Determinants of Early and Long-term Efficacy of Catheter-directed Thrombolysis in Proximal Deep Vein Thrombosis

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ABSTRACT

Purpose: Catheter-directed thrombolysis (CDT) for proximal deep vein thrombosis (DVT) effectively enhances clot removal and recently has been shown to reduce the development of postthrombotic syndrome (PTS). This study was performed to identify potential markers for early and long-term efficacy of CDT, adverse events, and their interrelationship.

Materials and Methods: Patients aged 18–75 years (mean, 54 y; 33 women) with first-time proximal DVT and symptoms up to 21 days were included in subanalyses in an open, multicenter, randomized, controlled trial. Early efficacy was assessed with a thrombus score based on daily venography. Six-month and 2-year follow-up included iliofemoral patency assessed with duplex ultrasound and air plethysmography, and PTS was assessed with the Villalta scale.

Results: A mean clot resolution of 82% ± 25 was achieved in 92 patients. Successful lysis (ie, ≥ 50%) was obtained in 83 patients. Early efficacy was equal for femoral and iliofemoral thrombus and not related to thrombus load before CDT, symptom duration, or predisposing risk factors. Lower thrombus score at completion of CDT was associated with increased patency at 24 months (P = .040), and increased patency after 6 and 24 months was correlated with reduced development of PTS after 24 months (P < .001). Bleeding complications were mainly related to the puncture site, and popliteal vein access led to fewer bleeding incidents.

Conclusions: CDT via popliteal access was safe, effectively removed clots, and restored iliofemoral patency. Preprocedure evaluation did not identify patients who did not benefit from treatment. Early efficacy and follow-up patency are of importance to reduce the risk for PTS.

ABBREVIATIONS

CDT = catheter-directed thrombolysis, DVT = deep vein thrombosis, PTS = postthrombotic syndrome

Acute deep vein thrombosis (DVT) of the lower limb is a common disease associated with increased mortality and substantial morbidity (1), with an estimated annual incidence of approximately 1 in 1,000 (2). Current guidelines recommend anticoagulant therapy and use of elastic compression stockings to prevent postthrombotic syndrome (PTS) (3). Despite adequate anticoagulation, which reduces thrombus propagation, embolization, and recurrence, PTS develops in 20%–50% of patients following a proximal DVT—ie, DVT localized in the popliteal vein and above (4)—with approximately 5%–10% of cases being severe. Recent clinical studies suggest that compression therapy may reduce the rate of PTS by approximately 50% (5,6), which substantiates the importance of such preventive measures.

PTS evolves from residual venous obstruction caused by incomplete thrombus resolution causing impaired venous return and/or venous insufficiency caused by destruction of
Informed consent was obtained, patients were randomized to criteria have been published elsewhere (14). After written 2 years were excluded. Complete inclusion and exclusion with increased risk of bleeding or life expectancy shorter than study reported by Enden et al (14), which was the first expense of an increased risk of complications (15,16). Thrombus removal and shorten treatment time, possibly at thrombectomy and pharmacomechanical thrombolysis may further enhance are matters of debate. Contemporary venous thrombectomy and adjunctive angioplasty, and total CDT treatment time predefined variables, whereas choice of venous puncture factors, symptom duration, and thrombus extension are lying factors that need to be investigated further; including an intravenous multiple–side hole perfusion catheter. Fibrinolytic drug is delivered directly into the thrombus via invasive percutaneous thrombolytic technique whereby a catheter-directed thrombolysis (CDT), has been introduced to accelerate thrombus removal. The original CDT procedure is a minimally removal. The overall benefit of CDT depends on various underly- ing factors that need to be investigated further; including patient selection and technical approach. Predisposing risk factors, symptom duration, and thrombus extension are predefined variables, whereas choice of venous puncture site, adjunctive angioplasty, and total CDT treatment time are matters of debate. Contemporary venous thrombectomy and pharmacomechanical thrombolysis may further enhance thrombus removal and shorten treatment time, possibly at the expense of an increased risk of complications (15,16).

In the present report, we investigate baseline characteristics and technical aspects to identify potential markers for the early and long-term efficacy of CDT, adverse events, and their interrelationship.

