Percutaneous Options for Acute Deep Vein Thrombosis

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ABSTRACT

Anticoagulant therapy is associated with poor late limb outcomes in many patients with deep vein thrombosis (DVT). Because systemic thrombolysis and surgical thrombectomy have inherent limitations, image-guided percutaneous thrombus removal is currently favored. Pharmacologic thrombolysis is effective in removing thrombus, but long-term benefit has not been conclusively demonstrated and major bleeding rates appear to be higher than those observed with anticoagulation alone. Percutaneous mechanical thrombectomy is limited as a stand-alone DVT treatment method by inability to clear large thrombosed veins completely and by pulmonary embolism. Pharmacomechanical thrombolysis represents the most promising currently available method to treat DVT. Randomized trials with long-term follow-up are needed to determine the appropriate indications for these procedures. In the meantime, a highly individualized approach to selection of patients is recommended, taking into account the chronicity and anatomic extent of DVT, the presence of circulatory compromise, the patient's bleeding risk profile, life expectancy, and anticipated activity level.

KEYWORDS: Deep vein thrombosis, thrombolysis, thrombectomy, post-thrombotic syndrome, pharmacomechanical

Objectives: Upon completion of this article, the reader should be able to (1) specify the limitations of standard deep vein thrombosis (DVT) therapy, (2) name three percutaneous DVT treatment options, and (3) describe three patient selection considerations for percutaneous DVT therapy.

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The treatment of deep vein thrombosis (DVT) has advanced significantly in recent years, but major challenges remain. In particular, the late manifestations of DVT cause significant disability despite the use of standard therapies, and previously tested aggressive therapeutic options carry major limitations to widespread use. During the last decade, advances in mini-

mally invasive technologies have spurred a renaissance in the aggressive treatment of DVT using percutaneous techniques. The goals of this article are several: (1) to outline the major limitations of standard DVT therapy, (2) to highlight the clinical situations in which percutaneous treatment options may benefit DVT patients, and (3) to emphasize the need for rigorous outcomes

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assessment of these treatment modalities. It is our strong belief that following properly designed randomized trials to evaluate these techniques, interventional radiologists will play a critical role in the treatment of DVT.

ACUTE DVT: STANDARD OF CARE

The consensus recommendations of the Seventh American College of Chest Physicians (ACCP) on antithrombotic and thrombolytic therapy were published in September 2004.¹ Standard initial therapy for a first episode of acute lower extremity DVT is subcutaneous low-molecular-weight heparin (LMWH) or intravenous unfractionated heparin (UFH) for at least 5 days, with a transition to oral vitamin K antagonist therapy or continued LMWH for 3–12 months depending upon an analysis of the risk factors that contributed to the initial thrombotic episode. Patients with contraindications to anticoagulation, complications of anticoagulation, or recurrent venous thromboembolism (VTE) despite adequate anticoagulation are treated with placement of an inferior vena caval (IVC) filter. Using this approach, the incidences of pulmonary embolism (PE), PE-related death, and recurrent VTE from an initial episode of acute DVT have been drastically reduced.²

The post-thrombotic syndrome (PTS) is characterized most commonly by limb heaviness, edema, and/or pain, with a minority of patients experiencing more severe manifestations such as disabling venous claudication, limb hyperpigmentation, and/or ulceration. The impact of the various elements of standard DVT therapy upon the incidence and/or severity of PTS is only partially understood. In two randomized trials, 30–40 mm Hg compression stockings were observed to decrease significantly the incidence of PTS.^{3,4} Because anticoagulant therapy does lower the risk of recurrent DVT, the only proven risk factor for PTS, it might also be expected to lower the incidence of PTS.⁵ Placement of IVC filters, on the other hand, has been shown in one randomized trial to increase the incidence of recurrent DVT and might therefore be expected to increase the incidence of PTS.⁶

Despite the use of standard therapy, PTS is observed in a significant fraction of DVT patients. Published estimates of the actual incidence of PTS in DVT patients vary considerably. Observational series have indicated that PTS occurs in over 50% of all DVT patients who are treated with anticoagulant therapy alone and in over 90% of patients with iliofemoral DVT.⁷ In contrast, a large prospective European registry found a 30% incidence of PTS in all DVT patients treated with standard therapy, with only a 10% incidence of severe PTS.^{5,8,9} This apparent discrepancy may in part reflect different populations of patients and the regular use of compression stockings in the European study. In patients with iliofemoral DVT, PTS has been shown to

result in significant patient disability, utilization of health care resources, and costs.¹⁰ Hence, given the high baseline incidence of DVT in the population, even the 10% best-scenario estimate of severe PTS indicates the presence of a major unsolved public health problem.

