Endovascular Treatment of Iliocaval DVT

A new therapeutic approach using an aspiration cannula and circuit.

BY RIPAL T. GANDHI, MD; DAVID QUINTANA, MD; MELANIE SCHERNTHANER, MD; CONSTANTINO PEÑA, MD; ANDREW HALL, MD; NIBERTO MORENO, MD; JAMES F. BENENATI, MD; AND BARRY T. KATZEN, MD

Inferior vena cava (IVC) thrombosis is along the clinical spectrum of deep venous thrombosis (DVT), and largely shares the same predisposing clinical factors in Virchow's triad: hypercoagulability, venous stasis, and vascular injury. There are many causes of IVC thrombosis, including trauma, infection, and compression secondary to retroperitoneal neoplastic processes.[1] Intravascular causes, especially foreign bodies such as IVC filters, have been well documented as potential sources for IVC thrombosis.[1-4] Although the true incidence of IVC thrombosis is unknown, the rate has likely increased with the introduction of permanent or semipermanent intravascular devices, which are thrombogenic.[2,4,5]

Occlusion is the most common complication of IVC filters, with thrombosis reported in 2.7% of patients, due to three main causes: (1) new local thrombus formation/thrombogenicity of the device, (2) trapped embolus from a more distal source (lower extremity), or (3) cephalad extension of distal DVT.[5,6] Approximately 10% to 20% of patients with DVT involving the lower extremity have progression to the iliocaval segments.[7] It should be noted that filters primarily function to protect from large thromboembolism from the deep veins of the lower extremities, and so thrombus-bearing filters are not necessarily due to the filter itself. However, current estimates of IVC thrombosis following filter insertion range from 13% to 30% in longer-term studies.[6,8]
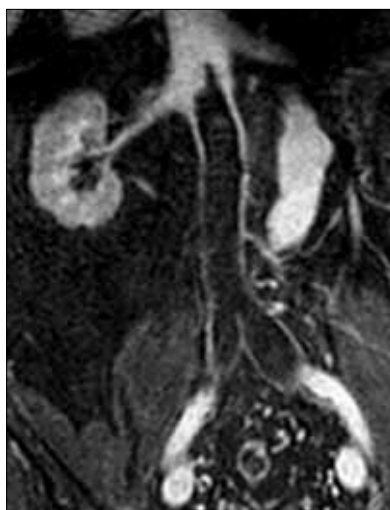
IVC thrombosis is a significant source of morbidity, and if left untreated, can lead to venous claudication, chronic venous stasis, ulceration, and recurrent thromboembolism. As a result,

Figure 1. Thrombotic occlusion of the IVC bilateral common iliac veins. The bilateral femoral veins were open at this time (not shown).

long-term goals regarding treatment largely involve preventing chronic venous insufficiency and postthrombotic syndrome, along with reducing the incidence of recurrent thromboembolism.

We present a case of filter-bearing IVC thrombosis with unusually large clot burden, as well as iliac and common femoral vein thrombosis, which was subsequently treated with mechanical thrombectomy primarily using the AngioVac device (AngioDynamics, Latham, NY).

CASE REPORT

A 72-year-old man with a history of coronary artery disease and benign prostatic hypertrophy presented with left lower extremity edema 3 weeks after laser prostatectomy for urinary retention. Subsequent venous duplex imaging revealed left femoral and popliteal DVT, and computed tomography (CT) angiography of the chest showed acute pulmonary emboli involving the left main pulmonary artery, as well as the bilateral segmental pulmonary arteries. The patient was started on anticoagulation with intravenous unfractionated heparin. He subsequently developed gross hematuria accompanied by a two-point drop in hemoglobin. Anticoagulation was stopped, and an Option IVC filter (Argon Medical Devices, Inc., Plano, TX) was placed. Additionally, the patient had several episodes of bright red blood per rectum, a colonoscopy showed a 5-cm ulcerating mass in the sigmoid colon, and pathology revealed adenocarcinoma. PET CT revealed peritoneal carcinomatosis, and the patient was therefore not a surgical candidate. He

Figure 2. IVC occlusion to the level of the IVC filter. A small amount of thrombus is attached to the filter hook.

was discharged with plans for outpatient systemic chemotherapy.