MATERIALS AND METHODS

Study Participants
Patients aged 18–75 years with duration of symptoms up to 21 days and a first-time objectively verified ilio- femoral or proximal femoral DVT (17) above midthigh level were recruited from 20 hospitals within the Norwegian Southeastern Health Region as part of the Norwegian Catheter-directed Venous Thrombolysis study (14). Patients with increased risk of bleeding or life expectancy shorter than 2 years were excluded. Complete inclusion and exclusion criteria have been published elsewhere (14). After written informed consent was obtained, patients were randomized to receive standard treatment alone or CDT in addition to standard treatment. The study is registered at clinical- trials.gov with unique identifier NCT00251771; was approved by the Regional Committee for Medical and Health Research Ethics (counterpart of an institutional review board), the Norwegian Medicines Agency, and the Norwegian Data Protecorate; and adhered to the principles outlined in the Declaration of Helsinki.

Procedures
The DVT diagnosis was verified by ultrasound (US) or, if inconclusive, by supplementary venography or computed tomographic (CT) venography. In accordance with local routines based on international guidelines, anticoagulant treatment was initiated the same day with the use of low molecular weight heparin (18). CDT was initiated on the subsequent working day, and low molecular weight heparin therapy was discontinued at least 8 hours before the procedure. A bolus dose of 5,000 IU unfractionated heparin was given at the start of the procedure, followed by an infusion of unfractionated heparin (15 U/kg/h) adjusted to keep activated partial thromboplastin time (Cephotest; Axis-Shield, Oslo, Norway) at 1.2–1.7 times prolongation, ie, 40–60 seconds.

The procedure was performed with the patient in the prone position on the angiography table. After local anesthesia was obtained, a 6-F introducer sheath was inserted into, preferably, the popliteal vein of the affected leg. US guidance was used for all punctures. Other optional puncture sites were the ipsilateral posterior tibial vein and the ipsi- or contralateral femoral vein. The anatomy and the complete extension of the thrombus were then visualized on venography. An appropriate-length perfusion catheter (Uni*Fuse infusion catheter; AngioDynamics, Latham, New York) was inserted with the multiple side holes covering 10–50 cm depending on the length of the thrombotic segments. Catheter-directed infusion of alteplase (Actilyse; Boehringer-Ingelheim, Ingelheim am Rhein, Germany) was then established. Alteplase 20 mg in 500 mL 0.9% NaCl was administered at a steady infusion rate of 0.01 mg/kg/h, with a maximum dose of 20 mg per 24 hours (corresponding to a maximum of 0.83 mg/h) and a non–weight-adjusted dose of 20 mg alteplase per 24 hours for patients larger than 83 kg. The infusion was only briefly discontinued during daily venography performed to monitor the progress of thrombolysis. The thrombolytic agent was given until complete lysis was achieved or venography showed no further improvement, with a maximum duration of 96 hours. Patients were confined to bed during the thrombolytic infusion and monitored in a hematologic ward (13). A thrombectomy device was used in only one patient. Adjunctive balloon angioplasty and insertion of stents were performed at the discretion of the operator to obtain flow and stenosis of less than 50%. No antiplatelet therapy was given. After CDT, all patients received standard therapy with oral anticoagulation for at least 6 months and were
Outcome and Safety
A total thrombus score was calculated before, during, and at the completion of CDT by adding the scores for the following seven vein segments: inferior vena cava, common iliac vein, external iliac vein, common femoral vein, proximal and distal segments of femoral vein, and popliteal vein. Scores were 0 when the vein was patent and completely free of thrombus, 1 in case of a partially occluded vein, and 2 in case of a completely occluded vein, ie, vein lumen totally filled with thrombotic material. Each segment was given a score, resulting in possible total thrombus scores of 0–14(9).

The early efficacy of CDT was defined based on postlysis thrombus score and clot lysis grade at the end of the procedure. Lysis grade was calculated by dividing the difference of the total pre- and postlysis thrombus scores by the prelysis score, resulting in a grade III indicating 100% lysis with no residual clots, a grade II indicating 50%–99% lysis, and a grade I indicating less than 50% lysis. Lysis grades II and III (ie, ≥50%) were considered successful outcomes.

The safety outcomes included complications related to thrombolysis during or shortly after the CDT procedure. Bleeding complications were categorized as major if they led to a hemoglobin decrease of at least 2 g/dL; required transfusion of at least 2 U of packed red blood cells; were retroperitoneal, intracranial, or in a critical organ; or contributed to death. Clinically relevant nonmajor bleeding included, for example, intervention for epistaxis, a visible large hematoma, or spontaneous macroscopic hematuria. All other hemorrhages were categorized as trivial (19).

