Proceedings of the symposium on the management of established deep vein thrombosis involving the lower limb, held in Durban, March 2010

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Introduction

There are major areas of controversy in the management of established deep vein thrombosis involving the lower limbs. In an attempt to establish guidelines for the management of this condition a symposium was held in Durban under the umbrella of the Vascular Society of Southern Africa. Recognised experts in the various facets of management gave presentations in their respective areas of interest.

The proceedings are published as summaries of the respective talks and the guidelines presented as a series of algorithms for clinical practice. Educational grants were made by Bayer Health Care and Baroque Medical, which made the meeting possible and for which the organisers are extremely grateful.

Faculty

- Professor J V Robbs, Chair & Organiser, Prof Emeritus Dept Surgery & Vascular Unit University of KwaZulu-Natal, Durban
- Professor A T O Abdool-Carrim, Vascular Unit, University of the Witwatersrand, Johannesburg
- Dr J Pillai, Senior Surgeon, Vascular Unit, University of the Witwatersrand, Johannesburg
- Dr P Matley, Vascular Surgeon, Kingsbury Hospital, Cape Town
- Professor J van Marle, Vascular Unit, University of Pretoria
- Professor D Muckart, Head: Trauma Unit, Inkosi Albert Luthuli Central Hospital, University of KwaZulu-Natal, Durban
- Dr N Paruk, Senior Surgeon, Vascular Unit, Inkosi Albert Luthuli Central Hospital, University of KwaZulu-Natal, Durban

Symposium programme

Chair Professor JV Robbs

1. Diagnosis of deep vein thrombosis – Professor A T O Abdool-Carrim
2. Anticoagulation in the management of deep vein thrombosis – Professor M Veller/J Pillai
3. The role of venous thrombectomy for ilio-femoral vein thrombosis – Dr P Matley
4. Thrombolysis for deep venous thrombosis – Professor J van Marle
5. Pulmonary embolism – Professor D Muckart
6. Vena caval filters: an evidence-based review – Dr N Paruk

Diagnosis of deep vein thrombosis

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Deep vein thrombosis (DVT) is a common condition with an annual incidence of 67/100 000 among the general population.[1] Approximately 1 million patients annually undergo investigation for suspected acute DVT in North America.[2] It is particularly important that an accurate and timely diagnosis of DVT be made, as an untreated proximal DVT is associated with 30 - 50% risk of pulmonary embolism, with a concomitant 12% mortality.[2] Incorrect diagnosis of DVT also has consequence of expense and risk of unnecessary anticoagulation. Purely clinical signs and symptoms of pain, swelling and calf tenderness cannot be used to diagnose DVT, but they alert one to the possibility of DVT and hence the need for further testing becomes necessary to exclude or confirm the diagnosis. A number of strategies and investigations have been formulated to aid in the diagnosis of DVT and these are reviewed:

Clinical pre-test probability prediction rules

Clinical assessment giving an estimate of the pre-test probability of disease does have a role. Wells *et al.*[3] validated a system which comprised symptoms, signs, risk factors and possible alternative diagnosis to stratify patients with low, moderate and high risk pre-test probability. Their analysis of multiple variables resulted in the scoring system shown in Table I. In their study, 3%, 17% and 75% of the patients with low, mode and high pretest probability, respectively, had DVT.[4] Subsequently the Wells Probability Model has been validated in several prospective trials and has excellent reproducibility (K=0.75) even in comparing providers with different backgrounds.[5,6] The Wells prediction rule for DVT has been validated and is frequently used to estimate the probability of DVT before performing more definitive testing.

D-dimer testing

D-dimers are products of the degradation of cross-linked fibrin upon cleavage by plasmin. D-dimer blood levels reflect the presence of intravascular fibrin and are sensitive for the diagnosis of DVT. Several assays have been used to measure D-dimer levels. Four methods are currently available: the enzyme-linked immunosorbent assay (ELISA) has the highest sensitivity (96.8%) but it is time consuming.[7,8]

Table I. Scoring system

Clinical feature	Score
Active cancer (treatment ongoing or within previous 6 months or palliative)	1
Paralysis, paresis or recent plaster immobilisation of the lower extremities	1
Recently bedridden >3 days or major surgery within 4 weeks	1
Localised tenderness along the distribution of the deep venous system	1
Entire leg swollen	1
Calf swelling by more than 3 cm compared with the asymptomatic leg (measured 10 cm below tibial tuberosity)	1
Pitting oedema (greater in the symptomatic leg)	1
Collateral superficial veins (non-varicose)	1
Alternative diagnosis as likely or more likely than that of DVT	-2

Low probability ≤0 points; moderate probability 1 - 2 points; high probability ≥3 points; 0 points; moderate probability 1 - 2 points; high probability ≥3 points. (Modified from Wells PS, Anderson DR, Bormanis J, et al. 4)

There are several rapid semiquantitive assays available that yield sensitivities equivalent to the ELISA method. D-dimer levels have poor specificity (35.2%) but high sensitivity, therefore a negative D-dimer test excludes a DVT (negative predictive vale of 95%). Raised levels of D-dimer are associated with DIC, malignancy, postoperative states, infection, trauma and pre-eclampsia.[7,8] D-dimer levels use in diagnosis of DVT in the postoperative phase is therefore not helpful.

In summary, a positive D-dimer test will require further confirmatory testing, but a negative D-dimer test almost rules out a DVT (negative predictive value of 95%). Given the limitations, D-dimer is valuable as an adjunct to other diagnostic modalities.[2] It can be used to triage patients for further testing.

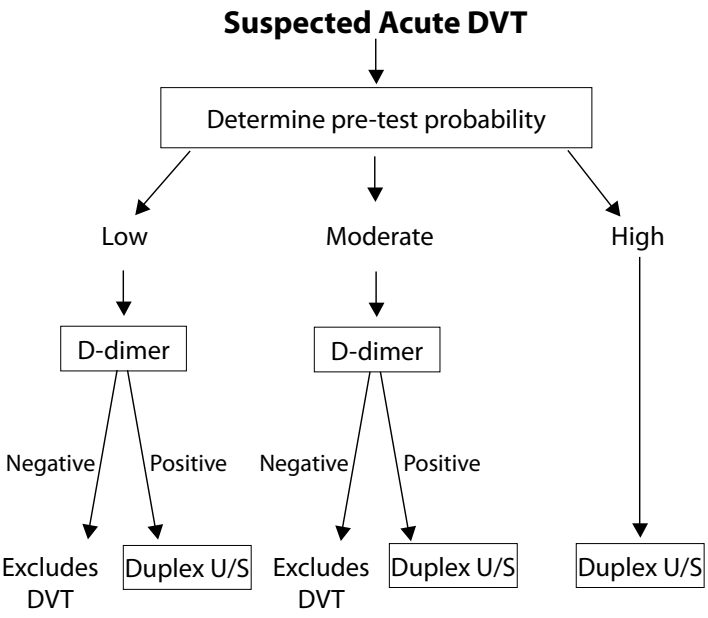

Figure 148 – Diagnostic algorithm incorporating combined clinical probability/D-dimer determination and venous duplex ultrasonography. Patients with high pretest probability are triaged directly to ultrasound. If a sensitive D-dimer assay is used,* patients with non-high (low and moderate) pretest probability and a negative D-dimer can be managed without further diagnostic testing. If a less sensitive D-dimer assay is used, moderate pretest probability patients should be triaged to duplex. (From Meissner MH: Off hours vascular laboratory utilization. In Pearce WH, Matsumura JS, Yao JST (eds): Trends in Vascular Surgery. Chicago, Precept Press, 2003, pp 47-60. Reproduced with permission.)

