Catheter-Based Therapies for DVT

The current state of endovascular technology for treating deep vein thrombosis and the improvements that are still needed.

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Venous thromboembolic disease is the third most common vascular disease in the United States and a frequent cause of disability and death. Yet, effective treatment continues to be a major unmet public health need. This article briefly reviews the state of endovascular therapy for deep vein thrombosis (DVT) and attempts to address the shortcomings of the current generation of tools for this indication.

Almost 2 decades after the article by Semba and Dake describing catheter-based treatment of lower extremity DVT was published,[1] the predominant treatment for patients with DVT remains anticoagulation alone. Although there has been substantial progress in the development of newer anticoagulants to overcome certain limitations of older agents, they are all designed to prevent clot formation and propagation rather than removal. In the setting of DVT, the clearance of thrombus from the veins is left to the body's own intrinsic thrombolytic mechanisms. This is a serious limitation of the current approach to treating patients with DVT. Although anticoagulation is an adequate treatment in smaller, more distal veins, the volume of clot in the larger, more proximal veins overcomes the body's endogenous lytic ability, predisposing patients to long-term sequelas such as postthrombotic syndrome.

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Additionally, the management strategy of anticoagulation alone has two other major problems: (1) treatment algorithms are based solely on the presence or absence of thrombus without consideration of the extent and location of the involved venous segments and (2) presence of underlying anatomic abnormalities within the veins is underappreciated and frequently disregarded.[2]

RATIONALE FOR INTERVENTIONAL THERAPY

It is estimated that < 2% of patients who are diagnosed with DVT are treated using active clot removal strategies.[3] There are three major objectives for the targeted endovascular treatment of DVT: (1) to prevent postthrombotic syndrome by restoring venous patency and preserving valvular function; (2) to reduce the risks of pulmonary embolism and recurrent DVT; and (3) to provide immediate symptom relief that may otherwise

(Courtesy of Medrad Interventional/Possis.)

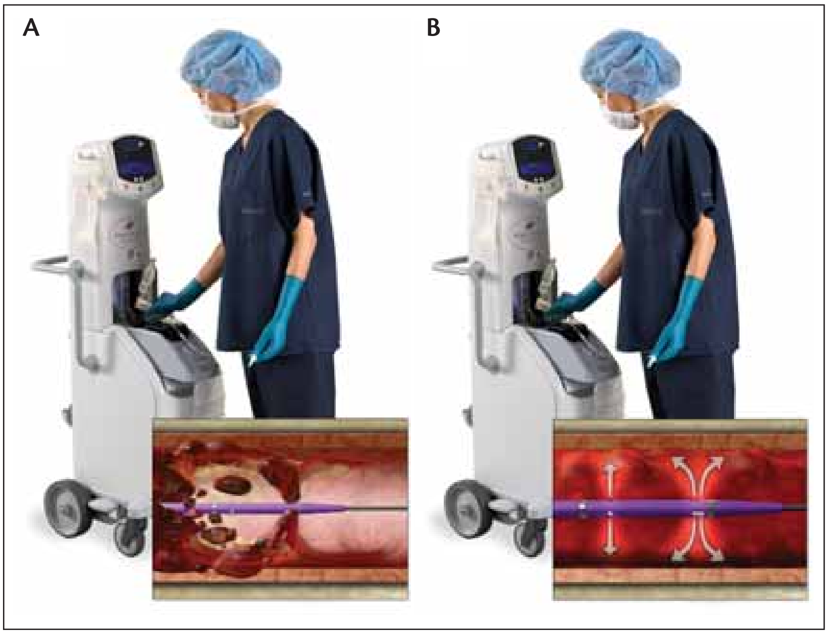


Figure 1. The new console for the AngioJet ultra thrombectomy system with integrated disposables and easier set up as compared to the older model. The catheter works through a rheolytic mechanism to remove thrombus.

take many days to weeks to resolve with anticoagulation alone.

Although no level 1 scientific data that quantify the actual superiority of adjunctive interventional approaches over anticoagulation alone currently exist, evidence supporting the benefits of early clot removal does exist. Detailed analysis of the literature on this subject is beyond the scope of this article, and readers are referred to the article by Vedantham et al.[4]

ENDOVASCULAR THERAPIES FOR ACUTE DVT

The main technical objective of endovascular therapies is to re-establish inline flow from the extremity to the heart with clot removal and treatment of obstructive lesions in the outflow venous structures. To that end, devices for catheter-based clot removal are divided into three basic categories. First are those designed for passive infusion of fibrinolytic drugs into the clot. These consist mostly of multisidehole infusion catheters with various drug distribution efficiencies. It is theorized that catheters with more even drug distribution characteristics lead to more effective thrombolysis. Although the clinical outcomes associated with individual infusion catheters have not been compared in the literature, they are not likely to be significantly different. Innovations in catheter design for simple infusion have been minor, including spiral diffusion capabilities, which presumably lead to more efficient clot lysis and valved sideholes that have more even drug distribution. However, improved procedural and clinical outcomes will have to await the development of thrombolytic agents with better safety and efficacy profiles. The main limitations of catheter-directed thrombolysis (CDT) using simple infusion catheters are the prolonged treatment times and the potential risk for bleeding associated with the use of current thrombolytic drugs.

