Iliocaval Reconstruction: Review of Technique, Challenges, and Outcomes

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Abstract

Iliocaval thrombosis is a major source of morbidity for patients, with a range of clinical presentations, including recurrent lower extremity deep venous thrombosis and postthrombotic syndrome. Endovascular reconstruction of chronic iliocaval occlusion has been demonstrated to be a technically feasible procedure that provides long-lasting symptom relief in combination with antithrombotic therapy and close clinical monitoring. Herein, we describe the etiologies of iliocaval thrombosis, patient assessment, patient management prior to and after intervention, procedural techniques, and patient outcomes.

Keywords
- iliocaval thrombosis
- postthrombotic syndrome
- iliocaval recanalization
- venous reconstruction

Iliocaval thrombosis causes significant morbidity in patients, with a range of clinical presentations, including recurrent lower extremity deep venous thrombosis (DVT) and postthrombotic syndrome (PTS). Endovascular reconstruction of chronic iliocaval occlusion has been demonstrated to be a technically feasible procedure that provides long-lasting symptom relief in combination with antithrombotic therapy and close clinical monitoring. Here, we discuss etiology of iliocaval thrombosis, preintervention assessment and imaging, techniques and considerations for recanalization, and long-term follow-up and outcomes.

Etiology

Virchow's triad of circulatory stasis, hypercoagulable state, and endothelial injury are classically considered the major contributory factors of thrombosis.[1] A fourth factor important to consider in the etiology of thrombus is inflammation. Proinflammatory conditions of surgery, obesity, infection, malignancy, and autoimmune disorders are known risk factors for thrombosis and should be assessed in the workup and management of venous disease. Inflammatory processes result in increased hypercoagulability and endothelial injury due to activation of cytokines and leukocytes.[1] Several factors may contribute to chronic inferior vena cava (IVC) occlusion, at times more than one in the same patient. Causes include congenital IVC agenesis, atresia, the presence of indwelling foreign bodies such as IVC filters, IVC tumor (i.e., renal cell cancers), prior ligation or clipping of the IVC, and external compression as a result of lymphadenopathy or a retroperitoneal mass.

IVC Agenesis/Atresia

The infrahepatic IVC develops as a composite structure during the 6th to 8th weeks of embryogenesis by the continual emergence and regression of three paired embryonic veins that develop in order: the postcardinal, subcardinal, and supracardinal veins, eventually giving rise to the adult IVC through an intricate process of development, degeneration, and anastomoses.[2,3] Congenital IVC agenesis

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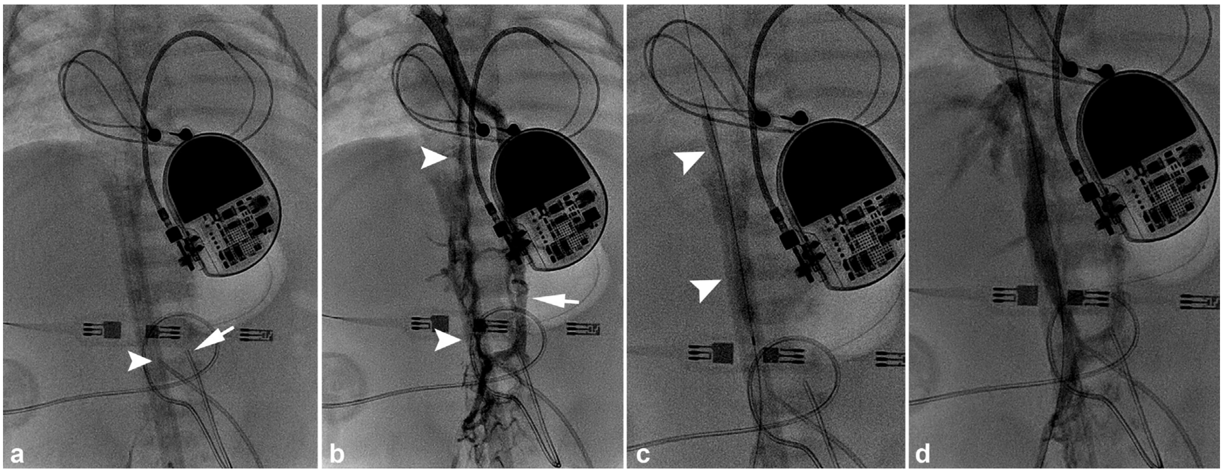

Fig. 1 A 9-day-old female with congenital heart disease. (**a**) Fluoroscopic image demonstrating an umbilical arterial catheter (arrow) and central venous catheter (arrowhead). (**b**) Fluoroscopic image from venography revealing tip of venous catheter at the iliocaval confluence with inferior vena cava (IVC) stenosis (arrowheads) and large hemiazygos vein (arrow). (**c**) Spot image of balloon inflation in the IVC with area of waists noted (between arrowheads). (**d**) Completion venogram with patent IVC.

is a rare cause of iliocaval occlusion. Embryologically, agenesis results from the failure of specific segments to adequately develop and/or anastomose. Infrarenal IVC atresia is more common than suprarenal IVC atresia. Agenesis or atresia of the entire IVC is also possible. In the theorized secondary or "acquired" IVC atresia, perinatal or intrauterine IVC thrombosis results in stenosis and resorption of the formed IVC, possibly related to neonatal venous catheterizations or hypercoagulable states (►**Fig. 1**).[4,5] In the literature, treatment approaches in these patients have included surgical and endovascular construction of a neocava.[6,7]

IVC Filters

IVC filters (IVCF), while useful in the prevention of pulmonary embolism, are a known source of recurrent DVT, particularly in the iliocaval system, and can result in chronic iliocaval occlusion. After permanent IVCF implantation, the Prevention du Risque d'Embolie Pulmonaire par Interruption Cave (PREPIC) study found a cumulative incidence of DVT of 8.5, 20.8, and 35.7% at 1, 2, and 8 years, respectively.[8] A meta-analysis of 37 clinical studies of retrievable IVC filters and 842 categorized reports of FDA-approved retrievable filters demonstrated an overall recurrent DVT rate of 5.4% in patients with IVC filters. The incidence of IVC thrombosis or stenosis was 2.5%, with lowest rate reported with the Celect filter (0.6%) and highest reported with the Option filter (8%).[9] More data regarding the outcomes of patients with IVCF are forthcoming after the completion of the Predicting the Safety and Effectiveness of Inferior Vena Cava Filters (PRESERVE) IVC filter study.

