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REVIEW ARTICLE

Postinterventional antithrombotic management after venous stenting of the iliofemoral tract in acute and chronic thrombosis: A systematic review

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Abstract

Venous stenting has become a common treatment option for central deep venous outflow obstructions and postthrombotic syndrome. Following successful recanalization and stenting, stent patency is endangered by in-stent thrombosis and recurrent venous thromboembolism. Antithrombotic therapy might reduce patency loss. This systematic review summarizes the literature on antithrombotic therapy following (post)thrombotic venous stenting. A systematic PubMed, MEDLINE, EMBASE, and Cochrane search was performed for studies addressing antithrombotic therapy prescribed following venous stenting of the iliofemoral tract indicated by acute or chronic thrombotic pathology. A total of 277 articles was identified of which 64 (56 original studies) were selected. Overall, a mean primary patency rate of 82.3% was seen 1 year after the intervention, which decreased to 73.3% after 2 years. In the majority (43 of 56 studies, 77%), treatment was based on use of vitamin K antagonists, either with (18%) or without (59%) use of antiplatelet drugs. Only two studies (4%) directly assessed the effect of antithrombotic therapy on treatment outcomes. The impact of postinterventional antithrombotic therapy on stent patency remains unknown because of limited and insufficient data available in current literature. Further clinical research should more clearly address the role of antithrombotic therapy for preservation of long-term patency following venous stenting.

KEYWORDS

antithrombotic agents, deep vein thrombosis, postthrombotic syndrome, venous stenting, vascular patency

1 | INTRODUCTION

Over time, venous stent placement has become a more commonly used treatment modality for symptomatic central venous obstructions. Stenting is applied in the acute thrombotic phase in addition to thrombus removal (eg, following catheter-directed thrombolysis [CDT] in acute iliofemoral deep vein thrombosis [IFDVT]) to alleviate symptomatology, restore and preserve patency, and in an attempt to prevent the postthrombotic syndrome (PTS). Furthermore, stenting is used in the treatment of existing chronic venous pathology associated with venous hypertension in patients with PTS or nonthrombotic venous obstructions. Unfortunately,

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in-stent thrombosis (IST) is a frequent and clinically important complication.[1-3] IST may induce recurrence of symptoms and complaints that, as a result, necessitate reinterventions. Therefore, preservation of venous patency after a successful venous stent placement is important.

Many factors (eg, venous flow, stent characteristics, stent localization) may affect venous patency following stent placement and thus the risk of adverse outcomes. The role of periprocedural antithrombotic management in the preservation of stent patency and prevention of PTS is not clearly defined. Current international guidelines provide no specific recommendations with regard to postinterventional antithrombotic management.[4] The increased use and expanding possibilities of venous stent placement combined with the introduction of novel anticoagulant treatment options resulted in a large variety of postinterventional antithrombotic treatment regimens.[5] A previous systematic review concluded that none of these treatment regimens are evidence-based because of a lack of relevant studies on this subject.[6] Given the increasing use of venous stenting as a treatment modality for (post)thrombotic venous obstructions and the more frequent application of direct oral anticoagulants (DOAC) we set out to perform an up-to-date analysis to assess the available evidence on postinterventional antithrombotic management after venous stenting of the (post)thrombotic iliofemoral tract.

Essentials

- Venous stenting has become a more common treatment for (thrombotic) venous outflow obstructions.
- Despite its presumed importance, evidence on postprocedural antithrombotic management is lacking.
- Consistent and comparable reporting of treatment outcomes is scant yet suggests a beneficial effect.
- In order to formulate evidence-based recommendations there is an urgent need for clinical trials.

2 | METHODS

2.1 | Study selection

Before the literature search, the research question was formulated using the PICO format. Inclusion criteria for eligible studies were specified and documented in a protocol that was registered at the International Prospective Register of Systematic Reviews (PROSPERO, protocol number: 147 539).

The primary objective for this review is to assess and summarize the antithrombotic treatment regimens prescribed (including agent, dosing, intensity, and duration) in patients receiving venous stent placement of the iliofemoral tract following deep vein thrombosis (DVT).

Treatment indications could be either acute IFDVT or chronic postthrombotic lesions. Treatment combinations with complementary procedures (eg, CDT, percutaneous mechanical thrombectomy, percutaneous transluminal balloon angioplasty, endophlebectomy, creation of an arteriovenous fistula) were permitted. Postinterventional antithrombotic treatment could be based on the use of anticoagulants (vitamin K antagonists [VKA], DOAC, unfractionated heparin, low molecular weight heparin [LMWH], and fondaparinux), antiplatelet drugs (cyclooxygenase inhibitors and ADP-receptor antagonists), or a combination of both. Only original articles reporting postinterventional antithrombotic therapy were eligible. There were no restrictions regarding the duration of follow-up.

The outcome of interest was the postinterventional antithrombotic treatment regimen prescribed in patients receiving venous stenting. Furthermore, patency rates and the occurrence of recurrent deep vein thrombosis (reDVT), pulmonary embolism (PE), IST, major bleeding, and PTS during follow-up were assessed. Different definitions for these outcomes could be applied in the respective studies.

2.2 | Data sources and searches

The final search was performed in week 14 of 2020 (31 March) using PubMed, MEDLINE, EMBASE, and Cochrane databases. We used the search terms as presented in a previously published systematic review by our group[6] because modification of the search by adding alternative search terms did not influence the search results. The search was limited to English articles that were available in full text. No restrictions regarding publication date were imposed. The exact search strategy can be found in Supplementary Information. The first selection of search results was performed by one researcher (P.N.) assessing title and abstract for relevance in relation to the research question. Subsequently, a full appraisal of the selected publications and hand search of the reference lists was performed by two researchers independently (P.N. and A.t.C.H.). Decisions regarding eligibility needed to be unanimous and reasons for exclusion were registered.

2.3 | Data extraction and quality assessment

A prespecified form was used to record data regarding study eligibility, study design, study characteristics, and relevant study outcomes. Data extraction was performed by a single researcher (P.N.) and checked for accuracy by a second researcher (A.t.C.H.). Furthermore, quality assessment of the selected publications was performed by two researchers independently (A.t.C.H. and P.N.). Randomized controlled trials were assessed using the Cochrane risk-of-bias tool.[7] For the assessment of nonrandomized studies, a previously adapted version of the Newcastle-Ottawa Scale[8,9] was

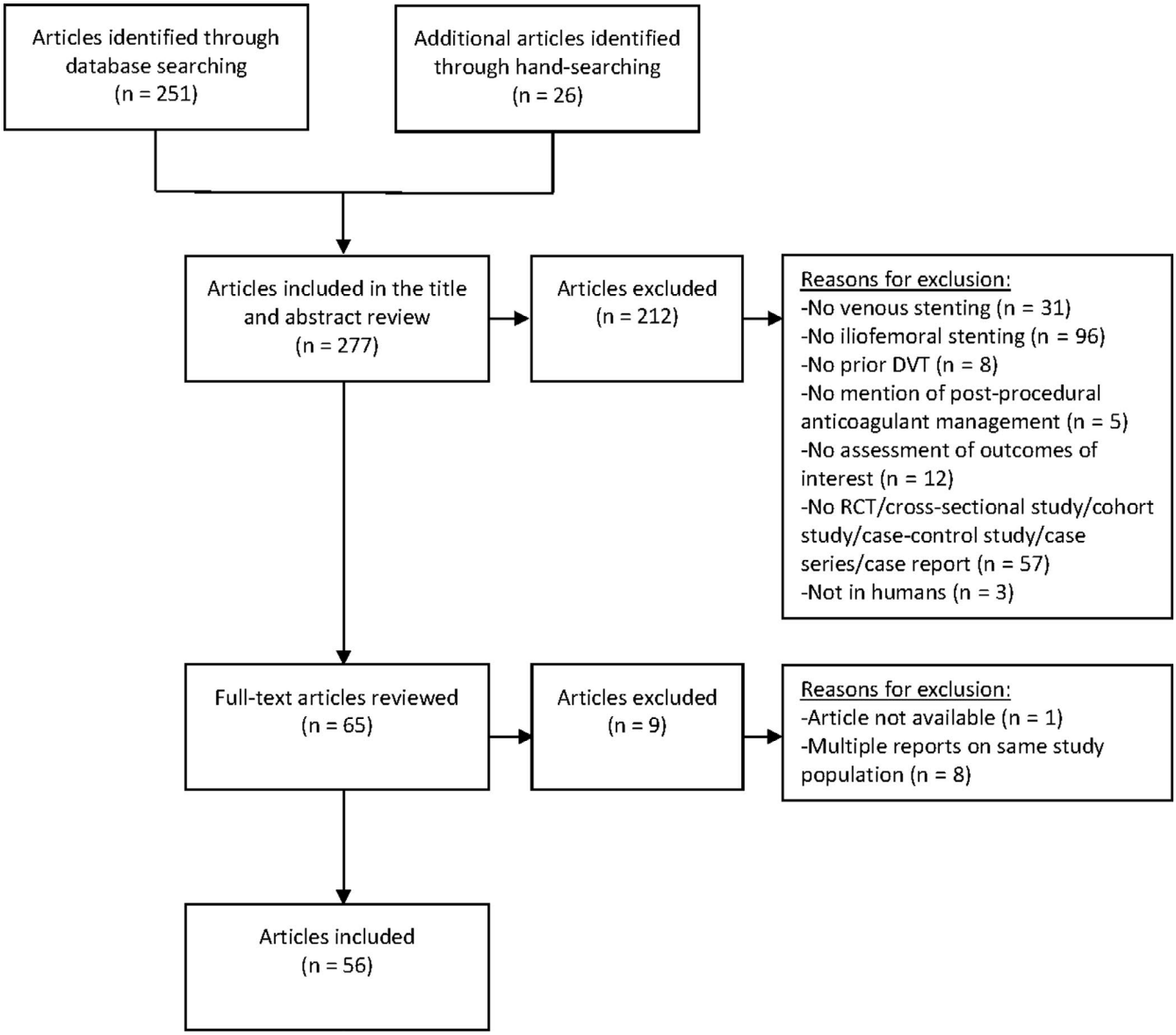

FIGURE 1 PRISMA flow chart: Summary of evidence search and selection. DVT, deep vein thrombosis; RCT, randomized controlled trial

used.[6] To meet the specific needs of this review, it included a selection of five relevant qualitative study features of which each item can be graded 1 point, leading to a maximum total score of 5 (Supplementary Information).

2.4 | Data analysis

Treatment indications as well as study outcomes were classified and reported using a wide range of definitions. Moreover, outcomes were rarely specified for patients receiving venous stenting of the (post)thrombotic iliofemoral tract. Because of the lack of comparable data in the selected publications, a comparative meta-analysis could not be performed. Available data regarding the outcomes were tabulated and a systematic analysis was provided. Outcomes were clustered for publications specifically aimed at intervention during the acute phase and publications that (also) included interventions performed for chronic pathology.

3 | RESULTS

3.1 | Search results

A total of 277 articles was identified in our search of the PubMed (n = 236), MEDLINE (n = 1), EMBASE (n = 5), and Cochrane databases (n = 9) in combination with articles identified by hand searching of the reference lists (n = 26). Appraisal of title and abstract resulted in a first selection of 65 articles. Subsequently, an extensive full content review of these articles was performed that resulted in the selection of 64 articles that were derived from 56 original studies relevant for this review (Figure 1).

3.2 | General aspects of the studies

The selected studies included six randomized controlled trials (11 publications[2,10-19]), 32 cohort studies (35 publications; eight prospective[3,20-26] and 27 retrospective[27-53]), eight case series,[54-61] and 10 case reports.[62-71] These studies included a total of 5153 patients, of which 3235 (62.8%) were stented. In 26 of 56 studies (46%), the complete study population was stented. The study population in 43 of the 56 studies (77%) consisted exclusively of patients with a (history of) DVT: 30 studies (36 publications) of which reported on interventions performed during the acute phase, 12 (12 publications) on treatment of chronic (postthrombotic) pathology and obstructions, and one (one publication) entailed a combined study population with acute and/or chronic postthrombotic sequelae. The remaining 13 studies (23%) reported on stenting for thrombotic as well as nonthrombotic indications such as iliac vein compression syndrome. A summary of the selected publications is shown in Table 1.

Patients' age ranged from 13 to 96 years,[23,53] with an overall median age of 48 years (43-53). With the exception of the randomized trials, study populations were predominantly female: 35 of 56 studies (63%). The prevalence of important prothrombotic risk factors was assessed in various studies: 37 studies (66%) reported on hypercoagulability, 19 studies (34%) on active malignancies, and 30 studies (54%) on underlying deep venous pathology such as iliac vein compression syndromes.

3.3 | Quality assessment

Quality assessment was performed on all selected studies with the exception of case series and case reports (Supplementary Information). Using the Cochrane risk-of-bias tool for randomized trials (2.0[7]), three randomized trials were considered to have a high risk of bias.[14,16,17] The maximum score of 5 points on the modified Newcastle-Ottawa scale was awarded to seven cohort studies,[3,20,23,32,43,48,50] and two studies[44,52] were awarded with the lowest score of 2 points. In five studies,[25,26,37,45,51] the studied cohort was considered a true representative for patients receiving (post) thrombotic iliofemoral stent placement. Additional selection criteria were used in another five studies.[29,33,35,44,52] A follow-up time of ≥ 24 months was seen in 15 studies[3,20,22,23,26,29,32,33,35,38,43,46-48,50] with reported losses to follow-up ranging from 0.0% to 34.4%.[38]

4 | OUTCOMES

4.1 | Antithrombotic management

All studies performed treatment of acute or chronic thrombotic iliofemoral venous obstructions using venous stent placement (including adjunctive procedures) and all studies provided information on the postinterventional antithrom-botic therapy prescribed (Table 1). Details on preinterventional and peri-interventional antithrombotic treatment were provided in 28 (50%)[2,3,10-19,26,31,35-37,43,45,51,54,55,57,59,60,62,64-71] and 46 (82%)[2,3,10-28,30-32,34-36,41-47,50-61,63-65,67,69-71] studies, respectively. Information about eventual (dis)continuation of existing antithrombotic therapy during the intervention was provided in 19 studies (34%).[2,3,10-16,18,19,24,26,27,30,43,51,63-65,67-70]

A broad variety of postinterventional antithrombotic treatment regimens was reported in the selected studies. This variation applied to antithrombotic drug of choice as well as to prescribed dosage and treatment duration. However, full details on the postinterventional antithrombotic regimen including type of antithrombotic agent, dosage, frequency, treatment intensity, treatment duration, and eventual indications for adjustments were rarely reported (Table 2). Full-dose anticoagulant treatment based on VKA or DOAC was prescribed in 33 studies (59%).[2,3,10-13,16-22,24,26-28,33,35-39,44,46-50,52,54-56,58,61-63,66,71] Generally, VKA in the acute phase was initiated with concurrent use of LMWH for a limited number of days or until the international normalized ratio was stabilized at an intensity of 2.0 to 3.0. Predominantly, treatment was continued for a minimum of 6 months with alternative durations of treatment in case of hypercoagulability, recurrent venous thromboembolic events (reVTE), postthrombotic lesions, stenting, or preexisting indications for antithrombotic treatment.[20,21,35,38,44,47,54] Concomitant or subsequent use of antiplatelet drugs was prescribed in another 10 studies (18%),[14,15,40,43,45,57,59,60,64,65,69] stent placement being the principal reason for additional antiplatelet therapy. There was only one study[41] (2%) that prescribed antiplatelet drugs as single postinterventional antithrombotic treatment in (post)thrombotic patients. However, if antithrombotic treatment with VKA was indicated before the intervention, which was the case in 95.5% of the population, it was continued accordingly. In six additional studies (11%),[29,32,34,51,53,68] various treatments or treatment combinations were prescribed depending on the complexity of the lesion or the extensiveness of the procedure (eg, mere stent placement or with adjunctive procedures), the location and the extent of the affected trajectory, documented hypercoagulability, or preexisting indications for anticoagulation. Antithrombotic treatment consisted of LMWH followed by antiplatelet drugs or DOAC in six studies (11%)[23,25,30,31,42,67,70] with VKA only prescribed in case of hypercoagulability, recurrent or unprovoked thrombosis, extensive stenting, or preinterventional use.[23,25,30,31,42]

