Manual aspiration thrombectomy for acute and subacute inferior vena cava thrombosis and lower extremity deep venous thrombosis

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Abstract

Deep vein thrombosis (DVT), which can lead to pulmonary embolism (PE), is a major contributor to the global disease burden and is the third most common cardiovascular pathology after coronary artery disease and stroke. Venous thromboembolic disease, which encompasses the disease entities of DVT and PE, affects up to 10 million cases every year and represents a serious and potentially life-threatening condition. Standard anticoagulation therapy alone is ineffective at promoting deep venous system thrombus removal. Many patients develop postthrombotic syndrome (PTS) despite being on adequate anticoagulation therapy. Aggressive therapy for rapid thrombus removal is important to prevent the development of PTS. Besides impeding the onset of PTS, rapid clearance of the thrombus is also required in the treatment of phlegmasia cerulea dolens, an uncommon but life-threatening complication of acute DVT that can lead to arterial insufficiency, compartment syndrome, venous gangrene, and limb amputation. Manual aspiration thrombectomy (MAT) can provide rapid and effective therapy that could be compared to the open surgical thrombectomy approach with minimal risk of morbidity, mortality, or recurrence after surgery. Though many devices have been developed to date for pharmacomechanical thrombolysis, the cost of the treatment using these devices is very expensive. MAT is simple to perform, easy to learn, inexpensive, and rapid. This review will outline and dissect several studies and case reports, sourced from the PubMed database, on the subject of the use of MAT in treating inferior vena cava thrombosis and lower extremity DVT, including in patients with compression of the iliac vein and phlegmasia cerulea dolens.

Keywords: thrombectomy; venous thrombosis; lower extremity; vena cava; inferior

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INTRODUCTION

Deep venous thrombosis (DVT), which can lead to pulmonary embolism (PE), is a major contributor to the global disease burden and is the third most common cardiovascular pathology after coronary artery disease and stroke. Venous thromboembolic disease, which encompasses the disease entities of DVT and PE, results in up to 10 million cases every year and is also a serious and potentially life-threatening condition (1).

Standard anticoagulation therapy alone is ineffective in deep venous system thrombus removal (2,3). Many patients end up developing postthrombotic syndrome (PTS) despite their use of adequate anticoagulation therapy (2,4). The implementation of aggressive therapy for rapid thrombus removal is important to prevent the development of PTS (4-7). Besides preventing PTS, rapid clearance of the thrombus is also necessary in the treatment of phlegmasia cerulea dolens (PCD), an uncommon but life-threatening complication of acute DVT that can lead to arterial insufficiency, compartment syndrome, venous gangrene, and limb amputation (8,9).

Manual aspiration thrombectomy (MAT) is as rapid and effective as an open surgical thrombectomy approach but it minimized the typical risk of morbidity, mortality, or recurrence after surgery (9-11). MAT can be a good alternative in patients in whom heparin or thrombolytic agents are contraindicated (8). Though many devices have now been developed for pharmacomechanical thrombolysis, the cost of treatment when using these devices is very expensive. MAT is simple to perform, easy to learn, inexpensive, and rapid (9,12-14).

The present review will outline and dissect several studies and case reports about the use of MAT in treating inferior vena cava (IVC) thrombosis and lower extremity DVT, including in those patients with compression of the iliac vein and phlegmasia cerulea dolens. The articles discussed in this review were obtained from searching the PubMed database with the following keywords: “manual thrombectomy,” “manual aspiration,” and “venous thrombosis.” Following a thorough reading of the available relevant abstracts and full article contents, there were 8 studies and 3 case reports that were selected for inclusion in this review.

LUMEN SIZE OF THE ASPIRATION CATHETER

The most commonly used catheter sizes were 8-French (Fr) and 9-Fr, which were used in 5 studies and 2 case reports. One study (15) and 1 case report (13) used specifically only the 8-Fr catheter, while another study (16) and case report (8) used specifically only the 9-Fr catheter, with 3 studies (9,14,17) using both the 8-Fr and 9-Fr catheters. These catheters were used to aspirate thrombus in proximal lower limb DVT and IVC thrombosis.