Fig. 1. Algorithm for diagnosis of DVT.

Duplex ultrasonography

Duplex ultrasonography has now replaced venography as the most widely used diagnostic test for an acute DVT.[2] Advantages of Duplex ultrasonography are that it is widely available and portable. Disadvantages are that it is expensive and operator dependent, and also that iliac veins and calf veins are difficult to evaluate. Evaluation includes assessment of vein flow, vein compressibility, intraluminal echoes and luminal colour filling and augmentation.[2]

Duplex ultrasonography has excellent sensitivity and specificity of 97% and 94% respectively, with positive and negative predictive values of 97% and 98% respectively for proximal DVT.[9] The sensitivity and specificity for calf veins is around 75%.[9] The extent of examination with Duplex ultrasonography is controversial, whether one does a full examination or a simple compression study. The consensus is that a full thorough examination of the deep veins be performed. This will not miss the isolated calf vein thrombosis and will add only 4 - 5 minutes per extremity. Limited examination failed to detect 7.3% of proximal thrombosis and 27% of isolated calf thrombosis.[10] If equivocal examination on ultrasound is found serial ultrasound examination will be necessary. However, the use of clinical pre-test probability and D-dimer tests will help in the decision process.

Ascending venography

Ascending venography has been the 'gold standard' for diagnosis of DVT. Venography is highly accurate but has certain limitations: venepuncture is unsuccessful in 2 - 3% of studies. In 10 - 30% of cases all venous segments are not adequately visualised.[11,12] Iodine sensitivity and the fact that it is time consuming are other limitations. One may resort to venography when Duplex ultrasound is equivocal and where clinical probability is high.

Computed tomography venography (CTV)

This test can be performed with CT pulmonary angiography when excluding pulmonary embolism as well. In comparison with venous ultrasonography CTV has been reported to have sensitivity

of 98 - 100% and specificity of 94 - 100% with positive and negative predictive values of 92 - 100% for pelvic and thigh thrombosis.[13-17] However, the study by Stoves *et al.*[18] reported 50% false positive rates for pelvic DVT. Calf DVT has not been studied with CTV. It is also quite costly and involves contrast media with its concomitant problems.

Magnetic resonance imaging

Conventional MRI using spin echo technique can detect central vein thrombi and has a sensitivity of 90% and specificity of 100%.[19-21] It is time consuming and expensive. Magnetic resonance venography (MRV) has been developed to image the venous circulation. It distinguishes stationary from moving signals. Contrast-enhanced (CE) MRV has excellent sensitivity (100%) and specificity (97 - 100%) for femoral and iliac veins.[22] However, it is costly and has limitations for calf veins.

In approximately 27% of patients with pulmonary embolism, Duplex ultrasonography is negative, and MRV may act as a complementary test to confirm pelvic or inferior vena cava (IVC) thrombosis.[23] Combining pulmonary MRA with lower limb MRV may help in diagnosing venous thrombo-embolic disease in its entirety.

In conclusion, all the various tests for diagnosis of DVT have been reviewed. A rational approach to making an accurate diagnosis is important and utilising the pre-test clinical probabilities score and D-dimer levels combined with ultrasound will yield excellent results in the majority of cases. However, where results are equivocal further complementary tests as outlined above or repeating the ultrasound examination will help as well. The algorithm (Fig. 1) adopted from Meissner[24] using the pre-test clinical probability D-dimer level and ultrasonography seems a logical and simple way of making the diagnosis of DVT and should be utilised.

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Anticoagulant management of DVT

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Introduction[1-5]

The current options for therapeutic anticoagulation are unfractionated heparin (UFH), warfarin and low molecular weight heparin (LMWH). Although warfarin and UFH are effective anticoagulants, both drugs have safety problems. Warfarin has been the only oral anticoagulant since 1940; it has a narrow therapeutic window and requires monitoring. There is a high risk of bleeding and its action is affected by diet and many drugs. The introduction of newer oral anticoagulants such as dabigatran and rivaroxoban has led to promising prophylactic studies that are likely to change prophylaxis protocols in the future. Over the next 5 years these drugs will be extensively investigated as therapeutic agents. For now LMWH and warfarin are the 'gold standard' therapeutic agents for established venous thromboembolism. Fondaparinux and hirudin need to be considered when heparin-induced thrombocytopenia has been diagnosed.

Initial therapy with LMWH[1-3, 6]

The primary objectives of treatment for DVT are to prevent clot extension, fatal and non-fatal pulmonary embolism (PE) and to reduce the risk of recurrent thrombosis. The long-term objective is to reduce the incidence of pulmonary hypertension and the risk of developing complications of chronic venous hypertension. LMWH has replaced UFH to initiate anticoagulation; compared with UFH, LMWH has been shown to be more effective and is associated with a lower incidence of major bleeding, and has a mortality benefit. It is mandatory to begin LMWH as soon as possible in the acute phase of DVT. Clot propagation and the development of pulmonary emboli need to be 'arrested'

rapidly. Other benefits of using LMWH include a reduced incidence of heparin-reduced thrombocytopenia (HIT) and hospital stay. LMWH should continue for at least 5 days and evidence suggests that even a longer period of 7 - 10 days may decrease the risk of long-term chronic venous hypertension. Although the risk of HIT is lower when using LMWH, platelet count still needs to be monitored. A platelet count should be obtained at 72 hours after LMWH has been started. If the platelet count drops below 100 000 cells/µl or 50% of its initial value, heparin should be stopped and substituted with a hirudin derivative.

Use of warfarin[1-3, 6]

Initial therapy with warfarin alone is associated with a high rate of recurrence. In most patients 5 mg of warfarin should be given immediately after the first dose of LMWH. The INR is monitored from 72 hours onwards anticipating a therapeutic range of 2 - 3. LMWH should be stopped after 5 days provided the INR remains in the therapeutic range for at least 2 consecutive days.

Very careful monitoring of the INR is mandatory, particularly in high-risk groups. These include patients who have a bleeding tendency, are malnourished or debilitated, in heart failure, have liver disease, or are elderly. In these patients it may be necessary to decrease the initial warfarin dose early in therapy and subsequent target INR should also be adjusted. If warfarin is contraindicated, inconvenient or if therapeutic ranges have not been achieved, long-term therapy with LMWH should be considered.