Only two studies directly assessed the impact of different postinterventional antithrombotic management regimens following iliofemoral venous stent placement on postinterventional clinical outcomes.[3,26] The first study,[26] a prospective cohort study in patients with acute IFDVT treated with CDT and stenting, found that treatment with rivaroxaban (n = 73) or VKA (n = 38) for a minimum of 3 months following the intervention was equally effective in preserving stent patency at 24 months. A total of 15 reVTE occurred: one PE (1.4%) and seven IST (9.6%) in the rivaroxaban-group vs one contralateral DVT (2.6%) and six IST (15.8%) in the VKA group. Five of these IST developed within 30 days of the procedure (three in the rivaroxaban group vs two in the VKA group, $P = .78$); the other

TABLE 1 Study characteristics

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Randomized controlled trials						
Enden, 2012[10] (CaVenT)	Acute DVT	Patients aged 18-75 y with a first time objectively verified iliofemoral DVT (± popliteal and calf vein thrombosis) and symptom duration <21 d	CDT (n = 90) vs. STND (n = 99) • Age: 53.3 vs. 50.0 y[b] • Male: 58 (64.4%) vs. 61 (61.6%) • All post-DVT. N = 189, 100%. a. Acute: 100% • Thrombophilia: 39 (43.3%) vs. 39 (39.4%) • Cancer: 3 (3.3%) vs. 1 (1.0%)	N = 189 Not all stented. Stented: **N = 15 (7.9%; 15/90 = 16.7% of CDT patients)**	Standard treatment with additional CDT (n = 90) vs. standard treatment alone (n = 99).	Start LMWH (200 IU/kg dalteparin or 1.5 mg/kg enoxaparin) at day of diagnosis in both groups. -STND group: LMWH was to be continued for a minimum of 5 d or until adequate INR on warfarin. -CDT group: One hour after removal of the catheters, treatment with therapeutic weight-adjusted dose of LMWH 2 each day and concurrent warfarin was initiated. In both groups, warfarin was prescribed for at least 6 mo with a target INR of 2.0-3.0.
Enden, 2009[11] (CaVenT)	Acute DVT	Prespecified interim results: 6-mo follow-up	CDT (n = 50) vs. STND (n = 53) • Age: 53.0 vs. 51.3 y[b] • Male: 32 (64.0%) vs. 32 (60.4%) • All post-DVT. N = 103, 100%. a. Acute: 100% • Thrombophilia: 21 (42.0%) vs. 20 (37.7%) • Cancer: 2 (4.0%) vs. 1 (1.9%)	N = 103 Not all stented. Stented: **N = 8 (7.8%; 8/50 = 16% of CDT patients)**	Standard treatment with additional CDT (n = 50) vs. standard treatment alone (n = 53)	See Enden 2012
Haig, 2013[12] (CaVenT)	Acute DVT	Subgroup analysis: patients from the CDT group at 24 mo follow-up	CDT (n = 92) • Age: 54 y[b] • Male: 59 (64.1%) • All post-DVT. N = 92, 100%. a. Acute: 100% • Thrombophilia: 37 (40.2%) • Cancer: 0 (0%) • MTS: 5 (5.4%)	N = 92 Not all stented. Stented: **N = 16 (17.4%)**	Standard treatment with additional CDT.	See Enden 2012
Haig, 2016[13] (CaVenT)	Acute DVT	Prespecified sub analysis: 5-year follow-up	CDT (n = 87) vs. STND (n = 89) • Age: 58 vs. 53 y[c] • Male: 57 (66%) vs. 53 (60%) • All post-DVT. N = 176, 100%. a. Acute: 100% • Thrombophilia: 37 (42.5%) vs. 32 (36.0%)	N = 176 Not all stented. Stented: N = not specified	Standard treatment with additional CDT (n = 87) vs. standard treatment alone (n = 89).	See Enden 2012

(Continues)

TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Sharifi, 2012[14] (TORPEDO)	Acute DVT	Patients with acute femoropopliteal (or more proximal) DVT with severe complaints (ie, edema, erythema, induration, pain, tenderness)	PEVI (n = 91) vs. STND (n = 92) • Age: 61 y[b] • Male: 103 (56.3%) • All post-DVT. N = 183, 100%. a. Acute: 100%	N = 183 Not all stented, **N = 27 (14.8%, 27/91 = 29.7% of PEVI-patients)**	Percutaneous endovenous intervention (one or more of a combination of thrombectomy, balloon venoplasty, stenting, and/or local low-dose thrombolytic therapy) with standard anticoagulation (n = 91) vs. standard treatment alone (n = 92).	Initiation of warfarin (target INR 2.0-3.0) with concurrent use of LMWH (enoxaparin 2 each day 1 mg/kg or UFH IV [loading dose: 80 u/kg, continuous infusion: 18 U/kg/h]). -STND: LMWH or UFH had to be continued for at least 5 d with 1-day overlap of therapeutic INR. -CDT: Parenteral anticoagulation was stopped as soon as INR became therapeutic. Additionally, Aspirin 81 mg 1 each day for at least 6 mo was prescribed. In case of femoropopliteal stenting with a low risk of bleeding, clopidogrel 75 mg 1 each day was also prescribed for 2-4 wk.
Sharifi, 2010[15] (TORPEDO)	Acute DVT	Prespecified interim results: 6-mo follow-up	PEVI (n = 91) vs. STND (n = 92) • Age: 61 y[b] • Male: 103 (56.3%) • All post-DVT. N = 183, 100%. a. Acute: 100%	N = 183 Not all stented, **N = 27 (14.8%, 27/91 = 29.7% of PEVI patients**)	Percutaneous endovenous intervention (one or more of a combination of thrombectomy, balloon venoplasty, stenting, and/or local low-dose thrombolytic therapy) with standard anticoagulation (n = 91) vs. standard anticoagulation alone (n = 92).	See Sharifi 2012
Cakir, 2014[16]	Acute IFDVT	Patients with acute iliofemoral-popliteal DVT	PAT (n = 21) vs. STND (n = 21) • Age: 53 vs. 59 y[b] • Male: 15 (71.4%) vs. 13 (61.9%) • All post-DVT. N = 42, 100%. a. Acute: 100% • Thrombophilia: 0 (0%)	N = 42 Not all stented. Stented: **N = 14 (33.3%; 14/21 = 66.7% of PAT patients)**	Additional percutaneous aspiration Thrombectomy (n = 21) vs. standard anticoagulation alone (n = 21).	Initiation of warfarin (target INR 2.5-3.0) at the day of diagnosis with concurrent use of LMWH for at least 5 d. Procedures were performed at the first or second day of anticoagulation.
Zhang, 2014[17]	Subacute IFDVT (≤4 wk)	IFDVT (CFV or more cranial) patients lacking effective treatment in the acute phase	CDT (n = 190) vs. CDT + PTA (n = 186) • Age: 57.6 y[b] • Male: 210 (55.9%) • All post-DVT. N = 386, 100%. a. Acute: 100% • Hypercoagulability: 9 (4.7%) vs. 10 (5.4%) • MTS: 91 (47.9%) vs. 86 (46.2%)	N = 386 Not all stented. Stented: **CDT vs. CDT + PTA: N = 44 (23.2%) vs. N = 37 (19.9%)**	Additional catheter-directed thrombolysis vs. additional catheter-directed thrombolysis with balloon dilatation. (n = 186)	Initiation of warfarin (target INR 2.0-3.0, treatment duration 6-12 mo) within 6 h of diagnosis with concurrent LMWH for 5-7 d. LMWH were only discontinued when INR reached ≥2 for 2 consecutive days. Use of NSAIDs and antiplatelets was discouraged.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Vedantham, 2017[18] (ATTRACT)	Acute DVT	Patients with symptomatic proximal deep vein thrombosis involving the femoral, common femoral, or iliac vein (with or without other involved ipsilateral veins)	CDT (n = 336) vs. STND (n = 355) • Age: 53 y[c] • Male: 426 (62%) • All post-DVT. N = 691, 100%. a. Acute: 100%	N = 691 Not all stented. Stented: **N = 82 (11.9%; 82/336 = 24.4% of CDT patients)**	Standard treatment with additional pharmacomechanical thrombolysis (catheter-mediated or device-mediated intrathrombus delivery of rtPA and thrombus aspiration or maceration, with or without stenting (n = 336) vs. standard treatment alone (n = 355).	Both groups were initiated on warfarin (or DOAC when they became available) with concurrent LMWH immediately at diagnosis according to international guidelines. During thrombolysis, oral anticoagulation was discontinued and replaced with either therapeutic doses of LMWH or UFH IV. Within 2 h after hemostasis following removal of the catheters, oral anticoagulation was reinstalled according to the same guidelines.
Comerota, 2019[19] (ATTRACT)	Acute DVT	Subgroup analysis: patients with IFDVT	CDT (n = 196) vs. STND (n = 195) • Age: 52 y[c] • Male: 208 (53%) • All post-DVT. N = 391, 100%. a. Acute: 100%	N = 391 Not all stented. Stented: **N = 70 (17.9%; 70/196 = 35.7% of CDT-patients)**	Standard treatment with additional pharmacomechanical thrombolysis (catheter-mediated or device-mediated intrathrombus delivery of rtPA and thrombus aspiration or maceration, with or without stenting (n = 196) vs. standard treatment alone (n = 195).	See Vedantham 2017
Notten, 2020 (CAVA)[2]	Acute IFDVT	Patients aged 18-85 y with a first-time acute iliofemoral deep vein thrombosis and symptoms for no more than 14 d.	CDT (n = 77) vs. STND (n = 75) • Age: 49 vs. 52.0 y[c] • Male: 39 (51%) vs. 38 (51%) • All post-DVT. N = 152, 100%. a. Acute: 100% • Cancer: 4 (5%) vs. 1 (1%)	N = 152 Not all stented: **N = 35 (23.0%; 35/77 = 45.5% of CDT patients)**	Standard treatment with additional UACDT (n = 77) vs. standard treatment alone (n = 75)	For both groups, anticoagulation therapy was performed according to international guidelines using either VKA (acenocoumarol or phenprocoumon; installed with concurrent use of LMWH for at least 5 d until therapeutic range of 2.0-3.0 was reached), DOACs (rivaroxaban, apixaban, or dabigatran), or LMWH. -CDT group: Oral anticoagulants were replaced with therapeutic dose LMWH for the duration of CDT only to be reinstalled 1 h after removal of the catheter.
Cohort studies, prospective						

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
AbuRahma, 2001[20]	Acute IFDVT	Patients with acute IFDVT (<2 wk)	STND (n = 33) vs. MULTI (n = 18) • Age: 49 vs. 46 y[b] • Male: 14 (42.4%) vs. 7 (38.9%) • All post-DVT. N = 51, 100%. a. Acute: 100% • Thrombophilia: 10 (19.6%). 7/33 (21.2%) vs. 3/18 (16.7%) • Cancer: 11 (21.6%). 7/33 (21.2%) vs. 4/18 (22.2%)	N = 51 Not all stented. Stented: **N = 10 (19.6%, 10/18 = 55.6% of MULTI-patients)**	Standard treatment vs. additional multimodal treatment. -Standard therapy was performed in all patients and consisted of systemic heparinization (UFH IV, loading dose 5000-10 000 IU followed by continuous infusion of 1000-2000 IU/h for 5-7 d) concurrent with initiation of warfarin (started within 48-72 h after start of heparinization and to be continued at a target INR of 2.0-3.0 for 6 mo unless PE, [9-12 mo] hypercoagulability [indefinitely], or recurrent DVT [indefinitely]), limb elevation, and gradient compression stockings. -Multimodal treatment could entail additional lytic therapy (urokinase, loading dose 4500 U/kg followed by infusion of 4500 U/kg/h for 24-48 h. During the study, urokinase was replaced with rtPA [loading dose 4-8 mg, infusion 2-4 mg/h]), PTA, and percutaneous stenting (indicated if underlying stenosis of ≥50%). If stents were placed, warfarin was indicated indefinitely.	All patients were treated with systemic heparinization (UFH IV, loading dose 5000-10 000 IU followed by continuous infusion of 1000-2000 IU/h for 5-7 d) concurrent with initiation of warfarin (started within 48-72 h after start of heparinization and to be continued at a target INR of 2.0-3.0 for 6 mo unless PE, [9-12 mo] hypercoagulability [indefinitely], recurrent DVT [indefinitely]), or performed stenting [indefinitely].
Grommes, 2011[21]	Acute DVT	Patients with acute DVT treated with additional UACDT	• Age: 44 y[c] • Male: 7 (58.3%) • All post-DVT. N = 12, 100%. a. Acute: 100% • Cancer: 0 (0%) • MTS: 6, 50% (3 MTS were directly diagnosed and adequately treated, 3 MTS became evident after occurrence of rethrombosis)	N = 12 (13 limbs) Not all stented. Stented: **N = 3 (25.0%)**	Standard treatment with additional UACDT (EKOS-system; EKOS Corporation) using rtPA (10/13 = 76.9%) or urokinase (3/13 = 23.1%).	VKA was prescribed for 3 mo in case of provoked DVT and 6 mo in case of idiopathic DVT. In was initiated with concurrent LMWH and targeted at an INR of 2.0-3.0.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Manninen, 2012[22]	Acute IFDVT	Patients with acute DVT including the iliofemoral vein (with or without caval involvement) or high femoral vein (with or without popliteal-crural involvement	Age: 48 y[b] Male: 26 (46%) All post-DVT. N = 56, 100%. Acute: 100% Thrombophilia: 19 (33.9%) Cancer: 3 (5%)	N = 56 Not all stented. Stented: **N = 9 (16.1%, all iliac)**	Selective thrombolysis with PTA and percutaneous stenting.	Initiation of warfarin with concurrent UFH IV. Warfarin was prescribed for at least 6 mo.
Raju, 2014[23]	Chronic obstruction (iliac)	Patients stented with cavo-iliac vein obstruction treated with Wallstents using the Z-technique in cavoiliac veins	• Age: 58 y[c] • Male: 33% (Male:Female 1:2) • Not all post-DVT. Post-DVT: 75% a. Primary cause: Postthrombotic 1:3 • Primary cause: 25%	N = 217 limbs All stented. N = 217 (100%)	PTA and percutaneous stent placement in the cavo-iliac veins using Wallstents and the Z-technique.	Patients with pre-interventional indications for long-term anticoagulation (thrombophilia, recurrent thrombosis, unprovoked thrombosis) continued their anticoagulant treatment. All other patients received LMWH for up to 6 wk followed by long-term use of aspirin.
Srinivas, 2014[24]	Subacute DVT (1-8 wk)	Patients with DVT existing 1-8 wk	CDT (n = 27) vs. STND (n = 28) • Age: 39 y vs. 53 y[b] • Male: 14 (51.9%) vs. 16 (57.1%) • All post-DVT. N = 55, 100%. a. Acute: 100% • Cancer: 2 (7%) vs. 6 (21%) • MTS: 3 (5.5%, all in CDT-patients: 3/27 = 11.1%)	N = 55 Not all stented. Stented: **N = 6 (10.9%; 6/27 = 22.2% in CDT-group)**	Standard therapy with additional CDT (mechanical thrombus aspiration and streptokinase infusion [1 lakh units/h; two-thirds through the catheter and one-third through the intravenous sheath) along with UFH [loading dose: 5000 IU; continuous infusion 1000 IU/h], n = 27) vs. standard anticoagulation alone (n = 28)	All patients started warfarin or acenocoumarol on the day of the DVT diagnosis and was continued for 6 mo. -STND: UFH IV 1000 IU/h for 48 h followed by 5 d of bolus UFH (5000 IU 6 hourly) or LMWH (1 mg/kg).

