

# Aspiration Thrombectomy Using a Guiding Catheter in Acute Lower Extremity Deep Vein Thrombosis: Usefulness of the Calf-Squeeze Technique<sup>1</sup>

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**Purpose:** The effectiveness of the calf-squeeze technique during aspiration thrombectomy using guiding catheter in the treatment of an acute lower extremity deep vein thrombosis (DVT) was evaluated by the use of imaging and the clinical follow-up of patients.

**Materials and Methods:** A prospective analysis of ten patients (seven women, three men; median age, 56.9 years) with common iliac vein (CIV) obstruction and ipsilateral DVT was performed for this study. All patients presented with leg edema or pain and were treated with catheter-directed thrombolysis via an ipsilateral popliteal vein approach after insertion of a temporary inferior vena cava (IVC) filter. Subsequently, the patients were treated with by aspiration thrombectomy using a guiding catheter to remove the residual thrombus. The calf-squeeze technique during aspiration thrombectomy can be used to induce the proximal migration of thrombi in the popliteal, tibial, and muscular veins were used to increase venous flow.

**Results:** The calf-squeeze technique was employed at mean of 1.3 times (range, 1-3 times). All patients showed proximal migration of a popliteal and muscular vein thrombus during the execution of the calf-squeeze technique. Successful recanalization was achieved in all patients (100%) without any complications. On duplex ultrasonography, which was performed immediately after the aspiration thrombectomy, four patients had a residual thrombus in the soleal muscular veins. However, none of the patients had a thrombus in the popliteal and tibial veins; and, during follow-up, no DVT recurred in any patient.

**Conclusion:** The use of the calf-squeeze technique during aspiration thrombectomy after catheter-directed thrombolysis can induce the proximal migration of thrombi in the popliteal and muscular veins and is an effective method that can remove a thrombus in calf veins.

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Acute deep vein thrombosis (DVT) can result from common iliac vein (CIV) stenosis or occlusion. Aggressive treatments have been proposed to alleviate pain, as well as avoid residual swelling and venous ulceration (1-4). Most patients with acute DVT have extensive thrombosis in the popliteal vein and calf muscular veins, as depicted on contrast-enhanced computed tomography (CT). Treatment strategies for DVT include systemic thrombolytic therapy, surgical thrombectomy, catheter-directed thrombolysis (CDT) and percutaneous mechanical thrombectomy (PMT) (4-11). Recently, the use of thrombolytic therapy and PMT can result in the rapid reduction of the thrombus burden and potentially preserve venous valvular function as well as prevent postthrombotic syndrome (8-11). Percutaneous access to the thrombosed vessel for CDT and PMT can be achieved through popliteal vein access (4-11). Therefore, a venous thrombus below the popliteal vein access can remain after treatment. Some studies have attempted treatments such as retrograde CDT, contralateral CDT, and CDT through posterior tibial vein access for a thrombus located below the popliteal vein (6, 12, 13).

The purpose of the present study was to use imaging and clinical follow-up of patients to evaluate the effectiveness of the use of the calf-squeeze technique during PMT in the treatment of an acute DVT.

## Materials and Methods

### Patients

Ten consecutive patients (7 male, 3 female; mean age 56.9 yrs; age range 35-72 yrs) with acute ipsilateral DVT were included in this study that took place between January 2007 and January 2008. The mean duration of DVT symptoms was 3.8 days (range, 2-6 days). The institutional review board of our university and the ethics committee of the Institute of Medical Science approved this study. The procedure was explained in detail to all patients, and informed consent was obtained prior to performing the procedure.

Patients were included in the prospective study if they had documented CT confirmation of an acute DVT affecting the iliofemoral, popliteal, and calf muscular veins and common iliac vein obstruction. All patients presented with leg edema and pain.

Exclusion criteria for thrombolysis included the presence of an isolated infrapopliteal thrombus, DVT with a duration of more than seven days (beyond this duration threshold, the condition is considered to be subacute),

and any contraindications for the use of anticoagulation therapy, contrast media, or thrombolytic agents. Contraindications for thrombolytic agents include active internal bleeding, a recent cerebrovascular accident, allergy to thrombolytic agents and coagulopathy.