Patient Assessment

Presentation

Patients with iliocaval occlusion may present with recurrent DVT, PTS progressing to phlegmasia, or a variety of nonspecific symptoms, including back pain/radiculopathy, and abdominopelvic pain or fullness. Additional unusual symptoms can be lightheadedness due to venous pooling and decreased cardiac return with standing and/or difficulty swallowing related to dilated azygos and hemiazygos veins compressing the esophagus. History-taking from the patient should include assessment of present symptoms, including onset of lower extremity and abdominopelvic symptoms, exercise tolerance, as well as a relevant past medical history. This includes inciting factors such as presence of IVC filters, known congenital conditions, prior venous access and interventions, prior history of DVT or thrombophilia, medical treatments and medications, and childhood conditions requiring cardiac catheterization or central lines.

Assessment of the patient's clinical presentation also includes evaluation of PTS. The venous clinical severity scale (VCSS), Villalta scale, and Ginsberg criterion are the three most commonly used clinical outcome markers to define the progression of PTS.[10] PTS is defined as daily leg swelling and discomfort that is resolved by rest or leg elevation at least 6 months following the DVT event, according to the Ginsberg criteria. The Villalta scale consists of five patient-reported symptoms and six clinician-reported physical indicators, evaluated on a 4-point scale, ranging from 0 to 3. The VCSS scale rates pain, varicose veins, venous edema, skin pigmentation, inflammation, induration, and ulcer number, duration, and leg size from 0 to 3. There is no established assessment for back and abdominopelvic symptoms in the context of iliocaval reconstruction planning, but a descriptive clinical assessment and its documentation is helpful. Pre- and postprocedural exercise testing can also be considered as a noninvasive measure of cardiorespiratory fitness in the clinical evaluation of venous outflow obstruction; a recent study of exercise testing on three patients with iliocaval occlusion demonstrated a 74% increase in total work at maximum exercise and 19% increase in exercise time after reconstruction compared to preintervention.[11]

Indications

Indications for iliocaval recanalization include severe PTS or symptoms of pelvic venous reflux and obstruction, recurrent DVT, or limitations in activities of daily living. Patients with longstanding iliocaval occlusion may have adapted to their disability so effectively that they consider their lifetime limitations a life-choice rather than a disability. Immobile patients or those with paraplegia may still benefit if they have venous hypertension and lower extremity edema, with or without ulceration.[12]

Timing

The ideal time to treat iliocaval thrombosis is in the acute phase (usually within 2 weeks of onset), during which thrombolysis can be performed, or in the chronic phase (>3 months of onset), after the thrombus is contracted and organized.[12] During the subacute phase, patients are frequently managed with anticoagulation, compression stockings, ambulation, and leg elevation, although treatment patterns vary by operator.[13] The justification for waiting for intervention until the chronic phase is to allow for thrombus maturation. In the acute phase, thrombus is soft and pliable, allowing for effective thrombolysis and/or mechanical thrombectomy. In the subacute phase, thrombus is large, bulky, and difficult to aspirate or thrombolyse, and, in our experience, the treated venous segment is prone to acute rethrombosis due to a high inflammatory state. These veins commonly do not allow for effective balloon dilation and stent placement. In the chronic phase, intravenous thrombus becomes contracted and scarred, allowing the vessel to be more effectively dilated and stented.[12] In the authors' experience, no occlusion is too chronic or too extensive to consider recanalization in the appropriate clinical setting.[12,13]

Preprocedural Assessment

Thrombophilia testing including factor V Leiden mutation, protein C/S deficiency, antithrombin, and MTHFR mutations can all be considered if clinically appropriate. Any prior surgeries or interventions that would complicate access or recanalization should be elucidated. A patient's baseline activity status and appropriateness for sedation/anesthesia should also be assessed.[12] Preprocedural laboratory values include prothrombin time/international normalized ratio, partial thromboplastin time, fibrinogen, blood urea nitrogen/creatinine, and baseline complete blood count. It is suggested to hold anticoagulation prior to iliocaval reconstruction due to the risk of false passage creation. This is of even greater importance in the larger caliber iliocaval system than in the lower extremities due to potential for high rate of free hemorrhage/extravasation into the retroperitoneal space.

Imaging

Preoperative imaging studies are crucial to guide planning and intervention and to predict outcomes. Duplex ultrasound imaging can be initially useful in evaluating anatomy for access-site planning and dynamic flow characteristics of the lower extremity venous system. Anatomic variations in the lower extremity venous system are very common, and ultrasound is an optimal noninvasive method of evaluation.[14] Absence of flow phasicity and lack of phasic response to Valsalva maneuver can secondarily suggest presence of iliac and/or caval obstruction. One study showed that nonphasic flow was 69.2% sensitive, 82.8% specific for diagnosing iliocaval obstruction; nonresponsive flow to Valsalva was 13.6% sensitive and 97.6% specific for diagnosing iliocaval obstruction.[15] However, duplex ultrasound is limited as it will not directly visualize the extent of iliocaval anatomy and extent of disease. Therefore, cross-sectional imaging studies are considered standard preprocedural evaluation tools.

Computed tomography venography and magnetic resonance venography are helpful to evaluate iliocaval anatomy and anatomic variants, large collateral vessels, calcified segments, and prior interventions including stents and IVC filters. These are particularly important if sharp recanalization is being considered (►**Fig. 2**).[13]

Limitations of preprocedural imaging modalities are important to note. Blood pool studies like CT or MRI display venous segments in the preferential pressure-dependent flow pattern of the individual patient, and some patent veins which do not fill with contrast or have flow signal may be interpreted as occluded. Acute iliac vein thrombosis causes venous hypertension, distension, and hyperechoic signal in upstream veins which can be misinterpreted by compression ultrasound as acute DVT in deep veins of the thigh. Only in the rare patient should cross-sectional or DVT imaging be used to cancel recanalization attempts. Ascending venography may be helpful in the assessment of inflow vessels of the thigh and calf and the need for optimization of inflow at the time of iliocaval recanalization, to maintain stent patency.