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Sarici, 2014[25]	PTS	Patients with chronic PTS (symptoms and signs of CVI in a leg previously affected by DVT [>6 mo ago]) receiving PTA and stenting	• Age: 58 y[b] • Male: 13 (25%) • All post-DVT. N = 52, 100%. a. Chronic: 100% • Thrombophilia: 21 (40.3%)	N = 52 (59 limbs) All stented. **N = 52 (100%)**	PTA and percutaneous stenting	Following the intervention, patients received UFH IV 1000 IU/h for 1 d. Subsequently, 2 mo of clopidogrel and life-long use of aspirin was indicated. Patients with thrombophilia were treated with life-long warfarin (target INR 2.0-3.0).
Sebastian, 2018[26]	Acute IFDVT	All patients with acute IFDVT treated with CDT and/or PMT followed by nitinol stent placement	VKA (n = 73) vs. rivaroxaban (n = 38) • Age: 46 y[b] • Male: 41 (37%) • All post-DVT. N = 111, 100%. a. Acute: 100% • Thrombophilia: 17 (15%), 9 (12%) vs. 8 (21%) • Cancer: 4 (4%), 3 (4%) vs. 1 (3%)	N = 111 (119 limbs) All stented. **N = 111 (100%)**	Postinterventional treatment with 3 mo of VKA (n = 73) vs. rivaroxaban (n = 38)	Within 24 h after the intervention UFH IV was converted to either VKA (with concurrent LMWH for at least 5 d and until a stable target INR of 2.0-3.0 was reached) or rivaroxaban. Both treatments were prescribed for at least 3 mo.
Notten, 2020[3]	Obstruction (cavo-iliofemoral; post-thrombotic (acute or chronic) or IVCS)	Patients with acute cavo-iliofemoral DVT, chronic deep venous obstruction resulting from the presence of postthrombotic sequelae (ie, PTS with postthrombotic synechiae), or (nonthrombotic) IVCS treated with PTA and venous stent placement	Low target INR (2.0-3.5, n = 40, 50.4%) vs. high target INR (2.5-4.0, n = 39, 49.6%) • Age: 41.3 y[b] • Male: 27 (34.2%) • Not all post-DVT: N = 74, 93.7%. a. Acute: 13.5% (10/74). Chronic: 86.5% (64/74) • Thrombophilia: 13 (16.5%; 13/26 = 50.0% of tested patients)	N = 79 All stented. N = 79 (100%)	Postinterventional target INR "low" (2.0-3.5. n = 40 (50.6%)) vs. "high" (2.5-4.0. n = 39 (49.4%))	VKA therapy was continued for at least 6 mo in patients with preinterventional antithrombotic treatment. In all other patients, LMWH was given directly following the procedure and VKA therapy was initiated according to international guidelines at the first postinterventional day. Treatment was continued for at least 6 mo. Target INR (2.0-3.5 or 2.5-4.0) and treatment duration was at the discretion of the treating physician.
Cohort studies, retrospective						

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
O'Sullivan 2000[27]	Chronic obstruction (IVCS)	Patients with endovascular treatment of IVCS (acute or chronic)	• Age: 43 y[b] • Male: 9 (23%) • Not all post-DVT. Post-DVT: N = 19, 48.7%. a. Acute: 100% • Cancer: 0 (0%) • MTS: 39 (100%)	N = 39 Not all stented. Stented: N = 35 (89.7%)	PTA and percutaneous stenting with additional CDT (urokinase 120 000-180 000 IU/h), in thrombotic patients. During the last 3 y of the study, thrombotic patients with a symptom duration >4 weeks were treated with PTA and stenting alone.	Warfarin (target INR 2.0-3.0) for at least 6 mo.
Kölbel, 2007[28]	Acute IFDVT	Patients with acute iliocaval DVT treated with CDT (and stent placement)	• Age: 31 y[c] • Male: 11 (29.7%) • All post-DVT. N = 37, 100%. a. Acute: 100% • Thrombophilia: 25 (67.6%; 25/32 of tested patients, 78.1%)	N = 37 (44 limbs) Not all stented. Stented: **N = 31 (83.8%; 36 limbs: 81.8%)**	Additional CDT (alteplase, continuous infusion 1-2 mg/h) with or without percutaneous stenting.	Warfarin (target INR 2.0-3.0) for 6 mo.
Knipp, 2007[29]	Chronic obstruction (IVCS)	Patients with IVCS treated with PTA and stenting	• Age: 41.6 y[b] • Male: 8 (13.8%) • Not all post-DVT. Post-DVT: N = 52, 89.7%. a. Chronic: 100% • Thrombophilia: 19 (32.8%) • MTS: 58 (100%)	N = 58 All stented. N = 58 (100%)	PTA and percutaneous stenting (with/without adjunctive chemical thrombolysis, mechanical thrombus fragmentation, AVF creation, IVC filter placement)	There was no protocol on postinterventional anticoagulant treatment: warfarin with variable treatment durations was prescribed in 42 (72.4%) patients, antiplatelets (aspirin, clopidogrel, or both) for a minimum of 6 wk in 11 (19.0%) patients, and in 5 (8.6%) patients' postinterventional anticoagulant treatment was unknown.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Neglén, 2007[30] (Neglén cohort)	Chronic obstruction (femoro-ilio-caval)	Patients with chronic nonmalignant obstruction of the femoroiliocaval veins treated with endovascular stent placement.	• Age: 54 y[c] • Male: 242 (27.8%) • Not all post-DVT. Post-DVT: N = 464/982 limbs (47.3%) • Thrombophilia: 173/454 limbs available in patency analysis and tested for thrombophilia (38.1%) • Primary cause: 518 limbs (52.7%)	N = 870 (982 limbs) All stented. N = 870 (100%; 982 limbs: 100%)	PTA and percutaneous stenting	Dalteparin 2500 IU was given directly after the procedure as well as the next morning. An additional 30 mg ketorolac was given before discharge. Aspirin 81 mg 1 each day was indicated indefinitely for all patients. Patients with thrombophilia or preinterventional use of VKA were treated with life-long warfarin. During the extended study period, the following amendments were made regarding postinterventional antithrombotic therapy: discontinuation of warfarin 2 d before the procedure until the day of the procedure; dosage of postinterventional dalteparin was changed into 5000 IU 2 each day for the first 36-48 h after the procedure; 30 mg Toradol was administered at the moment of recanalization and at 8-hour intervals until discharge; aspirin was dosed at 81 mg twice weekly in patients with concomitant warfarin; warfarin was (re)started in patients with thrombophilia, recurrent VTE, or other preexisting indications; patients with homocystinemia were treated with aspirin, vitamin B6, and folate therapy.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Neglén, 2000[31] (Neglén cohort)	Chronic obstruction (femoro-ilio-caval)	Subgroup analysis: first 137 patients of cohort (chronic primary or postthrombotic venous iliac vein obstructions treated with endovascular stent placement)	• Age: 48 y[c] • Male: 50/139 limbs (36.0%) • Not all post-DVT. Post-DVT: N = 78, 56.9%. a. Chronic: 100% • Thrombophilia: 41 (29.9%) • Cancer: 1 (0.7%) • MTS: 47 (34.3%)	N = 137 (139 limbs) All stented. N = 137 (100%)	See Neglén 2007	See Neglén 2007
Hartung, 2009[32]	Chronic obstruction (iliocaval)	Patients with endovenous stenting for chronic iliocaval obstructive lesions	• Age: 43 y[c] • Male: 17 (19.1%) • Not all post-DVT. Post-DVT: N = 44, 49.4%. a. Chronic: 100% • Thrombophilia: 19 (21.3%; 19/44 = 43.2% in tested patients) • MTS: 52 (58.4%)	N = 89 (96 limbs) Not all stented. Stented: N = 87 (97.8%)	PTA and percutaneous stenting.	Up to 2003 all patients received 6 mo of warfarin (initiated with LMWH). Thereafter, patients stented for MTS received LMWH for 15 d and antiplatelets (not specified) for at least 1 year. Patients with complex lesions (ie, postthrombotic and recanalization mainly. N = 52, 58.4%) were treated with oral anticoagulation for a minimum of 12 mo.
Kölbel, 2009[33]	Chronic obstruction (iliac)	Patients with endovenous stenting for chronic iliac occlusions	• Age: 39 y[c] • Male: 21 (35.6%) • Not all post-DVT. Post-DVT: N = 44, 74.6%. a. Chronic: 100% • Thrombophilia: 32 (54.2%; 32/48 = 66.7% of tested patients) • Cancer: 0 (0%)	N = 59 (66 limbs) All stented. N = 59 (100%)	PTA and percutaneous stenting	Warfarin (target INR 2.0-3.0) for at least 6 mo.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Raju, 2009[34]	Chronic obstruction (postthrombotic)	Patients with postthrombotic chronic total occlusions of femoro-iliocaval vein segments treated with percutaneous recanalization	• Age: 53 y[c] • Male: 53 (33.3%) • All post-DVT. N = 159, 100%. a. Chronic: 100% • Thrombophilia: 44 (27.7%; 44/131 = 33.6% of stented patients)	N = 159 (167 limbs) Not all stented. Stented: **N = 131 (82.3%; 139 limbs: 83.2%)**	PTA and percutaneous stenting	In the beginning of the study, aspirin (or warfarin in case of thrombophilia) was prescribed as postinterventional anticoagulation. Later, this changed into injection of dalteparin 2500 IU (before, directly afterwards, and 3-5 d following the procedure) combined with prophylactic dosage of fondaparinux sodium for 4-6 wk. Therapeutic dosage of fondaparinux as well as long-term warfarin was prescribed if recanalization comprised ≥3 vein segments, suprarenal stent placement, thrombophilia, or other indications for long-term anticoagulants.
Baekgaard, 2010[35] (Gentofte-cohort)	Acute IFDVT	Patients with IFDVT treated with CDT	• Age: 29 y[c] • Male: 78 (22.8%) • All post-DVT. N = 101, 100%. a. Acute: 100% • Thrombophilia: 55 (54.5%)	N = 101 (103 limbs) Not all stented. Stented: **N = 57 (56.4%)**	Additional CDT, PTA, and percutaneous stenting. In the first 9 patients CDT was performed using the Mewissen Infusion Catheter (Boston Scientific; loading dose 1 mg alteplase with 1000-5000 IU UFH followed by continuous infusion of 1 mg/h alteplase and 1000 IU/h UFH). Thereafter, patients were treated with a pulse-spray technique (injection of 10 mg alteplase with 1000-5000 IU UFH for 15-30 min using the Pro Infusion Catheter; AngioDynamics) before thrombolysis as described for the first 9 patients.	Warfarin (initiated with concurrent Tinzaparin [100 U/kg 2 each day for 14 d]) for at least 12 mo or lifelong if at high risk for recurrent thrombosis (eg, serious coagulant defects: antithrombin deficiency, homozygous FVL, protein C and S deficiency).
Sillesen, 2005[36] (Gentofte-cohort)	Acute IFDVT	Subgroup analysis: first 45 patients of cohort	• Age: 31 y[c] • Male: 7 (15.6%) • All post-DVT. N = 45, 100%. a. Acute: 100% • Thrombophilia: 30 (66.7%)	N = 45 Not all stented. Stented: **N = 30 (66.7%)**	See Baekgaard 2010	See Baekgaard 2010