### **Endovascular Procedure: IVC filter, Thrombolysis, and Thrombectomy**

To prevent a pulmonary thromboembolism (PTE) during or after thrombolysis and thrombectomy, an inferior vena cava (IVC) filter (OptEase; Cordis, Roden, The Netherlands) was placed in the IVC in all patients via a contralateral femoral approach. The attending physician made the retrieval decision in each individual case.

Percutaneous access to the thrombosed vessel was achieved via popliteal vein access. A 7-F vascular sheath (Cook, Bloomington, IN, USA) was inserted, through which all subsequent catheter and wire exchanges were performed. An ascending venography was performed using nonionic contrast material (320 mg/mL).

The infusion was performed using a 5-F multiple-side hole catheter system (65-100 cm whole catheter system, 10-15 cm infusion length; Boston Scientific, Watertown, MA, USA). The catheter was placed two-thirds of the distance into the thrombosed venous segment, and urokinase (Green Cross, Yongin, Korea) was administered continuously overnight at 30,000-60,000 U/h (1000-2000 U/kg/h) in split doses. One-third of the drug was administered through the 7-F vascular sheath and two-thirds of the drug was administered through the infusion catheter.

The thrombin and partial thromboplastin times were obtained every 4 hours after the initiation of thrombolytic therapy. Clauss fibrinogen level, hemoglobin level, hematocrit, and platelet counts were measured every 6 hours. If the Clauss fibrinogen level decreased to less than 100 mg/dL, fresh frozen plasma or cryoprecipitate was administered until the level was brought up to 150 mg/dL. If a patient had gum bleeding, thrombolytic therapy was temporally stopped and restarted when the patient required additional thrombolysis. After securing the catheters in place, patients were transferred to a standard inpatient hospital ward. Repeated venography was performed at 6-15 hours intervals. Aspiration thrombectomy using guiding catheter in patients with residual thrombi after follow-up venography was performed with the use of an 8-F guiding catheter (Cordis) via a 10-F introducer sheath. Fresh and resolving thrombi after thrombolysis were

easily removed with the use of a aspiration thrombectomy catheter. The aspiration catheter was usually inserted through a guide wire to prevent venous rupture. Aspirated thrombi contained fresh thrombi and white thrombi.

**The Calf-Squeeze Technique**

A venogram after aspiration thrombectomy was performed. If residual thrombi in the iliofemoral and popliteal segment were not present after aspiration thrombectomy, the vascular sheath after insertion of the guide wire was removed. A manual squeeze of the calf muscle was performed for migration of residual thrombi in the popliteal and muscular veins. If a venogram after calf-squeeze showed migration of residual thrombi, a repeated aspiration thrombectomy was performed. On ultrasonography of calf muscular veins or tibial veins, if there was remaining residual thrombus, the calf-squeeze repeated. If there is no apparent residual thrombus in the calf veins on ultrasonography, the procedure was stopped.

**Endovascular Procedure: Stent Deployment**

Subsequent to the follow-up venography after thrombolysis and aspiration thrombectomy, an angioplasty was performed whereby stents were inserted via the same route, assuming no evidence of fresh thrombi in the deep vein. After angioplasty, when the venography showed persistent stenosis in the common iliac vein, the lesion was treated by deployment of a self-expandable stent (SMART control; Cordis, Miami Lakes, FL, USA) with a diameter of 12-14 mm and length of 60-80 mm. Deployed stents were fully expanded with the use of an angioplasty balloon of an appropriate diameter. After

endovascular therapy, anticoagulation therapy with sodium warfarin was initiated and continued for six months. Therapy was adjusted to attain an International National Ratio (INR) in the range of 2.0-3.0.

**Follow-up and Complications**

All patients underwent a color Doppler ultrasonography (US) examination to detect the presence of thrombi in the popliteal and muscular veins before and after the use of the calf-squeeze technique. In addition, all patients underwent a color Doppler US examination of the areas of the original DVT and contrast-enhanced chest CT for evaluation for a PTE and the IVC filter after the procedure one or two days later. Patients were followed up by clinic visits, and stent patency and recurrence of DVT were assessed by color Doppler US performed at 1, 3, 6, and 12 months after the procedure.