Reconstruction Technique

Key to the success of venous reconstruction is both sufficient inflow and outflow of the iliocaval venous system.[12] The goal should be to maximize the improvement of clinical symptoms and maximize duration of patency.

Williams described a standard technique for chronic venous recanalization, composed of four essential steps: vascular access, recanalization with through and through wire access, restoration of the lumen, and establishment of inflow. Multiple venous accesses are commonly required, and catheters and hydrophilic wires are approximated in the IVC from jugular and lower extremity access points. Through-and-through wire access is commonly obtained by use of a loop snare and exchange-length wire. Then, serial balloon dilation is performed of the occluded segment, and self-expandable stents are placed in the entirety of the previously occluded iliocaval system[12] (►**Fig. 3**).

Anesthesia

General anesthesia is ideal for recanalization of chronic iliocaval thrombosis because of the length of the procedure, pain associated with recanalization and balloon dilation, and

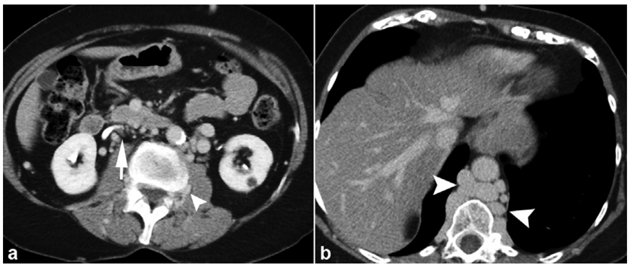

Fig. 2 A 55-year-old male with lower extremity swelling and severe postthrombotic syndrome. (**a**) Axial image from contrast-enhanced CT of the abdomen revealing diminutive IVC (arrow) and prominent perivertebral collaterals (arrowhead). (**b**) Axial image of the lower thorax highlighting enlarged collateral veins (arrowheads).

need for adequate breath-holds for optimal intraprocedural imaging.[13] Conscious sedation or anxiolytics alone are therefore not advised in complex reconstructions.

Vascular Access

In iliocaval recanalization, the right internal jugular and bilateral great saphenous veins (GSVs) are all accessed; in iliac recanalization, the right internal jugular vein and ipsilateral GSV to the occluded iliac vein are accessed.[12] The GSV is commonly accessed by the authors in order to allow for adequate assessment or treatment of the common femoral vein (CFV), although CFV access is also appropriate if not diseased. Access of the bilateral posterior tibial or popliteal veins may also be considered, particularly in the case of lower extremity involvement or difficulty with deep vein access via the GSV.

Through-and-Through Recanalization

After placement of vascular sheaths, contrast digital subtraction venography and intravascular ultrasound (IVUS) are commonly performed to visualize the obstruction, although techniques vary. Contrast angiography is performed from a peripheral to central approach in order to visualize a thin "string" of contrast that represents the narrowed or occluded lumen. It can be difficult to identify the main vessel among the numerous collateral vessels.[12] Recanalization is then initially performed in a peripheral to central approach with attempts to follow intraluminal path, aided by intermittent contrast injections, advancement of catheter and guidewire, rotational fluoroscopy, and knowledge of the CT venous anatomy unique to the patient and correct anatomical pathways in the pelvis and abdomen. However, at times it