Monitoring LMWH[1-3, 6-11]

LMWH anticoagulant activity is measured using an anti-Xa activity assay. Anti-Xa monitoring is indicated in pregnancy, renal failure or morbidly obese patients in whom larger doses are anticipated. It is important to realise that the various LMWHs are distinct drug products. They require clinical validation for specific indications. Each LMWH must be dosed according to the manufacturer's recommendations. The dose recommended for each product has optimum benefit/risk ratio as shown by clinical trials.

Duration of warfarin therapy[1, 2, 12-14]

In the modern era the duration of therapy should be individualised. Generally it is a balance between the risk of recurrence, the risk of haemorrhage, the patients' state of health and whether there are transient or persistent predisposing factors. The following recommendations need to be considered:

- Isolated calf vein thrombosis associated with transient risk factors: duration of therapy 3 months
- Idiopathic calf vein thrombosis: duration of therapy >3 - 6 months
- First episode proximal vein thrombosis: duration of therapy at least 6 - 12 months
- In relatively mild thrombophilic disorders (anti-phospholipid antibodies, factor V Leiden, prothrombin 20210 gene mutation): duration of therapy at least 12 months
- In severe thrombophilic disorders (antithrombin III, protein C and S deficiencies): continue therapy indefinitely
- In patients with recurrent thrombosis not induced by trauma or surgery: continue therapy indefinitely.

Graduated compression stockings[15, 16]

Patients should be mobilised immediately with a class II compression stocking. This reduces pain and swelling and decreases the incidence of the post-thrombotic syndrome.

LMWH as an alternative to warfarin[1-3, 12-14]

Therapeutic doses of LMWH are as safe and effective as warfarin (for 3 - 6 months). Thus LMWH is an alternative option in patients in whom INR control is difficult. LMWH also appears to be more effective than warfarin in reducing recurrent DVT in patients with cancer. In pregnant patients who require anticoagulation, LMWH is the current treatment of choice because it does not cross the placenta. Women who become pregnant while on warfarin should immediately change to LMWH.

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The role of venous thrombectomy for ilio-femoral vein thrombosis

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The natural history of patients with ilio-femoral vein thrombosis treated by anticoagulation alone is not good. In a cohort of such patients studied by Akesson,[1] within 5 years 95% had developed ambulatory venous hypertension with 95% demonstrating skin changes of venous insufficiency including venous ulceration in 15%. A further 15% reported symptoms of venous claudication. O'Donnell[2] reported venous ulceration in nearly 80% of patients within 5 years. This form of thrombosis requires a more aggressive approach than infra-inguinal DVT, which is associated with fewer post-thrombotic

sequelae. Conventional anticoagulation, while limiting the risk of clot propagation and pulmonary embolism, does not directly address the thrombotic obstruction.

Complete lysis of ilio-femoral DVT with anticoagulation alone is unusual. Persisting venous obstruction is often associated with secondary valve incompetence in vein segments not affected by the initial thrombosis. A combination of obstruction and valve incompetence is responsible for the most severe cases of the post-thrombotic syndrome.

There is good clinical and experimental evidence that rapid clot removal is beneficial in terms of preservation of endothelial and valve function, preventing further thrombosis and improving both the short- and long-term clinical outcomes. Rapid clot removal enables the recognition of possible underlying physical factors that may have led to the thrombosis such as the May-Thurner syndrome (a venous stenosis caused by compression of the left iliac vein by the iliac artery). These conditions are usually correctable.

Early clot removal is achieved by either mechanical thrombectomy using an open or endovascular approach, or catheter-directed thrombolysis. Occasionally these techniques may be combined. Thrombectomy achieves more rapid clot removal and avoids the risks of thrombolysis. It is particularly attractive in patients in whom thrombolysis is contraindicated because of the risk of haemorrhage.

Patients with acute limb-threatening venous thrombosis (phlegmasia) require immediate clot removal to preserve the viability of the limb. Anticoagulation alone is insufficient in such patients, many of whom have malignancy, are pregnant or have recently undergone major surgery. Thrombolysis may be contraindicated in many of these situations. Iliac vein thrombosis following renal transplantation is an absolute indication for this procedure.

The long-term benefits of surgical venous thrombectomy have been documented in a randomised controlled trial comparing this with standard anticoagulation.[3] Patients randomised to venous thrombectomy enjoyed better venous patency rates, lower ambulatory venous pressures, better valve function and less post-thrombotic morbidity when assessed at both 5 and 10 years following treatment.

A CT venogram is recommended prior to intervention to document the extent of the thrombosis and particularly to determine whether thrombus is present in the inferior vena cava.

Open surgical thrombectomy is usually performed under general anaesthesia with positive end expiratory pressure but it is feasible under local or regional anaesthesia. Facilities for intra-operative angiography are mandatory. The patient is placed in the Trendelenberg position and the entire leg is prepared. The femoral vein and its tributaries in the groin are controlled. A transverse venotomy enables the introduction of a venous Fogarty catheter for extraction of thrombus from the iliac vein. The completeness of the clot removal is verified by on-table venography. Frequently an iliac vein stenosis is uncovered. This is immediately dealt with by stenting using a self-expanding nitinol stent. Clot below the inguinal ligament is usually removed by applying an Esmarch bandage or the judicious use of a Fogarty catheter introduced in a retrograde fashion. Most authorities recommend the construction of a temporary arterio-venous fistula using a branch of the long saphenous vein and the femoral artery in order to improve vessel patency. This is closed after 6 weeks. Postoperatively the patient remains anticoagulated. Intermittent pneumatic compression devices are useful and full-length stockings are recommended.

Complications of the procedure are usually confined to the groin and include wound infection, haematoma and lymph leaks. The re-thrombosis rate in the Swedish randomised study was 13%.[3] Clinically significant pulmonary embolism is rare. No case was recorded in over 300 venous thrombectomies reported by Ekloff.[4] New perfusion defects on perfusion lung scanning are noted in up to 20% of cases. The low incidence of pulmonary embolism implies that vena caval filters are not routinely required for this procedure. It is however prudent to use one if the thrombus extends into the IVC.

More recently, percutaneous mechanical thrombectomy has been introduced to achieve clot removal using a purely endovascular technique under local anaesthesia. This technique employs a variety of catheters such as the AngioJet (Possis Medical, Minneapolis, MN) and the Trellis-8 (Bacchus Vascular, Santa Clara, Calif.). Thrombus is cleared rapidly and exposure to thrombolytic drugs is reduced or eliminated, but there may be a slightly higher risk of pulmonary embolism and a higher requirement for vena caval filters.