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Jeon, 2010[37]	Acute DVT (with MTS)	Patients with acute (<2 wk) IFDVT from MTS treated with CDT and stenting of the left CIV	• Age: 56.7 y[b] • Male: 8 (26.7%) • All post-DVT. N = 30, 100%. a. Acute: 100% • MTS: 30 (100%)	N = 30 All stented. **N = 30 (100%)**	Endovascular intervention (ie, CDT, PAT, PTA, and percutaneous stenting)	Warfarin (target INR 2.0-3.0, at least 6 mo) initiated with concurrent LMWH or UFH IV.
Rosales, 2010[38]	Chronic obstruction (iliofemoral, post-thrombotic)	Patients with chronic postthrombotic cavo-iliofemoral occlusions receiving endovascular interventions	• Age: 41 y[c] • Male: 15 (50%) • All post-DVT. N = 34, 100%. a. Chronic: 100% • Thrombophilia: 17 (50.0%)	N = 34 Not all stented. Stented: **N = 32 (94.1%)**	PTA and percutaneous stenting	Initiation of warfarin with concurrent dalteparin 100 U/kg 2 each day. Warfarin was prescribed at least 6 mo, indefinitely in case of thrombophilia, and tailor-made in other patients.
Titus, 2010[39]	Obstruction (iliofemoral)	Patients receiving iliofemoral venous PTA and stenting for symptomatic iliofemoral occlusive venous disease	• Age: 45.6 y[b] • Male: 9 (25.0%) • Not all post-DVT. Post-DVT: N = 14, 38.9% a. Acute: 100% • Thrombophilia: 8 (22.2%; 8/14 = 57.1% of tested patients • MTS: 15 (41.7%)	N = 36 (40 limbs) All stented. N = 36 (100%)	PTA and percutaneous stenting	Warfarin (target INR 2.0-3.0) or enoxaparin for at least 6 mo.
Wahlgren, 2010[40]	Chronic obstruction (femoro-ilio-caval, post-thrombotic)	Patients with chronic postthrombotic femoro-iliocaval venous disease	• Age: 45 y[b] • Male: 20 (40%) • All post-DVT. N = 50, 100%. a. Chronic: 100% • Thrombophilia: 15 (30%)	N = 50 (51 limbs) Not all stented. Stented: **N = 16 (32%)**	Additional endovascular treatment including percutaneous stenting.	In the beginning of the study, warfarin was initiated with concurrent UFH IV. In time, this changed into concurrent use of LMWH until therapeutic levels were reached. Warfarin was continued for at least 6 mo in all patients. Additional aspirin 75 mg 1 each day was prescribed for 1 mo in patients with stent placement.
Nayak, 2012[41]	PTS	Patients with chronic PTS	• Age: 42.2 y[b] • Male: 20 (45.5%) • All post-DVT. N = 44, 100%. a. Chronic: 100% • Thrombophilia: 7 (15.9%) • Cancer: 4 (9.1%)	N = 44 Not all stented. Stented: **N = 39 (88.6%, 45 limbs)**	Endovascular interventions (with/without percutaneous stenting). Adjunctive EVLA was performed in case of saphenous reflux.	All patients received aspirin (81 mg 1 each day following the intervention. If patients were already on anticoagulants before the intervention, there were continued thereafter.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Blanch, 2013[42]	Chronic obstruction (iliofemoral, post-thrombotic)	Patients with postthrombotic chronic iliofemoral flow obstruction secondary to stenotic or occlusive lesions with a clinical CEAP ≥3 or venous pain receiving percutaneous stent placement	• Age: 50 y[c] • Male: 16 (44%) • All post-DVT. N = 36, 100%. a. Chronic: 100% • Thrombophilia: 17 (47.2%)	N = 36 (41 limbs) Not all stented. Stented: **N = 34 (94.4%; 39 limbs: 95.1%)**	PTA and percutaneous stenting	Prophylactic dosage LMWH at 6 and 24 h after procedure with Aspirin 100 mg 1 each day for long-term use in 5 patients (14.7%). The other 29 patients (85.3%) were treated with therapeutic dosage LMWH and long-term oral anticoagulation because of thrombophilia, stents comprising ≥3 vein segments, or previous indication for anticoagulation.
Stanley, 2013[43]	Acute or chronic DVT	Patients with acute or chronic DVT of the CIV, EIV, CFV, FV or PopIV	• Age: 45.8 y[b] • Male: 44 (55.0%) • All post-DVT. N = 80, 100%. a. Acute: 65% (52/80). Chronic: 35% (28/80) • Thrombophilia: 24 (30.0%) • MTS: 34 (42.5%)	N = 80 Not all stented. Stented: **N = 52 (65.0%)**	Either immediate PMT with/without UACDT, primary UACDT with subsequent PMT, or UACDT alone. Ten minutes before start of the procedure the tenecteplase (TNKase) was injected. PMT was performed using AngioJet (10 mg TNKase), Trellis (mean 6.5 mg TNKase), or Omniwave (mean 6.0 mg TNKase). UACDT was performed through the EKOS system (continuous infusion 0.25 mg/h TNKase for 12 h) in combination with UFH IV.	All chronic patients were on systemic anticoagulation at presentation. In case of acute DVT, patients were admitted immediately and started with UFH, LMWH, or argatroban. After the procedure all patients were prescribed warfarin (target INR 2.0-3.0) or LMWH for at least 6 mo. Treatment duration depended on hypercoagulable state, residual clot, and recurrent events. Stented patients continued life-long antiplatelet therapy after discontinuation of warfarin.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Liu, 2014[44]	Chronic obstruction (IVCS)	Patients with IVCS (visualization of >50% reduction in luminal diameter, formation of collateral circulation, pressure gradient >2 mmHg across stenosis while in supine position) receiving PTA and stenting	• Age: Postthrombotic 41.8 y[b] vs. nonthrombotic 39.4 y[b] • Male: 15 (31.3%) • Not all post-DVT. Post-DVT: N = 12 (25.0%). a. Chronic: 100% • MTS: 48 (100%)	N = 48 Not all stented. Stented: N = 46 (95.8%)	PTA and percutaneous stenting	For the first 3 postinterventional days 4000 IU LMWH was given twice daily. Concurrently, warfarin was installed and continued for at least 6 mo (≥12 mo for postthrombotic patients).
Park, 2014[45]	Acute DVT (with MTS)	Patients with acute (<2 wk) IFDVT from MTS treated with CDT and iliac stenting.	• Age: 70 y[c] • Male: 14 (27.5%) • All post-DVT. N = 51, 100%. a. Acute: 100% • Thrombophilia: 1 (2.0%) • Cancer: 5 (9.8%) • MTS: 51 (100%)	N = 51 All stented. **N = 51 (100%)**	CDT, PTA, and percutaneous stenting	Warfarin (target INR 2.0-3.0) was prescribed for at least 3 mo and until symptom relief. Followed by another 3-6 mo of antiplatelet therapy (aspirin or clopidogrel).
Sang, 2014[46]	PTS	Patients with endovascular stenting for PTS	• Age: 44.0 y[b] • Male: 36 (53.7%) • All post-DVT. N = 67, 100%. a. Chronic: 100% • Thrombophilia: 4 (6.0%) • Cancer: 0 (0%)	N = 67 Not all stented. Stented: **N = 63 (94.0%)**	PTA and percutaneous stenting. Ultimately, only 36 of 63 procedures could be performed using only endovascular techniques.	Initiation of warfarin with concurrent enoxaparin 4000 IU twice daily until INR was stabilized at 2.0-2.5. Warfarin was to be continued for at least 6 mo.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Ye, 2014[47]	Chronic obstruction (iliofemoral, post-thrombotic)	Patients with endovascular PTA and stent placement for postthrombotic chronic total occlusion of the iliofemoral vein	• Age: 51 y[b] • Male: 44 (40.0%) • All post-DVT. N = 110, 100%. a. Chronic: 100%	N = 110 (118 limbs) Not all stented. Stented: **N = 104 (94.5%; 112 limbs: 94.9%)**	PTA and percutaneous stenting	Initiation of warfarin (target INR 2.0-3.0) with concurrent LMWH 4000 IU twice daily. Warfarin was prescribed for at least 6 mo or long-term in case of thrombophilia.
Catarinella, 2015[48] (MUMC-cohort)	Chronic obstruction	Patients with severe venous symptoms (CEAP 4-6) or venous claudication combined with deep venous obstruction (partial or complete) on DUS or MRV	• Age: 43.5 y[b] • Male: 46 (30.1%) • Not all post-DVT. Post-DVT: N = 112, 73.2%. a. Chronic: 100%	N = 153 All stented. N = 153 (100%)	PTA and percutaneous stenting (with or without endophlebectomy and/or AVF creation)	VKA (target INR 2.5-3.5) initiated with concurrent LMWH for 5 d. VKA were to be continued for at least 6 mo.
deWolf, 2013[49] (MUMC-cohort)	Chronic obstruction	Subgroup analysis: first 63 patients of the cohort	• Age: 44 y[b] • Male: 18 (28.6%) • Not all post-DVT. Post-DVT: N = 54, 85.7%. a. Chronic: 100% • Thrombophilia: 11 (17.5%; 11/21 = 52.4% of tested patients) • MTS: 36 (57.1%)	N = 63 All stented. N = 63 (100%)	See Catarinella 2015	See Catarinella 2015
Shi, 2016[50]	Chronic obstruction (IVCS)	All patients with IVCS who received endovascular treatment	• Age: ≥40 y: 154 patients (66.1%) • Male: 126 (54.1%) • Not all post-DVT: N = 167, 71.7%. a. Acute: 47.2% (110/233). Subacute/chronic: 24.5% (57/233) • MTS: 233 (100%)	N = 233 Not all stented: N = 225 (96.6%)	PTA and percutaneous stenting for subacute/chronic DVT and non-thrombotic pathology. In acute DVT adjunctive procedures such as CDT (500 000-700 000 IU Urokinase IV per day, maximum of 3-5 d), PMT, and thrombectomy were performed.	Initiation of warfarin (target INR 2.0-3.0) with concurrent LMWH. Warfarin was prescribed for 6 mo.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Comerota, 2019[51]	Chronic obstruction (iliofemoral, post-thrombotic)	Patients with incapacitating postthrombotic iliofemoral obstruction involving the CFV who underwent hybrid operative procedures to restore unobstructed venous drainage from the involved leg to the patent vena cava	• Age: 46 y[b] • Male: 13 (42%) • All post-DVT. N = 31, 100%. a. Chronic: 100%	N = 31 (36 limbs) All stented. **N = 31 (100%)**	Hybrid intervention including endophlebectomy of the CFV and endovascular reconstruction of cranial vein segments.	Warfarin (3 d) and DOACs (1 d) were discontinued before the intervention. Aspirin 81 mg 1 each day and clopidogrel 75 mg 1 each day (as well as cilostazol 100 mg 2 each day if placement of a prosthetic graft was anticipated) were started 3 d before the intervention. In the last 14 patients, a sheath was placed in the ipsilateral popliteal vein for peri-procedural anticoagulation. Following the intervention patients received UFH IV concurrent with initiation of warfarin (target INR 2.0-3.0). Warfarin as well as aspirin were indicated indefinitely. If a prosthetic graft was used, cilostazol was also continued indefinitely. Clopidogrel was continued for 8 wk. In the last 14 patients, UFH was continued for 5 d at a continuous rate of 600-700 IU/h. Furthermore, the target INR was increased to 3.0-4.0 for the first 6-12 mo. Subsequently to be reduced to 2.0-3.0 or to convert to treatment with direct oral Xa inhibitors. Cilostazol had to be discontinued after 8 wk if anticipated PTFE graft was not used.
Dumantepe, 2018[52]	Subacute DVT (<1 mo)	All patients with acute (<1 mo) massive lower extremity DVT	• Age: 49.5 y[b] • Male: 36 (52.9%) • All post-DVT. N = 68, 100%. a. Acute: 100% • Cancer: 9 (13.2%) • MTS: 4 (5.9%)	N = 68 Not all stented: **N = 11, 16.2% (including all 4 MTS-patients)**	Rheolytic thrombectomy with percutaneous stenting	Rivaroxaban 15 mg 2 each day for 3 wk, followed by 20 mg 1 each day for 3-6 mo.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Endo, 2018[53]	Chronic compression and/or acute DVT	Patients with successful endovascular iliocaval stent placement	• Age: 49 y[c] • Male: 25 (40.3%) • Not all post-DVT. Post-DVT: N = unknown a. Acute: 48.4% (30/62). Chronic: Unknown. • Thrombophilia: 7 (11.3%) • MTS n = 29 (46.8%), DVT (non-MTS) n = 30 (48.4%), and tumor compression n = 3 (4.8%)	N = 62 (71 limbs) All stented. N = 62 (100%)	Percutaneous stenting	Following the intervention 24 patients (38.7%) used anticoagulation alone, 2 patients (3.2%) used antiplatelets alone, and 36 patients (58.1%) used both anticoagulants and antiplatelets. In 22 patients (35.5%), multiple anticoagulants were used or a change between anticoagulants was made. Use as specified per agent: warfarin (48.4%, n = 30), enoxaparin (62.9%, n = 39), oral DOAC (rivaroxaban, apixaban. 25.8%, n = 16), aspirin (n = 26, 41.9%), clopidogrel (n = 8, 12.9%), aspirin with clopidogrel (n = 4, 6.4%).
Case series						
Acharya, 2005[54]	Subacute DVT (≤3 wk ≤6 wk postpartum)	Patients with symptomatic acute (<3 wk) DVT within 42 d of childbirth treated with CDT	• Age: 30 y[b] • Male: 0 (0%) • All post-DVT. N = 5, 100%. a. Acute: 100% • Thrombophilia: 2 (40%)	N = 5 Not all stented. Stented: **N = 2 (40%)**	Additional CDT (Alteplase [loading dose 5 mg in 10 mL 0.9%NaCl; continuous infusion 0.01 mg/kg/h] and UFH [loading dose: 5000 IU; continuous infusion 300 IU/kg/d])	Warfarin for 1 year or indefinitely when stented.
Dayal, 2005[55]	Critical chronic compression and/or acute DVT	Patients with critical venous occlusive disease (acute or chronic)	• Age: 48 y[b] • Male: 14 (56%) • Not all post-DVT. Post-DVT: N = unknown a. Acute: 76.0% (19/25). Chronic: Unknown. • Cancer: 3 (12%)	N = 25 Not all stented. Stented: N = 15 (60%)	CDT (urokinase or alteplase) and concurrent UFH IV combined with additional endovascular interventions (mechanical thrombectomy [AngioJet], transluminal venoplasty, or [nitinol] stent placement).	Long-term systemic anticoagulant treatment (not specified).

(Continues)

TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Husmann, 2007[56]	Acute DVT (with MTS)	Patients with acute IFDVT (<1 wk) with underlying venous spur (from MTS) treated with a combination of surgical thrombectomy of the iliac veins and locoregional thrombolysis of veins below the groin	• Age: 34 y[b] • Male: 2 (18.2%) • All post-DVT. N = 11, 100%. a. Acute: 100%	N = 11 All stented. **N = 11 (100%)**	Additional locoregional thrombolysis, surgical thrombectomy, and percutaneous stenting	Patients received UFH IV for 12 h following the procedure. Subsequently, coumarins were initiated with concurrent LMWH. Treatment was targeted at an INR of 2.0-3.0 and was continued for 6 mo.
Murphy, 2009[57]	Acute DVT (with MTS and initiation of oral contraceptives)	Patients with DVT following initiation of oral contraceptives and unknown underlying MTS treated with CDT, stent placement and 6 mo of warfarin	• Age: 18.3 y[b] • Male: 0 (0%) • All post-DVT. N = 7, 100%. a. Acute: 100% • Thrombophilia: 3 (42.9%) • MTS: 7 (100%)	N = 7 All stented. **N = 7 (100%)**	Additional CDT, mechanical thrombectomy, PTA, and stent placement.	Postinterventional use of acenocoumarol (initiated with concurrent LMWH, target INR 2.0-3.0 for 6 mo) and aspirin (indefinitely) was prescribed.
Oguzkurt, 2011[58]	Phlegmasia cerulea dolens (from IFDVT)	Patients with phlegmasia cerulea dolens from acute IFDVT treated with manual aspiration thrombectomy	• Age: range 31-80 y • Male: 2 (28.6%) • All post-DVT. N = 7, 100%. a. Acute: 100% • MTS: 3 (42.9%)	N = 7 Not all stented. Stented: **N = 3 (42.9%, all MTS-patients)**	Percutaneous manual aspiration thrombectomy	Warfarin for 6 mo.

(Continues)

TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Bloom, 2015[59]	Acute IFDVT (during pregnancy or ≤6 wk postpartum)	Patients treated with PMT for symptomatic IFDVT during pregnancy or ≤6 wk postpartum	• Age: 26 y[b] • Male: 0 (0%) • All post-DVT. N = 11, 100%. a. Acute: 100% • Thrombophilia: 5 (45.5%) • MTS: 3 (27.3%)	N = 11 Not all stented. Stented: **N = 8 (72.7%)**	PMT and percutaneous stenting	Warfarin (target INR 2.0-3.0) was initiated with LMWH. Additionally, low-dose aspirin was prescribed for 3 mo in patients after stent placement.
Langwieser, 2016[60]	Chronic obstruction (iliofemoral, postthrombotic)	Patients with postthrombotic iliofemoral venous obstructions	• Age: 32 y[b] • Male: 2 (22.2%) • All post-DVT. N = 9, 100%. a. Chronic: 100% • Thrombophilia: 3 (33.3%) • MTS: 8 (88.9%)	N = 9 (10 limbs) All stented. **N = 9 (100%)**	Percutaneous stenting	All patients were prescribed rivaroxaban 20 mg 1 each day and clopidogrel 75 mg every other day (depending on individual drug response). At 6 mo, clopidogrel was stopped in all patients. Rivaroxaban was continued in 3 (33.3%), stopped in 3 (33.3%), and switched to acetylsalicylic acid in 3 (33.3%) patients, respectively.
Ming, 2017[61]	Acute IFDVT (with IVCS)	All patients with IFDVT combined with IVCS	No PTS (n = 173) vs. PTS (n = 74) • Age: 55.1 y[b] vs. 55.3 y[b] • Male: 89 (48.6%) vs. 30 (40.5%) • All post-DVT. N = 247, 100%. a. Acute: 100% • Cancer: 0 (0%) • MTS: 247 (100%)	N = 247 Not all stented. Stented: **N = 116 (47.0%)**	CDT (urokinase: loading dose 100 000-300 000 IU/h for 1 h; continuous infusion: 16 000-25 000 IU/h) with percutaneous stenting	Initiation of warfarin (target INR 2.0-3.0) with minimally 5 d of concurrent LMWH treatment. Warfarin was continued for 6 mo.
Case reports						
Kapranov, 2003[62]	PTS (after IFDVT)	Patient with PTS (continuing complaints of pain, heaviness, and edema as well as absent recanalization) 11 mo after IFDVT	• Age: 31 y • Male • All post-DVT. N = 1, 100%. a. Chronic: 100% • Thrombophilia: 0 (0%) • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	Percutaneous stenting	Acenocoumarol (2 mg/d) was initiated with concurrent enoxaparin 60 mg/d for 6 d.
Oguzkurt, 2008[63]	Phlegmasia cerulea dolens (from IFDVT with MTS)	Patient with phlegmasia cerulea dolens as a result of IFDVT with MTS	• Age: 77 y • Female • All post-DVT. N = 1, 100%. a. Acute: 100% • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	Manual aspiration thrombectomy and percutaneous stenting	Warfarin for 6 mo.