One day after discharge, the patient presented to the emergency department again with dizziness and presyncope, back pain, and increased pain and swelling in his lower extremities. Magnetic resonance venography demonstrated acute thrombosis of the IVC to the level of the previously placed IVC filter, as well as thrombosis of the bilateral iliac veins (Figure 1). Subacute thrombus in the left femoral and popliteal veins was also noted, but the common femoral veins were patent. The patient's symptoms were likely related to the caval thrombosis, and perhaps decreased venous return, leading to poor cardiac output. The hematology department was consulted and prescribed low-dose fondaparinux (2.5 mg subcutaneously daily) due to the previously mentioned bleeding complications. Over the course of several days, the patient developed debilitating scrotal edema, and his bilateral lower extremity pain and swelling worsened, which precluded him from ambulating.

Given that the patient had recent hematuria and gastrointestinal hemorrhage from a colonic adenocarcinoma, he was not a good candidate for catheter-directed thrombolysis. A decision was made to use the AngioVac device to remove caval and iliac thrombus. Initial access was achieved via the right internal jugular vein, and a cavagram demonstrated occlusion of the IVC to the level of the IVC filter (Figure 2). A small amount of thrombus was noted at the filter hook. The Option IVC filter was initially retrieved using a standard gooseneck snare and an 11-F sheath (Günther Tulip Vena Cava Filter Retrieval Set, Cook Medical, Bloomington, IN).

Ultrasound interrogation of the bilateral common femoral veins demonstrated interval thrombosis at the time of intervention. The right common femoral vein was accessed, and a venogram demonstrated complete thrombosis (Figure 3). Next, attention was turned back to the right internal jugular vein, which was serially dilated, and a 26-F DrySeal sheath (Gore & Associates, Flagstaff, AZ) was placed. Through this sheath, the 22-F AngioVac cannula was placed into the IVC. A 16-F reinfusion cannula was placed into the left internal jugular vein.

The patient was anticoagulated with bivalirudin, and aspiration thrombectomy was initiated via the AngioVac cannula while he was on extracorporeal bypass (Figure 4). The device was advanced and withdrawn in the thrombosed IVC multiple times. Significant thrombus was aspirated, and the AngioVac filter had to be replaced once. A repeat cavagram demonstrated persistent residual thrombus (Figure 5). Multiple additional passes with the device were made in the IVC.

The device was then advanced into the left common iliac vein for further thrombectomy. There was some difficulty in advancing it into the right common iliac vein. To accomplish this, a wire and catheter were advanced into the AngioVac device via the right common iliac vein. This established a rail, which allowed the device to pass into the right common iliac vein.

Because the large-profile AngioVac device did not easily pass through the left external iliac vein to the left common femoral vein, we achieved access to these veins via a crossover approach from the right common femoral vein access. A venogram demonstrated significant thrombus (Figure 6). An AngioJet Solent thrombectomy catheter (Bayer, Indianola, PA) was used to perform mechanical thrombectomy of the left external iliac and common femoral veins (Figure 7). The right external iliac and common femoral veins were then accessed with the AngioJet catheter via the right internal jugular sheath.

Final venograms demonstrated an excellent result, with rapid, spontaneous blood flow (Figure 8). A Günther Tulip IVC filter was placed to protect the patient from recurrent thromboembolic disease. Hemostasis was achieved via a U-stitch and manual compression.

There were no immediate procedure-related complications. The patient was anticoagulated for 24 hours and then placed on low-dose fondaparinux (2.5 mg daily). The lower extremity edema and scrotal edema significantly improved over the course of the next several weeks. At 1-month follow-up, a duplex ultrasound demonstrated patent bilateral iliac veins and IVC. At 4 months postprocedure, the patient had only

Figure 3. A venogram from the right common femoral vein demonstrates occlusion of the external and common iliac veins. The right common femoral vein was also occluded (not shown).