EARLY THROMBUS REMOVAL: A NEW STRATEGY

PTS results from ambulatory venous hypertension, which is caused by two main factors after an episode of DVT: valvular insufficiency and chronic venous obstruction. Venous thrombosis causes progressive valvular insufficiency in both involved venous segments (by direct valvular damage) and uninvolved segments (by increasing ambulatory venous pressures below the obstruction).^{11,12} However, distal valvular reflux develops very infrequently in uninvolved venous segments *after* recanalization of the previously thrombosed upstream vein has occurred, and early clot lysis is a consistent finding in the minority of DVT patients who do experience long-term complete symptom resolution.^{12–14} Unfortunately, in most anticoagulated patients the rate of spontaneous venous recanalization is not sufficient to prevent valvular damage, and valvular reflux is observed in 40% of patients just 1 month after a DVT episode and in 67% within 1 year.

In the subset of patients with iliofemoral DVT who are treated with anticoagulation, spontaneous recanalization rarely occurs and subsequent valvular reflux is more frequent (95% of patients within 10 years in one study).¹⁰ Some studies indicate that development of PTS progresses at a faster rate in these patients, although evidence to the contrary has been presented.⁵ One long-term observational study demonstrated that nearly all iliofemoral DVT patients develop chronic leg edema, with 50% experiencing venous claudication and more than 85% showing venous ulcerations within 10 years.¹⁰ These patients had significant job disability and health care utilization related to care of their chronic venous disease, with an average of eight clinic visits per year and five DVT-related hospitalizations over this 10-year period.

The rationale favoring more aggressive strategies for DVT is therefore founded upon the substantial incidence of PTS in DVT patients following standard anticoagulant therapy and the preliminary finding that early clot lysis is correlated with less valvular reflux and better long-term clinical outcome.

In the 1970s and early 1980s, numerous randomized clinical trials were performed to evaluate the use of systemically administered (i.e., through a peripheral intravenous line distant from the affected limb) thrombolytic agents (mainly streptokinase) for the treatment of DVT. The results of these studies were summarized in

several meta-analytic studies.^{15,16} In these trials, streptokinase provided complete clot lysis in 45% of DVT patients and at least partial lysis in 60–65% of patients, compared with < 5% complete lysis and 15–20% partial lysis for anticoagulant therapy. Two long-term follow-up studies found significantly reduced incidences of PTS in the thrombolysis-treated patients, although the sample sizes were insufficient to permit broad conclusions to be drawn.^{17,18} Although the United States Food and Drug Administration did approve streptokinase for the treatment of DVT, the high frequency of associated major bleeding complications (14% for streptokinase versus 4% for heparin alone) prevented this approach from gaining widespread acceptance.¹⁵

Surgical thrombectomy for DVT has been evaluated in numerous studies with conflicting results. In one small European randomized trial, surgical thrombectomy with temporary arteriovenous fistula creation did provide significantly better long-term limb outcomes in terms of PTS than anticoagulation alone.¹⁹ However, because relatively high rates of early rethrombosis, perioperative PE, and death were observed in other surgical studies, these methods have not been widely adopted.²⁰

Hence, studies evaluating the incidence of PTS in DVT patients are concordant in demonstrating favorable results with early thrombus removal strategies, but the sample sizes have been insufficient to permit generalization of their conclusions and the treatment modalities were associated with significant safety limitations.

PERCUTANEOUS OPTIONS FOR ACUTE DVT

During the 1990s, several technological advances contributed to renewed interest in treating DVT using aggressive means: (1) improvements in noninvasive vascular imaging, including duplex ultrasound and helical CT scanning, enabled more complete noninvasive characterization of the extent of VTE; (2) improved ultrasound technology permitted access into the deep lower extremity veins to be obtained safely and reliably; and (3) the use of catheter systems specifically designed for local intravascular drug delivery for arterial applications provided evidence of the feasibility of this general approach.²¹ Since then, multiple image-guided pharmacologic or mechanical methods, or both, have been used to remove acute thrombus from the deep venous system.