(Continues)

TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Salam, 2010[64]	Acute IFDVT (with EIV stenosis from repetitive microtrauma)	Patient with IFDVT based on repetitive microtrauma of the EIV stenosis from cycling	• Age: 70 y • Male • All post-DVT. N = 1, 100%. a. Acute: 100% • Thrombophilia: 0 (0%) • Cancer: 0 (0%) • EIV stenosis (due to repetitive microtrauma)	N = 1 All stented. **N = 1 (100%)**	CDT (Alteplase [loading dose 2.0 mg; continuous infusion 0.5 mg/h] with UFH 500 IU/h) and percutaneous stenting	Warfarin (target INR 2.0-3.0) was initiated with concurrent enoxaparin. Warfarin was continued for 3 mo. Additionally, aspirin was indicated indefinitely.
Sharifi, 2010[65]	Acute IFDVT	Patient with IFDVT and worsening presentation under anticoagulation treatment	• Age: 82 y • Male • All post-DVT. N = 1, 100%. a. Acute-on-chronic: 100% • Thrombophilia: 100% (protein C and S deficiency) • Previous DVT treated with ICV filter and stenting of the left CIV	N = 1 All stented. **N = 1 (100%)**	CDT (tPA [1.0 mg/h] and UFH [12 IU/kg/h]) and percutaneous stenting (stent expansion)	Following the intervention, warfarin was initiated (with concurrent use of enoxaparin), Aspirin 81 mg 1 each day as well as 2 wk of clopidogrel 75 mg 1 each day.
Wormald, 2012[66]	Acute IFDVT (with MTS)	Patient with acute IFDVT (and MTS)	• 66 y • Male • All post-DVT. N = 1, 100%. a. Acute: 100% • Cancer: 0 (0%) • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	Mechanical thrombectomy (Trellis device; Covidien) and percutaneous stenting	Warfarin for 6 mo.
Singh, 2017[67]	Acute IFDVT (with MTS and pelvic mass) and PE	Patient with IFDVT based on MTS complicated with PE and spontaneous retroperitoneal hematoma	• Age: 55 y • Female • All post-DVT. N = 1; 100%. a. Acute: 100% • Thrombophilia: 0 (0%) • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	Percutaneous stenting	Following the intervention, UFH IV was continued and later switched to apixaban 5 mg 2 each day.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Kohler, 2018[68]	Severe PTS (after cavo-iliacal DVT)	Patient with severe PTS 11 y after cavo-bilateral DVT	• Age: 46 y • Male • All post-DVT. N = 1, 100%. a. Chronic: 100% • Thrombophilia: 0 (0%)	N = 1 All stented. **N = 1 (100%)**	Percutaneous stenting	Initially: rivaroxaban 15 mg 2 q.d. and clopidogrel (loading dose of 600 mg, maintenance of 75 mg 1 each day. Because of recurrent IST, multiple regimens were tried (UFH IV with clopidogrel, dabigatran with clopidogrel, dabigatran and prasugrel) before successful anticoagulant treatment was found with prasugrel with phenprocoumon.
Lakha, 2018[69]	Acute IFDVT (with MTS)	Patient known with Behcet's disease presenting with IFDVT and underlying MTS	• Age: 19 y • Male • All post-DVT. N = 1; 100%. a. Acute: 100% • Thrombophilia: 0 (0%) • Cancer: 0 (0%) • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	PMT, thrombectomy, and percutaneous stenting	Rivaroxaban and aspirin.
Rohr, 2019[70]	Acute IFDVT	Insufficient relief following IFDVT despite 1 wk of enoxaparin treated with attempted single-session CDT using the JETi device	• Age: 17 y • Male • All post-DVT. N = 1, 100%. a. Acute: 100% • Thrombophilia: 0 (0%) • MTS: 1 (100%)	N = 1 All stented. **N = 1 (100%)**	Single-session CDT (tPA, 6 mg) using the JETi device and percutaneous stenting	Therapeutic dosage of enoxaparin 1 mg/kg twice daily was continued following the intervention. This was converted to apixaban 5 mg 2 each day combined with aspirin 325 mg 1 each day after 2 wk. At 9 mo, full-dose apixaban was discontinued as aspirin was continued indefinitely.

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TABLE 1 (Continued)

Publication	Treatment Indication	Study Population	Study Population Demographics: Age, Sex, Postthrombotic status, Risk Factors (ie, Thrombophilia, Cancer, MTS)	Sample Size: Total Patient Number; Number of Stented Patients (%)	Intervention: Eventual Comparison of Treatment Groups	Intervention: Postinterventional Antithrombotic Therapy[a]
Barge, 2020[71]	Acute cavo-bi-iliacal DVT (also involving left renal vein)	Extensive acute DVT involving the ICV down to the popliteal veins bilaterally as well as the left renal vein treated with a combination of endovascular treatment modalities	• Age: 23 y • Male • All post-DVT. N = 1, 100%. a. Acute: 100% • Thrombophilia: 0 (0%) • MTS and congenital stenosis of the ICV	N = 1 (2 limbs) All stented. **N = 1 (100%)**	UACDT (Alteplase; 2.0 mg/h) and percutaneous stenting	Dalteparin 7500 IU 2 each day was continued for 2 wk following the intervention before converting to warfarin (target INR 2.0-3.0) for 6 mo. Subsequently, this was switched to apixaban 5 mg twice daily for a remaining 6 mo.

The shaded (dark gray) rows represent the outcomes of (pre specified) sub analyses regarding the study population from the primary study. The primary study is reported between brackets and its results are presented in the first unshaded row above.

All outcomes reported in **bold** represent data specified for the number of patients with post-DVT (acute or chronic) treatment indications receiving venous stent placement.

Abbreviations: AVF, arteriovenous fistula; CDT, catheter-directed thrombolysis; CEAP, clinical-etiology-anatomy-pathophysiology; CFV, common femoral vein; CIV, common iliac vein; CVI, chronic venous insufficiency; DUS, duplex ultrasound; DVT, deep vein thrombosis; DOAC, direct oral anticoagulants; EIV, external iliac vein; EVLA, endovascular laser ablation; FV, femoral vein; IFDVT, iliofemoral deep-vein thrombosis; ICV, inferior caval vein; INR, international normalized ratio; IU, international units; IV, intravenous; IVCS, iliac vein compression syndrome; LMWH, low molecular weight heparin; MRV, magnetic resonance venography; MTS, May-Thurner syndrome; MULTI, multimodal treatment; PAT, percutaneous aspiration thrombectomy; PE, pulmonary embolism; PEVI, percutaneous endovenous intervention; PopIV, popliteal vein; PMT, pharmacomechanical (catheter-directed) thrombolysis; PTA, percutaneous transluminal angioplasty; PTS, postthrombotic syndrome; rtPA, recombinant tissue plasminogen activator; STND, standard treatment; TNKase, tenecteplase; tPA, tissue plasminogen activator; UACDT, ultrasound-accelerated catheter-directed thrombolysis; UFH, unfractionated heparin; VKA, vitamin K antagonist.

[a]There were no adapted anticoagulation regimens used in specific patient groups (ie, stented patients) unless explicitly specified.

[b]Mean value.

[c] Median value.

TABLE 2 Postinterventional antithrombotic regimens

Publication	Population	Intervention: Postinterventional Antithrombotic Therapy
Full-dose anticoagulant treatment (VKA or DOAC)		
Randomized controlled trials		
Enden, 2012[10]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥6 mo
Cakir, 2014[16]	Acute DVT	VKA (target INR 2.5-3.0), treatment duration not specified
Zhang, 2014[17]	Subacute DVT (≤4 wk)	VKA (target INR 2.0-3.0), treatment duration not specified Use of NSAIDs and antiplatelets was discouraged
Vedantham, 2017[18]	Acute DVT	VKA, treatment duration ≥3 mo
Notten, 2020[2]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥3 mo (82.2% of population) or DOAC (11.8% of population: rivaroxaban, apixaban, or dabigatran) or LMWH (0.7% of population)
Cohort study, prospective		
AbuRahma, 2001[20]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥6 mo[a]
Grommes, 2011[21]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥3 mo[a]
Manninen, 2012[22]	Acute DVT	VKA, treatment duration 6 mo
Srinivas, 2014[24]	Subacute DVT (1-8 wk)	VKA, treatment duration 6 mo • Additionally, patients in the standard treatment group received continuous infusion of UFH IV for the first 48 h followed by bolus injections of UFH IV (every 6 h) or LMWH.
Sebastian, 2018[26]	Acute DVT	VKA (target INR 2.0-3.0) in 34.2% of population or Rivaroxaban in 65.8% of population, treatment duration 3 mo
Notten, 2020[3]	Obstruction, acute or chronic	VKA (target INR 2.0-3.5 or 2.5-4.0), treatment duration ≥6 mo • Additionally, patients without pre-interventional antithrombotic treatment received 5000 IU of UFH at the start of intervention.
Cohort study, retrospective		
O'Sullivan 2000[27]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo
Kölbel, 2007[28]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥6 mo
Kölbel, 2009[33]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo
Baekgaard, 2010[35]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥6 mo[a]
Jeon, 2010[37]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration ≥6 mo
Rosales, 2010[38]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo[a]
Titus, 2010[39]	Chronic obstruction	VKA (target INR 2.0-3.0) or LMWH, treatment duration ≥6 mo
Liu, 2014[44]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo[a]
Sang, 2014[46]	PTS	VKA (target INR 2.0-2.5), treatment duration ≥6 mo
Ye, 2014[47]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo[a]
Catarinella, 2015[48]	Chronic obstruction	VKA (target INR 2.5-3.5), treatment duration ≥6 mo
Shi, 2016[50]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration 6 mo
Dumantepe, 2018[52]	Subacute DVT (<1 mo)	Rivaroxaban (15 mg 2 q.d. for 3 wk, followed by 20 mg 1 each day for 3-6 mo)
Case series		
Acharya, 2005[54]	Subacute DVT (≤3 wk ≤6 wk postpartum)	VKA, treatment duration 12 mo[a]
Dayal, 2005[55]	Obstruction, acute or chronic	Long-term systemic anticoagulant treatment. No further specification
Husmann, 2007[56]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration 6 mo
Oguzkurt, 2011[58]	Acute DVT	VKA, treatment duration 6 mo
Ming, 2017[61]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration 6 mo
Case reports		
Kapranov, 2003[62]	PTS	VKA, treatment duration not specified
Oguzkurt, 2008[63]	Acute DVT	VKA, treatment duration 6 mo
Wormald, 2012[66]	Acute DVT	VKA, treatment duration 6 mo
Barge, 2020[71]	Acute DVT	VKA (target INR 2.0-3.0) for 6 mo followed by apixaban (5 mg 2 each day) for another 6 mo.
Full-dose anticoagulant treatment (VKA or DOAC) in combination with or followed by APT		

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TABLE 2 (Continued)

Publication	Population	Intervention: Postinterventional Antithrombotic Therapy
Randomized controlled trials		
Sharifi, 2012[14]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration not specified • In the CDT group (49.7% of population) LMWH was stopped as soon as therapeutic INR was reached (no minimum concurrent use of 5 d). Additionally, aspirin (81 mg 1 each day) was prescribed for ≥6 mo. If the femoropopliteal vein segments were stented 2-4 wk of clopidogrel (75 mg 1 each day) were added.
Cohort study, retrospective		
Wahlgren, 2010[40]	Chronic obstruction	VKA (target INR 2.0-3.0), treatment duration ≥6 mo • Additionally, aspirin (7 5 mg 1 each day) for 1 mo in stented patients (32% of population).
Stanley, 2013[43]	Obstruction, acute or chronic	VKA (target INR 2.0-3.0) OR LMWH, treatment duration ≥6 mo • Thereafter, antiplatelet therapy was indicated for life in stented patients (65% of population).
Park, 2014[45]	Acute DVT	VKA (target INR 2.0-3.0) for ≥3 mo followed by 3-6 mo of antiplatelets (aspirin or clopidogrel)
Case series		
Murphy, 2009[57]	Acute DVT	VKA (target INR 2.0-3.0) for ≥6 mo and aspirin indefinitely
Bloom, 2015[59]	Acute DVT	VKA (target INR 2.0-3.0), treatment duration not specified • Stented patients (72.7% of population) received additional aspirin for 3 mo.
Langwieser, 2016[60]	Chronic obstruction	Rivaroxaban (20 mg 1 each day) and clopidogrel (75 mg once a day or once every other day) for 6 mo. After 6 mo, clopidogrel was stopped. Rivaroxaban was continued in 33% of the population, switched to acetylsalicylic acid in 33% of the population, and stopped in 33% of the population.
Case report		

(Continues)

TABLE 2 (Continued)

Publication	Population	Intervention: Postinterventional Antithrombotic Therapy
Salam, 2010[64]	Acute DVT	VKA (target INR 2.0-3.0) for 3 mo followed by aspirin for life
Sharifi, 2010[65]	Acute DVT	VKA (target INR 2.0-3.0), aspirin (81 mg 1 each day), and 2 wk of clopidogrel (75 mg 1 each day)
Lakha, 2018[69]	Acute DVT	Rivaroxaban and aspirin
APT		
Cohort study, retrospective		
Nayak, 2012[41]	PTS	Aspirin (81 mg 1 each day indefinitely) after discharge. • VKA, if indicated before intervention, was continued accordingly (95.5% of the population)
Mixed or various treatments (between or within groups)		
Cohort study, retrospective		
Knipp, 2007[29]	Chronic obstruction	VKA (72.4% of population) with variable treatment durations or ≥6 wk of antiplatelets (19.0% of population: aspirin, clopidogrel, or both)
Hartung, 2009[32]	Chronic obstruction	VKA, treatment duration 6 mo • During the study adjustments were made: LMWH for 15 d and ≥12 mo of antiplatelets in MTS patients (41.6% of the population) versus VKA ≥12 mo for patients with complex lesions (ie, postthrombotic or mainly recanalization; 58.4% of the population)
Raju, 2009[34]	Chronic obstruction	Aspirin or VKA (in case of thrombophilia) • Later during the study prescribed treatment changed into peri-interventional dalteparin (2500 IU) and prophylactic dosage of fondaparinux sodium for 4-6 wk. Therapeutic dosage combined with long-term VKA was indicated if recanalization comprised ≥3 vein segments, suprarenal stent placement, thrombophilia, or in case of other indications for long-term anticoagulants

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TABLE 2 (Continued)

Publication	Population	Intervention: Postinterventional Antithrombotic Therapy
Comerota, 2019[51]	Chronic obstruction	VKA (target INR 2.0-3.0) and aspirin (81 mg 1 each day). for life with clopidogrel (75 mg 1 each day) for 8 wk. In case of a prosthetic graft placement, cilostazol (100 mg 2 each day) was also indicated for life. • In the last 14 patients (45.2% of the population), continuous infusion of UFH (600-700 IU/h) was administered the first 5 days following the intervention. Intensity for VKA treatment was increased to a target INR of 3.0-4.0 for the first 6-12 mo, thereafter to be reduced to 2.0-3.0 or converted to treatment with a DOAC.
Endo, 2018[53]	Obstruction, acute or chronic	VKA, LMWH, DOAC, or antiplatelets. No further specification
Case report		
Kohler, 2018[68]	PTS	Rivaroxaban (15 mg 2 q.d.) with clopidogrel (75 mg 1 each day and a loading dose of 600 mg). • Treatment was changed several times due to recurrent in-stent-thromboses: UFH IV with clopidogrel, dabigatran with clopidogrel, dabigatran and prasugrel, and ultimately prasugrel with phenprocoumon.
Heparin followed by APT and/or DOAC		
Cohort study, prospective		
Raju, 2014[23]	Chronic obstruction	LMWH for up to 6 wk followed by long-term aspirin. • If VKA was indicated prior to intervention (eg, thrombophilia, recurrent thrombosis, unprovoked thrombosis), this was continued thereafter accordingly.
Sarici, 2014[25]	PTS	Continuous infusion of UFH IV was given the first day following the intervention. Then clopidogrel (2 mo) and aspirin (indefinite) were prescribed. • Patients with thrombophilia (40.4% of the population) received VKA (target INR 2.0-3.0) for life.
Cohort study, retrospective		
Neglén, 2007[30]	Chronic obstruction	Dalteparin (2 gifts) and ketorolac (1 gift) during admission. Aspirin (indefinitely) after discharge. • If VKA was indicated before intervention (eg, thrombophilia, recurrent thrombosis), this was continued accordingly. a. During the observation of the extended cohort, the dosage of dalteparin was changed into 5000 IU 2 each day during the first 36-48 postinterventional hours; ketorolac was administered during the recanalization and continued at 8-h intervals until discharge, aspirin in patients with concomitant VKA was dosed 81 mg twice weekly; eventual VKA use was discontinued 2 d before the intervention until the day of the intervention and it was (re) installed in patients with thrombophilia, recurrent VTE, or other preexisting indications; patients with homocystinemia were treated with aspirin, vitamin B6, and folate therapy.
Blanch, 2013[42]	Chronic obstruction	Two gifts of LMWH following the intervention and indefinite use of aspirin (100 mg 1 each day). • VKA were indicated in case of thrombophilia, extensive stenting (≥3 vein segments), or a preinterventional indication for anticoagulation (80.6% of the population).