The term 'pharmaco-mechanical thrombectomy' (PMT) refers to a combination of percutaneous mechanical thrombectomy and the local use of low doses of thrombolytic drugs introduced through the catheter during the procedure. Using this combination it is possible to achieve near-total thrombus removal during a single session in 60 - 70% of cases.[5]

No randomised comparison of venous thrombectomy and catheter-directed thrombolysis has been undertaken. A review of the literature suggests similar outcomes for both approaches but mechanical thrombectomy is associated with shorter treatment times, lower ICU requirements, shorter hospital stays, and possibly lower overall cost.[6] The chief advantage over CDT is avoiding or limiting the risks of bleeding associated with thrombolytic therapy.

The AngioJet catheter is usually introduced via the popliteal vein using ultrasound guidance in the prone position. Alternative access sites include the short saphenous, internal jugular and common femoral veins. After the placement of a 6 - 8 Fr sheath an AngioJet DVX catheter is placed selectively in the thrombus. Heparin is given followed by 5 - 10 mg rTPA via the catheter using power pulse spray mode; 15 - 20 minutes later standard thrombectomy mode is selected to aspirate the thrombus. Complete clearance is verified by venography. The patient remains anticoagulated with heparin. Warfarin is commenced immediately following a successful procedure.

A review of five contemporary series[7-11] of the use of the AngioJet for ilio-femoral DVT suggests that greater than 50% clot clearance can be achieved in 60 - 99% of cases with complete clot removal possible in 25 - 65% of cases. Most cases can be definitively treated in a single session. Iliac stenting may be necessary in 35 - 65% of cases. Caval filter use was variable in these studies but no case of clinically significant pulmonary embolism was recorded.

The PEARL registry[12] has accumulated data on 116 patients undergoing AngioJet thrombectomy for DVT. The power pulse technique was used in 72% and additional stents required in 62% of cases. Additional catheter-directed thrombolysis was required in 41% and caval filters were used in 21%. Complete vessel patency was achieved in 69% of cases with a further 22% achieving partial resolution.

Current guidelines of the American College of Chest Physicians[13] recommend the use of PMT for patients with thrombosis <14 days in duration who have low risk of bleeding. Although the age of the thrombus is undoubtedly an important prognostic factor, Rao *et al.*[11] reported successful clot clearance in 89% of patients presenting with thrombus judged to be older than 14 days.

When acute iliofemoral DVT affects physically active patients with a projected

life expectancy of greater than 5 years, consideration should be given to a strategy of thrombus removal. For most patients, CDT will be first choice. Where thrombolysis is contraindicated or there is a need to reduce thrombolytic drug exposure or accelerate treatment times, PMT or surgical venous thrombectomy should be considered. Physically inactive patients or the elderly with serious co-morbidity will continue to be treated by anticoagulation and elastic compression alone.

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Thrombolysis for deep venous thrombosis

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Introduction

The standard treatment for DVT consisting of systemic anticoagulation with heparin followed by oral anticoagulation with a vitamin K antagonist is effective in reducing the risk of thrombus propagation, pulmonary embolism and death.[1] Although standard anticoagulation effectively prevents new clot formation, it has little effect on clot already present in the system. Thrombus dissolution and re-canalisation of the obstructed vein is left to the body's intrinsic fibrinolytic system[2]

Standard anticoagulation leads to partial regression of thrombus in only 50% of patients with a small minority of patients (6 - 12%) achieving complete venous re-canalisation.[3,4] Residual thrombus after completion of anticoagulation therapy is an independent predictor for recurrent DVT with an up to 8 times increased risk.[5] For these reasons post-thrombotic complications are common and occur in at least 50% of patients with iliofemoral DVT if managed with anticoagulation alone.[6,7]

Post-thrombotic syndrome

The post-thrombotic syndrome is the typical clinical presentation which develops after DVT of a limb and is caused by venous hypertension as a result of venous outflow obstruction and valve incompetence with venous reflux. Patients with the highest ambulatory venous pressures have the most severe post-thrombotic syndrome.[8] The typical clinical presentation consists of swelling, discomfort, pain, venous claudication, hyperpigmentation, stasis dermatitis venous eczema, induration, lipodermatosclerosis, varicose veins and ultimately venous ulceration (Fig. 1(a) and (b)). Mild to moderate symptoms occur in at least 50% of patients 5 years after DVT with 9 - 23% of patients developing severe post-thrombotic symptoms.[9,10] Venous ulcers are often chronic, frequently recur and cause major impairment to quality of life.[11]

Iliofemoral venous thrombosis

Up to 70 - 80% of clinically significant DVT involves the proximal venous segments.[12] Iliofemoral venous thrombosis (IFVT) is the most extreme form of DVT and is associated with the highest incidence of pulmonary embolism and the most severe post-thrombotic sequelae (Fig. 2).[12,13] The risk of recurrence after IFVT is also 2.4-fold that of patients with femoro-popliteal DVT.[14]

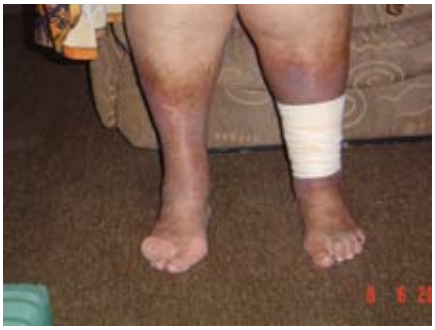

Fig. 1(a). Post-thrombotic limb.

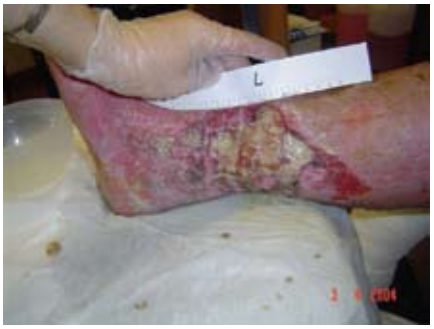

Fig. 1(b). Venous ulceration.

Rationale and evidence for clot removal from the iliofemoral venous system

Early removal of thrombus may protect against chronic outflow obstruction, valvular incompetence and chronic venous hypertension and therefore limit the development and severity of the post-thrombotic syndrome. Whereas calf vein DVT almost routinely re-canalises without major clinical sequelae, proximal DVT rarely results in normal venous haemodynamics after treatment with anticoagulation therapy only.[15] It has been shown that valve function is frequently preserved if clot lysis occurs early,[16] that persistent proximal vein obstruction causes distal valve incompetence[17] and that the combination of venous obstruction and valve incompetence causes the most

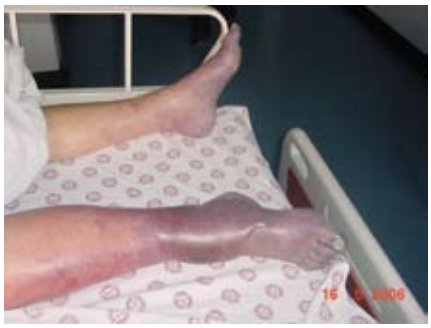

Fig. 2. Phlegmasia cerulea dolens.

severe morbidity.[18] Patients with IFVT treated with standard anticoagulation have been shown to have a significantly higher risk of recurrence compared with those with involvement of the infra-inguinal segments.[19]

The long-term benefits of restoring venous patency have been documented in a randomised trial comparing surgical venous thrombectomy to conventional anticoagulation.[19] Improved results were found with venous thrombectomy at 6 months, 5 year and 10 year follow-up with regards to better patency, less oedema, lower venous pressures, less post-thrombotic symptoms and fewer leg ulcers.

