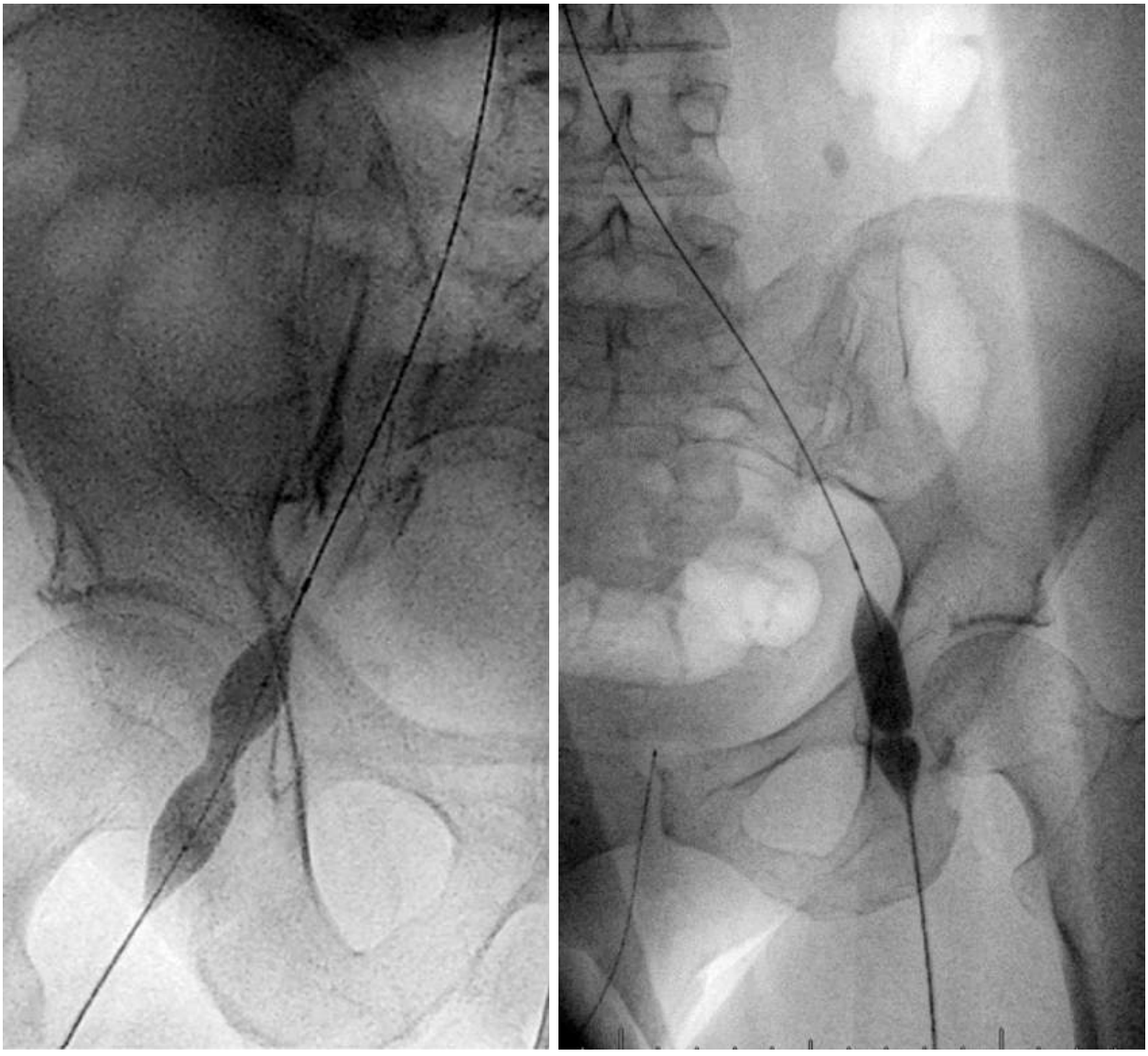

Figure 21.4. Predilation of the occluded CFVs after successful recanalization using 14×40 mm high-pressure balloon.
CFVs: Common femoral veins.

migration. Larger stents are used for the common iliac vein (CIV) and slightly smaller ones for the external iliac and CFVs. Precise stent implantation is of fundamental importance to prevent in-stent thrombosis and/or stenosis and ensure long-term patency. In contrast to arterial stenting, dedicated venous stents should be landed in healthy zones without post-thrombotic changes both distally and proximally. The entire affected segment should be covered without unnecessary extension into healthy segments that may cause new points of stenosis or thrombosis. Furthermore, too much oversized stents should be avoided in CIV. In cases of adjunct endophlebectomy, stent is to be landed right above the endophlebectomized CFV below the inguinal ligament (Figure 21.5a).

