Safety of catheter-directed thrombolysis for deep venous thrombosis in cancer patients

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Background: **The current study was conducted to demonstrate that catheter-directed thrombolysis for upper and lower extremity deep vein thrombosis is equally safe in patients with and without cancer.**

Methods: **A retrospective cohort of consecutive patients with acute iliofemoral or brachiosubclavian deep vein thrombosis treated with catheter-directed thrombolysis was identified. Demographic characteristics and clinical outcomes were compared between patients with cancer and without cancer.**

Results: **Catheter-directed thrombolysis was used to treat 202 limbs in 178 patients (75 limbs in 61 cancer patients and 127 limbs in 117 patients without cancer). The mean treatment duration for patients with cancer (29.7 ± 21.2 hours) and without cancer (28.8 ± 22.2 hours) was similar ($P = .7774$). Catheter-directed thrombolysis achieved grade III clot lysis in a similar proportion of cancer patients (50 of 75 limbs, 66.7%) and patients without cancer (82 of 127 limbs, 64.6%; $P = .7619$). Grade II clot lysis also was achieved in equal numbers of patients with (20 of 75 limbs, 26.7%) and without cancer (34 of 127 limbs, 26.8%; $P = .9872$). Three cancer patients (4.9%) and four noncancer patients (3.4%) experienced major bleeding during catheter-directed thrombolysis ($P = .6924$). Pulmonary embolism occurred in 1.6% (1 of 61) of cancer patients and in 1.7% (2 of 117) of patients without cancer ($P = .9999$) during catheter-directed thrombolysis. Patients aged ≥70 years had an increased risk of major bleeding.**

Conclusion: **Percutaneous catheter-directed thrombolysis is equally safe for patients with and without cancer who have acute symptomatic deep vein thrombosis. (J Vasc Surg 2008;47:388-94.)**

More than 350,000 Americans are diagnosed with a deep vein thrombosis (DVT) each year.[1] Symptomatic DVT is particularly common among cancer patients, occurring in as many as 15% during the clinical course of their disease.[2] Compared with patients without cancer, cancer patients who have DVT are at increased risk for recurrent venous thromboembolism (VTE) and anticoagulation-associated bleeding. In addition, cancer patients with VTE have a twofold higher mortality rate than cancer patients without thrombotic events.[2-4]

Standard medical therapy with anticoagulation is very effective at preventing thrombus progression and pulmonary thromboembolism.[5] However, anticoagulation does not directly promote thrombus dissolution,[6] and as consequence, many patients have residual thrombus at the end of treatment that predisposes them to the development of venous valvular dysfunction and post-thrombotic syndrome.[7,8] This consideration is particularly relevant for cancer patients, who often have greater initial clot burdens in proximal veins and achieve less venographic improvement on anticoagulation than patients without cancer who develop DVT.[2]

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Competition of interest: none.

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In contrast to conventional anticoagulation, catheter-directed thrombolytic (CDT) therapy can result in a rapid reduction in thrombus burden, symptom relief, preserve venous valvular function, and potentially reduce the risk of recurrent thrombosis.[9] In a large multicenter study, CDT was associated with complete or partial clot lysis in 83% of patients and a significantly improved quality of life compared with a historical cohort of patients treated with anticoagulation alone.[10,11]

Despite its potential benefits, CDT is also associated with greater potential risks than conventional anticoagulation, including a greater risk of major bleeding, longer hospital stays, and higher medical costs.[12,13] These disadvantages and the greater risk of bleeding complications in patients with cancer have limited the acceptance of endovascular DVT therapy in oncology patients.[13-15] As a consequence, patients with malignancies have been excluded from participation in a number of clinical trials of thrombolysis for DVT.[16-18] However, to our knowledge, no direct comparisons of CDT in patients with cancer and without cancer have been reported to date to confirm this clinical impression of heightened risks of CDT in patients with malignancies. The present study was conducted is to test our hypothesis that CDT is an equally safe treatment for patients with and without cancer who have acute proximal extremity DVT.

MATERIALS AND METHODS

Patients. After Institutional Review Board approval was obtained, we searched our clinical database to retrospectively identify patients who were treated percutaneously for symptomatic extremity DVT. The study was

limited to consecutive patients with acute (symptom duration <14 days) proximal iliofemoral or brachiosubclavian DVT who underwent CDT with urokinase (Abbott Laboratories, North Chicago, Ill), alteplase (Genentech, South San Francisco, Calif), or reteplase (Centocor, Malvern, Pa) between May 1995 and January 2007. Patients treated with CDT were divided into two groups for analysis; one group had active cancer and patients in the other group were without a known malignancy.