Thrombolytic therapy

Thrombolytic agents belong to a family of drugs called plasminogen activators. These drugs act indirectly by converting fibrin-bound plasminogen to plasmin which actively dissolves thrombus. Thrombolytic therapy was initially given systemically via a peripheral intravenous infusion. Comerota reviewed the results of 13 studies comparing anticoagulation v. thrombolytic therapy for acute DVT.[20] Lytic therapy achieved significant or complete clot lysis in 45% of patients and partial lysis in 18% of patients compared with 4% and 14% respectively of patients who received standard heparin treatment only. Preservation of venous valve function with a significant reduction of post-thrombotic sequelae has been reported in patients with successful thrombolysis.[21] These results, however, were marred by a 3.8-fold risk of major bleeding, including intracranial haemorrhage, in those patients receiving thrombolytic therapy.[22]

Catheter-directed thrombolysis (CDT)

This entails catheter-directed infusion of a thrombolytic agent directly into the thrombus. This has the advantage of protecting the plasminogen activator from neutralisation by circulating plasminogen activator inhibitors (PAI1 and PAI2). The activated plasmin is also protected from neutralisation by circulating α-2 anti-plasmins and α macroglobulin. This technique was first reported by Okrent *et al.* in 1991 and further popularised by Semba and Dake in 1994.[23,24] A systematic review comparing CDT to systemic and loco-regional administration of thrombolytic agents found that CDT was more effective with regard to complete, early opening of occluded veins, with fewer complications and a decreased prevalence of post-thrombotic complications.[25]

There are numerous reports on the efficacy and safety of CDT. The results of five large series with adequate follow-up are summarised in Table I.[25-29] The National Venous Thrombolysis Registry reported on the management of 287 patients with iliofemoral venous thrombosis managed with urokinase. Complete dissolution of thrombus was achieved in 31% of patients and 50 - 99% dissolution in 32% of patients, giving an overall success rate of >80%.[26] Primary patency at 1 year was 64%, but subgroup analysis of those patients who presented with a proven acute first-time IFVT was much better, with 96% patency at 1 year and 72% normal valve function. Patients receiving CDT also experienced significantly improved quality of life with a better health utilities index, physical functioning, fewer stigmas of chronic venous disease and health distress and fewer post-thrombotic symptoms.[30] Sillesen *et al.* reported a 90% success rate with re-opening of thrombosed venous segments with no re-thrombosis after 24 months and 95% normal venous function, i.e. the absence of reflux.[28] In a long-term follow-up study Baeckgaard *et al.* reported excellent results, with 82% of limbs being patent with competent valves and without any skin changes or venous claudication 6 years after a CDT for IFVT.[29] AbuRahma *et al.* compared conventional therapy to lysis and percutaneous transfemoral angioplasty and stenting. They found significantly improved primary iliofemoral venous patency rates for active intervention compared with standard conventional therapy (83% and 69% for CDT v. 24% and 18% for anticoagulation therapy) at 1 and 5 years respectively. Long-term symptom resolution was achieved in 87% of patients who had received active intervention compared with 30% in patients on standard anticoagulation therapy only.[31] A randomised controlled trial published in 2002 compared CDT for IFVT with conventional anticoagulation and reported a patency rate of 72% at 6 months with an 11% incidence of venous reflux in the CDT group compared with 12% patency and 41% reflux in the anticoagulation group.[32] Initial results published recently from a still ongoing RCT (CaVenT study) reported a 6-month patency of 64% in the CDT group v. 36% in a control group, corresponding to an absolute risk reduction of 28%.[33]

Complications of CDT

Bleeding complications occur in 5 - 10% of patients with the majority occurring at the puncture site.[34] Intracranial bleeding is rare (<1%) with significant retroperitoneal haematoma reported in 1% of cases and musculo-skeletal, genito-urinary or gastrointestinal bleeding occurring in 3% of patients.[26] Symptomatic pulmonary embolism has been reported in +1% of patients.[25,26] Mortality secondary to thrombolysis has been reported in 0.4% of patients.[26]

Adjunctive treatment

PTA and stenting. Residual stenosis after successful thrombolysis is common and should be corrected to prevent recurrent DVT. Underlying anatomical or structural abnormalities have been reported in 44% of patients in the National Venous Registry, whereas Silleson *et al.* and Lin *et al.* reported the requirement for PTA and stenting in 67% and 80% of patients respectively.[28,35] Iliac vein primary patency can be significantly improved by the use of stents v. angioplasty alone.[25-29]

IVC filter. There are no clear guidelines for the placement of IVC filters during

Table I. Efficacy and complications of CDT in 5 series

	Bjarnason *et al.*[25]	Mewissen *et al.*[26]	Comerota *et al.*[27]	Sillesen *et al.*[28]	Baekgaard *et al.*[29]
Date published	1997	1999	2000	2005	2010
No. of patients	77	287	58	45	101
Initial success	79%	83%	84%	93%	96%
Primary patency (%)	1 yr (63%)	1 yr (64%)	1 yr (78%)	2 yrs (93%)	6 yrs (82%)
Complications					
Intracranial bleeding	0%	<1%	0%	0%	0%
Other bleeding	5%	11%	9%	2%	1%
Pulmonary emboli	1%	1%	0%	0%	0%
Mortality	0%	0.4%	0%	0%	0%

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thrombolytic therapy, although its use has been advocated in the presence of floating thrombus or in patients who already have poor pulmonary reserve due to previous pulmonary embolism.[29,36]

Intermittent pneumatic calf compression. IPC of the foot and calf has been shown to reduce oedema with improved lysis, better valve function and late patency without increasing the risk of pulmonary embolism.[37]

Elastic compression stockings. Elastic compression stockings have been shown to significantly prevent post-thrombotic sequelae and should be worn from the time that the patient becomes ambulatory.[38]

Anticoagulation therapy. After completion of thrombolysis standard anticoagulation therapy is prescribed, starting with LMWH (Enoxaparin 1 mg/kg 2x/day) together with an oral anticoagulant (vitamin K antagonist) until a therapeutic INR of >2 has been achieved when the LMWH can be discontinued. Duration of treatment depends on various factors (see current ACCP recommendations for the duration of anticoagulation[39]).

