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REVIEW ARTICLE

Comparative analysis of catheter-directed thrombolysis and mechanical thrombectomy in iliofemoral deep vein thrombosis: clinical evidence and perspectives – a narrative review

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ABSTRACT

BACKGROUND: Iliofemoral deep vein thrombosis (DVT) involves thrombus formation in the iliac and/or femoral veins and can lead to significant morbidity, including pulmonary embolism and post-thrombotic syndrome (PTS). Traditional anticoagulation remains the standard treatment, but newer endovascular techniques such as catheter-directed thrombolysis (CDT), percutaneous mechanical thrombectomy (PMT), and pharmacomechanical thrombolysis (PMT) are gaining prominence for their potential benefits in clot removal and limb preservation.

OBJECTIVE: This review aims to compare the efficacy and safety of these minimally invasive endovascular modalities in the management of iliofemoral DVT.

METHODS: A comprehensive literature review was conducted, analysing articles published between June 2019 and June 2024 from PubMed, Lilacs, and Cochrane Library databases. Inclusion criteria comprised clinical studies, systematic reviews, and meta-analyses in English, Portuguese, or Spanish. Data from 50 selected articles were synthesised qualitatively, focusing on treatment success, vessel patency, symptom relief, incidence of PTS, and complications.

RESULTS: Both CDT and PMT demonstrated high success rates, with complete thrombus removal in 82% and 72% of cases, respectively. Combined approaches such as pharmacomechanical thrombolysis showed promising short- and medium-term patency and symptom improvement. Studies highlighted reduced PTS severity using advanced techniques like ultrasound-assisted thrombolysis and AngioJet thrombectomy, though long-term data remain limited. Safety profiles revealed low complication rates, primarily minor bleeding, with serious adverse events being infrequent.

CONCLUSION: Endovascular interventions, including CDT and PMT, offer effective, minimally invasive alternatives to anticoagulation in iliofemoral DVT, with advantages in early thrombus removal and limb salvage. Careful patient selection and procedure planning are critical to optimise outcomes, and long-term studies are warranted to further assess durability and complication rates.

Keywords: Deep Vein Thrombosis; Catheter-Directed Thrombolysis; Mechanical Thrombectomy; Endovascular Treatment; Post-Thrombotic Syndrome.

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INTRODUCTION

Iliofemoral deep vein thrombosis (DVT) is characterised by the presence of a thrombus in the iliac and/or common femoral veins, which may or may not extend to the inferior vena cava.[1] In Brazil, according to data from the Ministry of Health, the number of venous thrombosis cases reached a record high in 2023, surpassing 489,000 occurrences.[2] Contributing factors include population ageing and the COVID-19 pandemic.[3] Other risk factors for DVT include pregnancy and the postpartum period,[4] as well as prolonged immobilisation, obesity, malignancies, major surgeries with extended anaesthesia, polytrauma, and varicose veins in the lower limbs.[5]

The primary objectives of DVT treatment are to prevent pulmonary embolism and the post-thrombotic syndrome (PTS). Additionally, the aim is to achieve early recovery of function and reduction of acute limb pain and swelling.[6] Accordingly, anticoagulant therapy is the standard treatment for DVT.[7] Thrombolytics may be administered systemically via a peripheral vein, locally or regionally through a vein near the clot, or directly into the thrombus via a catheter placed within the occlusive thrombus, known as catheter-directed thrombolysis (CDT).[8]

Currently, an alternative therapeutic option for iliofemoral DVT is percutaneous mechanical thrombectomy (PMT). This procedure utilises a catheter and guidewire inserted into the veins of the lower limbs to remove the clot, restoring vascular patency in a single session. While its application in Brazil remains limited, it is gaining increasing prominence on the international stage.

This study analyses the efficacy and safety of percutaneous mechanical thrombectomy compared to other treatment methods, such as catheter-directed thrombolysis and conventional anticoagulant therapy.