Minor complications were defined as those with no significant clinical sequelae and requiring minimal therapy, such as a local puncture site hematoma that did not require transfusion or other therapy. Major complications were defined as those that necessitated a specific therapy and increased level of care, or resulted in a permanent adverse event such as a symptomatic PTE or systemic bleeding requiring specific therapy, including a transfusion.

**Results**

Results are shown in Table 1. Causes of DVT and common iliac vein obstruction were May-Thurner syndrome in all patients and the lesion was left-sided in all patients. In addition, all patients had a thrombus running from the popliteal and calf muscular vein to the

Table 1. Clinical Data and Results of 10 Patients

No.	Sex	Age (Years)	Symptom Duration (Days)	Obstruction of CIV	Site	Urokinase Infusion (IU)	Aspiration Thrombectomy	No. of Calf Squeeze	Stent	Residual Thrombi on US after Procedure	Thrombus in the IVC Filter after Procedure
1	F	82	2	+	Left	None	+	1	+	None	-
2	M	72	3	+	Left	600000	+	1	+	Soleal	-
3	M	45	3	+	Left	500000	+	3	+	Soleal	-
4	M	56	6	+	Left	500000	+	1	+	None	-
5	M	62	4	+	Left	500000	+	1	+	Soleal	-
6	F	49	2	+	Left	800000	+	1	+	Soleal	-
7	M	52	3	+	Left	800000	+	1	+	None	-
8	M	35	4	+	Left	600000	+	1	+	None	-
9	F	55	5	+	Left	600000	+	1	+	None	-
10	M	61	6	+	Left	500000	+	2	+	None	-

Note.— CIV = common iliac vein

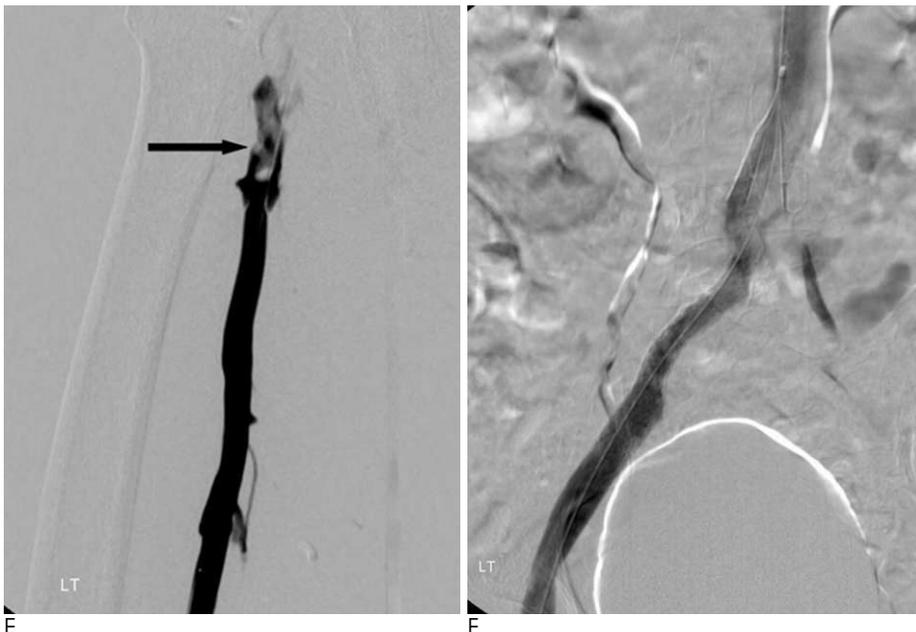
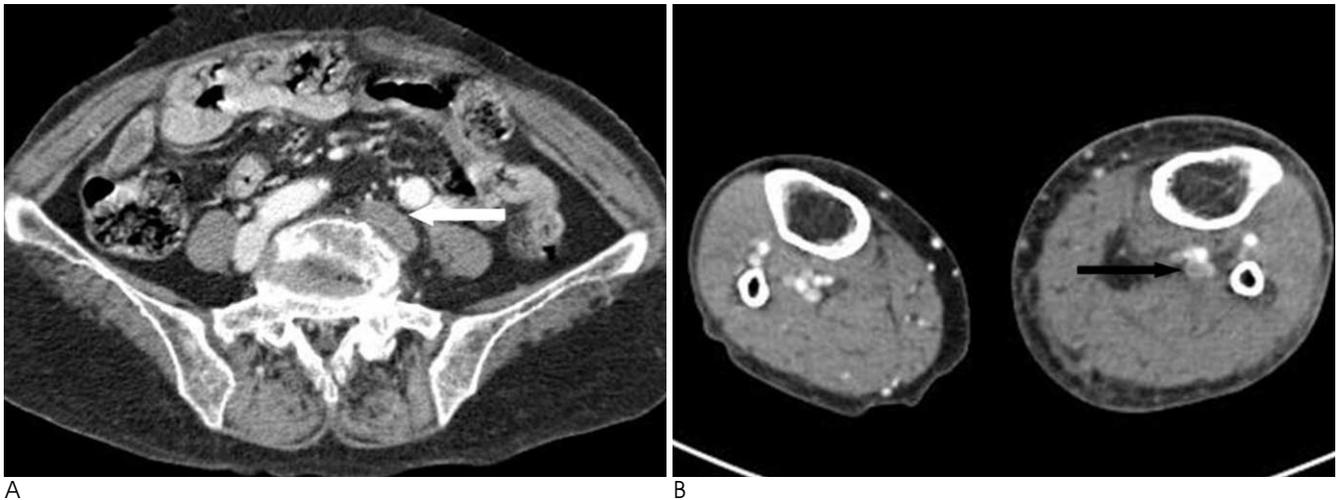