Active cancer was defined as the presence of a pathologic diagnosis of cancer (excluding basal cell or squamous cell cancer of the skin) for which the patient was undergoing treatment with chemotherapy, radiotherapy, or surgery at the time of the thrombotic event. Patients with measurable recurrent or metastatic cancer not undergoing active treatment at the time of their DVT diagnosis or ≤6 months of diagnosis were also considered to have active cancer.

The following information was collected on each subject by chart review: demographic data, clinical data relevant to the subject's thrombotic event, immediate clinical efficacy, including the degree of thrombus reduction; the treatment duration, the total lytic dose, and the periprocedural complications of therapy.

Thrombolytic technique. All patients were treated initially with a continuous intravenous infusion of unfractionated heparin, adjusted to maintain an activated partial thromboplastin time (aPTT) ratio between 2 and 2.5 times control. Before the initiation of CDT, informed consent was obtained from each patient after a discussion of the risks of bleeding complications and benefits of nonsurgical treatment of DVT with CDT and thrombectomy. The presence of contraindications to percutaneous thrombolysis, including primary or metastatic central nervous system malignancy, coagulopathy, stroke ≤3 months, surgery ≤1 month, or gastrointestinal bleeding ≤3 months was assessed. Patients at risk for cerebrovascular accidents or cerebral metastasis were further evaluated by computed tomography before CDT treatments.

Percutaneous access to the thrombosed vessel was achieved through the popliteal vein for lower extremity DVT or the brachial vein for upper extremity DVT. Using a 6F vascular sheath (Cordis, Miami, Fla), we crossed the clots using a 5F hydrophilic hockey-stick catheter (Terumo Medical, Somerset, NJ) and a 0.035-in hydrophilic guide wire (Terumo Medical) combination. Venograms were performed using iodine contrast through the sheath or catheter. In patients with impaired renal function (serum creatinine level >1.5 mg/dL or creatinine clearance <60 ml/min), gadolinium or carbon dioxide gas contrast was used.

In patients who received adjuvant percutaneous mechanical thrombectomy (PMT), we performed PMT using a 6F over-the-wire Angiojet rheolytic thrombectomy catheter (Possis Medical, Minneapolis, Minn) or an 8F Trellis-8 peripheral infusion system (Bracchus Vascular Inc, Santa Clara, Calif). We performed PMT in a peripheral to central direction in two to three cycles. Residual thromboses were treated with CDT. Patients who were treated with PMT alone, without CDT, or who were treated with the PowerPulse spray technique with the AngioJet device were excluded from the study.

All CDT procedures were initiated through multiside-hole infusion catheters (Angiodynamics, Queensbury, NY) that were securely placed within the thrombosed veins. Catheter-directed thrombolysis was performed using urokinase, alteplase, or reteplase. The individual attending physicians performing the procedures determined the duration and rate of infusion. No predetermined time points were set for either venographic assessments or the termination of therapy. Use of PMT was left to the discretion of the individual attending physicians and according to the operator's prior experience.

Any stenosis remaining after thrombolysis was treated with balloon venoplasty using balloon angioplasty catheters or stents. During CDT, subtherapeutic doses (250-500 U/h) of unfractionated heparin were given through the access sheath to maintain patency.

At the completion of CDT, intravenous unfractionated heparin was reinitiated to maintain an aPTT ratio of 2 to 2.5 times control, followed by ongoing oral anticoagulation with warfarin adjusted to maintain an international normalized ratio of 2 to 3. The duration of warfarin therapy was determined by the patients' referring attending physicians.

The general practice of physicians at The Johns Hopkins Hospital is to treat patients with a DVT with warfarin therapy for at least 3 months. Longer durations of therapy are considered for patients with idiopathic thrombotic events or in the presence of thrombophilic conditions associated with a significant risk of recurrent thromboembolism. Cancer patients with VTE are generally treated for the duration of their active cancer and its treatment or for a period appropriate for their thrombotic event (at least 3-6 months), whichever was longer. Low-molecular-weight heparin was not routinely used for the long-term treatment of VTE in cancer patients in this cohort.

Study end points and definitions. The study end points were the rate of clot lysis, major bleeding, and pulmonary embolism during CDT of proximal extremity DVT in patients with and without cancer. Clot lysis was assessed quantitatively by comparison of venograms performed before and after treatment. Post-treatment venograms were performed at the end of thrombolysis but before any adjunctive procedures such as balloon venoplasty or stent placement.