The largest lumen used was 12-Fr, as reported by Zhang et al. (18), to aspirate thrombus from the iliac vein proximal to the femoral vein. Bozkaya et al. (19) used a 7-Fr catheter to aspirate thrombus from the iliac vein to the popliteal vein. Srinivas et al. (20) used a 6-Fr catheter to aspirate thrombus from the IVC to the popliteal vein.

Oguzkurt et al. (9) reported the use of several sizes of catheters ranging from 5-Fr to 9-Fr. The 6-Fr to 9-Fr lumen catheters were used to aspirate thrombus in the IVC, iliac veins, femoral veins, great saphenous veins, and popliteal veins. As for small-diameter veins (e.g., saphenous veins), a 5-Fr or 6-Fr lumen catheter was used to aspirate the thrombus.

There was 1 case report (11) that mentioned using an 8-Fr sheath introducer instead of a guiding catheter to aspirate the thrombus of lower extremity DVT.

BRAND AND TYPE OF THE CATHETER

Catheters produced by Cordis (Hialeah, FL, USA) were used the most in studies that mentioned the brand of the catheter (8,9,14-17,20). Three studies (9,14,16) mentioned using the company’s Vista Brite Tip® catheter, without mentioning more specifics on the type of the catheter (e.g., Judkins, Amplatz, extra back up, etc.), while 2 of the studies (15,20) mentioned using both straight-tip and angled multipurpose guiding catheters based on the course of the target veins. Two studies (15,20) mentioned the use of a Judkins right guiding catheter (JR 3.0). The type of Vista Brite Tip® catheter was categorized into the categories of Judkins left, Judkins right, Amplatz left, Amplatz right, extra back-up: right coronary artery (RCA), extra back-up: left coronary artery (LCA), coronary bypass, and internal mammary, which all have different shapes, as shown in Figure 1.

The other 2 studies (13,19) mentioned using the Mach 1™ catheter produced by Boston Scientific (Natick, MA, USA), without mentioning more specifics about the type or shape of the catheter. The different shapes of the Mach 1™ catheter are shown in Figure 2. One study (11) that used a sheath introducer employed the Desilets-Hoffman introducer sheath produced by Cook Medical (Bloomington, IN, USA) (Figure 3).

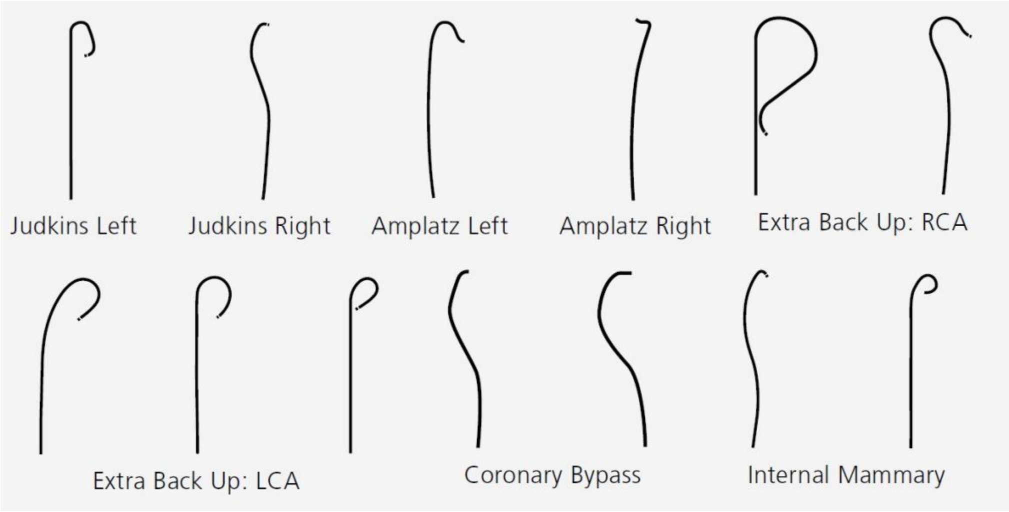

Figure 1. Type and shape of Vista Brite Tip® (Cordis, Hialeah, FL, USA) guiding catheter (21).