At follow-up after 6 and 24 months, the venous system, including the iliac, femoral, and popliteal veins, was examined with duplex US and air plethysmography. Iliofemoral patency was defined as regained when the following findings were present: flow in the pelvic and femoral vein, compressibility of the femoral vein, and no functional venous obstruction at any level (20). PTS was considered successful outcomes.

Statistical Analysis
Continuous data are presented as means ± standard deviation or median with interquartile range as appropriate. When assessing correlation between pre- and postprocedural findings and procedure-related variables, significance for dichotomous categoric variables was tested with a $\chi^2$ test reporting linear-by-linear significance, and the Spearman correlation coefficient was used for continuous or categorically ranked data. When comparing nonnormally distributed continuous variables, a two-sided Mann–Whitney or Kruskal–Wallis test was used. All statistical tests were two-sided, and a 5% significance level was used. All statistical analyses were performed by using the SPSS statistical package (version 18.0; SPSS, Chicago, Illinois).

RESULTS
The present report includes the 92 patients who received CDT procedures after allocation to the CDT arm in the Norwegian Catheter-directed Venous Thrombolysis Study (14). Mean age was 54 years ± 16 (range, 20–76 y), and 33 patients (36%) were female. The median duration of symptoms before thrombolysis was 5 days (interquartile range, 3–7 d), and the mean time from inclusion in the study to initiation of the CDT procedure was 1.4 days ± 1.3. At least one transient, permanent, or inherited risk factor for venous thrombosis was reported in 72 patients (78%), with transient risk factors being more common among women (81.8%) than men (25.4%). Inherited thrombophilia was present in 37 patients (40%), four of whom had a combination of two thrombophilic factors. These risk factors were more common among women than men ($P = .001$); 97.0% versus 67.8%. Other baseline characteristics have been published previously (14).

Procedural findings are presented in Table 2. The preferred puncture site, ie, the popliteal vein, was successfully used for venous access in 71 patients (77%), and was partially or totally occluded in 48 of cases (67.6%). The perfusion catheters had a mean coverage of 35.9 cm ± 12.9, and a 50-cm perfusion catheter was most commonly used (in 41.1% of patients). A mechanical thrombectomy device combined with a vena cava filter was
used in one patient with thrombus extending to the renal veins judged as potentially life-threatening.

Adjunctive angioplasty was performed in 40 patients (44.4%). Dilation with a balloon only was performed in 24 patients (26.7%); 16 were in the femoral vein. Wallstents (average diameter, 15.7 mm [range, 12–18 mm]; Boston Scientific, Natick, Massachusetts) were inserted in the iliac veins of 16 patients (17.8%). Stents were inserted in women more often than men ($P = .015$): 10 (30.3%) versus six (10.2%). Left-sided DVT extended more often into the pelvic veins (65.3% vs 35.7%; $P = .005$) and was more often treated with a stent (28.0% vs 4.8%; $P = .004$). Successful lysis was obtained in 22 patients (91.7%) following balloon dilation and in 15 (93.8%) after stent insertion. Five patients, three of whom were women, were identified with May–Thurner syndrome (ie, iliac vein compression) and treated with adjunctive angioplasty: two with a balloon only and three with stents.

**Immediate Thrombolysis**

Successful lysis was achieved in the majority of patients with iliofemoral (89.1%) and femoral (91.3%) DVT. Mean thrombus scores were 7.2 ± 2.6 at the start of CDT and 1.3 ± 1.9 at completion. Mean clot resolution was 82% ± 25, and the distribution of lysis scores is presented in the **Figure**. Postlysis thrombus scores were 1.8 ± 1.1 for patients with grade II lysis and 5.6 ± 2.4 for patients with grade I lysis. Among the nine cases of unsuccessful lysis, CDT was prematurely ended in two patients as a result of bleeding complications and there were two cases of technical failure without establishment of thrombolytic infusion as a result of agenesis of the inferior vena cava ($n = 1$) and chronic DVT findings only ($n = 1$). The postlysis thrombus score was correlated with the prelysis score ($P = .023$) and inversely correlated with lysis grade ($P < .001$), but there was no correlation between the prelysis thrombus score and lysis grade. The lysis grade obtained did not differ between left- and right-sided DVT or between popliteal or calf vein access. There were no statistically significant correlations between the (i) predisposing risk factors, symptom duration, thrombus localization, or perfusion catheter length and (ii) postlysis thrombus score or immediate lysis grade.