Catheter-Directed Pharmacologic Thrombolysis

Randomized trials have shown that thrombolytic agents administered systemically have significant activity in DVT and offer a potential for improved late limb status but with an unacceptably high risk of major bleeding.^{15,16} During the 1990s, image-guided catheter-

directed drug delivery methods were recognized as one potential avenue by which the safety and efficacy of thrombolytic therapy might be enhanced. Specifically, the theoretical advantages of using of image-guided catheter placement methods to infuse pharmacologic thrombolytic agents directly into the thrombosed vein were several: (1) the ability to achieve a high intra-thrombus drug concentration and to avoid bypass of the drug around the occluded venous segments through collaterals; (2) the ability to reduce thrombolytic agent dose, treatment time, hospital resource utilization, and bleeding complications by achieving more efficient thrombolysis; and (3) the ability to prevent recurrent DVT episodes by concomitantly using adjunctive catheter-based techniques such as stent placement to address any anatomic venous abnormalities that may have contributed to the initial thrombotic episode.

The following clinical and anatomic parameters are typically established first to define an optimal treatment approach: (1) the presence and extent of venous thrombus; (2) the presence of an obvious anatomic cause of thrombosis (i.e., stenosis or extrinsic venous compression); (3) the duration and severity of symptoms, with the accompanying radiologic assessment of whether thrombus is acute or chronic; (4) the presence of underlying malignancy or other predisposing risk factors for DVT; and (5) the patient's overall condition and suitability for aggressive management, including any contraindications to anticoagulation or surgery. This information is easily obtained through directed clinical history combined with duplex ultrasound and/or helical CT. Contraindications to thrombolytic therapy include a history of hemorrhagic stroke; recent ischemic stroke (within 1 year); central nervous system malignancy, arteriovenous malformation, or infection; recent surgery; ongoing pregnancy, or recent delivery; recent gastrointestinal bleeding; thrombocytopenia; severe uncontrolled hypertension; severe hepatic dysfunction; and other conditions that might predispose to bleeding.

If the patient is an appropriate candidate, he or she is brought to the angiographic suite. A lower extremity vein below the lowest extent of thrombus is selected for access—the popliteal vein and posterior tibial vein are the two most commonly used veins, although other veins can be used as well.^{22–25} Under direct ultrasound guidance, the vein is accessed and a catheter is used to perform venography to define the extent of thrombosis. Venography can also help to determine whether acute or chronic thrombus is present when the clinical history is not clear. Generally, dilatation of the involved vein with voluminous filling defects and limited collateralization suggest acute thrombosis, and diminutive venous channels, irregular stringy filling defects (corresponding to webs and synechiae), and mature collateralization indicate chronic venous occlusion.

This represents a critical distinction because the overall success of thrombolytic therapy is greater for acute disease compared with chronic obstruction for several reasons. First, guidewire passage across the region of occlusion is nearly always possible in less organized (soft) acute thrombus but may not be achieved in some chronically occluded segments because of the hard consistency of the intraluminal material. Second, the chemical susceptibility of thrombus to pharmacologic thrombolytic agents is significantly greater for acute thrombus. Third, patients with acute thrombosis are more likely to benefit ultimately from clot removal,

whereas patients with chronic occlusion may already have suffered irreversible valvular damage. That said, recanalization of carefully selected chronic iliac vein occlusions can decrease symptom severity in many patients.

A multisidehole catheter is then placed across the thrombosed venous segment and attached to an infusion of a pharmacologic thrombolytic agent. The two most commonly used agents are urokinase (Abbott Laboratories, North Chicago, IL) (typically given at 120,000–180,000 units/hour) and alteplase (Genentech, South San Francisco, CA) (typically given at 0.5–1.0 mg/hour).^{25–27} Other agents that can be used include

Figure 1 A 32-year-old woman who underwent recent cesarean section presented with a 5-day history of acute swelling of the entire left leg. Duplex ultrasonography showed deep vein thrombosis extending into the iliac vein. (A) Venogram demonstrates a large intraluminal filling defect in the left femoral vein. (B) Digital subtraction venogram demonstrates thrombus extending into the common femoral vein and (C) involving the entire iliac vein. A multisidehole catheter was placed through ultrasound-guided left popliteal vein access. (D) After catheter-directed pharmacologic thrombolysis using urokinase, the left iliac vein thrombus has resolved, and a focal left common iliac vein stenosis is unmasked consistent with May-Thurner syndrome. (E) A 14-mm Smart Stent (Cordis Endovascular, Miami Lakes, FL) was placed in the left common iliac vein. Note the “waisting” at the level of the stenosis.