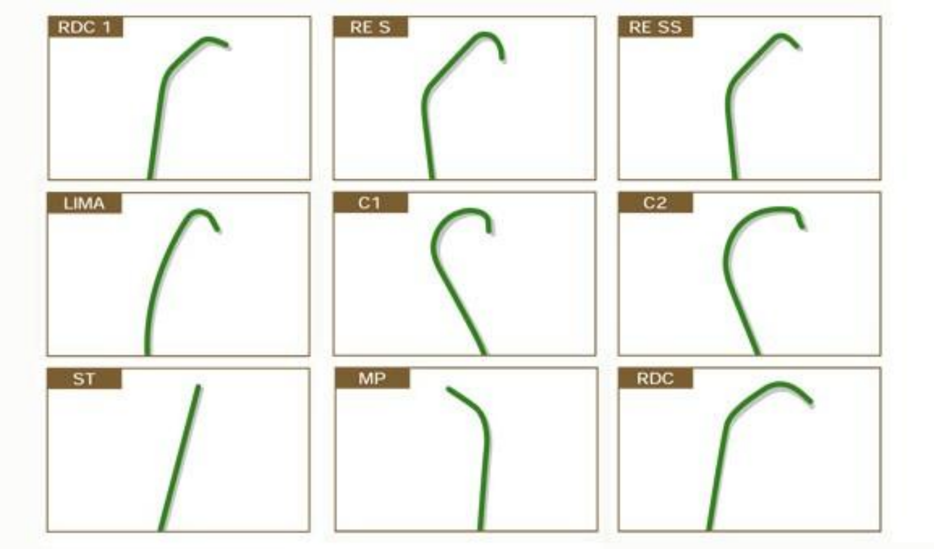

Figure 2. Type and shape of the Mach 1™ (Boston Scientific, Natick, MA, USA) guiding catheter (22).

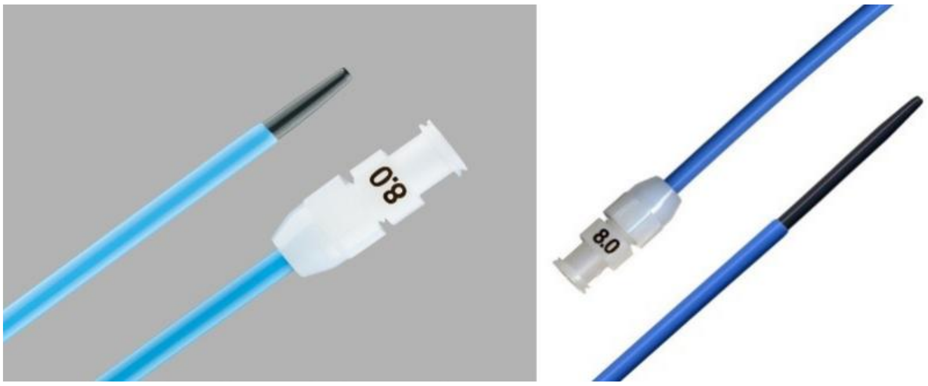

Figure 3. Desilets-Hoffman introducer sheath (Cook Medical, Bloomington, IN, USA) (23).

The other 2 studies (13,19) mentioned using the Mach 1™ catheter produced by Boston Scientific (Natick, MA, USA), without mentioning more specifics about the type or shape of the catheter. The different shapes of the Mach 1™ catheter are shown in Figure 2. One study (11) that used a sheath introducer employed the Desilets-Hoffman introducer sheath produced by Cook Medical (Bloomington, IN, USA) (Figure 3).

SHEATH SIZE AND SYRINGE SIZE

There were 3 sizes of the sheath mentioned in 5 studies (9,11,14,16,17) and 2 case reports (8,18). The largest in terms of diameter was a 12-Fr sheath that was used over a 12-Fr catheter, which was mentioned in 1 case report (18). Two studies (14,17) used either a 9-Fr or 10-Fr sheath over an 8-Fr or 9-Fr catheter. One case report (8) mentioned using a 9-Fr sheath over a 9-Fr catheter. Three studies mentioned using a 10-Fr sheath, with 1 study using it over a 9-Fr catheter (16), 1 using it over a 5-Fr to 9-Fr catheter (9), and 1 using it over an 8-Fr introducer sheath (11). Four studies mentioned the sheath that was used was produced by Cordis (9,14,16,17). One study (11) and 1 case report (18) used a sheath produced by Cook Medical.