Figure 4. The AngioVac device is advanced through a 26-F DrySeal sheath placed via the right internal jugular vein. The patient is on extracorporeal bypass with a reinfusion cannula in the left internal jugular vein (not shown).

mild residual lower extremity edema. There were no recurrent gastrointestinal bleeding episodes.

Figure 9 illustrates the significant thrombus removed during the procedure.

DISCUSSION

Thrombus removal is preferred by many who manage IVC thrombosis, as it is thought likely to minimize the long-term complications of chronic venous insufficiency and postthrombotic syndrome. Although anticoagulation has level 2B evidence for treating DVT,[9] medical therapy only reduces clot propagation and lacks thrombolytic potential, relying on the body's own intrinsic thrombolytic pathway for clot removal, which is ineffective in large clot burden. This ultimately increases the risk of postthrombotic syndrome, which can occur in up to 50% of patients with proximal DVT within the first 2 years.[10]

There are several different options for treating symptomatic iliocaval DVT. In our practice, catheter-directed thrombolysis with or without concomitant mechanical thrombectomy is the initial strategy for these cases. Given our patient's recent bleeding complications, thrombolysis was contraindicated. Mechanical thrombectomy alone with devices such as the AngioJet and Trellis (Covidien, Mansfield, MA) were considered; however, it was believed that these devices would not be adequate without thrombolytics in the presence of such a large burden of thrombus. The AngioJet rheolytic system, which relies on Bernoulli's principle, is a powerful thrombectomy catheter and was very effective in removing thrombus from the external iliac and common femoral veins. However, the use of this device is limited for large-volume thrombectomy (especially in the absence of thrombolytics) because of hemolysis, which may result in renal failure or even pancreatitis in rare cases.[11,12] In contrast, large-volume thrombectomy may be achieved with virtually no hemolysis with AngioVac, and the blood

(which is aspirated during thrombectomy) is reinfused, minimizing procedural blood loss.

The AngioVac catheter is indicated for use in procedures requiring extracorporeal circulatory support for periods of up to 6 hours and consists of a 22-F balloon-actuated, expandable funnel-shaped tip enabling high flow, which is connected to a circuit for extracorporeal bypass. The funnel-shaped distal tip facilitates en bloc removal of large extraneous material while preventing device occlusion. During extracorporeal circulation, the blood passes through a filter, which traps thrombus and other particulate material before being recirculated into the patient via a 16-F reinfusion sheath.

Because the existing IVC filter was occluded, and there was thrombus projecting cranially from the filter hook, our initial plan was to perform AngioVac thrombus aspiration from a right internal jugular vein approach with reinfusion into the right common femoral vein, while IVC filter retrieval would be performed via a left internal jugular approach. The rationale behind this approach was that the AngioVac device would be actively aspirating during manipulation and retrieval of the IVC filter, minimizing the risk of pulmonary thromboembolism. Although the magnetic resonance venogram had demonstrated only IVC and iliac vein thrombus, there was interval thrombosis of the bilateral common