The percentage of clot lysis was estimated by the difference between the volume of thrombus before and after treatment. Clot lysis was categorized as grade III if complete clot lysis occurred, grade II if 50% to 99% clot lysis occurred, and grade I if <50% clot lysis was achieved.[11,19] Treatment duration and lytic doses were retrieved from the medical record. Efficacy was analyzed on a per-limb basis.

Major bleeding was defined as any clinically overt bleeding that resulted in the cessation of therapy, further hospitalization, permanent sequelae, or death; or a decrease

in the hemoglobin level of at least 2.0 g/dL, the need for transfusion of ≥2 U of blood, or surgical intervention. All other bleeding episodes were considered minor.[19,20]

Symptomatic pulmonary embolism during CDT required objective radiologic documentation by contrast computed tomography angiography, ventilation/perfusion scanning, or pulmonary angiography.

Statistical analysis. Continuous variables are reported as means ± standard deviations. Comparison of continuous variables was performed using the Student *t* test, and proportions were compared using a *z* test for proportions. Small proportions (numerator value <5) were compared using the Fisher exact test. A χ^2 test of association was used to compare subcategoric variables among frequency data. Statistical significance was considered with a two-tailed or one-tailed $P < .05$. Statistical analysis was performed using Stata 9.1 software (StataCorp, College Station, Tex).

RESULTS

Catheter-directed thrombolysis treatment was performed on 202 limbs in 193 consecutive patients with acute symptomatic iliofemoral or brachiosubclavian DVT between May 1995 and January 2007 at The Johns Hopkins Medical Institutions. All DVT were initially suspected due to acute swelling of the affected extremities associated with pain. Clinical diagnosis was confirmed by duplex Doppler ultrasound or computed tomography (CT) venography.

We performed CDT in 75 limbs of 61 cancer patients (29 men, 32 women) with a mean age of 55.8 ± 14.5 years. During the same time period, we performed CDT in 127 limbs of 117 noncancer patients (50 men, 67 women) with a mean age of 39.5 ± 15.5 years. Patients without cancer were younger and had a higher prevalence of thrombophilia and anatomic risk factors for thromboembolism than the patients with cancer (Table I).

The mean lytic treatment duration among cancer patients was 29.7 ± 21.2 hours, similar to the 28.8 ± 22.2 hours for patients without cancer ($P = .7774$). Adjunctive PMT was used in 44 cancer patient limbs (58.7% of limbs treated) and 68 limbs in noncancer patients (53.5% of limbs treated; $P = .4789$). The two groups did not differ in mean total lytic dose or number of intraprocedural venograms (lysis check) required (Table II).

Grade III or complete clot lysis was achieved in 50 of 75 limbs (66.7%) of cancer patients and in 82 of 127 limbs (64.6%) of patients without cancer. Grade II or partial lysis was achieved in 20 of 75 limbs (26.7%) of cancer patients and 34 of 127 limbs (26.8%) of noncancer patients. Only a small fraction of extremity DVT (5 of 75, 6.7%) among cancer patients or noncancer patients (11 of 127, 8.7%) had grade I lysis or persistent thrombosis. There were no significant differences in the degree of clot lysis between the two groups. Stenting was required after thrombolysis in 36.0% of cancer patients and in 21.3% of noncancer patients ($P = .0222$).

Symptomatic pulmonary embolism during CDT treatment was rare. One cancer patient (1.6%) and two noncancer patients (1.7%) sustained a symptomatic pulmonary embolism during percutaneous treatment ($P = .9999$). Major bleeding occurred in three cancer patients (4.9%) and four noncancer patients (3.4%; $P = .6924$). Minor bleeding also occurred with a similar frequency in oncology patients (6.6%) and nononcology patients (5.1%; $P = .7376$). No intracranial hemorrhage occurred in either patient group (Tables III). There were no significant differences in major bleeding rates between different thrombolytic agents (Table IV).

Subgroup analyses found no significant differences in clot lysis rates or complications between the patients with and without cancer after being divided into brachiosubclavian and iliofemoral DVT (Table V). Patients aged ≥70 showed a trend toward less complete clot lysis and greater major bleeding. Otherwise age, sex, a history of DVT, immobilization at the time of thrombosis, or type of cancer had no impact on the efficacy or safety of CDT (Tables VI and VII).