Fig. 1. Images from an 82-year-old woman with acute left leg swelling. A, B. A contrast-enhanced CT scan shows the acute thrombus (arrow) from the common iliac veins (A) to the popliteal vein (B) and the tibial veins. C. Ascending venography in the prone position extensively shows an acute thrombus in the left leg veins. D. After deployment of an IVC filter, aspiration thrombectomy using an 8-F guiding catheter shows good patency of the left leg veins with no evidence of thrombi in the femoral vein and iliac veins. E. After removing the sheath with the inserted guide wire, a manual squeeze of the calf muscle is performed. Venography shows the migrated thrombus in the superficial femoral vein (arrow). A repeated aspiration thrombectomy is performed. F. A final direct venography shows good patency of the left common iliac vein after insertion of a 14-mm by 80-mm self-expandable stent and no evidence of thrombi in the entire vein.

common iliac vein.

Urokinase infusion was performed in nine patients with a dose of 500,000–800,000 IU (mean, 600,000 IU). The duration of urokinase infusions was 5–14 hours (mean, 11 hours) in eight patients with overnight infusion and in one patient without overnight infusion. One patient did undergo direct aspiration thrombectomy using a guiding catheter without UK infusions due to old-age and poor general condition.

Aspiration thrombectomy using a guiding catheter, was performed in all patients, including one patient where the procedure was performed without thrombolysis. Thrombus located above the access of the popliteal vein was successfully removed using a catheter in all patients during aspiration thrombectomy (Fig. 1).

The mean frequency of the calf-squeeze technique was 1.3 times (range, 1–3 times). All patients showed proximal migration of the popliteal and muscular vein