Finally, the implanted stent is post-dilated using equivalent high-pressure balloons to reach their actual diameter (Figure 21.5b). Final phlebography is essentially performed in two anteroposterior and lateral views. Once successfully recanalized, there should be a rush washout of contrast media throughout the stented iliac veins to the IVC without any significant collaterals visible anymore (Figure 21.5c).

INTRAVASCULAR ULTRASOUND (IVUS)

Intravascular ultrasound is a key tool used during endovascular recanalization to guide and optimize the intervention. By providing real-time, high-resolution images of the vessel, it helps confirming adequate stent placement and expansion. It can also identify any residual stenosis or dissection that may not be apparent on fluoroscopy alone. The use of IVUS increases the precision of the procedure and can significantly improve the procedural success rate by allowing immediate correction of any inadequacies before concluding the procedure (Figure 21.6).

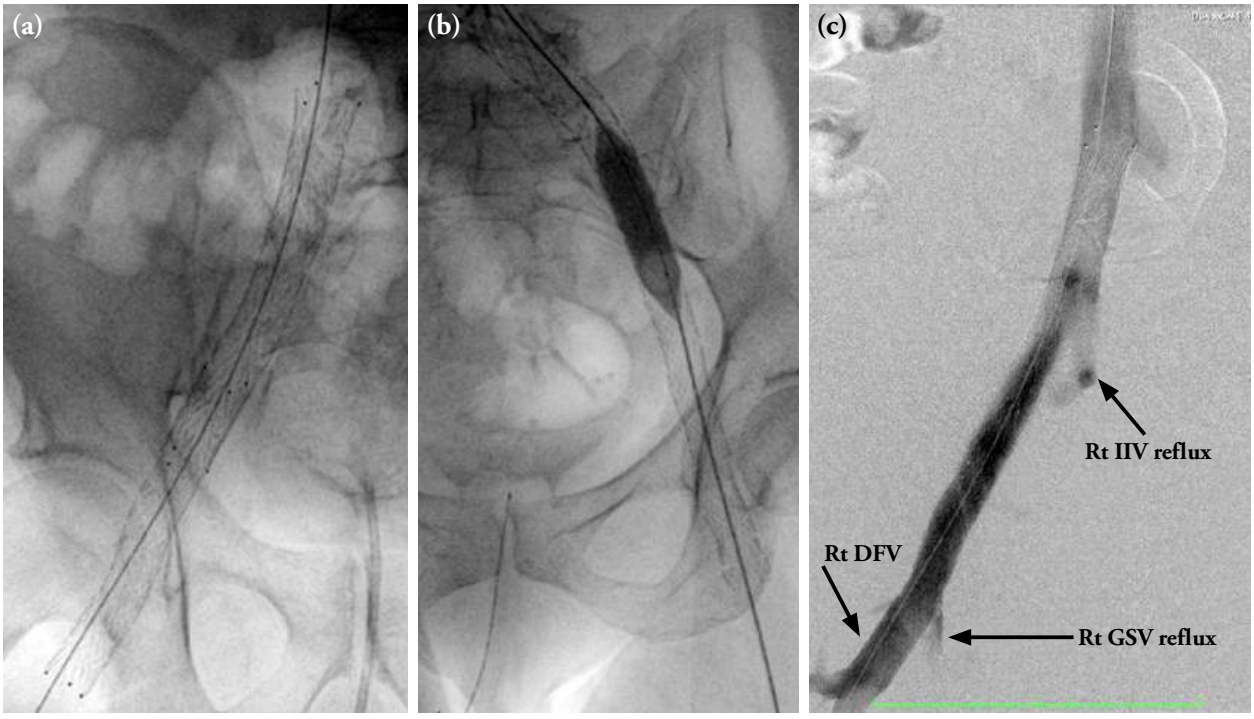

Figure 21.5. **(a)** Stent venoplasty using dedicated venous stents (16×140 mm stent in CIV and 14×100 mm in EIV down to CFV); **(b)** post-dilatation using 14×40 mm high-pressure balloon; **(c)** final phlebogram after venous recanalization and stent venoplasty.