METHODS

The research included articles published in the last five years (15 June 2019 to 15 June 2024). Databases utilised included PubMed, Lilacs, and Cochrane Library, with specific keywords like "catheter-directed thrombolysis", "endovascular treatment", "thrombolytic therapy", and Portuguese terms "trombólise direcionada por cateter". Filtering the results yielded 301 relevant articles. The selection was performed using the Rayyan platform, initially screening titles and abstracts with strict inclusion criteria: articles on catheter-directed thrombolysis, clinical studies, systematic reviews, or meta-analyses that were available in full text in English, Portuguese, or Spanish. Excluded were duplicate articles, pre-clinical studies or animal studies, and publications such as letters to the editor, editorials, and conference abstracts. The initial screening resulted in 50 selected articles. Relevant data were extracted from each included article, including title, authors, publication year, study type, sample size, catheter-directed thrombolysis methods, main outcomes, conclusions, and study limitations. The collected data were qualitatively analysed and synthesised, with a detailed description of study characteristics and a comparison of methods and main results in a Google Sheets table.

DVT TREATMENTS: METHODS AND APPROACHES

Invasive procedures such as catheter-directed thrombolysis and percutaneous mechanical thrombectomy, discussed below, should be considered only for patients with acute iliofemoral DVT who strictly meet established inclusion and exclusion criteria.

According to Burihan et al, the proposed inclusion criteria are: individuals aged 18 to 75 years, minors admitted only with guardian consent; symptom onset within 21 days; iliofemoral DVT diagnosis confirmed by Doppler ultrasound, CT angiography, or MR angiography. [9]

Exclusion criteria for the therapy proposed by Burihan *et al.* are: contraindications for thrombolytic or anticoagulant therapy; prior pulmonary embolism with cardiovascular impairment; contraindication to iodinated contrast; phlegmasia cerulea or alba dolens; severe anaemia; severe thrombocytopenia; severe kidney failure; severe hypertension; pregnancy or puerperium under 7 days; major trauma or surgery within 14 days; history of subarachnoid haemorrhage, tumour, arteriovenous malformation, and intracranial aneurysm; life expectancy under 24 months; medications or mental state interfering with treatment; active malignancy or ongoing chemotherapy.[9]

The CDT mechanism involves percutaneous catheter introduction into the venous system, commonly via popliteal, jugular, femoral, veins, or tibial veins, with fluoroscopic guidance to the target vessel and prolonged infusion of a thrombolytic agent such as r-tPA directly into the thrombus. The catheter is left in situ, and the infusion continues for at least 24 hours under close clinical monitoring.[9]

This method's superiority lies in reducing the overall thrombolytic dose required and minimising systemic drug exposure, thus lowering systemic bleeding risk. Moreover, ultrasound-guided percutaneous access is advised to preserve site integrity and reduce bleeding risk.[10]

CDT is recommended early in DVT to preserve endothelial and vascular integrity, restoring anatomy and function. In patients with post-thrombotic syndrome (PTS), the technique dissolves clots occupying the central vessel portion and those filling intra-trabecular channels of partially recanalised segments, facilitating guidewire and catheter progression in endovascular reconstruction procedures.[10]

In percutaneous mechanical thrombectomy (PMT), devices are categorised as rotational, rheolytic, or ultrasound-enhanced, typically inserted into ipsilateral popliteal or posterior tibial veins. These devices offer an attractive endovenous solution for aggressive thrombus removal, potentially complementing or replacing CDT. PMT can decrease CDT morbidity by reducing thrombolytic drug dosage.[11]

Rotational devices employ high-speed rotary blades or nitinol cages to macerate the thrombus. The Trellis device uses a sinusoidal nitinol wire to disrupt the thrombus

infused with thrombolytic agent between proximal and distal balloons to control and prevent PE. The AngioJet device, using a rheolytic mechanism, generates a high-pressure saline jet after the thrombus is sprayed with a thrombolytic drug, resulting in rheolytic thrombectomy with aspiration of softened thrombus into the catheter. Ultrasound devices deploy ultrasonic energy to expand and thin the fibrin component of the thrombus, thereby enhancing the transport of thrombolytic agents within the target thrombus.[11]

EFFICACY OF TREATMENTS

Clinical Outcomes and Patency

Clinical outcome evaluation is crucial for assessing treatment efficacy as it explores the impact on patient health and quality of life. This review considers not only success rates but also treated vessel patency and symptom improvement.