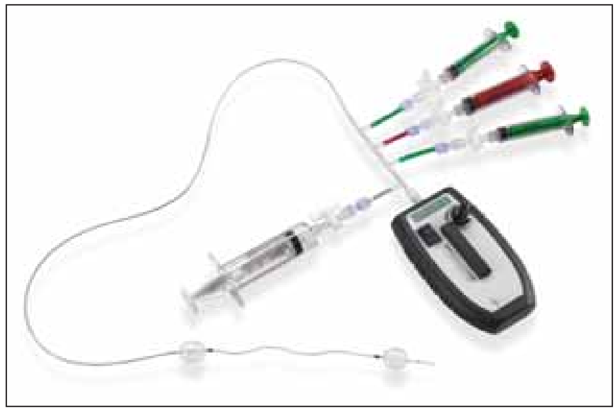
Without an improved pharmacologic agent on the horizon, these shortcomings have led to the development of the second category of devices, percutaneous mechanical thrombectomy (PMT) catheters. To date, there have been a large number of such devices introduced into the market that employ various mechanisms of clot disintegration and aspiration. The AngioJet (Medrad Interventional/Possis, Indianola, PA) is the most commonly used device in United States for this purpose (Figure 1). As a standalone technique, the current generation of PMT devices have a low efficacy rate in proximal veins compared to pharmacologic CDT. In a study using PMT without fibrinolytic agents, Kasirajan et al reported 50% thrombus extraction in 59% of patients,[5] which parallels my own experience in patients with DVT. These devices tend to work well for removing hyperacute clots; hence, it is not a surprise that they fall short in patients with DVT who may harbor clots that are 2 to 3 weeks old.

The third category of clot-removing instruments involves lytic-assisted devices, including pharmacomechanical and sonically enhanced thrombolysis. These devices are designed to augment the efficacy of thrombolysis, shorten the procedure time, and possibly reduce the necessary drug dose required for clot dissolution. The current popular approaches include the use of the Trellis catheter (Covidien, Mansfield, MA), EkoSonic endovascular system (Ekos Corporation, Bothell, WA), and the combination of the AngioJet and a thrombolytic drug to employ the power pulse technique (Figures 2 and 3).

Single-session treatment of patients with DVT have been reported using both the Trellis catheter and the power pulse technique. In my experience, a single-session strategy can be successful if the clot is limited to the femoral or popliteal veins with adequate inflow

(Courtesy of Ekos Corporation.)

Figure 2. The EkoSonic endovascular system that uses MicroSonic-accelerated thrombolysis.



(Courtesy of Covidien.)

Figure 3. The Trellis peripheral infusion system for isolated thrombolysis. Mechanical drug dispersion occurs between the two balloons designed to minimize drug loss from the targeted segment.

from patent caudal veins and unobstructed outflow through the iliocaval segments. Involvement of larger venous structures, such as the iliacs and inferior vena cava, often requires the use of adjunctive techniques such as CDT and/or stenting.

Once the acute thrombus is removed, occlusive lesions in the outflow veins need to be treated. A common anatomic impediment to flow is iliac vein compression (eg, May-Thurner syndrome). This is caused by the overriding right iliac artery compressing the underlying vein and leading to stasis of flow. The most commonly affected vein is the left common iliac vein. Other less frequently affected locations include the left external iliac vein, inferior vena cava (just above the confluence of iliac veins), and right common iliac vein. Adherent residual thrombus may also cause flow obstruction.

Stenoses caused by residual chronic clot or synechiae caused by May-Thurner syndrome are hence treated by placing appropriately sized stents. Although the outcomes in central veins have been good, stent designs are not optimized for veins. This is especially true in the common iliac and brachiocephalic veins in which obstructive lesions often extend to the point of confluence of these structures. Additionally, experience with the current generation of metallic stents in the femoral veins below the saphenofemoral junction has been largely disappointing and is not recommended.

CONCLUSION

The toolbox for treating various venous conditions, while improving, remains incomplete. As a stand-alone device, all current PMT catheters fall short of expectation: combination therapies may remove thrombus in a single session in femoral veins but are not as effective in iliocaval segments; available stents are not designed for veins; there are no solutions for chronically occluded larger peripheral veins (femoropopliteal, axillosubclavian); and finally, there is currently no device to restore valve function in peripheral veins.

Despite progress during the past decade, the venous space is in dire need of innovative approaches in all aspects of endovascular care. This includes safer and faster-acting pharmacologic agents, more effective clot removal devices for large veins, more optimized tools for recanalization and maintenance of patency in obstructive lesions, and devices for restoring venous function. ■

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