Figure 1 (continued) (F) Immediate postprocedure venogram demonstrates wide patency of the femoral vein, (G) common femoral vein, and (H) iliac vein. The patient was subsequently anticoagulated and is asymptomatic at 1-year follow-up.

reteplase (Centocor, Malvern, PA) (0.25–0.75 units/hour) and tenecteplase (Genentech, South San Francisco, CA) (0.25 mg/hour).^{28,29} The agent is infused continuously overnight, and patients also receive intravenous heparin during the infusion. Although full-dose heparin (aimed at partial thromboplastin time [PTT] 1.5–2.5 times control) has traditionally been used, in our institution subtherapeutic heparin (~500 units/hour) is typically given. Fibrinogen determinations are obtained every 6 hours and maintained over 100 mg/dL through adjustments in thrombolytic agent dose. Other laboratory parameters that are monitored at these intervals include hematocrit, PTT, and platelet count. During the infusion, patients are observed in an intensive care unit or step-down unit. If significant active bleeding is observed or if the fibrinogen level drops to less than 100 mg/dL, the infusion is discontinued.

Patients are restudied venographically at 8- to 16-hour intervals. If complete (>95%) thrombolysis is achieved (treatment success) or if no thrombolysis is noted (treatment failure), pharmacologic thrombolysis is discontinued. If only partial (>50%) thrombolysis is achieved, an angioplasty balloon is used to macerate grossly the softened residual thrombus to increase its surface area and thereby speed the thrombolytic process. Thrombolytic infusion is then continued. After thrombolysis is completed, venography is repeated and any visualized stenoses are treated with balloon venoplasty (femoral vein stenosis) or endovascular stent placement (iliac vein stenosis).²² Appropriate treatment of venous stenosis is extremely important because the incidence of PTS is increased sixfold when recurrent DVT occurs.⁵ Repeated venography is then performed to confirm patency of the venous system (Fig. 1). Full-dose anticoagulant therapy is reinitiated and patients are subse-

quently switched to long-term oral vitamin K antagonist therapy and are asked to wear class II (30–40 mm Hg) compression stockings.

Catheter-directed pharmacologic thrombolysis has been evaluated in several observational studies and in one prospective multicenter registry. In terms of early efficacy, the rate of significant (complete or partial) thrombolysis was ~83%, which appears superior to the 63% observed for systemic pharmacologic thrombolysis.^{16,17,26} Lower primary patencies were observed in patients with femoropopliteal DVT than in patients with iliofemoral DVT. Many DVT patients have undergone initially successful treatment of iliac vein stenoses with stents, although the incidence of recurrent DVT has not been assessed. In terms of late efficacy, one study has provided preliminary evidence that successful catheter-directed pharmacologic thrombolysis improves health-related quality of life in iliofemoral DVT patients.³⁰

Unfortunately, catheter-directed delivery of thrombolytic agents does not appear to have significantly affected the rate of thrombolytic bleeding complications and health care resource utilization, which represent two major impediments to widespread use of this technique for DVT. In the urokinase registry study, major bleeding complications were observed in 11% patients, including 0.6% patients who suffered intracranial bleeding.²⁵ The incidence of PE was only 1%. The mean total urokinase dose administered was 6.8 million units and the mean thrombolytic infusion time was 48 hours, only slightly lower than the expected duration of therapy for systemically administered thrombolytic therapy. Many explanations for these findings have been proposed, including nonuniform use of ultrasound to access the venous system (with more arterial punctures and access site

bleeds as a result), better reporting of complications in the registry study than in previous observational studies, widely varying urokinase dose regimens used in the registry, and lack of experience of many operators who contributed cases to the registry.

Percutaneous Mechanical Thrombectomy

The two major limitations of catheter-directed pharmacologic thrombolysis, according to current evidence, are the rate of major bleeding complications and the extensive use of health care resources necessitated by the thrombolytic infusion, multiple venograms, repeated laboratory studies, and intensive care unit monitoring. Anecdotal experience suggests that minor adjunctive mechanical elements such as transcatheter thromboaspiration, balloon maceration, and external pneumatic compression can be useful in speeding thrombolysis.³¹ Given this experience, the use of mechanical methods to debulk and/or macerate thrombus appears worthy of study as one potential way to accomplish effective DVT treatment in accelerated fashion without the bleeding risks of thrombolytic therapy.