Table I. Baseline demographic and clinical characteristics of the study population

Characteristic	*Patients with cancer, 61 (75 limbs)*	*Patients without cancer, 117 (127 limbs)*	P
Age, mean ± SD years	55.8 ± 14.5	39.5 ± 15.5	<.0001*
Gender, % (No.)			
Male	47.5 (29/61)	42.7 (50/117)	.5399
Female	52.5 (32/61)	57.3 (67/117)	.5399
Clot locations, % (No.)			
Brachiosubclavian	28.0 (21/75)	23.6 (30/127)	.4889
Iliofemoral	72.0 (54/75)	76.4 (97/127)	.4889
Other risk factors, % (No.)			
Thrombophilia†	14.7 (11/75)	36.2 (46/127)	.0010*
Previous DVT	46.7 (35/75)	52.0 (66/127)	.4666
Immobilization‡	21.3 (16/75)	28.4 (36/127)	.2709
Anatomic risk factor§	6.7 (5/75)	27.6 (35/127)	.0003*

*Statistically significant.
†Documented biochemical hypercoagulable disorder.
‡Immobilization for >4 days ≤4 weeks before onset of deep venous thrombosis.
§For example, May-Thurner syndrome in lower extremities or thoracic outlet syndrome, effort induced thrombosis in upper extremities.

DISCUSSION

We report on the safety of 202 consecutive CDT treatments of acute extremity DVT in 178 patients with and without cancer. Despite their older age and the additional comorbidities associated with an active malignancy, cancer patients undergoing CDT for DVT experienced clinical results that were comparable with noncancer patients. Both patient groups had similar DVT lysis grade, pulmonary embolism, and bleeding during CDT. These data from this large comparative study of patients with and without cancer indicate that CDT is a safe and effective treatment for cancer patients with acute symptomatic extremity DVT

Table II. Clinical outcomes of catheter-directed thrombolysis in patients with and without cancer

Outcome	*Patients with cancer, n = 61 (75 limbs)*	*Patients without cancer, n = 117 (127 limbs)*	P
Treatment duration, mean ± SD h	29.7 ± 21.2	28.8 ± 22.2	.7774
Urokinase doses, mean ± SD million U	3.6 ± 3.0 (27 limbs)	4.8 ± 5.1 (41 limbs)	.2157
Reteplase doses, mean ± SD U	23 ± 0 (1 limb)	22.5 ± 9.9 (8 limbs)	.9999
Alteplase doses, mean ± SD mg	15.1 ± 10.1 (47 limbs)	17.5 ± 12.5 (78 limbs)	.2672
Intra-procedure venograms (lysis checks), mean ± SD No.	2.5 ± 0.9	2.4 ± 1.0	.4839
Clot reduction, % (No.)			
Grade III	66.7 (50/75)	64.6 (82/127)	.7619
Grade II	26.7 (20/75)	26.8 (34/127)	.9872
Grade I	6.7 (5/75)	8.7 (11/127)	.6122
Stent placements, (No.)	36.0 (27/75)	21.3 (27/127)	.0222[a]
Complications during CDT, % (No.)			
Major bleeding	4.9 (3/61)	3.4 (4/117)	.6924
Minor bleeding	6.6 (4/61)	5.1 (6/117)	.7376
Pulmonary embolism	1.6 (1/61)	1.7 (2/117)	.9999

CDT, Catheter-directed thrombolysis; *TPA*, tissue plasminogen activator.
[a]Statistically significant.

Table III. Bleeding complications associated with catheter-directed thrombolysis in patients with and without cancer

Bleeding complications	*Patients with cancer, n = 61*	*Patients without cancer, n = 117*
Major bleeding, % (No.)		
GI bleed	1.6 (1)	0
Intra-abdominal wall	1.6 (1)	0
Access site hematoma	0	2.6 (3)
Around a central line	0	0.9 (1)
Acute anemia with no identified bleed	1.6 (1)	0
Total	4.9 (3)	3.4 (4)
Minor bleeding, % (No.)		
Hematuria	1.6 (1)	0.9 (1)
Access site hematoma	3.3 (2)	1.7 (2)
Venous extravasation	1.6 (1)	0
Hemoptysis	0	0.9 (1)
Intra-abdominal wall	0	0.9 (1)
Retroperitoneal	0	0.9 (1)
Total	6.6 (4)	5.1 (6)

Table IV. Comparison of treatment complications associated with different thrombolytic agents during catheter-directed thrombolysis

Complications during CDT	*Urokinase (n = 60)*	*Alteplase (n = 109)*	*Reteplase (n = 9)*
Major bleeding, % (No.)	5.0 (3)	3.7 (4)	0 (0)
Minor bleeding, % (No.)	3.3 (2)	6.4 (7)	11.1 (1)
Pulmonary embolism, % (No.)	1.7 (1)	1.8 (2)	0 (0)

CDT, Catheter-directed thrombolysis.

and that clinicians need not exclude appropriately selected cancer patients as candidates for percutaneous catheter-directed therapies for DVT.