Method of thrombolysis

Acute thrombi respond better to lytic therapy than established DVT due to organisation of thrombus over time. Acute DVT is defined as symptoms being present for less than 14 days and/or imaging indicative of venous thrombosis having occurred within 14 days.[36] Lytic agents currently used in the published trials are urokinase, tissue plasminogen activator (tPA) and recombinant tissue plasminogen activator (rtPA). Grunwald *et al.* found no difference between these various drugs regarding efficacy or safety.[40]

Venous access is obtained through an unaffected venous segment upstream from the thrombus using a micropuncture technique under ultrasonographic guidance. In the majority of cases the ipsilateral popliteal vein will be the access site of choice, but where the popliteal vein is thrombosed access may be obtained through the posterior tibial vein. A 5F sheath is placed and a venogram performed to confirm position. A 0,035 hydrophilic guidewire is placed across the occluded venous segment. Venography is performed to confirm intra-luminal position, to evaluate extent of the thrombus and visualise collaterals and vessels downstream from the thrombus. A multiple side-hole catheter is placed into the thrombus, covering as much of the extent of the thrombus as possible. The thrombolytic agent is administered via the multiple side-hole catheter using a starting dose of 10 mg rtPA dissolved in 100 ml of a heparin saline solution injected over half an hour using a 'pulse spray technique'. After 30 minutes venography is performed and the catheter repositioned if necessary. The patient is returned to a high care unit with a continuous infusion of 1 - 3 mg rtPA administered either as a continuous infusion or, where available, using the pulse spray technique. The Society of Interventional Radiology recommends a dosing rate for tPA of 0.5 - 1.0 mg/hour[41] but we have used up to 3 mg/hour without any increase in bleeding complications. The rtPA is dissolved in a larger volume to give an infusion rate of 100 ml/hour. Intravenous heparin is given to maintain an ACT of ±200 - 220 (APTT 80 - 100 seconds). Treatment is monitored with APTT, thrombin time, fibrinogen, D-dimer, Hb and platelets. Subsequent venography is performed after 12 hours. In case of incomplete lysis, lytic therapy is continued until complete lysis has been obtained. Where an underlying lesion has been unmasked, PTA and stenting is performed using a large calibre self-expanding nitonol or stainless steel stent (Fig. 3(a)(b)(c)(d)). After termination of lysis, the patient is treated with standard anticoagulation as already described.

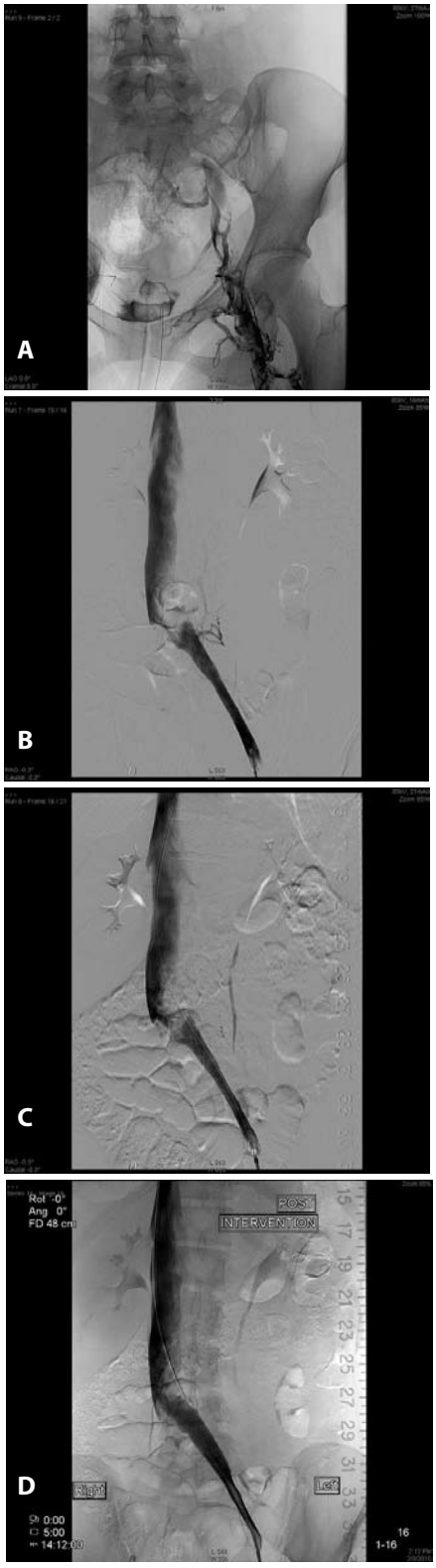

Fig. 3. Intervention for IFVT secondary to May Thurner syndrome. A – left iliofemoral venous thrombosis; B – post thrombolysis; C – post PTA; D – post stenting.

Pharmaco-mechanical thrombolysis (PMT)

Various mechanical techniques have been combined with catheter-directed infusion of a thrombolytic agent. A number of studies have reported improved results with PMT in the management of IFVT with regard to more effective thrombus

Table II. Possible indications for DVT thrombolysis

- Extensive thrombosis with a high risk of pulmonary embolism
- Iliofemoral or IVC thrombosis
- Acute limb compromise (phlegmasia, caerulea dolens)
- An anatomical cause for DVT (May Thurner syndrome)
- Good physiological reserve (20 - 70 years)
- Life expectancy >6 months
- Short onset of symptoms <14 days
- Failure of standard LMWH therapy
- No contraindications for thrombolysis

Table III. Contraindications for thrombolysis

- Bleeding diathesis/ thrombocytopenia
- Organ-specific bleeding risk (recent MI, CVA, GI bleed, surgery or trauma)
- Renal or hepatic failure
- Malignancy, e.g. brain metastases, increase risk of bleeding
- Pregnancy
- Uncontrolled hypertension

removal, in less time and with reduced dose of the thrombolytic agent.[42,43] Lin *et al.* also reported reduced ICU and total hospital length of stay and hospital cost when using PMT compared with CDT alone.[35] A more detailed description of this technique is discussed in the relevant section.

Current recommendations and indications

The most recent guidelines from the American College of Chest Physicians recommend that CDT should be used in patients with extensive venous thrombosis (iliofemoral involvement) that have an acute presentation (<14 days) and have a life expectancy >1 year and good functional status. The guidelines also recommend the use of a combination of CDT and PMT over CDT alone as well as the use of venous angioplasty and stenting in the presence of residual stenoses and reversible causes of thrombosis.[44] Possible indications and contraindications for thrombolytic therapy in DVT are given in Tables II and III.[45]

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Pulmonary embolism

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History

Venous thromboembolic disease (VTE) has been recognised for over two thousand years. The Indian medical doctrines record the work of Sisruta (circa 1000 BC), who described unilateral swelling of the lower limb which was refractory to treatment.[1] In the nineteenth century two medical stalwarts, Rudolph Virchow and Friederich Trendelenberg, outlined the pathophysiology and complications of venous thrombosis. The former delineated the classic triad of intimal injury, stasis and hypercoagulability as the major predisposing causes of thrombosis and coined the term 'embolia' to describe the distal lodgement of thrombi in the pulmonary vasculature. The latter, recognising that large clots within the pulmonary circulation may be rapidly fatal, attempted the first pulmonary embolectomies. Although unsuccessful, later attempts within his lifetime by other surgeons were lifesaving.