Figure 5. Significant residual thrombus in the IVC is still noted after an initial pass with the AngioVac device.
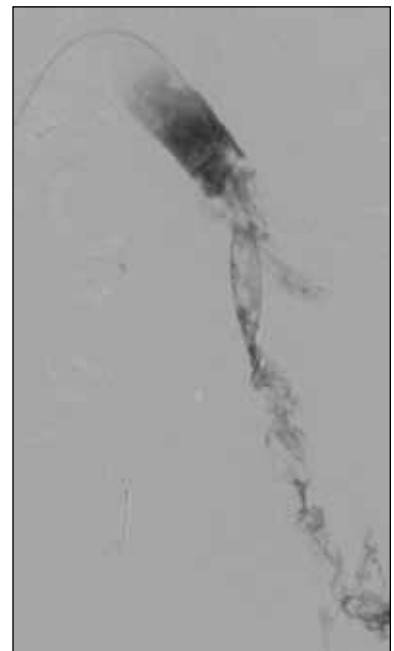
Figure 6. Significant thrombus is noted in the left external and common femoral veins. The left common iliac vein has been cleared of thrombus by the AngioVac device.
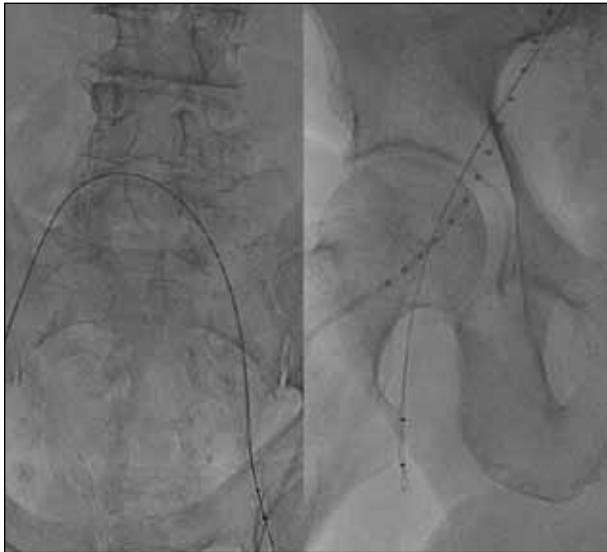
Figure 7. AngioJet thrombectomy via a Solent catheter of the bilateral femoral and external iliac veins.

femoral veins by the time of the intervention, and therefore, this approach was not feasible.

The 16-F reinfusion sheath was placed into the left internal jugular vein, and there was an existing left subclavian central venous catheter. However, an 11-F filter retrieval sheath may have also been placed via a left internal jugular approach, but given the presence of several left-sided venous lines, we decided to perform filter retrieval via the right internal jugular vein without activation of the AngioVac. The 11-F retrieval sheath was advanced through the 26-F DrySeal sheath before placement of the AngioVac device. The 26-F sheath was aspirated during filter retrieval to minimize risk of pulmonary embolism.

The AngioVac device comes with an inner dilator and is advanced over a guidewire to the desired location. Subsequently, the dilation and guidewire are removed, the pump is activated to create suction, and the catheter is advanced "to and fro" under fluoroscopic guidance. In contrast to other catheter-based mechanical thrombectomy devices, the AngioVac requires blood flow in order to function effectively. If placed in an entirely thrombosed vessel, the device will stop aspirating, and the pump flow rates will decrease. As a result, in the present case, the device had to be continuously moved back and forth in the IVC to maintain flow, given the significant amount of thrombus. There was continual feedback from the perfusionist regarding pump flow rates throughout the duration of the procedure. When the flow rates decreased or stopped, the device was withdrawn into a patent portion of the IVC until flow resumed. At this point, the device could be readvanced into the thrombosed vein.

Once the AngioVac device is in place and active, the interventionist cannot introduce a guidewire through it without disconnecting it. This is of practical concern because the device does not have directionality, and advancing the device into different vessels may require adjunctive techniques. In the present case, we had some difficulty advancing the device into the right common iliac vein. As previously described, we advanced a guidewire and catheter from the right femoral access, which functioned as a rail, allowing the device to be placed into the right iliac vein. At one point in the procedure, the device would not advance into the left common iliac vein. To facilitate this, a balloon via the right femoral approach was advanced to the caval bifurcation and dilated to push the AngioVac to the left.