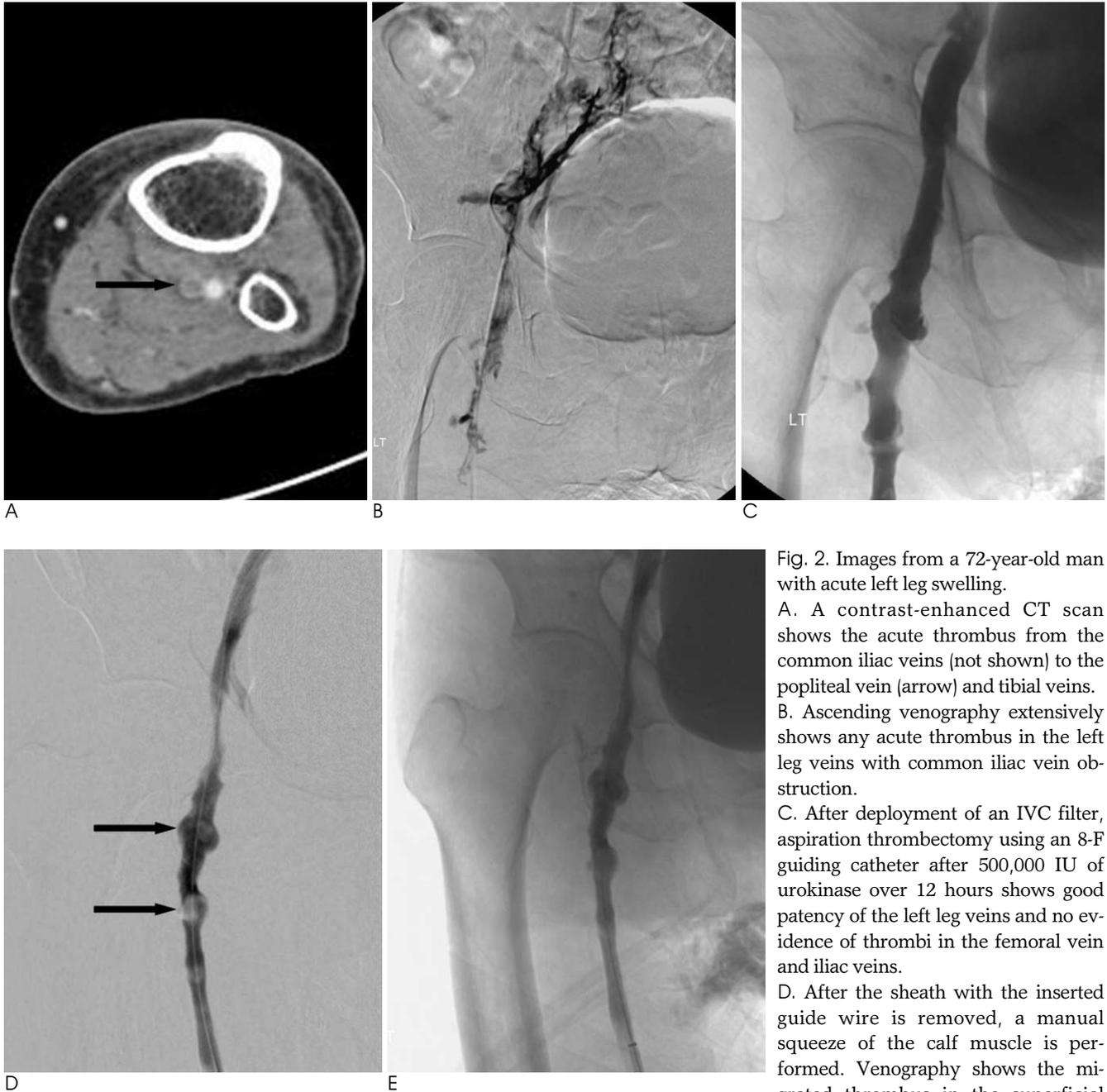


Fig. 2. Images from a 72-year-old man with acute left leg swelling. A. A contrast-enhanced CT scan shows the acute thrombus from the common iliac veins (not shown) to the popliteal vein (arrow) and tibial veins. B. Ascending venography extensively shows any acute thrombus in the left leg veins with common iliac vein obstruction. C. After deployment of an IVC filter, aspiration thrombectomy using an 8-F guiding catheter after 500,000 IU of urokinase over 12 hours shows good patency of the left leg veins and no evidence of thrombi in the femoral vein and iliac veins. D. After the sheath with the inserted guide wire is removed, a manual squeeze of the calf muscle is performed. Venography shows the migrated thrombus in the superficial femoral vein (arrows). A repeated aspiration thrombectomy is performed. E. Final direct venography shows good patency of the left common iliac vein after insertion of a 14-mm by 80-mm self-expandable stent (not shown) and no evidence of thrombi in the entire vein.

A repeated aspiration thrombectomy is performed. E. Final direct venography shows good patency of the left common iliac vein after insertion of a 14-mm by 80-mm self-expandable stent (not shown) and no evidence of thrombi in the entire vein.

thrombi during use of the calf-squeeze technique. On US that were immediately performed after the calf-squeeze, four patients had a residual thrombus in the soleal muscular veins (Fig. 2) and in six patients, a thrombus was not seen in the popliteal and muscular veins.