In the latter half of the twentieth century the natural history of pulmonary embolism (PE) and the role of anticoagulation were clearly described.[2,3] Dalen and Alpert estimated that approximately one-third of deaths from PE occurred within the first hour. Of those who survived more than 60 minutes, but in whom the diagnosis was not reached and therapy not commenced, the mortality rate was 30% compared with 8% in those who received appropriate anticoagulation. Ninety per cent of the deaths from PE arose in patients who did not receive anticoagulation. In untreated survivors, the recurrence rate was 50%. Subsequent studies have confirmed these estimates which have remained unchanged for the past 40 years.[4]

Epidemiology

The exact incidence of PE has been difficult to determine for a number of reasons. As many as 50% of emboli may be asymptomatic.[4] The clinical presentation is extremely variable, many patients presenting with nonspecific symptoms and signs, and a lack of postmortem data may lead to an underestimation. Furthermore, the number of postmortems being performed has been declining annually. An estimate has been made that as many as one million people per annum in the USA may develop this complication. In Europe a postmortem study on the population of Malmo revealed VTE in 25% of all deaths. Of those with VTE, 72% had an associated PE which was considered the cause of death in 70% of cases.[4] Despite these findings, as many as 40% of acutely ill hospitalised patients still do not receive prophylaxis for VTE.[5]

Pathophysiology

Although the initial nonspecific symptomatology is primarily respiratory, the main effects of PE are cardiovascular, which become apparent once 30 - 50% of the pulmonary vasculature has become occluded. This magnitude of pulmonary arterial obstruction markedly increases pulmonary vascular resistance, resulting in right ventricular failure. As a result, left ventricular preload is decreased and cardiac output falls. Right ventricular dilatation may compromise left ventricular diastolic function, resulting in a dual cause for systemic hypotension. The increased oxygen demand of the right ventricle coupled with a reduction in coronary perfusion may cause myocardial ischaemia. A decrease in cardiac output, an increase in dead space ventilation and major ventilation-perfusion mismatch result in systemic arterial desaturation.

Clinical presentation and investigation

The signs and symptoms of PE are extremely variable and are dependent on the size of the emboli. Minor emboli may be asymptomatic or present with a myriad of nonspecific respiratory or cardiovascular complaints. Major emboli may result in complete cardiovascular collapse. Both presentations present diagnostic problems as a number of pathologies may account for these scenarios. Three strategies may be used either alone or in combination to confirm the diagnosis: markers of venous thrombosis, evidence of right ventricular dysfunction, and radiological visualisation of thrombi within the pulmonary vasculature. Although the clinical presentation is notoriously atypical, a balance needs to be struck between over-investigation and missing the diagnosis. For that purpose patients may be stratified into three risk groups, namely low, intermediate or high on the basis of either the Wells[6] or Geneva[7] classification systems. Once stratified, a logical diagnostic algorithm follows.

Markers of venous thrombosis

Given the strong association between venous thrombosis of the lower limb and PE this should be considered the first step in the diagnostic ladder. Plasma D-dimer is a degradation product of cross-linked fibrin and is elevated in the presence of acute clot formation due to the simultaneous actions of coagulation and fibrinolysis. The negative predictive value of D-dimer using ELISA-based assays is high and normal levels virtually exclude VTE or PE in those patients with a low clinical probability of PE. Omitting further investigation in this risk group on the basis of a negative test would result in a 3-month embolic rate of <1%. Although a positive D-dimer level is not diagnostic of VTE or PE and may occur in a number of conditions, it indicates that further investigation is necessary.

Compression ultrasound of the common femoral and popliteal veins with or without colour flow Doppler is extremely sensitive and specific in experienced hands with positive and negative predictive values exceeding 95%. In combination with D-dimer, a negative result should be adequate to exclude PE in low and probably intermediate risk patients.

Evidence of right ventricular dysfunction

The classic ECG findings of right ventricular strain in the presence of PE are S waves in lead I, Q waves in lead III, and inverted T waves in lead III (S1Q3T3). These are uncommon, nonspecific and insensitive, occurring in only 20% of patients. The gold standard for cardiac assessment is echocardiography. Dilatation of the right ventricle may be demonstrated in 25% of patients with PE.[4] This has implications for risk stratification and management. The highest sensitivity and specificity occurs in the high-risk patient with or without hypotension where the absence of signs of right ventricular overload virtually excludes the diagnosis.

Brain natriuretic peptide (BNP) is secreted by the ventricles in response to myocyte stretch. In isolation it is unreliable to confirm PE, the main role being prognostic. Similarly, elevated troponins are not diagnostic but in the presence of PE carry a worse prognosis. Acute

ischaemia alters the binding capacity of albumin for transition metals, producing a metabolic variant termed ischaemia-modified albumin (IMA). Although this has been shown to be a sensitive marker of myocardial ischaemia, at present it cannot be used as an isolated investigation to confirm PE.

Radiological confirmation of pulmonary embolus

Initial plain chest radiography is virtually always normal in acute PE. The Westermark sign (dilatation of a proximal pulmonary artery and collapse of distal vessels) and the Hampton hump (a triangular infiltrate as a consequence of pulmonary infarction) are rare.

Although a negative ventilation/perfusion scan (V/Q) excludes PE in almost 100% of patients, most scans produce an indeterminate result.[8] The present role of V/Q scanning is as an alternative modality for patients in whom CT scanning is contraindicated or not available. In such situations, the combination of D-dimer, compression ultrasound, and V/Q scanning may be diagnostic in 99% of patients.[9]

The gold standard for diagnosing PE is multi-detector CT pulmonary angiography (MDCT-PA), allowing visualisation of the pulmonary arteries down to the subsegmental level.[8] A further advantage lies in the diagnostic yield of other thoracic pathologies which may account for the patient's symptoms. Although highly accurate, selective use remains of importance because of the high radiation exposure, especially to breast tissue.

The choice of diagnostic modality is based on the clinical risk stratification. Low-risk patients should be screened using D-dimer and compression ultrasound. If negative no further investigation is warranted; if positive MDCT-PA should be performed. In those who fall into the intermediate risk category in addition to D-dimer and ultrasound, echocardiography should be performed. In those with positive findings, MDCT-PA is essential. The reason for including echocardiography is because of therapeutic implications. For high-risk patients, if haemodynamically stable, MDCT-PA is the preferred initial modality. Patients in whom transportation to the radiology department is deemed unsafe due to systemic hypotension should be screened by bedside testing, namely D-dimer, ultrasound and echocardiography, and therapy instituted based on these findings alone.