IIV: Internal iliac vein; DFV: Deep femoral vein; GSV: Great saphenous vein; CIV: Common iliac vein; CFV: Common femoral vein; EIV: External iliac vein.

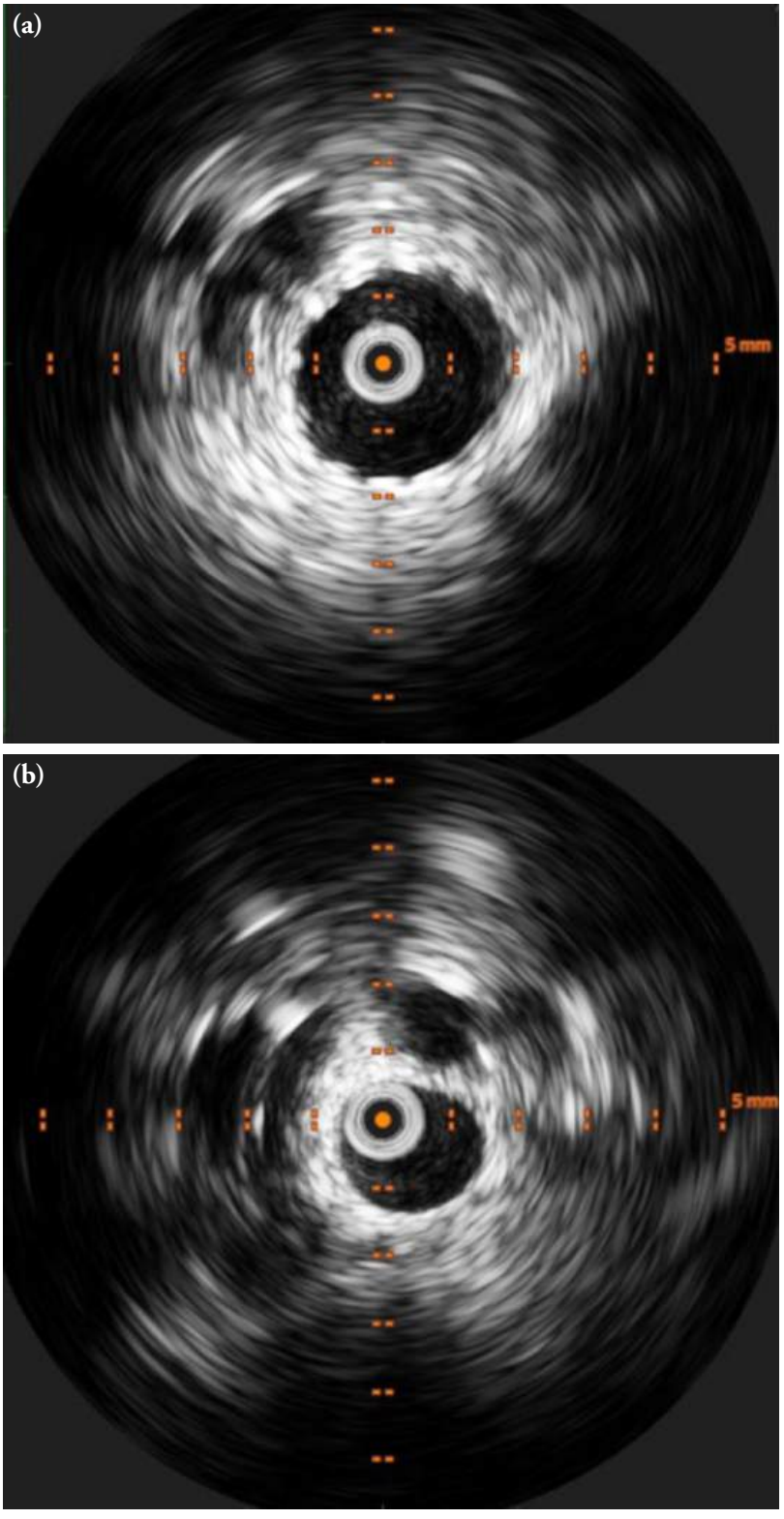

Figure 21.6. Intravascular ultrasound images of **(a)** the implanted venous stent in common femoral vein with regular round shape and geometry and **(b)** healthy external iliac vein.