Successful recanalization and clinical success was achieved in all patients (100%) without complications. A self-expandable stent in all patients were deployed into the stenosis of the common iliac vein after thrombolysis and aspiration thrombectomy. On contrast-enhanced chest CT that was performed after the procedure one or two days later, no thrombus was seen in the IVC filter and pulmonary artery (Fig. 2). Also, all patients did not show into the lower extremity portion of the femoral vein, and four patients had a residual thrombus in the soleal muscular veins on ultrasonography, one or two days later.

The clinical follow-up period was 1–12 months (mean, 6.5 months). For four patients with a thrombus in the soleal muscular veins depicted on US performed immediately after the calf-squeeze technique, three patients did not show the presence of any thrombus in the muscular veins. The fourth patient had chronic thrombi and collapse of the soleal vein. A follow-up Doppler US examination showed intimal thickening without flow limitation in one patient. All patients had no recurrent DVT and valvular insufficiency for the valsalva maneuver.

## Discussion

Nonsurgical treatment of an extensive iliofemoral DVT caused by May-Thurner syndrome is performed by CDT, mechanical thrombectomy with the use of a catheter and device, balloon dilatation, and stent deployment (4–11, 14–17).

CDT has been effective in the treatment of an iliofemoral DVT (3–5, 18), but several disadvantages inherent with this treatment have limited its widespread acceptance (6, 19, 20). First, complications have been recorded in as many as 25% of patients in a single-center series and in 11% of patients in a multicenter venous registry study (6, 19–21). Second, most patients require admission to a monitoring bed and have indwelling venous sheaths for 1–3 days. Finally, the cost of providing a monitoring bed, thrombolytic infusions, multiple venogram procedures, and laboratory studies is considerable.

A mechanical thrombectomy not only physically mac-

erates the thrombus; it also exposes greater portions of the thrombus to the thrombolytic agent (22). Several studies have reported that CDT with PMT was associated with a reduction in treatment duration and total lytic agent dose when compared with the use of CDT alone, and does so with equivalent safety and efficacy (8–11). Vedantham *et al.* (11) demonstrated a procedural success rate of 82% as well as a reduced thrombolytic agent dose requirement and infusion times compared with previously published series of patients treated with CDT alone. Kim *et al.* (9) reported that CDT with rheolytic PMT was associated with a 46% reduction in treatment duration and a 56% reduction in the total lytic agent dose compared to the use of urokinase CDT alone.

A thrombus can be cleared during mechanical thrombectomy with a catheter by using thrombolysis with transcatheter aspiration (8, 23). The potential disadvantages of mechanical thrombectomy are theoretically increased risks of pulmonary embolism and venous valvular damage. In an animal study, the Amplatz mechanical thrombectomy device did not cause physiologically significant damage to valves 7 mm or larger in diameter (24). Also, an 8-F sheath dilator did not injure venous structures with a mean diameter of  $5.5 \pm 0.6$  mm (24). In our study, we performed aspiration thrombectomy with 8.0-F guiding catheters after thrombolysis instead of a mechanical thrombectomy with a device. All patients can remove the thrombus in veins of the lower extremity by aspiration thrombectomy using a guiding catheter.

Thrombi within in the femoropopliteal veins (above knee), and less often those limited to the calf veins (below knee), are more likely to cause pulmonary emboli (25). Proximal spread from thrombi residing in the calf veins is thought to occur in 20% of cases. In our study, we performed the calf-squeeze technique for migration of residual thrombi in the popliteal and muscular veins. If the venogram after the calf-squeeze showed migration of residual thrombi, a repeated aspiration thrombectomy was performed. Migration of residual thrombi occurred in all patients after employment of the calf-squeeze technique. For US that was performed immediately after calf-squeeze, four patients had a residual thrombus in the soleal muscular veins and six patients did not show a thrombus in the popliteal and muscular veins. Patients with migrated thrombi underwent a repeated aspiration thrombectomy. Some studies have used treatments such as retrograde CDT, contralateral CDT, and CDT via the posterior tibial vein access for a

thrombus below the popliteal vein (6, 12, 13). Retrograde passage of a catheter-guide wire infusion system caused minimal to no damage to the venous valves in experimental models (12). However, repeated mechanical thrombectomy can cause injury to the venous valves due to the use of a large device system. Contralateral CDT and PMT for the treatment of a below the knee DVT cannot be applied, as our case, in patients with CIV obstruction. In addition, an approach via the posterior tibial vein cannot be performed with a mechanical thrombectomy using a device or an 8-F guiding catheter due to a small vessel size. Calf-squeeze for the treatment of a below the knee DVT is a simple technique and can remove residual thrombi below the knee after CDT and PMT.