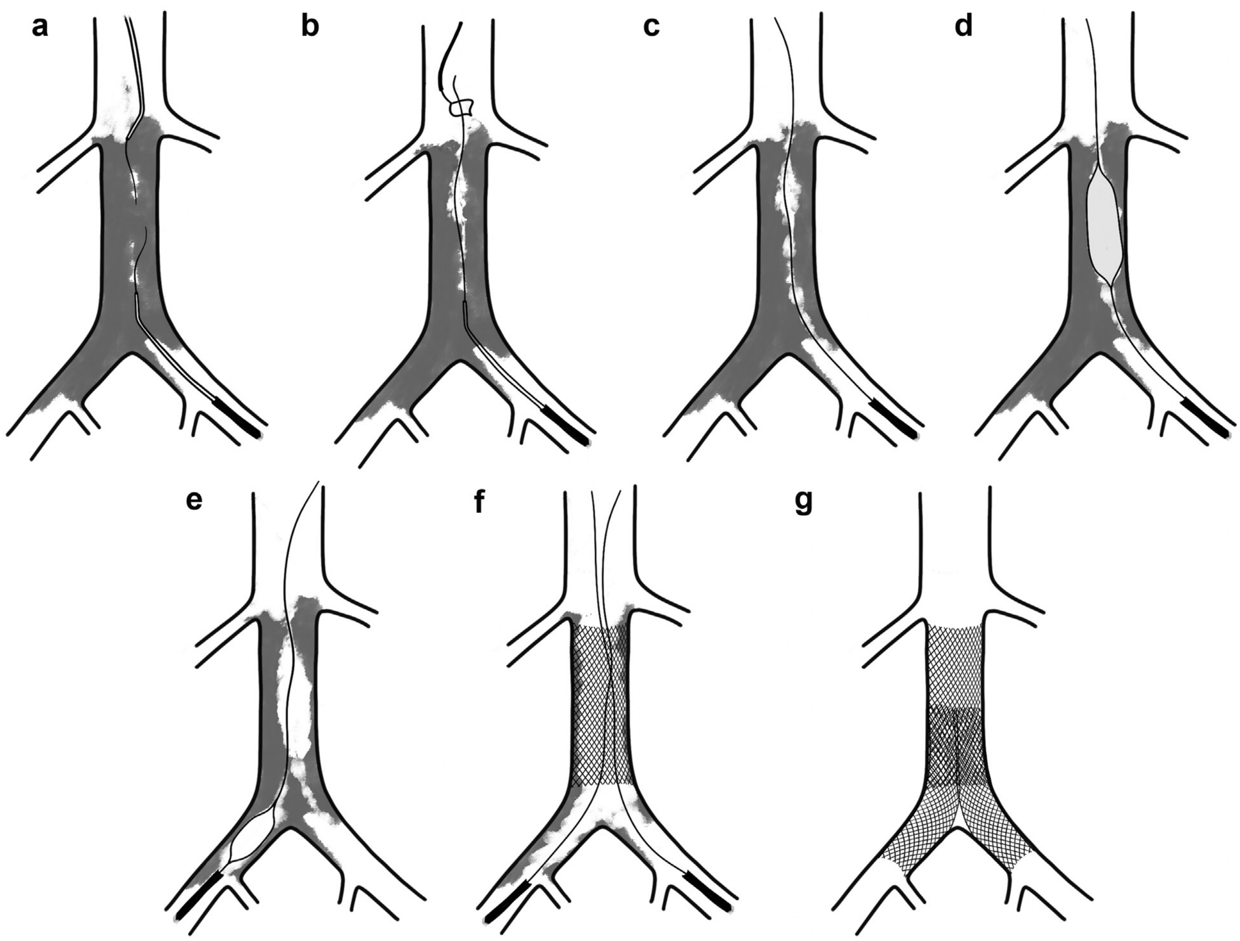

Fig. 3 Illustration of procedural steps of iliocaval reconstruction. (**a**) Via jugular and lower extremity access, Glidewire, and angled-tip catheter, blunt recanalization is performed. (**b**) A loop-snare is used to grasp an exchange-length wire. (**c**) Through-and-through access is obtained. (**d**) Balloon angioplasty is performed throughout the occluded segment. (**e**) Balloon angioplasty is performed in the iliac segments. (**f**) A self-expanding stent is deployed in the IVC. (**g**) Simultaneous self-expanding stents are deployed in the bilateral iliac veins.

is necessary to switch access to recanalize from a different approach, especially when false passages are created.

Blunt Recanalization

An angle-tipped catheter and hydrophilic guidewire (such as a straight, stiff hydrophilic wire) are placed into the CFV or GSV access and gently probed through the occlusion. A similar approach is taken from the opposite access point with the goal of approximating the catheter tips in the IVC. Multiple attempts are often necessary to pass the wire in the correct intraluminal plane, and creation of false passages into an eccentric or extraluminal plane is not uncommon. When false passages are created, the catheter and guidewire are pulled back and redirected. Retracting the wire from the correct postthrombotic vein often has a "sticky" feel. Use of orthogonal planes by rotating the fluoroscope can be helpful to correctly direct the catheter and wire in three dimensions. Given low pressures in the venous system, short-segment extraluminal passage of catheters and wires have not been clinically significant, and self-expanding stent grafts such as the Viabahn (Gore Medical, Flagstaff, AZ) can be placed across major venous tears, although are not frequently necessary.[12] When one access point appears to be making little progress, it is advantageous to alternate to different access points and attempt to probe further to ultimately approximate the wires in a tip-to-tip fashion (►**Fig. 4**).

When the wires are approximated in the venous system, through-and-through access can be attempted. The recanalization wires are exchanged for an exchange-length hydrophilic wire from one end and loop-snare from the opposite end; the exchange-length wire is snared, pulled through so that the same wire is accessible from both ends. Clamps are placed on both ends when the wire is not in use, to ensure that access is maintained during the subsequent steps of iliocaval reconstruction. Once occlusions are crossed and intravascular location is confirmed with IVUS, heparin is administered. If the patient has heparin-induced thrombocytopenia, bivalirudin or argatroban may be administered, although the authors prefer argatroban due to the ease of similar dosing approaches.

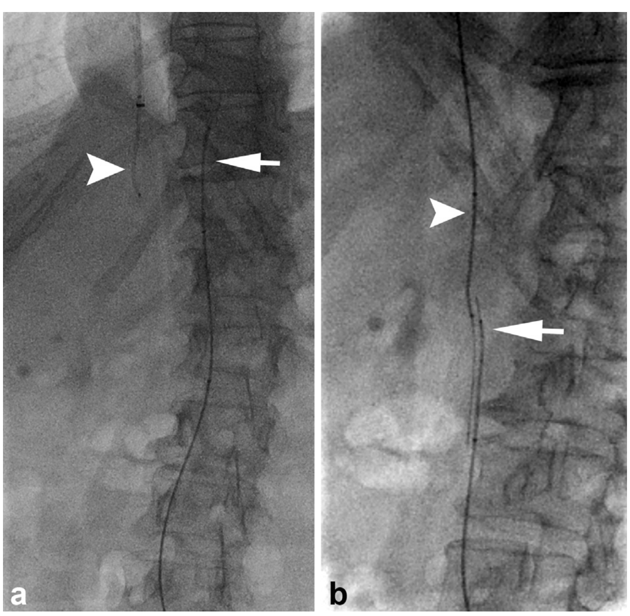

Fig. 4 A 55-year-old male with lower extremity swelling and severe post thrombotic syndrome. (**a**) Fluoroscopic image from recanalization demonstrating catheters from the internal jugular (arrowhead) and femoral venous accesses (arrow) in differing channels. (**b**) Fluoroscopic image highlighting catheters from the internal jugular (arrowhead) and femoral venous accesses (arrow) in the same channel.