A syringe with the volume of 20 mL was mentioned by 3 studies to be used for thrombus aspiration with an 8-Fr or 9-Fr catheter (14,16,17). Two case reports mentioned using a syringe with a 50 mL volume, which was used with 8-Fr and 12-Fr catheters, respectively (13,18). Zhang et al. mentioned a consideration to improve the adapter diameter of the syringe and catheter in which a large-diameter syringe could be designed to fit a large lumen catheter. Thus, repeated catheter removal and reinsertion could be omitted, which could greatly reduce the procedure and radiation exposure time (18).

METHODS OF MAT PROCEDURE

Access point

Eight studies (9,11,14-17,19,20) and 2 case reports (8,18) mentioned puncturing the popliteal vein as the first access point. Three of these studies also discussed puncturing the posterior tibial vein (9,14,17), 2 studies punctured the femoral vein (15,19), and 1 study punctured the great saphenous vein (9) as an access point if necessary. One case report mentioned puncturing through the jugular vein as the access point (13).

Duration and frequency

Regarding the duration of the MAT, 1 case report mentioned 15 min was spent to completely clear the acute thrombus from the patient (8). A different study mentioned that the total procedure time varied from 45 min to 90 min (average: 67 min) (16). Depending on the thrombus burden, aspiration of the whole thrombus required 15–30 passes of the catheter (9).

Choice of catheter shape during the procedure

Two studies mentioned using different catheters to aspirate the thrombus based on the course of the veins. Thrombi in straight-course veins (e.g., popliteal, femoral, or great saphenous vein) were aspirated with a straight-tip guiding catheter, while thrombi in curved course veins (e.g., iliac veins or saphenofemoral junction) were aspirated with an angled multipurpose guiding catheter (9,14). One of the studies also mentioned using a smaller diameter, angled tip guiding catheter for aspirating thrombi from small-diameter veins (e.g., saphenous veins) (9). An angled guiding catheter could be used in a straight vein if there was a subacute thrombus adherent to the wall that was resistant to aspiration with a straight catheter (14).

The usage of guidewires

One study mentioned that the guiding catheter was advanced without a guidewire. The guidewire was used if there was tortuosity of the vein or resistance to advancement of the catheter to ensure safe advancement to prevent dissection (14). Two studies and 1 case report mentioned using the guidewire as the aspiration catheter was introduced, while a different study mentioned the need of using the guidewire to prevent venous injury (11,16,18).

Direction of aspiration

One case report mentioned that aspiration was performed from the iliac vein proximal to the femoral vein (18). Another study mentioned aspirations were performed from the caudal to cranial ends, with the most cranial part aspirated last to prevent embolization of a thrombus fragment (14).

Catheter maneuvers

Maintaining negative pressure or vacuum during aspiration of the thrombus and removal of the catheter is important to achieve a more effective aspiration thrombectomy (11,14,16,18). Gentle movement of the catheter during aspiration is also important to prevent venous injury. Specifically, the catheter is moved back and forth and rotated during aspiration, and with this dynamic movement of the aspiration catheter, a large thrombus could be remodeled and aspirated out. If blocked up a by large thrombus, the guiding catheter has to be pulled out of the sheath with negative pressure maintained during this process (16). One study explained its use of catheter maneuvering in detail, specifically the maneuver called the pullback technique. This technique is a dynamic withdrawal of the aspiration catheter or sheath while maintaining negative pressure using a syringe. The maneuver involves advancing and withdrawing the catheter in the vein filled with thrombus while aspirating until the thrombus was macerated and aspirated. Large thrombus remodeling can be performed via this technique due to the powerful negative pressure. Thus, a more effective aspiration thrombectomy can be performed and the thrombus can be placed into a more proximal portion (11).

Aspiration endpoint

One study mentioned repeated MAT was performed until the thrombus within the aspiration catheter was washed out and until more than 95% of thrombus clearance was shown in venography (16). One case report mentioned MAT was performed repeatedly under vacuum until venography revealed that blood flow in the occluded segment had been restored (18).

Combination with other treatments

One study mentioned using a metallic basket (Highflex; Bard-Angiomed, Karlsruhe, Germany) first, when the venous thrombus was hard, for fragmentation of the thrombus before repeated aspiration thrombectomy was performed (11).