Treatment of common iliac vein obstruction caused by May-Thurner syndrome involves stent deployment after CDT or PMT (5-8, 17). The one-year patency rate with acute symptoms for patients who have received stents is above 90% (5-8). In our study, patients had good stent patency in the common iliac vein and no evidence of thrombi in the pulmonary artery, based on an immediately performed follow-up chest CT. The patients were in good health and showed no evidence of DVT recurrence after clinical follow-up. In our study, a self-expandable stent in all patients were deployed into the stenosis of the common iliac vein after thrombolysis and aspiration thrombectomy.

This study has some limitations. First, we had a relatively small study population. Studies with a larger group of patients are needed to firmly establish the protocol. Second, we did not report the risks of a pulmonary embolism occurring for a DVT in the popliteal veins and muscular veins below the access of the popliteal vein after CDT and PMT. However, remaining thrombi in the popliteal veins and muscular veins after CDT and PMT can occur in a pulmonary embolism (25). Therefore, the simple calf squeeze technique can remove residual thrombi and decrease the risk of another pulmonary embolism.

In conclusion, endovascular management included stent deployment after CDT and PMT, with the use of a guiding catheter in patients with May-Thurner syndrome. With this in mind, extensive iliofemoral DVT is an effective method for the restoration of venous patency and relief of acute symptoms. Furthermore, the use of the calf-squeeze technique during aspiration thrombectomy after catheter-directed thrombolysis can induce proximal migration of a popliteal and muscu-

lar vein thrombus and is an effective method that can remove a thrombus in calf veins. Further randomized studies are needed to confirm these promising results.

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## 급성하지정맥혈전증에서 유도카테터를 이용한 흡입제거술: 종아리 압박술의 유용성<sup>1</sup>

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**목적:** 급성 하지 심부정맥혈전증 환자의 치료에서 유도카테터-흡인혈전제거술시 장딴지 압박술의 효과에 대해 알아보고자 하였다.

**대상과 방법:** 엉덩정맥의 폐쇄와 동측의 심부정맥혈전증이 있는 환자 10명을 대상으로 전향적 분석을 시행하였다. 모든 환자는 하지부종과 통증을 호소하였으며 하대정맥 필터를 삽입 후 동측 슬와 정맥을 통한 카테터-혈전용해술로 치료하였다. 그 다음에 유도카테터를 이용한 흡인혈전제거술로 남아 있는 혈전을 제거하였다. 장딴지 압박술은 흡인혈전제거술을 하는 동안 오금정맥, 정강정맥, 근육 내 정맥의 혈전의 근위부로의 이동을 유도하고, 정맥혈류를 증가시키기 위해 사용하였다.

**결과:** 평균 장딴지 압박술을 한 횟수는 1.3회(1-3)였다. 모든 환자에서 장딴지 압박술을 하는 동안 오금정맥과 근육 내 정맥의 혈전이 근위부로 이동하는 것을 볼 수 있었다. 모든 환자에서 성공적인 재개통을 보였으며 합병증은 없었다. 흡인혈전제거술 후 즉시 시행한 도플러 초음파에서 4명의 환자에서 가자미근내 정맥에 남아 있는 혈전이 있었다. 그러나 슬와정맥과 경골정맥에 혈전이 남아 있는 환자는 없었다. 추적관찰 기간 동안 심부정맥혈전증의 재발은 없었다.

**결론:** 카테터-직접 혈전용해술 후 흡인혈전제거술을 하는 동안 장딴지 압박술을 이용하는 것은 슬와정맥과 근육 내 정맥의 혈전의 근위부 이동을 유도하며 장딴지 정맥 혈전 제거의 효과적인 방법이다.