Sharp Recanalization

If a hydrophilic wire and catheter fail to progress, sharp recanalization may be performed with a transseptal needle such as the BRK needle (St Jude Medical Inc., St. Paul, MN), a Chiba needle (Cook Medical, Bloomington, IN), or a Rösch-Uchida (Cook Medical) needle, with subsequent advancement of an 0.018-inch wire to be loop snared from the opposite access.[12] There is a higher risk of arterial injury with recanalization attempts near the left central common iliac vein and the mid-IVC due to the proximity of bilateral common iliac and right renal arteries, respectively. Extra caution must be taken in these regions, and IVUS may assist in identifying and avoiding these arteries. There is also a risk of ureteral injury with iliac recanalization; a nephroureteral stent may be placed preprocedure to identify and help protect the ureter.[13]

Wallstent/Amplatzer Targeting

When blunt and sharp recanalization attempts fail to create a common channel through which a loop snare and transseptal needle can be used to create through-and-through access, targeting using a Wallstent Endoprosthesis (Boston Scientific, Marlborough, MA) or AMPLATZER Vascular Plug (St Jude Medical) can be employed, although snares or balloons are also frequently used.[16] A Wallstent Endoprosthesis or AMPLATZER Vascular Plug is partially deployed into a patent area of the occlusion opposite the transseptal needle, expanding the target vein segment. A transseptal (or other) needle is used to target and pierce the partly deployed device. Rotating fluoroscopy at orthogonal angles is important to confirm accurate localization, just as in sharp recanalization technique. Before withdrawing the transseptal needle and retracting the device deployment sheath, a 0.018-inch guidewire is advanced through the device interstices. Then, the device is collapsed and removed through the access sheath, establishing through-and-through access (►**Fig. 5**).[16]

Restoration of the Lumen

Prior to balloon angioplasty and stenting, the tract must be evaluated with repeat contrast or CO_2 angiography and intravascular ultrasonography to ensure its integrity. Inadvertent communication of the newly established tract to adjacent arteries, abdominopelvic organs, or the retroperitoneum can have devastating consequences if dilated and stented.[13] The consistent use of IVUS in iliocaval recanalization is suggested, both for evaluation of the lumen and for ensuring proper stent sizing at the transition from

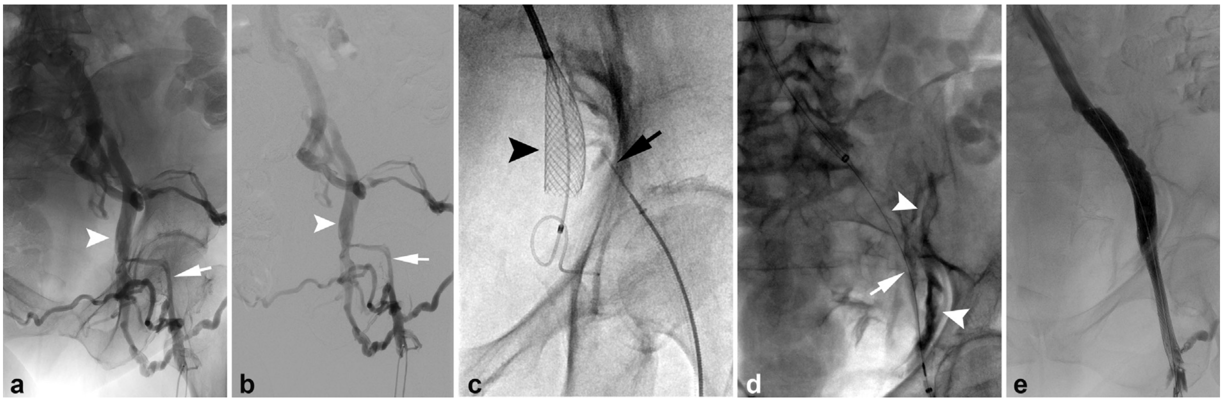

Fig. 5 A 43-year-old female with factor V Leiden mutation and recurrent left lower extremity deep vein thrombosis. Fluoroscopic (**a**) and digital subtraction (**b**) images from venography noting diminutive and centrally occluded left common femoral vein (arrow) with enlarged left internal iliac vein (arrowhead). Note the collateral venous pathways. (**c**) Spot image from sharp recanalization with needle from femoral access (arrow) and a partially deployed Wallstent in the left internal iliac vein (arrowhead) used for targeting. (**d**) Spot image noting contrast extravasation in the pelvic from attempted blunt recanalization (arrowheads) and through-and-through wire (arrow) from newly created tract. (**e**) Completion venogram after venoplasty and stenting following venous recanalization with inline flow from common femoral vein to IVC.

recanalized to recipient patent veins. The severity of disease by IVUS typically exceeds assessment by venography alone.[17] Following confirmation of the tract's integrity, a larger vascular sheath is placed for balloon dilation. If a larger sheath cannot be advanced because the tract is too constricted, predilation with a 4- to 6-mm high-pressure balloon can be performed. The IVC may be dilated to 18 mm, the common iliac vein to 16 mm, and the iliofemoral segments and CFVs to 14 mm, with differences in technique based on operator preference.[12] In more petite patients, common and external iliac may be better served with 14- and 12-mm balloons, respectively, based on reference vessel diameters or those noted on IVUS.

Establishment of Outflow

Plain balloon angioplasty alone is not a long-term treatment for chronic iliocaval thrombosis due to the risk of rethrombosis. As of 2014, there were no FDA-approved stents for use in the iliocaval system.[12] A large, self-expandable stent (12–24 mm) is needed in the central venous system; so, the Wallstent (Boston Scientific) has been used by many. Alternatives include Abre venous self-expanding stents (Medtronic, Minneapolis, MN), Venovo (BD, Franklin Lakes, NJ), and Zilver Vena Venous Self-Expanding Stent (Cook Ireland, Ltd. Limerick, Ireland). At the time of publication, VICI (Boston Scientific Corp., Maple Grove, MN) venous stents were off the market.

At least four approaches to stent placement at the iliocaval confluence have been described. The approach is tailored to the patient's anatomy, extent of occlusion, and technical factors, with the authors preferring a buttressing stent within the IVC and iliocaval stents extending within them most commonly as noted later (►**Figs. 3** and **6**).