**Patency and PTS during Follow-up**

Among the 59 veins with regained patency after 6 months, 57 were also patent after 24 months. After 24 months, there was an inverse significant correlation between the postlysis thrombus score and patency ($P = .040$) in femoral and iliofemoral DVT, but there was no correlation between postlysis thrombus score and PTS ($P = .473$) or Villalta score ($P = .723$). We did not find linearity or a threshold value between the postlysis thrombus score and Villalta score (data not shown).

Presence of iliofemoral patency at 6 and 24 months was correlated with reduced frequency of PTS ($P < .001$).

<table>
<thead>
<tr>
<th>Lysis Grade</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDT only</td>
<td>6 (11.5)</td>
<td>16 (30.8)</td>
<td>30 (57.7)</td>
</tr>
<tr>
<td>CDT/balloon angioplasty</td>
<td>2 (8.3)</td>
<td>15 (62.5)</td>
<td>7 (29.2)</td>
</tr>
<tr>
<td>CDT/balloon angioplasty/stent</td>
<td>1 (6.3)</td>
<td>9 (56.2)</td>
<td>6 (37.5)</td>
</tr>
<tr>
<td>Total</td>
<td>9 (9.8)</td>
<td>40 (43.5)</td>
<td>43 (46.7)</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages. CDT = catheter-directed thrombolysis.

* Two patients in whom there was technical failure did not receive thrombolytic infusion.
Presence of patency and PTS did not differ with regard to predisposing risk factors, symptom duration, venous puncture site, perfusion catheter length, or use of adjunctive angioplasty (data not shown). Women more often showed regained patency after 6 and 24 months, but their Villalta score (data not shown) and frequency of PTS did not differ compared with those of men (Table 4). Patients with left-sided DVT showed regained patency more often than those with right-sided DVT, and the mean Villalta score at 24 months was lower, at 3.53 versus 4.65 (P = .046), but there was no difference in PTS between DVT sides.

### Table 4. Effects of CDT on Acute and Long-term Results

<table>
<thead>
<tr>
<th>Result</th>
<th>Sex</th>
<th>Affected Side</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (n = 92)</td>
<td>Women (n = 33)</td>
<td>Men (n = 59)</td>
</tr>
<tr>
<td>Lysis grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>9 (9.8)</td>
<td>1 (3.0)</td>
<td>8 (13.6)</td>
</tr>
<tr>
<td>II</td>
<td>40 (43.5)</td>
<td>13 (39.4)</td>
<td>27 (45.8)</td>
</tr>
<tr>
<td>III</td>
<td>43 (46.7)</td>
<td>19 (57.6)</td>
<td>24 (40.7)</td>
</tr>
<tr>
<td>Patency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 6 mo*</td>
<td>59 (65.6)</td>
<td>26 (81.3)</td>
<td>32 (57.1)</td>
</tr>
<tr>
<td>At 24 mo†</td>
<td>67 (75.3)</td>
<td>29 (90.6)</td>
<td>38 (66.7)</td>
</tr>
<tr>
<td>PTS at 24 mo†</td>
<td>36 (40.4)</td>
<td>12 (37.5)</td>
<td>24 (42.1)</td>
</tr>
</tbody>
</table>

Values in parentheses are percentages. CDT = catheter-directed thrombolysis, PTS = postthrombotic syndrome.
* One patient was lost to follow-up and one had inconclusive patency.
† Three patients were lost to follow-up.

### Complications

A total of 20 bleeding complications (21.7%) were reported. Three (3.3%) were classified as major complications and five (5.5%) as clinically relevant. Sixteen (80%) occurred within the first 2 days of CDT. Thirteen of the 20 bleeding complications were related to bleeding at the puncture site. CDT procedures with calf or inguinal punctures led to bleeding complications more often than those with popliteal access (P < .001), ie, there were bleeding complications in five patients who underwent calf vein punctures (35%) and three who underwent inguinal punctures (50%), compared with five who had popliteal access (7%). There was no association between bleeding and duration of CDT. Ten patients (10.9%) experienced recurrent venous thromboembolism during follow-up, five in the ipsilateral leg, three in the contralateral leg, and two cases of pulmonary embolism. One of the patients with recurrent DVT was diagnosed on strong clinical suspicion without imaging verification. Two of the cases of recurrent thrombosis occurred during ongoing anticoagulation.