Some studies mentioned using additional thrombolytic treatments to dissolve thrombi in small veins and/or residual thrombi after MAT. One study used a sheath to infused urokinase (800,000 U) for 12 h (16). Another study employed catheter-directed thrombolysis to infuse urokinase continuously (80,000–100,000 U/h, one-third through the sheath, two-thirds through the catheter) for 24 h (11). Two studies used catheter-directed thrombolysis (CDT) to infuse streptokinase (100,000 units/h, one-third through the sheath and two-thirds through the catheter), with a mean infusion dosage of 10–11 million units and a mean duration of 108 (± 32) h (15,20). Three studies used CDT to infuse tissue plasminogen activator (1 mg/h) (9,14,17). One study infused tissue plasminogen activator (initial 5 mg, 1 mg/h) by CDT with and without the use of the EKOS catheter (EKOS Corporation, Bothell, WA, USA) (19).

Eight studies and 2 case reports mentioned using balloon angioplasty and stent to assist the treatment (8,9,11,14-20). Eight studies used balloon angioplasty and stent if there was compression, irregularity, or residual stenosis after thrombolytic treatment. As for 2 case reports, thrombolytic treatment was not used before the balloon angioplasty and stent placement (8,18).

One case report, however, mentioned using the Expedior AngioJet catheter (Possis Medical Inc., Minneapolis, MN, USA) after MAT. The total aspirated fluid volume in this procedure was 200 mL. To minimize hemolysis, forced hydration with saline infusion was administered (13).

SYMPTOMS DURATION AND PREPROCEDURAL PREPARATION

The symptoms duration of the patients ranged from 4 h to 30 days, but most of them exhibited such for less than 14 days. The diagnosis of patients was made based on the symptoms with Doppler ultrasound and/or computed tomography venography. All patients received digital subtraction venography prior to the procedure.

After the diagnosis of DVT was established, 1 case report and 1 study started standard heparin at a loading dose of 5,000 IU and an infusion dose of 1,000 IU/h to maintain an activated partial thromboplastin time of between 60 s and 90 s (8,9). Another case report mentioned using intravenous heparin (1,000 U/h) for 72 h (13). In 1 study, low-molecular-weight heparin (LMWH) 4,100 IU was injected subcutaneously twice a day for 5–7 days (16). In another study, LMWH (30–40 mg enoxaparin) was administered subcutaneously to all patients at 6–12 h before the procedure (11).

Five studies and 1 case report mentioned administering therapeutic-level heparin from the start of the procedure and during the procedure, with a target partial thromboplastin time of 60–90 s (9,11,14,17-19). One study (19) mentioned using 10,000 units of heparin, another study (11) mentioned administering 5,000 IU of heparin intravenously, and 1 case report mentioned injecting 4,000 IU heparin intravenously followed by 1,000 IU of heparin for every hour during the procedure (18). Most studies and case reports mentioned using heparin before the procedure, but there was 1 study that discontinued LMWH for at least 8 h before the procedure (20).

If there was a thrombus extension into the IVC, a retrievable IVC filter was inserted before the MAT procedure in 6 studies, which was removed as soon as possible (9,14,15,17,19,20). One study placed a prophylactic IVC filter in all patients to prevent the formation of PE. After no residual thrombus in the filter trap was confirmed, the IVC filter was removed. However, the IVC filter in the elderly patients were not removed to prevent the formation of PE (11). The need for IVC filter placement during endovascular management of an extensive DVT has been debated. Prophylactic IVC filter insertion in patients with a free-floating IVC thrombus that is longer than 5 cm is recommended (24). Noguchi et al. reported that retrievable IVC filters are useful and safe for the management of an acute proximal DVT, particularly in patients who require aggressive thrombus removal (25). A separate study by Davies et al. mentioned that the use of prophylactic IVC filter is not supported by evidence and should not be recommended (26). A recently published review revealed that the majority of articles believe that the use of IVC filter is safe and may decrease the risk of PE. Nonetheless, well-designed randomized controlled trials are needed in this area (27).