Double-Barrel Technique

A buttressing stent is used to stent the IVC adjacent to the iliac confluence, followed by placement and simultaneous release of two "kissing" iliac stents in the IVC spanning the iliac vein confluence, followed by balloon dilation.[13,18] The authors recommend this approach, with placement of continuous overlapping stents through the IVC and bilateral iliac limbs in a "kissing" or "double-barrel" fashion. It is important to ensure that the superior aspect of the iliac limb stents is in exactly the same position, in order to prevent compression of the superior aspect of one stent by the other. In cases of recanalizing alongside thrombosed Simon-Nitinol, TrapEase, of Optease filters, an IVC filter cannot be predictably expanded

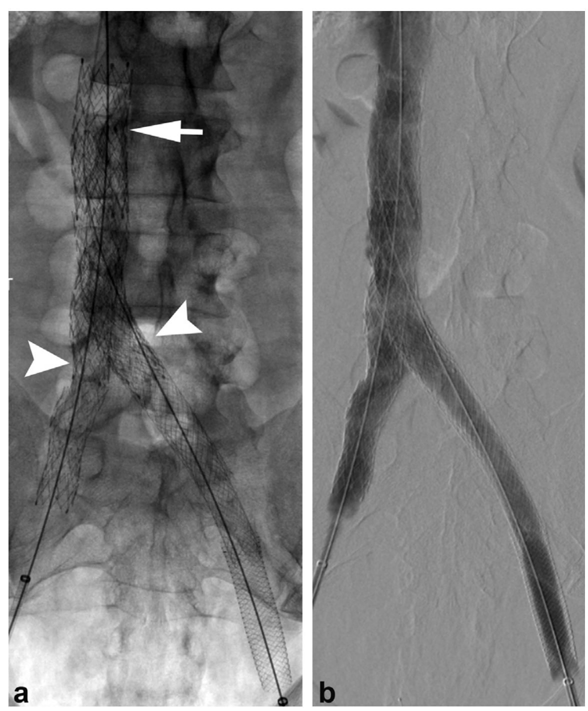

Fig. 6 A 58-year-old male with iliocaval occlusion from chronic IVC filter thrombosis. (**a**) Fluoroscopic image following recanalization and stenting highlighting buttressing IVC stent with kissing iliocaval self-expanding stents (arrowheads) within a buttressing IVC stent (arrow). (**b**) Completion venogram noting widely patent reconstructed IVC and iliac veins.

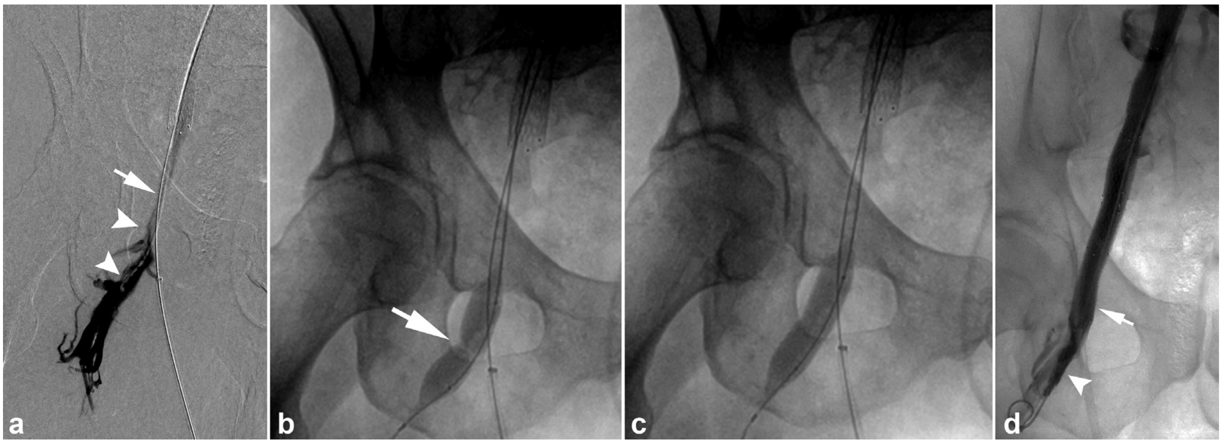

Fig. 7 A 45-year-old male with severe postthrombotic syndrome and history of congenital heart disease. (**a**) Digital subtraction image from recanalization procedure noting poor inflow with chronically disease common femoral (arrowheads) and external iliac (arrow) veins peripheral to iliocaval stent. Spot images noting area of stenosis during balloon inflation (arrow) (**b**) and resolution of stenosis (**c**). Image from completion venogram and highlighting widely patent stents extending into common femoral vein (arrow) with improved caliber peripherally (arrowhead) and inline flow (**d**).

through one of the rostral loops or single sector of the hexagonal filter; in these cases, side-by-side stents are deployed from just above the filter in separate loops or sectors, extending down into right and left common iliac veins.

Inverted Y Fenestration

A stent is placed from one side, covering the iliocaval confluence, and fenestrated from the other side using a sharp device, such as a Colapinto or other needle.[18] Per the authors of this technique, the second stent would be fenestrated from the initial side, so that flow from the cava would not pass exclusively through interstices to either limb.

Skip Stent

A stent is placed in the IVC, and non-overlapping stents are placed in the bilateral iliac limbs, all as close to the confluence as possible. This method is not preferred by the authors of this article, when disease is present close to the confluence due to possibility for flow turbulence, stasis, and rethrombosis. However, this method is preferred by some operators due to the risk of compression of one stent by another stent, particularly if the superior aspects are not accurately lined up.[19]

After stent deployment, postdilation of the stents with balloon angioplasty allows for full stent expansion.[17] Finally, repeat visualization using IVUS is recommended after all stents are deployed, to confirm wall apposition of the stents, equal diameter of the superior aspects of the kissing iliac stents, and patency of the inflow vessels.

Inflow

Adequate inflow is necessary to maintain patency of the iliocaval stents. After reconstruction and stenting, the common femoral, femoral, profunda femoris, and popliteal veins should be assessed for adequate inflow. Inflow disease is common as noted in one study of 120 patients with IVC obstruction where a significant proportion (93%) of patients had extension into the common iliac vein or peripherally.[20] The peripheral veins may require further angioplasty and stenting if indicated by venography and/or IVUS in order to maintain sufficient inflow into the reconstructed cava, which is crucial for long-term patency.[13] This is a topic of much discussion, but no consensus is established. The authors, however, feel that femoropopliteal venoplasty may need to be performed in addition to iliocaval stenting in many patients to confirm that adequate inflow is obtained, otherwise the stents may thrombose prematurely (►**Fig. 7**).