Percutaneous mechanical thrombectomy (PMT) devices are capable of macerating thrombus more effectively than balloon catheters, and the aspirating-type devices can remove the macerated thrombus fragments from the venous lumen. In addition, the use of PMT can increase the surface area of residual thrombus and create a central flow channel within an occluded vein, thereby improving the efficiency of thrombolysis. However, theoretical disadvantages of PMT methods include increased on-table procedure time, the potential for causing PE, and the potential for causing venous valve injury with the devices.³²⁻³⁵

Published experience with PMT for DVT is confined to several case reports describing use of several devices and a few small series that detail the use of two devices: (1) the nonaspirating Amplatz thrombectomy device (ATD) (EV3, Plymouth, MN) and (2) the aspirating Angiojet device (Possis, Minneapolis, MN).

In 1997, Uflacker reported use of the ATD without concomitant pharmacologic thrombolysis to treat a patient with IVC thrombosis. Although partial success was achieved, the patient experienced a clinically significant PE.³⁶ Gandini et al used the ATD without pharmacologic thrombolysis to treat acute ilio caval DVT and reported complete success in six of eight patients.³⁷ A temporary inferior vena cava filtration device was placed in these patients prior to device activation. Delomez et al also used the ATD without pharmacologic thrombolytic agents to treat 18 patients with ilio caval DVT and reported successful thrombus removal in 15 patients.³⁸ Despite the use of temporary filters in these patients, all experienced temporary oxygen desaturation during the procedure. Although pulmonary arteriography in these

patients did not demonstrate evidence of PE, five patients were noted to have thrombus trapped within the filters. Therefore, it seems clear that the ATD is somewhat effective in clearing thrombus but that it can produce clinically significant PE when used alone. These findings are not surprising given that this device does not actually aspirate thrombus from the vein.

Kasirajan et al treated 14 patients with iliofemoral DVT using the Angiojet rheolytic catheter and observed significant lysis in 8 patients.³⁹ No clinical evidence of PE was observed in these patients. Further studies have not been published, but anecdotal experience suggests that this device is not capable of consistently clearing sufficient thrombus from the larger veins when used in the conventional manner.

Hence, PMT using currently available devices has not been observed to be a particularly promising stand-alone technique for the treatment of DVT.

Pharmacomechanical Thrombolysis

Catheter-directed pharmacologic thrombolysis and PMT each possess significant limitations when used as stand-alone techniques. However, "pharmacomechanical" thrombolysis methods that combine mechanical thrombus maceration or aspiration with pharmacologic thrombus dissolution have several theoretical advantages: (1) the mechanical device can increase the surface area of thrombus, accelerate pharmacologic thrombolysis, reduce the required drug dose and infusion duration, and thereby reduce bleeding complications, and (2) the pharmacologic thrombolytic agent can dissolve mechanically created thrombus fragments that might otherwise contribute to symptomatic PE. Potential disadvantages of pharmacomechanical thrombolysis include increased on-table procedure time and the theoretical potential for causing venous valvular injury. The cost of the mechanical device must also be considered but may be offset by decreases in the amount of thrombolytic agent used, depending upon the respective costs of the specific device and thrombolytic agent used. Nevertheless, the combination of pharmacologic and mechanical means of removing thrombus is considered by many investigators to represent an extremely promising method by which currently available endovascular thrombus removal methods can be made safe enough for widespread usage in DVT patients.

Several authors have reported favorable results using MT devices with concomitant pharmacological thrombolysis to treat lower extremity DVT cases.^{23,36,40} In the study by Kasirajan et al referred to earlier, pharmacological thrombolysis was used in nine patients after failure of Angiojet PMT alone. The added thrombolytic agent was effective in most patients, and the total dose used was significantly less than that typically associated with pharmacological thrombolysis alone.³⁹

This observation was also made in an abstract presentation by Johnson et al, who treated nine DVT patients with urokinase and the ATD. These investigators reported a success rate that was comparable to that of 11 historical control patients treated with urokinase alone. These investigators also reported reduced total dose, infusion duration, and complications in the patients who received pharmacomechanical thrombolysis.⁴¹ We utilized the Helix device (the newest version of the ATD) in combination with reteplase and an early stenting protocol to treat 23 limbs with iliofemoral DVT and reported an excellent early success rate (96%) and minimal late venous disability at mean 20 months follow-up as graded by the Venous Disability Score.⁴² We have since used a nearly identical protocol but substituting urokinase for reteplase in 36 limbs with iliofemoral DVT and found similar early results. Bleeding complications were observed in less than 5% of the patients we treated with pharmacomechanical thrombolysis. We are therefore hopeful that this method, and other pharmacomechanical thrombolysis methods, will be suitable for treatment of large numbers of DVT patients.