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Figure. Distribution of clot resolution within the lysis grade groups (N = 92). Mean clot resolution in patients with grade II/III lysis was 88.2% ± 15.3. Mean clot resolution in patients with grade I lysis was 23.1% ± 16.2.
DISCUSSION

In patients with acute iliofemoral or proximal femoral DVT treated with additional CDT, successful lysis was achieved in 90%, with a mean clot resolution of 88%. The postlysis thrombus score alone, disregarding the prelysis score, did inversely correlate with regained patency after 24 months, and venous patency during follow-up was clearly correlated with a reduced frequency of PTS. This gives further support to the importance of patency for an improved clinical result as previously suggested (11,20,23,24).

No correlation was found between the lysis grade and patency or PTS. Lysis grade is a measure of percentage resolution of thrombus, and is not necessarily a good measure of residual thrombus. However, the thrombus score at the completion of CDT is a direct measure of residual thrombotic burden, which we believe may explain the correlation with patency at 24 months. Although it was recently shown that PTS is related to percentage of residual thrombotic burden, which we believe may explain the correlation with patency at 24 months. Although it was recently shown that PTS is related to percentage of residual thrombus (25), our findings could not confirm this. Whether residual thrombus or patency is the better surrogate outcome for clinical efficacy of CDT treatment remains to be investigated, but, all in all, the present findings support the “open vein hypothesis” for an improved outcome following extensive DVT.

Patency rate at 24 months (75.3%) was higher than at 6 months (65.6%), indicating an ongoing recanalization process between 6 and 24 months. The Villalta score at 24 months was lower with left-sided DVT, which may be because a treatable iliopelvic lesion is more likely to be present with left-sided DVT and 14 of the 16 stents were inserted on the left side.

The time window from DVT onset to initiation of CDT may play a role in successful thrombolysis, as time-dependent structural changes and organization of the clot may prevent resolution in time to salvage the vein valves. We included patients with acute DVT symptoms for as long as up to 21 days; however, the median symptom duration was 5 days, and there were no correlations between symptom duration and early efficacy, patency, or PTS development. Recent guidelines suggest that initiation of CDT should be performed within 10 days (18), whereas others, including the ongoing North American Acute Venous Thrombosis: Thrombus Removal with Adjunctive CDT study, have allowed for patients with symptoms for as long as 14 days (11,26). In a study by Mewissen et al (9), complete lysis was achieved in 34% of patients with symptoms for 10 days or less, compared with 19% among those with symptoms for longer than 10 days, and this difference was statistically significant. The present findings do not necessarily support the suggested 10–14-day cutoff, but four of the seven patients with symptoms for longer than 14 days (57%) developed PTS, compared with 39% of the patients with shorter symptom duration. This difference was not statistically significant.

Regarding the use of adjunctive angioplasty, a preference for stent insertion in pelvic veins and balloon angioplasty in the femoropopliteal vein segment has been suggested (27). Underlying iliofemoral vein anatomic variations have been commonly found (80%) with CT, and this may impede the restoration of flow (28). Adjunctive balloon dilation and stent placement were not widely used in the present study, and it is possible that the immediate outcome may be further improved with more aggressive use of angioplasty. In addition, increased use of adjunctive stent placement can reduce the duration of CDT, as clots that do not dissolve within 2 days may represent underlying chronic clots or abnormalities refractory to thrombolysis.

The CDT treatment time was limited to 96 hours in the present study protocol. Extending CDT beyond this time frame may improve the lysis grade, and two patients received thrombolysis for 6 days at the operator’s discretion (which represents a protocol violation; data not shown). Both patients showed further lysis between day 4 and day 6, and both cases showed complete lysis without complications. Fifty-eight percent of the patients received CDT for 1–2 days, resulting in successful lysis in 92.5%, and 2 days may represent a preferred treatment time because longer thrombolytic infusions may carry a higher risk of bleeding. However, to our knowledge (27), no maximum treatment time for CDT has been agreed on in the literature, and, with regard to the present study, two of the three major bleeding episodes occurred within the first 24 hours of thrombolysis. Prolonging treatment will nonetheless increase costs and time in hospital.

Some reports (15) indicate that pharmacomechanical thrombolysis with active mechanical fragmentation of the thrombus with or without aspiration is associated with shorter treatment time, lower total doses of thrombolytic agent, shorter intensive care unit and hospital stays, and therefore reduced costs. We have limited experience with venous thrombectomy devices, and the present study evaluated only CDT and adjunctive angioplasty. However, more aggressive endovascular therapy or higher doses of thrombolytic agent may be of importance for the long-term clinical outcome and for a wider acceptance of treatment with additional CDT, but possibly at the cost of increased complications. Again, this needs to be confirmed in properly designed controlled studies.