Thrombolysis/Thrombectomy

If angioplasty is unsuccessful in establishing a lumen by angiography, thrombolysis and/or thrombectomy may be needed prior to stent placement. In particular, in the case of chronic iliocaval occlusion with evidence of acute or subacute lower extremity DVT, thrombolysis and/or pharmaco-mechanical thrombectomy are clinically appropriate in order to establish adequate inflow.[21–23] The authors suggest standard single-session methods of catheter-directed therapies as described elsewhere.[24]

The Filter-Bearing IVC

The presence of a foreign body, most commonly an indwelling IVC filter, poses an additional challenge for reconstruction. Filters in the chronically occluded iliocaval system are commonly either retrieved or excluded. For complex filter retrieval, we recommend early use of 3-mm endobronchial forceps (LYMOL Medical, Woburn, MA), which can be advanced through a 16-Fr sheath, placed in the right internal jugular access. After this point, all further recanalization work is performed through the 16-Fr sheath. If the filter cannot be retrieved, prior studies have demonstrated successful exclusion of the filter from the lumen with a self-expanding stent.[21–23,25,26] The use of balloon-expandable stents for successful filter exclusion has also been described.[23,27,28] Cylindrical IVC filters such as the TrapEase IVC filter (Cordis, Milpitas, CA) in particular have a lower rate of successful retrieval and may be refractory to exclusion with self-expanding stents.[28] A case series of three patients with cylindrical filters demonstrated technical success with use of Viabahn VBX (W. L. Gore & Associates, Flagstaff, AZ) self-expanding stents to exclude these filters.[28]

Redo Recanalization

When an existing iliocaval stent is occluded, the same methods as above can be employed for recanalization. For additional troubleshooting in the case of difficulty-to-cross occlusions, radiofrequency wire recanalization can be employed, although this presents a higher risk of extraluminal passage, with consequential hemorrhage and damage to nearby structures. This should be used with caution, particularly in regions adjacent to the iliac arteries, renal arteries, and the ureter.

There is no standard approach for repeat interventions for chronically thrombosed stents, but the authors commonly utilize the techniques described previously and another described by Majdalany et al.[29] A catheter is placed through the lower extremity sheath, and catheter tip is centered at the occlusion site, usually at the inferior end of the occluded stent. A 0.035-inch radiofrequency wire is positioned with confirmation of positioning using oblique and rotational fluoroscopy. One- to 2-second pulses of 10 to 25 W energy are delivered. This process is repeated several times and a channel slowly created for advancement of the angiographic catheter. The wire automatically deactivates as it approaches the edges of the stents, in which case it is retracted and redirected with reapplication of energy.

While potentially perilous, this approach has high technical success rate. One study that used radiofrequency wire for iliocaval recanalization when other methods failed demonstrated a high technical success rate of 12 out of 13 patients who underwent 15 out of 17 procedures.[29]

Failure of Recanalization

If recanalization fails, the patient should be restarted on anticoagulation, and several months should be allowed to pass prior to a repeat attempt. Adequate interprocedural interval allows for false passages to heal.[12]

Follow-up

The most likely period of rethrombosis after iliocaval stenting is within the first 1 to 3 days. Therefore, establishing appropriate anticoagulation as soon as possible is of utmost importance.[12] Factors associated with higher rate of post-intervention rethrombosis include incomplete or untreated segments, poor inflow, and venous stenting below the inguinal ligament.[1]

Antithrombotic Therapy

According to 2021 Society of Interventional Radiology (SIR) Foundation Research Consensus Panel, the optimal medical management postintervention is not well-defined and based on retrospective small-scale analyses.[1] Based on extrapolations from smaller studies and those who have not undergone intervention, certain recommendations can be made. Postprocedure, the authors suggest that patients immediately are dosed with enoxaparin 1 mg/kg in the perioperative area or in the procedure room itself, followed by enoxaparin 1 mg/kg BID. Clopidogrel 75 mg daily and/or aspirin 81 mg daily may be utilized for antiplatelet therapy, although large studies have not been performed in this patient population. In the authors' experience, enoxaparin is transitioned to warfarin or a direct oral anticoagulant (DOAC) at clinic follow-up in 2 to 4 weeks, and clopidogrel is discontinued in 2 to 3 months, in many patients.[12] Many operators prefer enoxaparin or another low-molecular-weight heparin for the first month after intervention. This can be transitioned to DOACs after this period, provided no contraindications are present.

Meta-analyses have shown that vitamin K antagonists, heparin, and DOACs are all similarly effective in reducing the risk of recurrent thromboembolism in patients who have not undergone intervention.[30–32] These data may be extrapolated to guide postprocedure medications in patients after iliocaval reconstruction, although the patients are different and rigorous prospective studies are lacking. In patients who have had an unprovoked DVT, recurrent thrombosis, or cancer-associated thrombosis, an irreversible risk factor, or underlying thrombophilia, long-term anticoagulation beyond the initial 3 months, possibly lifelong, may be indicated.[33] The patient-year risk for recurrent VTE, estimated at 4.2, 9.7, 7.4, and 12% for transient, chronic, unprovoked, and recurrent, respectively, must be balanced against the risk of major bleeding on anticoagulants, approximately 2.1% annually.[1] There was a statistically significant reduction of in-stent restenosis and thrombosis with the use of triple antithrombotic therapy (anticoagulant, aspirin, and clopidogrel) compared to dual-antiplatelet therapy alone, indicating the importance of antithrombotic therapies to maintain venous stent patency.[34]

Several studies on iliocaval reconstruction outcomes have described the addition of antiplatelet therapies. The 2018 International Delphi Consensus statements indicated that in patients with multiple DVTs and iliac vein stenting, anticoagulation should be lifelong, and that antiplatelet agents confer an important benefit.[35] A retrospective study of 62 patients after iliocaval stenting showed that primary patency was associated with addition of antiplatelet therapy in 38 patients in addition to the standard anticoagulation regimen. This suggests that antiplatelet agents could improve stent patency.[36] Notably, the addition of an antiplatelet agent could increase bleeding risk. Overall, the antiplatelet recommendations are based on multiple smaller studies, and there is need for further comparative data on the addition of antiplatelet therapy and all combination antithrombotic therapy after iliocaval reconstruction and interventions for deep venous disease.