Significant success rates are noted with AngioJet mechanical thrombectomy, achieving thrombus removal in 72% of 32 patients, and CDT, with complete thrombus removal in 82% of 33 patients with acute lower limb DVT.[12] This is relevant as complete thrombus removal influences long-term disease outcomes.[13]

The efficacy of AngioJet mechanical thrombectomy is highlighted by the minimal fibrinolytic amounts required and shorter intervention time.[14,15] It ensures high-quality postoperative care, alleviating clinical manifestations of iliofemoral vein disease within a year and reducing future complications.[16,17] CDT is notably effective, especially compared to conventional anticoagulants alone, in achieving iliofemoral patency.[13] Tsai *et al.* report accelerated thrombus reduction with CDT combined with Rivaroxaban, achieving complete patency in 43.2% of patients within three months—a substantially higher rate than with Rivaroxaban alone.[17]

For catheter-directed pharmacomechanical thrombolysis (CDPT), studies like Budak *et al.* (2022) document short- and medium-term success in acute extensive proximal DVT and femoropopliteal DVT. Patients experienced significant immediate success rates of 94.7%, symptom relief, and high vascular patency rates, with 87.2% primary patency and 90.4% secondary patency.[18]

Post-Thrombotic Syndrome

The incidence of post-thrombotic syndrome following different DVT treatments is essential to understand clinical outcomes and guide medical practice. Here, we analyse various studies investigating surgical techniques and their effects on PTS incidence.

For adjunctive percutaneous mechanical thrombectomy (APMT), studies indicate efficacy in managing acute iliofemoral DVT, improving 24-month venous outcomes, including moderate to severe PTS.[19] APMT benefits more severe clinical presentations or prior DVT history. Left-sided popliteal DVT may predict better APMT outcomes, reducing leg pain and swelling, enhancing quality of life, and lowering PTS risk.[20] Weinberg *et al.* found that while APMT reduced late thrombus load, it did not prevent valvular reflux, which contributes to PTS development.[21]

Regarding pharmacomechanical thrombolysis (PMT), long-term patency and treatment success are reported, with single-session treatments showing better outcomes compared to CDT alone for post-thrombotic syndrome up to 24 months follow-up.[22]

The AngioJet thromboaspiration device has been associated with reduced severity of PTS compared to CDT, alongside lower rates of perioperative haemorrhagic events. Studies show improved quality of life following surgical intervention within six months, though longer-term studies are necessary for comprehensive assessment.[23]

Notten *et al.* found that ultrasonic-assisted catheter thrombolysis (USAT) reduces the incidence of mild PTS over the long term, with 8.1% in the USAT group versus 20.7% in controls. Although patients experienced better quality of life, the reduction in PTS risk was not statistically significant. Farrokhi *et al.* reported that USAT may improve venous recanalisation with a lower bleeding risk when compared to CDT, provided that patient selection and protocols are optimised. Overall, USAT seems more effective in symptom reduction and quality of life improvement, but does not eliminate PTS risk entirely.[24]

SAFETY OF TREATMENTS

Regarding complications associated with CDT, Nakamura *et al.* reported haemorrhagic events in 15% of patients, including local hematomas and gastrointestinal bleeding. Severe bleeding was defined as events resulting in haemoglobin drop of ≥2 g/dL, requiring transfusion, occurring in critical sites, or contributing to mortality. Six per cent required transfusions, and in one case, the procedure was discontinued.[26]

Tian *et al.* compared CDT and PMT, reporting no major complications or serious cardiovascular events. Local bleeding occurred in six CDT patients and two PMT patients ($P = 0.157$). Seven PMT patients experienced bradyarrhythmias, resolving after device removal. Two CDT patients developed renal failure due to haemolysis, with recovery under conservative management. Systemic complication rates were significantly higher with PMT (37.5%) versus CDT (4.0%) ($P = 0.007$).[27]

CONCLUSION

Both methods demonstrated high efficacy in thrombus removal and symptom improvement, with CDT achieving complete thrombus removal in 82% of cases, and AngioJet-based PMT reaching 72% success. Both approaches preserve vascular integrity and minimise the need for high-dose thrombolytics, reducing bleeding risks. The complication rates were low and manageable. In conclusion, both CDT and PMT are effective and safe options for the treatment of acute iliofemoral DVT. Symptomatic patients with iliofemoral DVT requiring early thrombus removal should undergo the chosen therapeutic procedure based on the clinician's judgment (Level IIa evidence), considering patient-specific factors and resource availability.

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