Two newer pharmacomechanical approaches that are being used by some investigators are the power-pulse mode of using the Angiojet device and use of the Trellis device (Bacchus Vascular, Santa Clara, CA). With the power-pulse method, the outflow lumen of the Angiojet is occluded and the inflow lumen device is used to pulse-spray the thrombolytic agent forcefully directly into the thrombus. Although this approach takes advantage of the efficiency of pulse-spray methodology, clinical experience with this technique has not yet been reported.⁴³ The Trellis device features two balloons that can "isolate" a segment of vein for treatment using pharmacomechanical thrombolysis. With the balloons inflated, a pharmacologic thrombolytic agent is injected directly into the thrombus in conjunction with mechanical dispersion using an oscillating wire. Although there are no published reports yet, two groups have presented their results using this device for DVT patients. Spencer and Garby described use of this device with alteplase in 19 patients and reported clinical improvement in all patients with only one major bleeding complication (5%). Although greater thrombus removal was observed when subsequent continuous pharmacologic thrombolytic infusion was used, in many patients significant thrombolysis was achieved without the need for continuous infusion or an intensive care unit stay.⁴⁴ McNamara et al treated 11 patients with iliofemoral DVT with the Trellis device and reteplase and observed clinical improvement in all patients.⁴⁵ Hence, the power-pulse Angiojet technique and Trellis device both appear promising but need to be studied more extensively before any conclusions can be drawn concerning their safety and effectiveness.

SELECTION OF PATIENTS FOR PERCUTANEOUS THERAPY

No published randomized trials evaluating percutaneous therapies for the treatment of DVT exist. Therefore, any recommendations regarding their use must be qualified significantly. Numerous concordant observational studies do indicate that the percutaneous methods described earlier are highly effective in clearing acute thrombus from the venous system. However, evidence indicating long-term reduction of PTS is limited to one non-randomized case-control study.³⁰ In addition, the actual rate of bleeding complications when using current methods needs further characterization.

For these reasons, a highly individualized approach to determining which DVT patients merit endovascular therapy is recommended, bearing in mind the results of the urokinase registry study. Major factors that affect the decision process include symptom duration and severity, the anatomic extent of DVT, the presence of signs of circulatory compromise, and the patient's bleeding risk profile, life expectancy, and anticipated activity level. Patients with a short life expectancy, those who do not ambulate, and those with factors predisposing to bleeding complications are relatively poor candidates for aggressive therapy. Patients with chronic DVT limited to the femoropopliteal segment are also best treated with standard therapy because the results of thrombolytic therapy in such patients were fairly poor in the registry study.²⁵ Patients with circulatory compromise should be treated with emergency catheter-directed thrombolysis unless a strong contraindication is present; if this is the case, emergency surgical thrombectomy should be performed. In patients with bleeding-related contraindications to pharmacologic thrombolysis, PMT devices may be used.

Ambulatory patients with proximal DVT, reasonable life expectancy, and no bleeding contraindications should be considered potential candidates for percutaneous therapy. The best subset of patients appears to be those with acute iliofemoral DVT—these patients are expected to achieve substantial benefit with early thrombus removal. Patients with acute femoropopliteal DVT and significant symptoms may also be good candidates for treatment if bleeding risks are not present. Patients with chronic iliac vein obstruction and symptoms of chronic venous insufficiency can experience significant symptom relief from iliac vein stent placement when inflow to the groin level is reasonably good, although such patients must be counseled that a return to completely asymptomatic status is highly unlikely.

CONCLUSION

Percutaneous therapy for DVT offers the potential to prevent post-thrombotic syndrome and improve quality

of life. Major impediments to widespread utilization include relatively high major bleeding rates and significant health care resource utilization for pharmacologic thrombolytic methods. Catheter-directed pharmacomechanical thrombolysis techniques have shown potential to provide patients with long-term benefit while also addressing the limitations of stand-alone treatment with pharmacologic thrombolysis or percutaneous mechanical thrombectomy. A highly individualized approach to selection of patients is recommended to optimize clinical benefit and to prevent complications. Randomized trials with long-term follow-up are needed to confirm that favorable outcomes are obtained using percutaneous methods of treating acute DVT.

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