The AngioVac device is relatively versatile and has been utilized in the central pulmonary arteries and right atrium, along with the central venocaval system.[13-17] Within the right atrium, the AngioVac device has been successful in removing undesirable obstructive infected vegetations from endocarditis and also right atrial thrombi.[13,15,18] Prior to the utilization of this device, patients were subject to cardiac surgery for removal; however, many patients with these conditions are not surgical candidates due to significant comorbidities. Subsequently, the AngioVac device is a minimally invasive procedure that has emerged as a potential surgical replacement and/or bridge to surgery in these patients.[15,18,19]

Dudiy et al demonstrated successful removal of a chronic large right atrial thrombus causing obstructive physiology, which measured over 7 cm. Postprocedure echocardiography demonstrated no residual atrial mass and no evidence of right ventricular thrombus or distal pulmonary embolism.[14] Patel et al described a case series of three patients in which the AngioVac device was used to extract infective
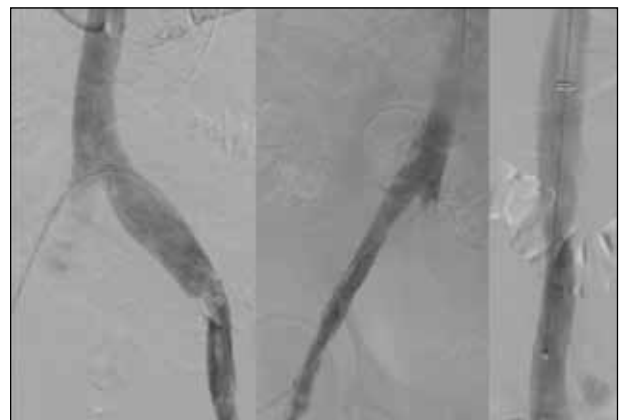
Figure 8. Final venography demonstrating patent bilateral iliac veins and IVC with rapid, spontaneous blood flow noted on real-time imaging.

Figure 9. Total thrombus removed via the AngioVac device during the procedure. The first filter was entirely full, and therefore, a second filter was required.

vegetations from endocarditis.[13] In all three cases, vegetations were associated with obstructive physiology and recurrent fever refractory to antibiotics. The AngioVac successfully demonstrated removal of the unwanted vegetations, subsequent resolution of infection, and reduced risk of septic pulmonary emboli, which can be seen in up to 55% of these patients.

More recently, Sakhuja et al described their single-center experience with the novel device in 14 consecutive patients with either right atrial, central pulmonary arterial, or venocaval thrombosis.[19] They report a 79% procedural success rate and complete success in the removal of intravascular thrombus in nine of 14 patients. In three patients, the lack of success was either due to pulmonary arterial thrombus beyond the site of catheter aspiration or residual tricuspid valve-infected vegetation.

CONCLUSION

There are a variety of catheter-based techniques in the treatment algorithm of DVT, which include mechanical thrombectomy, pharmacologic thrombolysis, and pharmacomechanical thrombolysis. IVC filter thrombosis is largely a complex, multifactorial problem that requires significant preprocedural planning and workup. Although IVC filters protect patients from embolic complications associated with DVT, if subsequent thrombosis occurs, aggressive interventions are often mandated, with the ultimate goal of reducing the risk of progression to postthrombotic syndrome and more adverse symptomatology.

In short, the AngioVac device can be very effective in the removal of clot burden while minimizing the harmful effects seen in other mechanical thrombectomy devices, with virtually no blood loss. This further supports the use of the AngioVac thrombectomy catheter in patients with large clot burden and should be included in the armamentarium for treating DVT and IVC thrombosis. ■

Ripal T. Gandhi, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has stated that he has no financial interests related to this article. Dr. Gandhi may be reached at (786) 596-5990; gandhi@baptisthealth.net.

David Quintana, MD, is with University of Miami Miller School of Medicine in Miami, Florida. He has stated that he has no financial interests related to this article.

Melanie Schernthaner, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. She has stated that he has no financial interests related to this article.

Constantino Peña, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has disclosed that he is a paid consultant to Cook Medical and Bard.

Andrew Hall, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has stated that he has no financial interests related to this article.

Niberto Moreno, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has stated that he has no financial interests related to this article.

James F. Benenati, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has disclosed that he is a paid consultant to Abbott, AngioDynamics, Gore, and Surefire.