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TABLE 2 (Continued)

Publication	Population	Intervention: Postinterventional Antithrombotic Therapy
Case report		
Singh, 2017[67]	Acute DVT	UFH IV followed by apixaban (5 mg 2 each day)
Rohr, 2019[70]	Acute DVT	LMWH was converted to treatment with apixaban (5 mg 2 each day) for 9 mo and aspirin (325 mg 1 each day) for life.

Abbreviations: APT, antiplatelet therapy; CDT, catheter-directed thrombolysis; DVT, deep vein thrombosis; DOAC, direct oral anticoagulants; INR, international normalized ratio; IU, international units; IV, intravenous; LMWH, low molecular weight heparin; MTS, May-Thurner syndrome; NSAID, nonsteroidal anti-inflammatory drugs; PE, pulmonary embolism; PTS, postthrombotic syndrome; UFH, unfractionated heparin; VKA, vitamin K antagonist.

[a]Alternative treatment durations were specified for patients with hypercoagulability,[20,35,38,47] recurrent venous thromboembolic events,[20,35] idiopathic venous thromboembolic events,[21] stent placement,[20,54] treatment of postthrombotic lesions,[44] or in case of individually tailored treatments.[38]

eight occurred after more than 30 days (four events in both groups, $P = .33$). There was no difference in the occurrence of major bleeding (one in each group, $P = .64$) or the number of patients free from PTS at the last follow-up visit (57 [85%] vs 29 [88%], $P = .76$). The second study[3] was a cohort study of patients stented for thrombotic (acute or chronic) or nonthrombotic obstructions of the cavo-iliofemoral venous tract and identified the time within therapeutic range (TTR), an indicative measure of the quality of antithrombotic treatment with VKA, as an important determinant for the development of IST. An increased risk was seen if the TTR was less than the cutoff value of 49.9%, which could further be specified for patients treated with stenting during the acute phase of thrombosis (cutoff value 69.4%) or for chronic postthrombotic sequelae (cutoff value 45.9%). IST developed in 16 of the 74 (21.6%) patients stented for thrombotic pathology of which four received stenting during the acute phase. No reDVT or PE was seen.

4.2 | Patency rates

Patency rates were reported in 40 studies (71%) (Table 3). Multiple definitions for patency were used (eg, primary patency, assisted primary patency, secondary patency, a maximum percentage of residual stenosis, a combination with the absence of reflux) and variable durations of follow-up were reported. Results were often not specified for patients with thrombotic (acute or chronic) or nonthrombotic treatment indications.

Nineteen studies (34%)[16,20,22,24,26,28,35,37,45,52,56,57,59,63,65-67,70,71] included only patients who received an intervention for acute DVT. Five studies[26,28,37,45,56] reported patency using the definitions primary patency, assisted primary patency, and/or secondary patency. Results were specified for stented patients in four studies,[26,37,45,56] of which three reported on stenting for acute DVT associated with underlying May-Thurner syndrome.[37,45,56] In the stented patients of these four studies, with a follow-up duration between 12 and 22 months, the mean primary patency was 82% (standard deviation [SD] 6.6), ranging from 72%[26] to 90%[26]; the mean assisted primary patency was 89% (SD 1.7), ranging from 87%[26,45] to 91%[26,56]; and the mean secondary patency was 93% (SD 3.1), ranging from 89%[45] to 97%.[26] Postinterventional antithrombotic treatment with either 3 months of DOAC or 3 months of VKA did not impact patency rates differently ($P > .10$).[26] The study that did not specify results for stented patients reported an overall primary patency of 77.3%, assisted primary patency of 86.4%, and a secondary patency of 88.6% 16 months after an intervention for acute IFDVT.[28]

In the study by AbuRahma et al[20] patency was defined as a ≤30% residual stenosis. A significant difference between standard treatment and additional multimodality treatment (including CDT, percutaneous transluminal balloon angioplasty, and/or stenting) was reported after 1 month, 3 months, 1 year, 3 years, and 5 years. It was not specified whether patients were stented for thrombotic or other indications. Another study[52] used a cutoff value of <50% restenosis to define patency. At 1 year, they reported a patency rate of 90.7% in patients with a subacute (complaints for less than 1 month) DVT. Baekgaard et al used a definition for patency which included the absence of reflux. The analysis of the first 45 patients included in the cohort showed a patency rate of 100% at 2 years of follow-up.[36] After extension of the cohort and the follow-up duration to 6 years, patency was seen in 82% of patients.[35]

Cakir et al[16] differentiated between completely patent, partially patent, and thrombosed. They found a significantly higher complete patency rate in patients randomized to additional percutaneous aspiration thrombectomy compared with standard treatment alone following acute iliofemoral-popliteal DVT at 1 month, at 3 months, and at 1 year (all $P < .001$). Specified for stented patients, complete patency was seen in 71.4%.

Vein segments were classified as either patent or occluded in four studies.[22,24,57,59] Manninen et al[22] found 87% of vein segments to be patent 3 years after an intervention. Srinivas et al[24] compared additional CDT to standard treatment alone in subacute DVT and found a significant difference at 6 months: 80.0% versus 26.9%, $P < .01$. Specifically, patency was 100.0% in stented patients with accompanying May-Thurner syndrome[57] and 87.5% in patients stented after an acute IFDVT during pregnancy or the first 6 weeks postpartum.[59] All six case reports reported patent stents[63,65,70,71] or stents without (residual) signs of DVT.[66,67]

Another 21 studies[23,25,27,29-34,38-40,42-44,46-50,53,60,62] included a mixed case load with patients treated for thrombotic (acute or chronic) or nonthrombotic venous pathology. Outcomes were mostly reported as primary patency, assisted primary patency, and secondary patency. Overall, the primary patency rates in these studies had a mean of 82.5% (SD 12.7) and ranged from 61%[40] to 100%[60] 1 year after the intervention.[27,29,39,40,44,46,49,50,53,60] After

TABLE 3 Outcomes

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Randomized controlled trials							
Enden, 2012 (CaVenT)[10]	Acute DVT	Not reported	ReVTE: 28/189 (14.8%) PE: **None (0/15)**	Not reported	3/189 (1.6%)	CDT vs. STND [§] 37/90 (41.1%) vs. 55/99 (55.6%). ARR 14.4% (0.2-27.9)	24 mo
Sharifi, 2012[14] (TORPEDO)	Acute DVT	Not reported	PEVI vs. STND ReVTE: 4/88 (4.5%) vs. 13/81 (16.0%), $P = .02$. PE: 0/88 (0%) vs. 4/81 (4.9%). All patients from PEVI group received ICV filters of which 10/91 (11%) showed thrombi.	**1/27 (3.7%)**	Not reported	PEVI vs. STND[**] 6/88 (6.8%) vs. 24/81 (29.6%), $P < .001$.	30 mo[a]
Cakir, 2014[16]	Acute IFDVT	At 1 mo: patent 13/21 (61.9%) vs. 0/21 (0%), partial thrombosis 8/21 (38.1%) vs. 5/21 (23.8%), full thrombosis 1/21 (4.8%) vs. 16/21 (76.2%), ($P < .001$). **Stented patients at 1 mo: patent 10/14 (71.4%), partial thrombosis 3/14 (21.4%), full thrombosis 1/14 (7.2%).** At 3 mo: patent 12/21 (57.1%) vs. 0/21 (0%), partial thrombosis 8/21 (38.1%) vs. 6/21 (28.6%), full thrombosis 1/21 (4.8%) vs. 15/21 (71.4%), ($P < .001$). **Stented patients at 3 mo: patent 10/14 (71.4%), partial thrombosis 2/14 (14.3%), full thrombosis 2/14 (14.3%).** At 12 mo: patent 12/21 (57.1%) vs. 1/21 (4.8%), partial thrombosis 8/21 (38.1%) vs. 15/21 (71.4%), full thrombosis 1/21 (4.8%) vs. 5/21 (23.8%), ($P < .001$). **Stented patients at 12 mo: patent 10/14 (71.4%), partial thrombosis 2/14 (14.3%), full thrombosis 2/14 (14.3%).**	PAT vs. STND ReDVT: 1/21 (4.8%) vs. 0/21 (0%). **In stented patients: None (0/14)** PE: 1/21 (4.8%) vs. 4/21 (19.0%). ICV filters placed in 2/21 PAT patients (9.5%).	**2/14 (14.3%)**	Not reported	Not reported	12 mo

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Zhang, 2014[17]	Subacute IFDVT (≤4 wk)	Not reported	CDT vs. CDT + PTA ReDVT: 3/186 (1.6%) vs. 4/190 (2.1%). PE: **None (0/81).** All patients received ICV filters	Not reported	**None (0/81)**	Not reported	24 mo
Vedantham, 2017[18] (ATTRACT)	Acute DVT	Not reported	CDT vs. STND ReVTE (reDVT, IST or PE), overall: 42/337 (12.5%) vs. 30/355 (8.5%). -Within first 10 d: 6/337 (1.8%) vs. 4/355 (1.1%).	Not reported	CDT vs. STND Overall: 19/337 (5.6%) vs. 13/355 (3.7%). -Within first 10 d: 6/337 (1.8%) vs. 1/355 (0.3%).	CDT vs. STND [§] 157/336 (46.6%) vs. 171/355 (48.2%).	24 mo
Notten, 2020[2] (CAVA)	Acute IFDVT	Not reported	CDT vs. STND ReVTE (reDVT, PE, or IST): 24 (17 vs. 7) events in 20 (14 vs. 6) patients. -ReDVT: 5/77 (6.5%) vs. 5/75 (6.7%). -PE: 0/77 (0%) vs. 2/75 (2.7%).	**12/77 (15.6%)**	CDT vs. STND 4/77 (5.2%) vs. 0/75 (0%).	CDT vs. STND -Original score: 22/77 (28.6%) vs. 26/75 (34.7%). [‡] -ISTH method: 32/77 (41.6%) vs. 33/75 (44.0%). [§]	12 mo[b]
Cohort studies, prospective							
AbuRahma, 2001[20]	Acute IFDVT	STND vs. MULTI: -At 1 mo: 3% vs. 83% ($P < .001$). -At 6 mo: 24% vs. 83% ($P < .001$). -At 1 yr: 24% vs. 83% ($P < .01$). -At 3 y: 18% vs. 69% ($P < .01$). -At 5 yr: 18% vs. 69% ($P < .01$).	STND vs. MULTI ReVTE: 2/33 (6.1%) vs. 2/18 (11.1%). PE: 2/33 (6.1%) vs. 0/18 (0%). No ICV filters used	Not reported	STND vs. MULTI: 2/33 (6.1%) vs. 2/18 (11.1%)	Not reported	63 mo[a] vs. 51 mo[a]
Grommes, 2011[21]	Acute DVT	Not reported	ReVTE: 4/13 (30%). **In stented patients: None (0/3)** PE: **None (0/3)**	**None (0/3)**	**None (0/3)**	Not reported	7 mo[a]

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Manninen, 2012[22]	Acute IFDVT	At 3 y: 41/47 (87%)	ReDVT: 2/56 (3.6%). PE: PE 1/56 (1.8%). ICV-filter placed in 5 (8.9%)	Not reported	**1/56 (1.8%)**	4/47 (8.5%)**	42 mo[a]
Raju, 2014[23]	Chronic obstruction (iliac)	PP and SP: 69% and 93%	ReDVT: -Early (<30 d): 4% -Late (>30 d): 1%	8/217 (3.7%)	Not reported	Not reported	24 mo
Srinivas, 2014[24]	Subacute DVT (1-8 wk)	CDT vs. STND 20/25 (80.0%) vs. 7/26 (26.9%).	CDT vs. STND PE: 14.8% (4/27) vs. 21.4% (6/28). ICV filters placed in 5/27 patients from the CDT group (18.5%)	Not reported	**None (0/6)**	CDT vs. STND § 5/25 (20.0%) vs. 19/26 (73.1%)	6 mo
Sarici, 2014[25]	PTS	**If primary disease: 86% If secondary disease: 90%.**	Not reported	**5/52 (9.6%)**	Not reported	Not reported	6 mo
Sebastian, 2018[26]	Acute IFDVT	**DOAC vs. VKA PP, aPP, and SP: -At 12 mo: 90% vs. 85%; 91% vs. 88%; 97% vs. 94% -At 24 mo: 87% vs. 72%; 89% vs. 88%; 95% vs. 94%**	**ReVTE (DVT, PE, or IST): 15/111 (14%) -ReDVT: 1/111 (1%; VKA group) -PE: 1/111 (1%; DOAC group)**	**13/111 (11.7%) -Early: 5/111 (4.5%). DOAC vs. VKA: 3/73 (4%) vs. 2/38 (5%) -Late: 8/111 (7.2%). DOAC vs. VKA: 4/73 (5%) vs. 4/38 (11%)**	**2/111 (2%). DOAC vs. VKA: 1/73 (1%) vs. 1/38 (3%)**	**DOAC vs. VKA ¶ Free of PTS: 85% vs. 88%**	24 mo[a]
Notten, 2020[3]	Obstruction (cavo-iliofemoral; postthrombotic (acute or chronic) or IVCS)	Not reported	**ReDVT: None (0/74) PE: None (0/74)**	16/79 (20.3%). **In post-DVT patients: 16/74 (21.6%; acute n = 4 (25.0%) vs. chronic n = 12 (75.0%))**	2/79 (2.5%). **In post-DVT patients: 2/74 (2.7%)**	Not reported	39 mo[b]
Cohort studies, retrospective							
O'Sullivan 2000[27]	Chronic obstruction (IVCS)	PP at 1 d, 1 mo, and 1 yr: -Overall: 97%, 93.6%, 93.6%. -Acute DVT: 100%, 93.1%, and 93.1%. -IVCS: 93.9%, 93.9%, and 93.9%	PE: **None**	2/35 (5.7%)	**None**	Not reported	12 mo[b]