Outcomes

Overall, iliocaval reconstruction has been technically and clinically successful in several studies. In a study of 167 patients with all-cause iliocaval thrombus, iliocaval recanalization was technically successful in 83% of occluded iliac veins and 98% successful in occluded filter-bearing IVCs, with 4-year primary and secondary patency rates of 35 and 72%, respectively, for iliac vein recanalization, and 40 and 80%, respectively, for IVC recanalization.[37] Another study of 71 patients, of whom 38 had IVC filters, 4 had prior caval ligation, and 27 had hypercoagulable state and demonstrated a similar reconstruction technical success rate of 85% with 5-year primary, primary-assisted, and secondary patency rates of 52, 85, and 93%, respectively.[38] Three complications (two hematomas and one renal failure) were observed.

When IVC filters are present, both retrieval and exclusion followed by iliocaval stenting are technically successful. Technical success rate was 100% in a study of 120 patients, of whom 30 had retrieved and 90 had excluded IVC filters, with 96, 95, and 87% overall primary patency rates at 6, 12, and 24 months, respectively.[26] Primary-assisted and secondary patency rates at 24 months were 90.3 and 94.2%, respectively. Six minor and two major complications (hemodynamically significant bleeding and renal vein thrombosis) were noted. A study of 25 patients who underwent single-session IVC filter retrieval and placement of self-expanding stent had a 100% technical success rate and primary patency rate of 96% at 1- to 3-month follow-up.[22] One major complication (acute pulmonary edema) and one minor complication (caval perforation after Greenfield filter retrieval) occurred. Retrospective analysis of 24 patients with severe PTS due to filter-bearing IVC occlusion (Optease or VenaTech) treated by iliocaval stenting with filter exclusion had a 1-year primary and secondary patency rates of 67 and 91%, respectively.[39]

Among 69 patients with non-IVC filter related chronic thrombosis, including 30 patients with IVC atresia, technical success rate of iliocaval reconstruction was 100%, and 6-, 12-, and 24-month primary patency rates were 91, 88, and 62%, respectively. There was a 100% secondary patency rate through 24-month follow-up.[40] Primary and secondary patency of IVC stenting for 53 filter-bearing versus 655 non–filter-bearing occluded IVCs were statistically similar (38 and 40% and 79 and 86%, respectively), suggesting that the presence of excluded IVC filters does not significantly impact IVC stent patency.[41]

Several studies have shown evidence of significant symptomatic benefit achieved from iliocaval reconstruction procedures. Twenty-five patients who underwent IVC filter retrieval and stent placement had a mean of 1.4-point improvement in the venous edema subscore and 0.6-point improvement in the pain subscore on the VCSS.[22] By 3.5 years after iliocaval stenting, 51% of 75 limbs with preintervention swelling and 75% with preintervention pain were free of those presenting symptoms. In the same study, 12 of 19 (63%) patients with active ulcers had completely healed ulcers at 2 years.[20] At a mean of 27 months of follow-up, 77% of 24 patients who underwent iliocaval reconstruction had complete pain relief, and 75% had resolution of swelling.[39] In a study of 89 patients with primarily iliac vein occlusion, primary and secondary patency rates were 86 and 97% at 3 years and 83 and 93% at 10 years, respectively.[42] A prospective study of 101 limbs in 87 patients demonstrated statistically significant improvement in quality-of-life scores as measured by revision of the VCSS (3.09-point decrease) and Villalta (5.21-point decrease) over 1 year.[43] At a mean of 4-year follow-up after iliocaval reconstruction in 71 patients, VCSS score improvement was 4.5 from pre- to postprocedure.[38] While the presentation, technical factors, outcome measures, and postprocedure management vary, all of these studies demonstrate efficacy of recanalization in improving symptoms and quality of life.

The outcomes of recanalization are impacted by technical and patient factors. While it is still unclear, many operators do not feel there is an impact of chronicity of occlusion on technical success.[12] In regard to stent placement, in general, smaller stents and stents below the inguinal ligament are more likely to occlude. Upon comparing different stenting techniques, the double-barrel approach has had superior primary and secondary patency rates of 73 and 100%, respectively, relative to the inverted fenestration approach, 41 and 90%, respectively.[18] The previously described "skip stent" technique in which nonoverlapping stents were placed in chronically occluded bilateral iliac veins and IVC have had a 4% rate of early iliac vein thrombosis (<30 days), and primary, assisted primary, and secondary patency rates at 30 months were 74, 83, and 97%, respectively.[19] In regard to anticoagulation and antiplatelet regimens, consensus guidelines overall suggest that anticoagulation and antiplatelet therapy should be considered in all of these patients. The consensuses described are based on smaller scale, often retrospective, studies. Large-scale, prospective or randomized controlled trials are needed for further determination.

Conclusion

In conclusion, iliocaval occlusive disease can be caused by the presence of IVC filters, foreign bodies, external compression due to masses, or congenital or neonatal atresia. Thorough medical workups including evaluation of PTS, testing for prothrombotic states, and cross-sectional imaging are necessary to assess these patients for potential iliocaval reconstruction. Technical aspects of reconstruction include adequate anesthesia, multi-site venous access, through-and-through recanalization, and establishment of a continuous, durable lumen with adequate inflow and outflow without compromising tributary caval veins. Finally postprocedural anticoagulation and close imaging and clinical follow-up are crucial aspects of patient care. With this consistent approach, iliocaval reconstruction and effective and durable treatment can alleviate patient morbidity and improve functional outcomes.

Conflicts of Interest

D.K. and A.L. have no disclosures or conflicts of interest.

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