POSTOPERATIVE CARE

Postoperative management is focused on preventing in-stent thrombosis and ensuring the long-term success of the procedure. Regular follow ups are required to detect any in-stent stenosis and intervene timely.

Anticoagulation: The intimal lesion following endophlebectomy and stent placement results in a hypercoagulable state postoperatively, which may lead to early in-stent thrombosis. This is considered the most common early postoperative complication and underlines the essential role of effective therapeutic anticoagulation both intraoperatively and immediately after the procedure. Adequate anticoagulation during the first 6 to 12 months after the procedure is crucial to prevent thrombotic complications in the newly recanalized venous segments. We recommend low-molecular-weight heparins (LMWHs) for the first two weeks postoperatively owing to their anti-inflammatory effects beside the anticoagulation. Beyond this period, LMWHs are commonly substituted by direct oral anticoagulants (DOACs). In case of ineffective anticoagulation or recurrent thrombosis under DOACs, we recommend switching to vitamin K antagonists with an International Normalized Ratio (INR) target of between 2.5 and 3.5.

Compression therapy: Postoperative adjunctive compression therapy alongside early mobilization plays an important role in maintaining early and long-term patency. Patients are advised to use Class II open-toe compression stockings for at least one year postoperatively. Moreover, intermittent pneumatic compression devices may be used to support the venous return.

Follow-up: Close postoperative surveillance with clinical examination and duplex ultrasound should be adhered to monitor stent patency and detect any complications timely. The most thrombotic complications tend to occur in the early postoperative period. On the other hand, the golden period to rescue a thrombosed stent using mechanical aspiration thrombectomy and thrombolysis is the first two weeks. Hence, it is of utmost importance to perform the first duplex ultrasound control prior to discharge and within two weeks of recanalization. The next follow-ups should be arranged in six weeks, three and six months, and annually thereafter. Anticoagulation may be adjusted based on the findings during follow-up.

COMPLICATIONS

Complications may include in-stent thrombosis and/or stenosis, access site hematoma, stent migration and fracture, and contralateral DVT due to jailing the other side. However, complication rates are usually as low as 3% in the literature. In particular, perioperative pulmonary embolism and spinal subdural hematoma due to extravasate recanalization are extremely rare.

TIPS & PITFALLS

- Access route selection:
  - Consider the superficial FV as the primary access site for iliofemoral occlusions.
- Guidewire techniques:
  - Use stiff hydrophilic guidewires (e.g., Glidewire®, Terumo Interventional Systems, Inc., NJ, USA) for crossing occlusions, as they provide the flexibility needed to navigate tortuous venous anatomy.
- Adjunctive techniques:
  - The IVUS is an invaluable tool for confirming wire position and identifying collateral vessels which may complicate the procedure.
- Stenting considerations:
  - Ensure adequate stent length to cover the entire diseased segment, including a healthy margin of non-stenosed vein on either end.
  - Stent sizing is critical: The stent should be 10 to 20% larger than the normal venous diameter to prevent migration and restenosis.
- Post-procedural care:
  - Anticoagulation should be continued for at least 6 months post-procedure to minimize the risk of restenosis or re-thrombosis
  - Post-dilation of the stent with the balloon is crucial to ensure optimal stent expansion and wall apposition.