Anticoagulation therapy for VTE in cancer patients has been associated with a twofold to sixfold increased risk of bleeding compared with patients without cancer.[14,15] The heightened risk for bleeding among cancer patients may be one reason why application of CDT to acute extremity DVT in cancer patients thus far has been restricted to individual case reports or small case series,[21-28] and some studies of thrombolysis in the treatment of DVT have specifically excluded cancer patients.[16-18] We also have noted reluctance of physicians at our institution to consider CDT of DVT in cancer patients, perhaps reflecting these concerns noted in the literature. However, previous clinical experience using alteplase or urokinase in the treatment of pulmonary embolism suggested that systemic thrombolysis was safe and effective for patients with and without cancer, although the reperfusion rate among cancer patients was less at 24 hours.[29] This experience prompted us to review our institutional experience with CDT in the treatment of acute symptomatic extremity DVT in patients with and without cancer.

Comparable with the previously published experience in thrombolysis for pulmonary embolism,[29] we noted similar safety of CDT in cancer patients and patients without cancer. Our results also compare favorably with those obtained in a national multicenter registry.[11] Adjuvant use of PMT has been associated with decreased treatment duration[30] and may have contributed to the excellent results obtained in this study. During CDT, only 4.9% of cancer patients and 3.4% of noncancer patients had a major hemorrhage and no intracranial hemorrhages occurred, which are promising results when compared with the 11% incidence of major hemorrhage noted in a multicenter CDT DVT registry.[11] Our results demonstrate that percutaneous catheter-directed therapy for a limited duration is as safe in cancer patients as in noncancer patients.

Several limitations of our study deserve discussion. The present study is a retrospective consecutive case series;

Table V. Clinical outcomes of catheter-directed thrombolysis of brachiosubclavian and iliofemoral deep venous thrombosis

	Brachiosubclavian thrombosis			*Iliofemoral Thrombosis*		
Outcome	*Patients with cancer*	*Patients without cancer*	P	*Patients with cancer*	*Patients without cancer*	P
Total patients (limbs)	20 (21)	30 (30)		41 (54)	87 (97)	
Clot lysis, % (No.)						
Grade III	61.9 (13/21)	66.7 (20/30)	.7263	68.5 (37/54)	63.9 (62/97)	.5687
Grade II	23.8 (5/21)	16.7 (5/30)	.7218	27.8 (15/54)	29.9 (29/97)	.7833
Grade I	14.3 (3/21)	16.7 (5/30)	.9999	3.7 (2/54)	6.2 (6/97)	.7120
Complications during CDT % (No.)						
Major bleeding	0 (0/20)	3.3 (1/30)	.9999	7.3 (3/41)	3.4 (3/87)	.3841
Minor bleeding	5.0 (1/20)	6.7 (2/30)	.9999	7.3 (3/41)	4.6 (4/87)	.6795
Pulmonary embolism	0 (0/20)	3.3 (1/30)	.9999	2.4 (1/41)	1.1 (1/87)	.9999

Table VI. Catheter-directed thrombolysis clot lysis in patients with cancer

Factors	*Limbs, No.*	*Grade III, % (No.)*	*Grade II, % (No.)*	*Grade I, % (No.)*
Sex				
Male	40	67.5 (27)	30.0 (12)	2.5 (1)
Female	35	65.7 (23)	22.9 (8)	11.4 (4)
Age				
<50	24	79.2 (19)	12.5 (3)	8.3 (2)
50-70	39	64.1 (25)	30.8 (12)	5.1 (2)
>70	12	50.0 (6)	41.7 (5)	8.3 (1)
Previous DVT				
Yes	35	65.7 (23)	28.6 (10)	5.7 (2)
No	40	67.5 (27)	25.0 (10)	7.5 (3)
Immobilization				
Yes	16	50.0 (8)	43.8 (7)	6.3 (1)
No	59	71.2 (42)	22.0 (13)	6.8 (4)
Cancer				
Leukemia	7	57.1 (4)	28.6 (2)	14.3 (1)
Lymphoma	4	50.0 (2)	50.0 (2)	0
Genitourinary	2	100.0 (2)	0	0
Breast	3	66.7 (2)	0	33.3 (1)
Gynecologic	16	62.5 (10)	37.5 (6)	0
Lung	11	81.8 (9)	9.1 (1)	9.1 (1)
CNS	3	33.3 (1)	66.7 (2)	0
Unknown primary	2	100.0 (2)	0	0
Pancreatic	2	100.0 (2)	0	0
Bone	1	0	0	100.0 (1)
Colon	6	83.3 (5)	16.7 (1)	0
Prostate	8	50.0 (4)	50.0 (4)	0
Skin	3	33.3 (1)	66.7 (2)	0
Testicular	2	100.0 (2)	0	0
Other	5	80.0 (4)	0	20.0 (1)

