A New Method for Aggressive Management of Deep Vein Thrombosis: Retrospective Study of the Power Pulse Technique

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Failure to treat deep vein thrombosis (DVT) is associated with significant morbidity and mortality. Anticoagulation, although effective at preventing clot progression, is not able to prevent postthrombotic syndrome. Catheter-directed thrombolysis is a more aggressive alternative, with some small studies suggesting a better long-term outcome, but the associated risks are significant, and the treatment can require 2–3 days in a monitored setting. This report describes the power pulse technique, in which mechanical thrombectomy is combined with thrombolytic agents to maximize the effectiveness of the treatment and reduce the need for prolonged infusion and its associated risks. A 24-patient retrospective study showed complete thrombus removal (>90%) in 12 patients, substantial thrombus removal (50%–90%) in seven patients, and partial thrombus removal (<50%) in five patients. All 24 patients had resolution of presenting symptoms. Only two patients required blood transfusion, and one patient experienced temporary nephropathy.

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Abbreviations: CDT = catheter-directed thrombolysis, DVT = deep vein thrombosis, IVC = inferior vena cava, PTS = postthrombotic syndrome

ALTHOUGH anticoagulation is effective in the treatment of deep vein thrombosis (DVT), it does not prevent postthrombotic syndrome (PTS), the long-term negative side effect of venous damage that consists of pain, swelling, discoloration, and leg ulcers (1). Catheter-directed thrombolysis (CDT) with urokinase or tissue plasminogen activator is a more aggressive alternative and has been reported to be associated with better long-term outcomes, but the use of thrombolytic agents increases the risk of bleeding, and CDT can be a prolonged procedure that requires 2–3 days in a monitored setting (2).

The use of mechanical thrombectomy devices alone or as an adjunct to CDT helps to minimize the risks of thrombolysis and maximize the effectiveness of the treatment; however, as mechanical thrombectomy is currently performed, prolonged lysis may still be necessary. Herein, we describe a new procedure known as the power pulse technique and present a multicenter retrospective study of 24 patients treated for iliofemoral DVT. The power pulse technique is a pharmacomechanical therapy in which the blood clot is bathed in the lytic agent before it is evacuated. Early aggressive therapy with the power pulse technique can be completed within 2–4 hours, and this retrospective review shows it to be equally efficacious and less time-consuming compared with other published techniques, with fewer return trips to the angiography suite. The purpose of this study was to evaluate the safety and efficacy of this method as a viable option for the aggressive management of DVT.

MATERIALS AND METHODS

Study Patients

Between March 2003 and October 2004, 24 patients from six academic and community-based sites with documented acute (<14 days) or subacute (>14 days) iliofemoral and/or inferior vena cava (IVC) DVT were treated with the power pulse technique. Patients were identified from a registry maintained by the departments of vascular and interventional radiology at the participating institutions. All identified patients were included in the study. The investigation was approved by the institutional review boards of each of the participating medical centers.

The study included 16 men and eight women (**Table 1**). Informed consent was obtained from each patient after discussion of risks and benefits

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Table 1
Patient Demographics (*N* = 24)

Demographic Category	Value
Sex	
Male	16
Female	8
Mean age ± SD, range (y)	43 (16–86)
IVC filter use	
None	5
Preexisting	9
Second retrievable filter placed and removed	1
Filter placed before Power Pulse treatment	8
Filter placed after Power Pulse treatment	1
Mean procedure time, range (h)	3.25 (1.75–6.5)

associated with thrombolysis of DVT and the off-label use of mechanical thrombectomy devices. The age range of those treated was 16–86 years (mean age, 43 y). All 24 patients had severe leg swelling, and three patients presented with phlegmasia cerulea dolens. Twenty patients had acute DVT, and four had subacute DVT. All 24 patients had thrombosis of at least one iliac vein. Fifteen of the patients had extension into the IVC, and nine patients had involvement of the popliteal or infrapopliteal vessels. Ten patients had preexisting IVC filters, and nine had undergone placement of filters before the procedure. IVC filters were not present in five cases. One patient had a filter placed after the intervention. One of the patients with a preexisting filter had a second retrievable filter placed that was removed after the procedure was concluded. Four patients had medical histories that excluded them from typical venous lysis procedures, including one patient each with gastrointestinal bleeding and postpartum bleeding and two with recent surgical procedures.