RESULTS

Satisfactory results with a prompt improvement of the symptoms mentioned in most of the studies and reports were noted (8,9,13,16,18,19). One case report mentioned swelling and cyanosis progressively decreased within 12 h and were almost completely resolved after 48 h, but the skin blisters turned into an open wound and swelling completely disappeared at the 2-week follow-up (8). One study mentioned that cyanosis disappeared in the same day as the procedure, swelling progressively decreased within 1 day and was completely resolved after 72 h, and skin blisters showed complete healing in about 15 days. Hospitalization time ranged from 2 days to 4 days (8,16).

Follow-up from 1 study showed complete resolution of symptoms in 82.6% patients and symptomatic improvement in 13% patients. The leg swelling decreased and the pain was relieved in the first postoperative month. Leg edema decreased in those with chronic venous hypertension and collapsed varicose veins (19).

MAT combined with CDT, balloon angioplasty, and stent placement as the first-line thrombus removal method is a safe, rapid, and effective treatment option for acute and subacute lower extremity DVT, including in those with compression of the iliac vein and phlegmasia cerulea dolens. It has a high rate of thrombus removal and also could reduce symptoms in most patients (9,14-20).

One study and 1 case report mentioned that MAT without catheter-directed thrombolysis is a safe and effective treatment for lower extremity acute DVT and those progressed to phlegmasia cerulean dolens. It is also able to minimize the risk of hemorrhagic complications, especially in those with a contraindication for thrombolytic therapy (8,11). One case report reported that the combination of MAT with rheolytic thrombectomy is useful for treating extensive IVC thrombosis and occluded IVC filters, especially when thrombolytic therapy is contraindicated (13).

ADVANTAGES AND DISADVANTAGES OF MAT

Advantages of MAT are as follows:

- MAT does not place the patient at risk of major bleeding and can be a good choice if bleeding is a concern, and so can be a good alternative in patients where heparin or thrombolytic agents are contraindicated (8,13).
- MAT is rapid, effective, and able to lower the thrombolytic agent infusion dose and duration (9,12,16).
- MAT is simple to perform and easy to learn (9,12-14).

- MAT is inexpensive and could decrease the overall hospital stay duration and subsequent economic burden (9,12-14).
- PE risks, vessel wall and valve damage, hemolysis, and hemoglobinuria are the potential complications of mechanical thrombectomy, but major damage to the vessel wall related to MAT manipulation was not observed (16,28,29).

Disadvantages of MAT are as follows:

- A decrease in hemoglobin levels may present with large amounts of thrombi aspiration or an aspiration of blood together with a thrombus. This may be a significant consideration in patients who have a history of anemia or who could experience anemia (14,15).
- Large vascular sheaths and guiding catheters are required for the aspiration; smaller guiding catheters can be used but are not as effective as larger ones (14).
- Multiple passes are needed to perform MAT; the operator must also perform repeated removals and reinsertions of the catheter (18).
- One study reported high recurrences, particularly in the first postintervention month (17).

CONCLUSION

All studies and case reports described herein mentioned that the use of MAT provides rapid and effective treatment for patients with massive acute and subacute lower extremity DVT, including those with compression of the iliac vein and phlegmasia cerulea dolens. It is also very helpful in patients with thrombolytic therapy contraindications. Each study made different choices of catheter, sheath, syringe, and methods of MAT. The best choices for tools and methods for the most effective thrombus removal are still not clear. A phantom study comparing the usage of various catheter lumen sizes, syringe sizes, and aspiration methods showed that there were no statistically significant differences in the total amount of aspirated thrombus among the various types of aspiration catheters and syringes; however, different aspiration methods showed significantly different results. Effective MAT relies on the length of the dynamic catheter withdrawal while maintaining continuous negative pressure using a syringe in the initial endovascular management of acute DVT in the lower extremities (10).

However, there were only a few clinical studies that tried to research in this area, so many aspects and using more detailed methods still require exploration. Though there are some disadvantages, mechanical thrombectomy provides rapid, effective, and inexpensive treatment for lower DVT and IVC thrombosis, which outweighs its disadvantages, especially for those who are economically underprivileged. Thus, a well-designed study about the techniques of MAT involving a large sample size is needed for us to understand better the most effective techniques for MAT to aspirate thrombus in DVT patients as the first-line thrombus removal method.

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