Barry T. Katzen, MD, is with Baptist Cardiac and Vascular Institute in Miami, Florida. He has stated that he has no financial interests related to this article.

1. Giordano P, Weber K, Davis M, Carter E. Acute thrombosis of the inferior vena cava. Am J Emerg Med. 2006;24:640-642.
2. McAree BJ, O'Donnell ME, Fitzmaurice GJ, et al. Inferior vena cava thrombosis: a review of current practice. Vasc Med. 2013;18:32-43.
3. Toumbouras M, Spanos P, Konstantaras C, Lazarides DP. Inferior vena cava thrombosis due to migration of retained functionless pacemaker electrode. Chest. 1982;82:785-786.
4. Tardy B, Page Y, Zeni F, et al. Acute thrombosis of a vena cava filter with a clot above the filter. Successful treatment with low-dose urokinase. Chest. 1994;106:1607-1609.
5. Athanasoulis CA, Kaufman JA, Halpern EF, et al. Inferior vena caval filters: review of a 26-year single-center clinical experience. Radiology. 2000;216:54-66.
6. Janjua M, Younas F, Moinuddin I, et al. Outcomes with retrievable inferior vena cava filters. J Invasive Cardiol. 2010;22:235-239.
7. Angle JF, Matsumoto AH, Al Shammari M, et al. Transcatheter regional urokinase therapy in the management of inferior vena cava thrombosis. 1998;9:917-925.
8. Duszak R, Parker L, Levin DC, Rao VM. Placement and removal of inferior vena cava filters: national trends in the medicare population. J Am Coll Radiol. 2011;8:483-489.
9. Kearon C, Akl EA, Comerota AJ, et al. Antithrombotic therapy for VTE disease: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. Chest. 2012;141(2 suppl):e419S-494S.
10. Kahn SR, Ginsberg JS. The post-thrombotic syndrome: current knowledge, controversies, and directions for future research. Blood Rev. 2002;16:155-165.
11. Piercy KT, Ayerdi J, Geary RL, et al. Acute pancreatitis: a complication associated with rheolytic mechanical thrombectomy of deep venous thrombosis. J Vasc Surg. 2006;44:1110-1113.
12. Arslan B, Turba UC, Matsumoto AH. Acute renal failure associated with percutaneous mechanical thrombectomy for iliocaval venous thrombosis. Semin Intervent Radiol. 2007;24:288-295.
13. Patel N, Azemi T, Zaeem F, et al. Vacuum assisted vegetation extraction for the management of large lead vegetations. J Card Surg. 2013;28:321-324.
14. Dudiy Y, Kronzon I, Cohen HA, Ruiz CE. Vacuum thrombectomy of large right atrial thrombus. Cathet Cardiovasc Intervent. 2011;79:344-347.
15. Mathie M, Peng YG. Innovative approach to remove an atrial vegetative mass with the AngioVac system: bypassing the cardiac bypass. Poster presented at: 2nd Thoracic Anesthesia Symposium; April 6–7, 2013; Miami Beach, FL.
16. Ramamoorthy S, High K. Extraction of atrial and pulmonary thrombi using an AngioVac aspiration system with transesophageal echocardiography and fluoroscopic guidance. Poster presented at: 2nd Thoracic Anesthesia Symposium; April 6–7, 2013; Miami Beach, FL.
17. Sobieszczyk P. Catheter-assisted pulmonary embolectomy. Circulation. 2012;126:1917-1922.
18. Divekar AA, Scholz T, Fernandez JD. Novel percutaneous transcatheter intervention for refractory active endocarditis as a bridge to surgery——AngioVac aspiration system. Cathet Cardiovasc Intervent. 2013;81:1008-1012.
19. Sakhuja R. A novel endovenous approach for treatment of massive central venous or pulmonary arterial thrombus, mass, or vegetation: the AngioVac suction cannula and circuit. J Am Coll Cardio. 2011;57:E1535.