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Kölbel, 2007[28]	Acute IFDVT	PP, aPP, and SP at 16 mo: 34/44 (77.3%), 38/44 (86.4%), and 39/44 (88.6%)	ReDVT: **1/36 (2.8%)** PE: **None (0/36).** ICV filters implanted in all patients before start of intervention. All were removed afterwards.	**5/44 limbs (11.4%)**	3/36 (8.3%)	Not reported	Patency: 16 mo[b] Clinical: 27 mo[b]
Knipp, 2007[29]	Chronic obstruction (IVCS)	PP, aPP, and SP: -At 1 y: 74.1%, 79.7%, 85.8% -At 5 y: 38.1%, 62.8%, 73.8%	Not reported	Not reported	1 (1.7%)	Not reported	30 mo[a]
Neglén, 2007[30](Neglén-cohort)	Chronic obstruction (femoro-ilio-caval)	PP, aPP, and SP at 72 mo: Overall: 67%, 89%, and 93% -NIVL: 79%, 100%, and 100% **-Post-DVT: 57%, 80%, and 86%.**	ReVTE (reDVT or IST): 47/982 (4.8%): -ReDVT: 16/982 (1.6%) -Early (<30 d): 7/982 (0.7%) -Late (>30 d): 9/982 (0.9%)	31/982 (3.2%) -Early (<30 d): 8/982 (0.8%) -Late (>30 d): 23/982 (2.3%)	2/982 (0.2%)	Not reported	22 mo[a]
Hartung, 2009[32]	Chronic obstruction (iliocaval)	PP, aPP, and SP at 3 and 10 y: 83%, 89%, 93%	ReVTE: 5/89 (5.6%) -In-hospital: 2/89 (2.2%) -During FU: 3/89 (3.4%).	Not reported	Not reported	Not reported	38 mo[b]
Kölbel, 2009[33]	Chronic obstruction (iliac)	PP, aPP, and SP: 67%, 75%, and 79%	ReVTE: 3/59 (5.1%)	Not reported	2/62 (3.2%)	Not reported	25 mo[b]
Raju, 2009[34]	Chronic obstruction (postthrombotic)	**SP at 4 y: 66%**	Not reported	**39/139 (28.1%)** **-Within 30 d: 10/139 (7.2%)** **-After 30 d: 29/139 (20.9%)**	**None (0/129)**	Not reported	Not reported
Baekgaard, 2010[35] (Gentofte-cohort)	Acute IFDVT	Patency without reflux at 6 y: 82%	ReVTE (DVT, IST): 6/101 (5.9%) -ReDVT: 5/101 (5.0%) -Early (<1 wk): 2/101 (2.0%) -Late: 3/101 (3.0%) PE: **None (0/57).** ICV-filter placed in 7 patients.	**1/101 (1.0%)** **-Early (<1 wk): 1/101 (1.0%)** **-Late: 0/101 (0%)**	1/101 (1.0%)	Not reported	50 mo[b]
Jeon, 2010[37]	Acute DVT (with MTS)	**PP and SP at 1 yr: 83.3% and 90%**	Not reported	**4/30 (13.3%)**	Not reported	Not reported	Not reported

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Rosales, 2010[38]	Chronic obstruction (iliofemoral, postthrombotic)	**PP, aPP, and SP at 2 y: 14/21 (67%), 16/21 (76%), 19/21 (90%)**	**ReVTE: 13/32 (40.6%)** **-Early (<1 mo): 2/32 (6.3%)** **-Late: 11/32 (34.4%).**	Not reported	Not reported	Not reported	33 mo[b]
Titus, 2010[39]	Obstruction (iliofemoral)	PP, aPP, and SP: -At 6 mo: 88.1%, 92.5%, 100.0% -At 12 mo: 78.3%, 82.7%, 95.0%. -At 24 mo: 78.3%, 82.7%, 95.0%.	PE: **None**. ICV filters already placed in 9 (25%) patients and in 2 (5.6%) patients as part of this study.	6/36 (16.7%) -Early: 1/36 (2.8%) -Late: 5/36 (13.9%)	**None**	Not reported	10 mo[a]
Wahlgren, 2010[40]	Chronic obstruction (femoro-ilio-caval, post-thrombotic)	PP and aPP/SP at 12 mo: 61% and 81%	Not reported	**7/16 (43.8%)** **-Early: 3/16 (18.8%)** **-Late: 4/16 (25.0%)**	**None (0/16)**	Not reported	23 mo
Nayak, 2012[41]	PTS	Not reported	PE: **None (0/39)**	**4/39 (10.3%)**	**None (0/39)**	Not reported	41.7 ± 13.2 d (range 20-108 d) [a]
Blanch, 2013[42]	Chronic obstruction (iliofemoral, postthrombotic)	**PP, aPP, and SP at 33 mo: 74%, 87%, 89%**	Not reported	**9/39 limbs (23.1%)** **-Early (<4 wk): 5/39 (12.8%)** **--Stenosis: 2/39 (5.1%)** **--Occlusion: 3/39 (7.7%)** **-Late (>4 wk): 4/39 (10.3%)** **--Occlusion: 4/39 (10%).**	Not reported	Not reported	21 mo[a]
Stanley, 2013[43]	Acute or chronic DVT	Acute vs. chronic -At 1 mo: 96% vs. 93% -At 6 mo: 92% vs. 89% -At 46 mo: 94% vs. 82%	PE: 6/80 (7.5%). ICV filter in 49/80 (61.3%)	Not reported	3/80 (3.8%)	Not reported	46 mo[a]
Liu, 2014[44]	Chronic obstruction (IVCS)	PP at 12 mo: 93.0% -Post-DVT vs. nonthrombotic: **81.8%** vs. 96.9%	ReDVT: 1/46 (2.2%) PE: **None (0/12)**	2/46 (4.3%)	1/46 (2.2%)	Not reported	12 mo

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Park, 2014[45]	Acute DVT (with MTS)	**PP at 6, 12, and 24 mo: 95.8%, 87.5%, and 84.3%**	ReVTE (DVT or IST): **4/51 (7.8%)** **-ReDVT: 1/51 (2.0%)** -PE: Not reported. All patients received ICV filters	**3/51 (5.9%)**	**1/51 (2.0%)**	Not reported	16 mo[a]
Sang, 2014[46]	PTS	**PP and SP:** **-At 12 mo: 87.9% and 93.1%** **-At 36 mo: 70.7% and 82.8%**	PE: **None (0/63)**	**11/63 (14.5%)** **-Early (<30 d): 7/63 (11.1%)** **-Late (>30 d): 4/63 (6.3%)**	**None (0/63)**	Not reported	36 mo[a]
Ye, 2014[47]	Chronic obstruction (iliofemoral, postthrombotic)	**PP, aPP, and SP at 3 y: 70%, 90%, and 94%**	PE: **None (0/112)**	**20/110 (18.2%; 21/112 limbs = 18.8%)**	**None (0/112)**	Not reported	25 mo[b]
Catarinella, 2015[48] (MUMC)	Chronic obstruction	PP, aPP, and SP: 65%, 78%, and 89%	Not reported	Not reported	Not reported	Not reported	24 mo
Shi, 2016[50]	Chronic obstruction (IVCS)	PP and SP: -At 1 yr: 93.2% and 100% -At 3 y: 84.3% and 93.3% -At 5 y: 74.5% and 92.0%	ReDVT: 11/225 (4.9%) PE: Not reported. IVC filter placed in 95 (40.9%) patients, all being post-DVT (95/110 = 86.3%)	37/225 (16.4%) -Caudal: 22/37 (59.5%) -Complete tract 15/37 (40.5%)	2/225 (0.9%)	Not reported	34 mo[b]
Comerota, 2019[51]	Chronic obstruction (iliofemoral, postthrombotic)	Not reported	Old vs. new method ReDVT: **5/17 (29.4%) vs. 0/14 (0%)**	Not reported	Old vs. new method **4/17 (23.5%) vs. 1/14 (7.1%)**	Not reported	Not reported
Dumantepe, 2018[52]	Subacute DVT (<1 mo)	At 12 mo: 59/65 (90.7%)	PE: Not reported. IVC filter placed in 10/68 (14.7%)	Not reported	1/68 (1.5%)	At 12 mo: 5/68 (7.3%) [§]	16 mo[a]
Endo, 2018[53]	Chronic compression and/or acute DVT	PP and SP: 70.0% and 92.4%.	Not reported	17/62 (27.4%) -Stenosis: 5/62 (8.1%) -Occlusion: 12/62 (19.3%).	3/62 (4.8%)	Not reported	12 mo[b]
Case series							

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Acharya, 2005[54]	Subacute DVT (≤3 wk ≤6 wk postpartum)	Not reported	ReDVT: **None (0/2)** PE: **None (0/2)**	**None (0/2)**	**None (0/2)**	Not reported	Not reported
Dayal, 2005[55]	Critical chronic compression and/or acute DVT	Not reported	ReVTE (reDVT or IST): 13/25 (48%) -Within 14 d: 1/25 (4%) -After 14 d: 12/25 (48%) -ReDVT: 7/25 (28%) PE: **None.** ICV filters placed in 11 patients	**6/15 (40%)**	3/25 (12%)	Not reported	11 mo[a]
Husmann, 2007[56]	Acute DVT (with MTS)	**PP and aPP: 81% (9/11) and 91% (10/11)**	Not reported	**2/11 (18.2%)** **-In-hospital: 1/11 (9.1%)** **-During FU: 1/11 (9.1%)**	**None (0/11)**	Not reported	22 mo[a]
Murphy, 2009[57]	Acute DVT (with MTS and initiation of oral contraceptives)	**PP: 100%**	ReDVT: **None (0/7)**	**None (0/7)**	**1/7 (14.3%)**	**None (0/7)** ††	16 mo[a]
Oguzkurt, 2011[58]	Phlegmasia cerulea dolens (from IFDVT)	Not reported	ReDVT: 2/7 (28.0%) -Early: 2/7 (28.0%). **In stented patients: 0/3 (0%)** -During FU: **None (0/3)** PE: **None (0/3).** ICV filters were placed in 3 (42.9%) patients. All were removed and none had emboli inside.	**None (0/3)**	**None (0/3)**	Not reported	4 mo

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Bloom, 2015[59]	Acute IFDVT (during pregnancy or ≤6 wk postpartum)	**PP: 87.5%**	ReDVT, early: 2/8 (25.0%) PE: **None (0/8).** All patients received an ICV filter. Thrombus was found inside the filter in 2 patients of which 1 with stent **(1/8, 12.5%)**	Not reported	**None (0/8)**	**None (0/8)** [§]	20 mo[b]
Langwieser, 2016[60]	Chronic obstruction (iliofemoral, postthrombotic)	**PP: 100%**	ReDVT: **None (0/9)**	**None (0/9)**	**None (0/9)**	Not reported	14 mo[b]
Ming, 2017[61]	Acute IFDVT (with IVCS)	Not reported	Not reported	Not reported	Not reported	74/247 (30%). [§] Stented vs. not stented: **25/116 (21.6%)** vs. 49/131 (37.4%)	Not reported
Case reports							
Kapranov, 2003[62]	PTS (after IFDVT)	**100%**	Not reported	**None (0/1)**	Not reported	Not reported	3 mo
Oguzkurt, 2008[63]	Phlegmasia cerulea dolens (from IFDVT with MTS)	**100%**	ReDVT: **None (0/1)**	**None (0/1)**	**None (0/1)**	**None (0/1)** [‡‡]	3 mo
Salam, 2010[64]	Acute IFDVT (with EIV stenosis from repetitive microtrauma)	Not reported	Not reported	**None (0/1)**	Not reported	Not reported	1 mo
Sharifi, 2010[65]	Acute IFDVT	**100%**	Not reported	**None (0/1)**	Not reported	**None (0/1)** [‡‡]	6 mo
Wormald, 2012[66]	Acute IFDVT (with MTS)	**100%**	ReDVT: **None (0/1)**	**None (0/1)**	Not reported	**None (0/1)** [‡‡]	6 mo
Singh, 2017[67]	Acute IFDVT (with MTS and pelvic mass) and PE	**100%**	PE: **None. Temporary ICV filter placed, removed after 4 d.**	Not reported	Not reported	Not reported	6 mo

(Continues)

TABLE 3 (Continued)

Publication	Treatment Indication	Outcomes					
		Patency (% and Term)	ReVTE	IST	Major Bleeding	PTS	FU
Kohler, 2018[68]	Severe PTS (after cavo-iliacal DVT)	Not reported	Not reported	**Multiple IST**	Not reported	Not reported	10 mo
Lakha, 2018[69]	Acute IFDVT (with MTS)	Not reported	Not reported	**Symptomatic IST and new stenosis of the left VIC distal to the stent at 5-month FU**	Not reported	Not reported	17 mo
Rohr, 2019[70]	Acute IFDVT	**100%**	ReDVT: **None (0/1)**	**None (0/1)**	**None (0/1)**	Not reported	9 mo
Barge, 2020[71]	Acute cavo-bi-iliacal DVT (also involving left renal vein)	**100%**	Not reported	**None (0/1)**	Not reported	**None (0/1)** ††	6 mo

Note: All outcomes reported in **bold** represent data specified for the number of patients with post-DVT (acute or chronic) treatment indications receiving venous stent placement. In the reporting of PTS, various definitions were used. These included the original definition[72] (‡), the ISTH consensus method[72,73] (§), a combination of the Venous Clinical Severity Score[75] and a revised Villalta-score[74] (¶), or alternative definitions (**). In some studies, no definition was specified (††). Furthermore, some studies reported an absence of symptoms (‡‡).

Abbreviations: aPP, assisted primary patency; ARR, absolute risk reduction; CDT, catheter-directed thrombolysis; CIV, common iliac vein; DOAC, direct oral anticoagulants; DVT, deep vein thrombosis; EIV, external iliac vein; FU, follow-up; ICV, inferior caval vein; IFDVT, iliofemoral deep vein thrombosis; IST, in-stent thrombosis; ISTH, International Society of Thrombosis and Haemostasis; IVCS, iliac vein compression syndrome; MTS, May-Thurner syndrome; MULTI, multimodal treatment; NIVL, nonthrombotic iliac vein lesions; PAT, percutaneous aspiration thrombectomy; PE, pulmonary embolism; PEVI, percutaneous endovenous intervention; PP, primary patency; PTA, percutaneous transluminal angioplasty; PTS, postthrombotic syndrome; reVTE, recurrent venous thromboembolic event; SP, secondary patency; STND, standard treatment; VKA, vitamin K antagonist.

[a]Mean value.

[b]Median value.

2 years,[23,33,38,39,48] a mean primary patency of 69.3% (SD 5.2) was found ranging from 65%[48] to 78.3%.[39] This remained stable after 3 years,[32,42,46,47,50] with a mean primary patency of 76.4% (SD 6.8) and a range from 70.0%[47] to 84.3%.[50] Mean primary patency dropped to 56.3% (SD 25.7) after 5 years with a range from 38.1%[29] to 74.5%.[50] Long-term follow-up data on patency rates are scarce: one study[30] reported 67% primary patency after 6 years, and another study[32] reported 83% primary patency after 10 years. Reported secondary patency rates varied from 81%[40] to 100%[50] after 1 year with a combined mean of 91.9% (SD 6.5),[29,39,40,46,49,50,53] which appeared to remain stable at longer durations of follow-up: 89.2% (SD 6.2; range 79%[33] to 95%[39]),[23,33,38,39,48] 90.4% (SD 4.7; range 82.8%[46] to 94%[47]),[32,42,46,47,50] and 82.9% (SD 12.9; range 73.8%[29] to 92.0%[50]) after 2, 3, and 5 years, respectively.

Some studies presented patency rates per-treatment indication being either primary or secondary[25,27,30,31,44] resulting in a combined mean primary patency of 83.2% (SD 14.7) versus 74.8% (SD 19.0). No statistically significant differences were seen for acute versus chronic thrombotic pathology at 46 months of follow-up ($P = .12$).[43]

4.3 | Recurrent venous thromboembolism

Information regarding reVTE was provided in 41 studies (73%)[3,23,27,30,32,33,38,39,41,43,44,46,47,49-51,55,60]; 23 of these studies included patients treated for acute DVT.[2,10-22,24,26,28,35,36,45,52,54,57,63,66,67,70] (Table 3). Studies used different definitions for reVTE, which could include reDVT, IST, PE, and/or the use of inferior caval vein filters. Although specification of results into these different entities was often not performed, when provided, these data will also be presented separately here.