CNS, Central nervous system; *DVT,* deep vein thrombosis.

therefore, these results must be considered preliminary. Although an unequal distribution of risk factors for recurrent VTE and bleeding may have influenced study results, we believe that the clinical characteristics of the two patient groups tend to favor an inferior outcome for the cancer patients. Cancer patients have been reported to have a threefold higher risk of recurrent VTE and twofold higher risk of major bleeding compared with patients without cancer.[14,15] As a consequence, the excellent outcomes obtained for both patient groups in our study support our assertion that CDT should be seriously considered for appropriate candidates regardless of the presence of cancer.

Another potential weakness of our study design is the use of three different thrombolytic agents during the study. Therefore, we cannot exclude the possibility that the study outcome was influenced by thrombolytic choice by individual providers. Although this variable could have influenced our results, no differences were evident in the use of the different thrombolytic agents between the two groups and there are no existing data from randomized controlled trials that indicate the superiority of one thrombolytic agent for CDT.

Table VII. Bleeding complications associated with catheter-directed thrombolysis in cancer patients

Factors	*Patients, No.*	*Major bleeding, % (No.)*	*Minor bleeding, % (No.)*
Sex			
Male	29	6.9 (2)	6.9 (2)
Female	32	3.1 (1)	6.3 (2)
Age, years			
<50	19	0 (0)	0 (0)
50-70	32	3.1 (1)	12.5 (4)
>70	10	20.0 (2)	0 (0)
Previous DVT			
Yes	26	3.8 (1)	7.7 (2)
No	35	5.7 (2)	5.7 (2)
Immobilization			
Yes	11	9.1 (1)	0
No	50	4.0 (2)	8.0 (4)
Cancer			
Leukemia	6	0	0
Lymphoma	4	0	0
Genitourinary	2	0	0
Breast	3	0	0
Gynecologic	14	7.1 (1)	7.1 (1)
Lung	8	0	12.5 (1)
CNS	2	0	0
Unknown primary	2	0	0
Pancreatic	2	0	0
Bone	1	0	0
Colon	5	20 (1)	0
Prostate	5	20 (1)	20 (1)
Skin	2	0	0
Testicular	1	0	0
Other	4	0	25.0 (1)

CNS, Central nervous system; *DVT,* deep vein thrombosis.

Another potential limitation of our study is that we included patients with upper and lower extremity proximal DVT treated with CDT in our analysis. Although the etiology of thromboses in these two locations may differ, we believe that valid conclusions about the safety of CDT can be drawn by examining both these populations of patients.

Finally, as a retrospective study, our results could be influenced by patient selection bias. As a consequence, these results may not be generalizable to all patients with acute extremity DVT. Nevertheless, we used standardized patient selection criteria and enrolled consecutive patients; therefore, use of these criteria should allow other investigators to identify patients who could potentially derive similar clinical benefits. Prospective studies would be useful to confirm these findings.

CONCLUSION

Our results indicate that catheter-directed thrombolysis is as safe in cancer patients as it is in noncancer patients for the treatment of acute proximal deep venous thrombosis. Therefore, appropriately selected cancer patients should not be excluded from receiving catheter-directed therapies for acute deep venous thrombosis. Prospective, randomized studies are needed to confirm these promising results.

AUTHOR CONTRIBUTIONS

Conception and design: HK, SP, JB, LP, MS
Analysis and interpretation: HK, SP, JB, LP, MS
Data collection: HK, SP
Writing the article: HK, SP, JB, LP, MS
Critical revision of the article: HK, SP, JB, LP, MS
Final approval of the article: HK, SP, JB, LP, MS
Statistical analysis: HK, SP, LP
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Overall responsibility: HK

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