Vena cava filters are not commonly used in Norway and were not intended to be part of the CDT procedure. However, we inserted a temporary vena cava filter in one patient with a large thrombus up to the renal veins that was judged to be potentially life-threatening. There were no cases of symptomatic pulmonary embolism related to CDT in the present study, but we did not investigate for asymptomatic embolism. Routine use of vena cava filters is not supported by the literature, and selective use of vena cava filters has been suggested (29). The present complication rates indicate that safety was at least as good as in previously reported studies (9,30,31), and that routine use of vena cava filters or intensive care unit observation can be avoided.

The popliteal vein was the preferred puncture site in the present study and is the recommended access site because
it allows for antegrade traversal of the catheter through the valves of the deep veins (9). A retrograde passage can be technically difficult and potentially traumatic, and hence may influence long-term clinical outcome. US guidance allowed for popliteal vein puncture even when the vein was occluded, with successful access in most cases. Alternatively, puncture of the posterior tibial vein may be used to achieve lysis of the proximal calf and distal popliteal vein segments as well, but this is technically more challenging, and may be of less importance. The risk of PTS is substantially lower in patients with distal DVT (7), and we therefore aimed to achieve thrombolysis of only the proximal veins. However, in some patients with popliteal vein thrombosis, we did observe lysis peripheral to the puncture site, followed by spontaneous antegrade flow in the popliteal vein (data not shown), indicating some effect of the thrombolytic agent distal to the puncture site. We did not find that calf vein puncture correlated with improved lysis grade or patency, but the number of cases was small. Routine thrombolysis of the calf veins requires longer perfusion catheters for thrombolysis distally and proximally; in addition, the initial puncture is more challenging, and, according to our results, may result in more bleeding complications.

In the present study, two of the major bleeding complications and 13 of 20 overall bleeding complications were related to vein puncture. Although popliteal punctures led to fewer bleeding complications than tibial vein and inguinal punctures, the latter were rare, used in only cases in which accessing the popliteal vein was not feasible for technical or practical reasons (eg, fracture osteosynthesis). The puncture site bleeding episodes occurred more commonly when the first puncture failed to establish venous access, indicating the importance of good planning of the puncture by a technically skilled operator, resulting in a single successful attempt. Our complication rate indicates that treatment with popliteal vein access is safe in patients with iliofemoral or proximal femoral DVT, and the results are in line with those of previous reports (8,9,20,32–35).

Limitations of the present study other than the relatively low number of patients treated with angioplasty and stents may include the absence of adjunctive mechanical device use in a more aggressive clot removal strategy. The evaluation of patency during follow-up included US and air plethysmography, but diagnostic imaging with contrast-enhanced CT or magnetic resonance imaging are probably better for evaluation of the pelvic veins (36–38). Moreover, the study protocol did not include any strategies for repeat intervention even when US findings indicated recurrence of occlusion, which may have affected the clinical outcome in a few patients.

In conclusion, popliteal vein access was feasible in most patients and should be preferred to reduce the risk of bleeding. CDT resulted in safe and effective thrombolysis in the great majority of patients with iliofemoral or proximal femoral DVT and duration of symptoms as long as 21 days. No baseline characteristics were associated with early efficacy or PTS after 24 months. However, the thrombus score at completion of CDT was associated with regained venous patency during follow-up, which again correlated with reduced development of PTS. More efforts should therefore be considered to achieve and maintain patency.

REFERENCES

In this issue of JVIR, Haig et al (1) present a subanalysis of the catheter-directed thrombolysis (CDT) treatment group from their landmark randomized CaVenT trial (Catheter-directed Venous Thrombolysis in Acute Iliofemoral Vein Thrombosis) (2). The CaVenT trial (2) demonstrated a 14.4% absolute risk reduction of developing postthrombotic syndrome (PTS) in patients with acute proximal deep vein thrombosis (DVT) who received anticoagulation plus CDT. The authors now reveal further details exclusively in those patients who received thrombolysis (1). The group consisted of 92 patients with proximal acute DVT defined by symptoms presenting within 21 days. Determinants of safety and efficacy of CDT were analyzed by reviewing the technical details and radiographic findings with comprehensive thrombus score calculations, and these data were correlated with complications and long-term clinical outcomes. In the parent CaVenT trial (2), the authors did not reveal specific clot burden data, so it was unclear why they...