The Power Pulse Technique

The power pulse technique has been previously described for use in peripheral arterial and portal venous occlusion (3,4). The technique is described here as a method to aggressively treat DVT.

The power pulse technique requires an AngioJet rheolytic thrombectomy system (Possis Medical, Minneapolis, MN). It consists of an Xpeedior catheter (0.035-inch guide wire compatible), a pump set, and a drive unit (**Fig 1**). In the usual thrombectomy mode, the pump set and drive unit produce a high-velocity saline solution jet that is directed backward from the tip of the device to outflow channels to produce a zone of low pressure (−1 atm) at the catheter tip. The low-pressure environment causes fragmentation and aspiration of the clot through the effluent lumen.

Ultrasound (US) guidance was used during vascular access. The ipsilateral popliteal vein was punctured while the patient was prone, or, if the common femoral vein was confirmed patent by US, common femoral vein puncture was performed with the patient in a supine position. A 4-F or 5-F micropuncture set was typically used for initial access. After diagnostic venography was performed, the 4-F micropuncture catheter was exchanged for a 6-F sheath. A 0.035-inch guide wire was then used to cross the thrombus and advanced into the IVC. The 6-F Xpeedior catheter was advanced over the 0.035-inch guide wire into the thrombus. The AngioJet was set up in the usual fashion but with the return port closed on the catheter with a stopcock. Closure of the return port of the AngioJet catheter enabled a powerful spray of diluted lytic agent (10-20 mg of alteplase [Genentech, South San Francisco, CA] or 250,000–500,000 U of urokinase [Abbott Laboratories, North Chicago, IL] in 50–100 mL of saline solution depending on the length of thrombus being treated) to be injected in an antegrade and retrograde direction with each 0.6-mL pulse of the AngioJet catheter at 1-mm increments throughout the length of the clot. When the entire dose was administered, the lytic agent was allowed to bathe and soften the clot for 20–45 minutes. The AngioJet catheter was reintroduced with its return port open. With outflow restored, the AngioJet device was used in its usual thrombectomy mode to further disrupt and evacuate thrombus. Repeat venography was performed to assess extent of thrombus removal. Additional AngioJet thrombectomy was then performed in areas of residual clot.

At the time of the procedure, the interventionalist performed adjunctive measures as indicated, which included CDT if there was residual clot and balloon angioplasty and/or stent placement. When CDT was used, the total duration of thrombolysis and amount of thrombolytic agent used were recorded. Some of the patients had preexisting IVC filters at the time of the procedure. At the discretion of the interventionalist, some other patients without preexisting filters had a filter placed. Systemic heparin was also administered during and/or after the procedure.

Pre- and postprocedural laboratory values were also recorded for all patients. These values included hemoglobin and hematocrit, blood urea nitrogen, and creatinine levels, and activated partial thromboplastin time. After the procedure, patients were cared for in a standard inpatient ward or an intensive care or "step-down" unit, depending on whether CDT was administered. Patients were discharged with an oral anticoagulation regimen for at least 6 months.

Data Collection

Medical records, radiology reports, procedural data, and venograms were reviewed for all patients in the study. The extent and cause of DVT, endovascular treatment modalities used, procedural time, total thrombolytic agent dose, venographic and clinical success, complications, and other data were recorded in detailed case report forms. Complications were classified as major or minor according to the Society of Interventional Radiology reporting standards. Specifically, intracranial bleeding or bleeding resulting in death, transfusion, surgery, or cessation of thrombolytic therapy was