TROUBLESHOOTING

- Inability to cross the occlusion:
  - If traditional guidewires fail to cross, switch to stiffer wires or reentry catheters.
  - Consider using contralateral or dual access to approach the lesion from both directions.
  - If crossing is still unsuccessful, sharp needle recanalization from a transjugular approach may be necessary for central venous occlusions.
- Perforation:
  - Small perforations are common during wire manipulation, but typically seal off with balloon tamponade.
  - If the perforation is large, covered stents may be needed to seal the defect. In rare cases, endovascular coils or embolization may be required.
- Stent migration:
  - If stent migration occurs, it is usually due to undersizing or incorrect deployment. Retrieve the stent using snare techniques and ensure proper sizing before redeployment.
- Re-thrombosis or restenosis:
  - Recurrent thrombosis can be mitigated with optimized anticoagulation regimens, but in some cases, restenosis due to intimal hyperplasia may require re-ballooning or re-stenting.
  - Consider regular duplex ultrasound follow-up to identify restenosis early and intervene accordingly.
- Poor flow post-recanalization:
  - If there is poor outflow despite successful recanalization and stenting, assess for unrecognized distal venous stenosis or occlusion.
  - Use IVUS to identify any remaining significant stenosis and treat with further balloon venoplasty or additional stents.

REFERENCES

1. De Maeseneer MG, Kakkos SK, Aherne T, Baekgaard N, Black S, Blomgren L, et al. Editor's choice - European Society for Vascular Surgery (ESVS) 2022 clinical practice guidelines on the management of chronic venous disease of the lower limbs. Eur J Vasc Endovasc Surg 2022;63:184-267. doi: 10.1016/j.ejvs.2021.12.024.
2. Jalaie H, Schleimer K, Barbati ME, Gombert A, Grommes J, de Wolf MA, et al. Interventional treatment of postthrombotic syndrome. Gefasschirurgie 2016;21(Suppl 2):37-44. doi: 10.1007/s00772-016-0156-4.
3. de Wolf MA, Jalaie H, van Laanen JH, Kurstjens RL, Mensinck MJ, de Geus MJ, et al. Endophlebectomy of the common femoral vein and arteriovenous fistula creation as adjuncts to venous stenting for post-thrombotic syndrome. Br J Surg 2017;104:718-25. doi: 10.1002/bjs.10461.
4. Jalaie H, Barbati ME, Piao L, Doganci S, Kucher N, Dumantepe M, et al. Prognostic value of a classification system for iliofemoral stenting in patients with chronic venous obstruction. Eur J Vasc Endovasc Surg 2024:S1078-588400873-6. doi: 10.1016/j.ejvs.2024.10.002.
5. Razavi MK, Black S, Gagne P, Chiacchierini R, Nicolini P, Marston W, et al. Pivotal study of endovenous stent placement for symptomatic iliofemoral venous obstruction. Circ Cardiovasc Interv 2019;12:e008268. doi: 10.1161/CIRCINTERVENTIONS.119.008268.
6. Black SA, Alvi A, Baker SJ, Beckett D, Breen K, Burfitt NJ, et al. Management of acute and chronic iliofemoral venous outflow obstruction: A multidisciplinary team consensus. Int Angiol 2020;39:3-16. doi: 10.23736/S0392-9590.19.04278-0.
7. Barbati ME, Avgerinos ED, Baccellieri D, Doganci S, Lichtenberg M, Jalaie H. Interventional treatment for post-thrombotic chronic venous obstruction: Progress and challenges. J Vasc Surg Venous Lymphat Disord 2024;12:101910. doi: 10.1016/j.jvsv.2024.101910.
8. Shekarchian S, Van Laanen J, Esmaeil Barbati M, Vleugels MJ, Nelemans P, Razavi MK, et al. Editor's choice - Quality of life after stenting for iliofemoral venous obstruction: A randomised controlled trial with one year follow up. Eur J Vasc Endovasc Surg 2023;66:678-85. doi: 10.1016/j.ejvs.2023.07.044.
9. de Graaf R, de Wolf M, Sailer AM, van Laanen J, Wittens C, Jalaie H. Iliocaval confluence stenting for chronic venous obstructions. Cardiovasc Intervent Radiol 2015;38:1198-204. doi: 10.1007/s00270-015-1068-5.
10. de Wolf MA, de Graaf R, Kurstjens RL, Penninx S, Jalaie H, Wittens CH. Short-term clinical experience with a dedicated venous nitinol stent: Initial results with the sinus-venous stent. Eur J Vasc Endovasc Surg 2015;50:518-26. doi: 10.1016/j.ejvs.2015.05.011.
11. Poredos P, Poredos P, Jezovnik MK. Heparin promotes recanalization of venous thrombotic occlusions. Int Angiol 2018;37:261-8. doi: 10.23736/S0392-9590.18.04001-4.