The incidence of reVTE was reported in 16 studies (29%).[2,10,12-15,18-21,26,30,32,33,35,36,38,45,50,51,55] Nine studies[2,10,12-15,18-21,26,35,36,45] included patients treated for acute venous pathology only. In two of these studies, the incidences for reVTE were specified for patients receiving stents: 0.0% in the study by Grommes et al[21] and 7.8% in the study by Park et al[45] Overall, incidences for reVTE ranged from 5.9%[35] to 30%,[21] with significant differences reported depending on received treatment but not on duration of follow-up. In the publication by Sharifi et al, treatment with additional venous interventions was compared with standard anticoagulant therapy that resulted in recurrence rates of 2.3% versus 14.8%, $P = .003$, after 6 months of follow-up,[15] whereas these rates were 4.8% versus 16.0%, $P = .02$, after a mean follow-up of 30 months.[14] Notten et al[2] assessed the number of events including IST and found events in 22.1% versus 9.3% ($P = .05$) of patients, respectively. For the seven studies that also included interventions for chronic pathologies,[30,32,33,38,50,51,55] the overall incidences varied from 4.8%[30] to 48%[55] without correlation to duration of follow-up.

ReDVT was registered as a separate entity in 24 studies (43%): 17 including only interventions for acute DVT[2,12,13,15-17,22,26,28,35,45,54,57-59,63,66,70] and seven studies (also) including chronic treatment indications.[3,23,27,30,44,55,60] In the studies including acute pathology only, incidence had a mean of 6.0% (SD 8.1) versus 4.6% (SD 9.6) in studies also including patients treated for chronic venous obstructions without influence of follow-up duration.

In 13 studies incidences could be specified for patients with (a history of) DVT who underwent venous stent placement[16,26,28,45,54,57,58,63,66,70]; reDVT was only seen in studies that included patients treated during the acute phase of DVT: Sebastian et al (1%),[26] Park et al (2.0%),[45] and Kölbel et al (2.8%).[28] ReDVT was absent in the other seven studies (including three case reports)[16,54,57,58,63,66,70] with an acute indication for intervention as well as in the other three studies with mixed treatment indications including both acute and chronic pathology.[3,27,60]

PE was reported in 25 studies (45%): 16 addressing interventions performed during the acute phase only,[2,10-17,20-22,24,26,28,35,54,58,59,67] and nine also including interventions during the chronic thrombotic phase.[3,39,41,43,44,46,47,49,55] Overall, including the total study population of these studies, incidences of PE ranged from 0.0% to 21.4%,[24] with two studies[16,24] reporting an incidence of more than 10%.

In 18 studies (10[10,17,21,26,28,35,54,58,59,67] solely directed at treatment of acute DVT vs eight[3,39,41,44,46,47,49,55] including chronic pathology) results were specified for stented patients. PE was absent in all but one study: Srinivas et al reported an incidence of 1%.[24] The use of (temporary) inferior caval vein filters was addressed in 16 studies (29%).[14-17,20,22,24,28,35,43,45,50,52,55,58,59,67]

4.4 | In-stent thrombosis

IST was reported as a separate entity in 41 studies (73%): 20 studies in which interventions were performed in the acute thrombotic phase[2,14-16,21,26,28,35-37,45,54,56-58,63-66,69-71] and 21 studies (also) including interventions for chronic thrombotic pathology.[3,23,25,27,30,31,34,38-42,44,46,47,49,50,53,55,60,62,68] (Table 3).

Specification of outcomes for patients stented following thrombosis was possible in all 20 studies reporting on interventions performed during the acute phase. Occurrence of IST was seen in 11 of these studies[2,14,16,26,28,35,37,45,56,57] and ranged from 1.0%[35] to 18.2%.[56] IST was absent in the remainder cohort study,[21] two case series,[54,58] and six case reports.[63-66,70,71] Differentiation of the occurrence rate into early and late IST was possible in the studies by Sebastian et al (4.5% vs 7.2%, $P = .57$)[26] and Husmann et al (9.1% vs 9.1%, $P > .99$).[56] No difference was seen when treated with 3 months of VKA or rivaroxaban: $P > .99$ for the early IST and $P = .54$ for the late IST.[26]

If study populations also included patients receiving interventions for chronic pathology,[3,25,31,34,38,40-42,46,47,55,60] the occurrence of IST in patients with (post)thrombotic stenting ranged from 0.0%[60,62] to 43.8%[40] next to the multiple recurrences resulting from nonresponsiveness to antithrombotic treatment in one[68] of the two case reports.[62,68] Early occurrences ranged from 5.4%[3] to 18.8%[40] and late occurrences from 3.8%[31] to 34.4%.[38] In studies that did not allow specification of outcomes for patients with thrombotic or nonthrombotic chronic pathology,[23,27,30,39,44,49,50,53] the overall risk of

IST ranged from 3.2%[30] to 27.4%.[53] Several studies also mentioned the occurrence of (in-stent) stenosis and occlusion without clarifying its cause being thrombotic or nonthrombotic.[32,38,42,46,53]

4.5 | Major bleeding

In 40 studies (71%), the occurrence of major bleedings was reported, 21 studies[2,10-13,15,17-22,24,26,28,35,36,45,52,54,56-59,63,70] aimed at interventions in the acute phase and 19 studies including chronic treatment indications[3,27,29-31,33,34,39-41,43,44,46,47,49-51,53,55,60] (Table 3). In studies comparing additional interventional treatment for thrombus removal to standard treatment alone, there appeared to be a higher risk of major bleeding in the intervention groups: 2.2% versus 1.1% during a mean hospitalization of 2.7 ± 1.1 versus 5.8 ± 1.3 days ($P = .57$),[15] 1.8% versus 0.3% ($P = .049$)[18] and 1.5% versus 0.5% during the first 10 days after the intervention ($P = .32$),[19] 5.2% versus 0.0% at 1 year of follow-up ($P = .06$),[2] and 11.1% versus 6.1% at long term ($P = .89$).[20]

The incidence of major bleeding could be specified for stented (post)thrombotic patients in 24 studies.[3,13,17,21,22,24,26,27,34,39-41,45-47,51,54,56-60,63,70] Major bleedings were absent in 10 of the 14 studies on acute pathology.[13,17,21,24,54,56,58,59,63,70] This included the two case reports addressing this complication.[63,70] Only a single study showed an incidence of more than 2.0%: the case series by Murphy et al found an incidence of 14.3%.[57] Of the studies including chronic venous pathology, eight found an incidence of 0.0%[27,34,39-41,46,47,60] and one of 2.7%.[3] The study by Comerota et al[51] compared incidences between patients treated according to their original peri-interventional protocol and after modifications that resulted in a significant risk reduction: 23.5% versus 7.1% ($P = .47$).

4.6 | Postthrombotic syndrome

PTS was assessed in 15 studies (27%),[2,10,12-15,18,19,22,24,26,52,57,59,61,63,65,66,71] all of which addressed venous interventions during the acute phase (Table 3). The definition for PTS varied among the different studies. The original definition,[72,73] requiring an elevated Villalta score on two separate measurements at least 3 months apart or the occurrence of venous ulceration, was used in one study[2] only. Comparing additional ultrasound-accelerated CDT (which included stenting in 45.5% of patients) to standard treatment alone, PTS developed in 28.6% and 34.7%, respectively. Most frequently used (seven studies[2,10,12,13,18,19,24,52,59,61]) was the definition according to the ISTH consensus method[73]: a single elevated Villalta score (≥5)[72] at 6 months or later after the acute event or the presence of venous ulceration. In four of these studies, outcomes were compared between groups treated with standard treatment alone or additional interventions, which sometimes included venous stenting. The reported incidence of PTS in these groups were 55.6% versus 41.1% ($P = .047$),[10] 73.1% versus 20.0% ($P < .01$),[24] 48.2% versus 46.6% ($P = .56$),[18] and 44.0% versus 41.6% ($P = .76$),[2] respectively. However, the incidence of PTS was not specified separately for patients who received venous stenting. Sebastian et al[26] used a revised Villalta score[74] and the Venous Clinical Severity Score[75] when comparing the use of DOAC to the use of VKA following (post) thrombotic stenting. Patients were reported to be free of PTS in 85% versus 88% of cases ($P = .76$). Alternative definitions were used by Sharifi et al[14,15] (presence of ≥two symptoms [leg burning, pain, aches, discomfort, restlessness, and tingling] combined with edema and venous reflux [classified as mild PTS], skin hyperpigmentation or lipodermatosclerosis [classified as moderate PTS], or an active or healed ulcer [classified as severe PTS]) and Manninen et al[22] (abnormal functioning of the venous system because of valvular incompetence with or without associated venous obstruction in a limb with a prior objectified DVT). In one study[57] and four case reports,[63,65,66,71] the definition of PTS was not specified but only the absence of the PTS was reported. Three of these case reports merely described that patients were free of symptoms during follow-up.[63,65,66]

5 | DISCUSSION

With the increasing numbers of venous interventions performed and the introduction of (dedicated) venous stents over the recent years, we expected that the available literature reporting on peri-interventional antithrombotic management would have expanded accordingly. We therefore set out to perform an update of a systematic review addressing the issue of peri-interventional antithrombotic management related to venous stenting published by our group 6 years ago.[6] At the time, we concluded that there was little information and much uncertainty on the role of antithrombotic treatment in the context of venous stenting. Unfortunately, not much has changed.

Our up-to-date search showed that in the year 2020, there still is no or little attention for antithrombotic treatment surrounding venous stent placement given that only two studies directly assessed this issue when reporting on study outcomes. Only one of these studies addressed the direct impact of antithrombotic treatment on IST following stenting procedures.[3] This study suggested that the risk of IST decreases with increased quality of antithrombotic treatment with VKA, expressed as TTR.

The majority of postinterventional antithrombotic regimens prescribed in the studies included in this review entail temporary use of VKA with concomitant LMWH during the initiation phase. The use of DOAC was still limited in the selected studies despite their convenience, presumed advantages in limiting PTS, and a lower risk of major bleeding. Partially, this could be explained by the fact that most studies in this systematic review are older and DOAC were not yet incorporated into daily practice. Specification of antithrombotic treatment for stented patients in particular was rarely provided. If antithrombotic treatment was described for stented patients specifically, it most often entailed the concomitant use of antiplatelet drugs. Furthermore, sole treatment with antiplatelet drugs,

sometimes with LMWH directly following the intervention, was frequent in patients stented for chronic pathology. Overall, it appears that choices in postinterventional antithrombotic management are driven by the patient's history of DVT and follow current guidelines for thrombotic management rather than to specifically adjust treatment if stenting is performed.

Following the increased acceptance of the "open vein hypothesis" and the rapid evolution of new treatment techniques, venous stent placement has become a more and more prominent treatment modality for both acute and chronic thrombotic as well as nonthrombotic deep venous pathology in an attempt to prevent or reduce the severity of symptoms and complaints. Subsequently, preservation of acquired patency is presumed essential to prevent the development of PTS or the recurrence of symptoms requiring reinterventions leading to additional health care costs. The value of peri-interventional antithrombotic treatment to achieve optimal long-term results may be presumed from Virchow's triad. This may explain why the apparent higher recurrence rate in nonthrombotic (eg, May-Thurner syndrome) patients is lower than in patients with prior thrombosis. In principle, anticoagulation corrects the hypercoagulability from preexisting prothrombotic risk factors and spans the time needed for the healing of endothelial perturbation following recanalization. It is striking to note that, although the influence of antithrombotic treatment on treatment outcomes is widely recognized, it still receives so little attention. This lack of attention extends to other potential confounders on outcomes surrounding the intervention, including selection of patients, thrombotic status, stent characteristics, and the interventional techniques used.[51] Moreover, study outcomes are reported using various definitions and classifications, which makes it difficult to extract specific results and leads to limited availability of comparable data.

Over time, the outcomes of interest reported seem to have shifted from the reporting of mainly technical (ie, patency rates) outcomes to inclusion of more clinical outcomes (ie, PTS). However, the correlation between technical success and clinical outcome remains uncertain.

Besides the many weaknesses that have to be taken into consideration when interpreting the reported study outcomes, one should also consider what is the minimal effect that should be deemed acceptable. Regarding the primary patency rate an overall mean of 82.3% (SD 10.8) was seen at 1-year of follow-up, which reduced to 73.3% (SD 7.9) at 2 years, and 76.4% (SD 6.8) at 3 years of follow-up. This means that in about 25% of patients, patency could not be preserved, potentially resulting in recurrence of symptoms or the need for a reintervention. Data on patency rates at longer durations of follow-up are limited. Second, one should assess whether and where adaptations can and should be made. Improvements could be targeted at either the stenting material, the interventional technique, or the peri-interventional circumstances including treatment indications and antithrombotic treatment. Over the years, outcomes for primary patency did not improve considerably despite progression and innovation regarding venous stenting procedures, suggesting the influence of stenting materials and interventional techniques to be less important. Parallel to the optimization of antithrombotic treatment regimen supporting stenting procedures in the arterial setting, one would expect that optimization of antithrombotic therapy could possibly also contribute to the reduction of IST and improved clinical outcomes in the venous setting. Although a meta-analysis could not be performed, an indication for a protective effect of postinterventional antithrombotic treatment was suspected. This is in particular based on the study by Notten et al[3] showing that a more adequately executed antithrombotic treatment could protect against the development of IST.

The overall quality of the studies reported is reasonable. However, there seems to be a discrepancy between acquired quality assessment score and our intuitive appraisal of the data. Therefore, we suggest the introduction of common data elements for the reporting of venous interventions and stenting to overcome these impediments. We propose that a clinical trial comparing outcomes in groups with different yet clearly defined and well-documented antithrombotic treatment regimens is necessary to gather valid data regarding its influence on long-term outcomes after (post)thrombotic iliofemoral venous stent placement. In addition, results should be presented after consideration of the various factors surrounding the intervention possibly intervening with its outcomes.

In conclusion, the results of this review show that there is a persistent hiatus in knowledge regarding antithrombotic management surrounding venous stent placement even though its clinical importance can be presumed. Future studies addressing this issue should be performed using specified treatment protocols and report on clearly defined study outcomes while also taking into consideration the broad variety of possible confounding factors surrounding an intervention.

CONFLICT OF INTEREST

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organization for the submitted work. Dr. ten Cate has received research grants and/or honorariums from Bayer, Pfizer, LEO Pharma, Gideon Pharmaceuticals, Alveron Pharma, and Coagulation profile outside the submitted work; no other relationships or activities that could appear to have influenced the submitted work.

AUTHOR CONTRIBUTION

Arina J. ten Cate-Hoek is the guarantor of this manuscript; she accepts full responsibility for the finished manuscript, had access to any data, and controlled the decision to publish. In addition, she originated the idea for this systematic review, supervised literature search and data collection, and contributed to data interpretation, composition of figures and tables, and writing of the manuscript. Pascale Notten contributed to the literature search, data collection, data analysis, data interpretation, composition of figures and tables, and writing of the manuscript. Hugo ten Cate contributed to critical review of the manuscript.

ETHICAL APPROVAL

No ethical approval was required for the conduct of this systematic review since it did not include patient participation.

DATA AVAILABILITY STATEMENT

Request for access to the data underlying the reported results should be directed to the corresponding author Arina J. ten Cate-Hoek (arina.tencate@maastrichtuniversity.nl).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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