Therapy

The choice rests between anticoagulation alone or in combination with clot lysis. Low-risk patients and those in the intermediate range with normal echocardiography are best managed by anticoagulation alone. Low molecular weight heparin (LMWH) or fondiaparinux are the initial drugs of choice followed by warfarin for at least 3 months. Patients in the intermediate risk group with evidence of right ventricular dysfunction have a better outcome if thrombolysis is included in the initial management. Thereafter management follows that for the low-risk group. High-risk patients with a confirmed diagnosis require thrombolysis and anticoagulation. Recombinant tissue plasminogen activator is the thrombolytic agent of choice.[10] With regard to anticoagulation, LMWH has not been tested and unfractionated heparin is the recommended drug. For those who have an absolute contraindication to thrombolysis, clot fragmentation or thrombectomy should be considered. Long-term anticoagulation with warfarin follows the regimen for the low- and intermediate-risk groups.

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Vena caval filters: an evidence-based review

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Significant progress has been made in understanding the natural progression of venous thromboembolism (VTE). VTE rates are quoted at 1/1 000 in the general population, increasing after age 60 with rates as high as 1/100.[1] This explosion in research has allowed us reliable guidelines on the use of special investigations to confirm a diagnosis of VTE as well as guidelines on the most effective therapeutic regimen. Unfortunately, the use of vena caval filters has not been subject to the same scrutiny as the above modalities. This has resulted in the use of filters based more on individual practice patterns and preferences rather than randomised evidence. Despite the distinct lack of robust evidence, the use of inferior vena caval (IVC) filters has increased dramatically, especially with the introduction of retrievable filters.

This review will address the commonly available vena caval filters, indications for their use and the quality of evidence on which these indications are based using information gained from current guidelines and expert consensus.

There are currently 10 IVC filters approved for use in the USA (Table I).[2] These filters may be permanent or retrievable. They differ in their components, design, introducer size, route of insertion (jugular or femoral) and maximal vena caval diameter into which they can be deployed.

There are no randomised data comparing the effectiveness or complication rate of the available filters. IVC filters are placed via a jugular or femoral route, usually in the angiography suite under local anaesthetic. Skill and imaging have improved, allowing placement of these filters at the bedside under Duplex ultrasound guidance. To date however, no filters have been retrieved using ultrasound.

Anatomical variation must also be considered when placing IVC filters. 2% and 0.5% of the normal population have been described with duplication of the inferior vena cava and a L-sided IVC respectively.[3]

Retrievable filters

These filters were developed with the intention of placement at a time when

the patient is at highest risk of pulmonary (PE) or venous thromboembolism. They are then removed after this high-risk period, thus reducing the long-term complications of filter use including filter and caval thrombosis, recurrent deep vein thrombosis and sequelae of post-thrombotic syndrome. These filters are often referred to as optional filters as they may be left *in situ* permanently. Retrievable filters have lowered the threshold for placement. However, up to 70% of all retrievable filters are never removed.[4] Common reasons for failure to retrieve the device are need for a second intervention, thrombus within the filter, incorporation of the filter into the vessel wall endothelium, angulation of the filter and penetration of a filter limb into the IVC wall.

Table II illustrates the common practice use of vena caval filters as well as special circumstances which perhaps justify use of filters.

Only a single randomised trial has assessed the value of IVC filters for any indication.[5] The PREPIC study randomised 400 patients with confirmed proximal deep vein thrombosis to either anticoagulation alone or IVC filter placement in combination with anticoagulation. All patients received vitamin K antagonists for a minimum of 3 months. At 12-day follow-up there were significantly fewer pulmonary emboli (symptomatic and asymptomatic) in the filter group (1.1% versus 4.8%, p=0.03). At 2 years, there was no difference in the symptomatic PE rate and no difference in survival. The filter group did have a significantly higher rate of recurrent DVT (20.8% versus 11.6%, p=0.02). At 8-year follow-up filters did reduce the risk of PE but with no difference in survival and a higher rate of DVT in the filter group. See Table III for results of the PREPIC study.

This study provides valuable information that the placement of filters is of little value in patients who have no contraindication to the use of anticoagulation. There currently exist no other randomised trials

Table I. Vena caval filters

Filter	Type	Manufacturer	Material	Maximum IVC diameter (mm)	Introducer size (Fr)	MRI compatible
Bird's nest	Permanent	Cook	Stainless steel	40	14	No
Greenfield stainless steel	Permanent	Boston Scientific	Stainless steel	28	14	No
Greenfield titanium	Permanent	Boston Scientific	Titanium	28	14	Yes
Simin Nitinol	Permanent	Nitinol Medical	Nitinol	28	9	Yes
TrapEase	Permanent	Cordis	Nitinol	30	8	Yes
Venatech	Permanent	Braun	Phynox	28	9	Yes
Celect	Retrievable	Cook	Conichrome	30	7 - 8.5	Yes
G2	Retrievable	Bard	Nitinol	28	9	Yes
Gunther Tulip	Retrievable	Cook	Conichrome	30	11	Yes
Optease	Retrievable	Cordis	Nitinol	30	8	Yes
ALN*	Retrievable	ALN	Amagnetic stainless steel	32	7	Yes

*Only filter not yet available in the USA.

Table II. Indications for inferior vena caval filter placement

Absolute	Relative	Special situations
VTE with contraindication to anticoagulation	Free floating thrombus	Trauma
PE with contraindication to anticoagulation	Poor pulmonary reserve	Oncology
Recurrent PE while on anticoagulation		Bariatric surgery
Known VTE with severe complication while on anticoagulation		Critically ill
Progression of DVT while on anticoagulation		Catheter-directed thrombolysis

Table III. Summary of PREPIC findings with filter use

Time	PE	Recurrent DVT	Survival
12 days	↓		
2 years	=	↑	=
8 years	↓	↑	=

Table IV. American College of Chest Physicians recommendations[6,13]

Indication	ACCP recommendation regarding filter use	Level of evidence
Routine use of filter + anticoagulation with DVT or PE	Against	Grade 1A
Proximal DVT with contraindication to anticoagulation	For	Grade 1C
Major trauma or spinal cord injury	Against	Grade 1C

to evaluate the other suggested indications for filter placement.

Several practice guidelines have emerged in the absence of randomised data to assist with decision making with respect to filter placement. The most widely quoted is the 8th American College of Chest Physicians (ACCP) Guidelines on Antithrombotic Therapy.[6] Additional guidelines have also been addressed by the American College of Chest Physicians: Consensus Pulmonary Embolism, International Consensus Conference on Thrombosis, Eastern Association for the Surgery of Trauma[7] and the Southern California Evidence Based Practice Centre. The American College of Chest Physicians guidelines are listed in Table IV.

The level of evidence is based on the grade[19] system. A strong recommendation is grade 1 and A indicates high-quality evidence. Grade 1C remains a strong recommendation with C however being low-quality evidence based on observational studies or case series. These are the only 'indications for filter placement' addressed directly by the ACCP (8th edition) guidelines.

Relative indications

Free-floating ileo-femoral thrombus

This remains a commonly proposed indication for vena caval filters. Norris *et al.*[8] documented an extremely high risk of PE among patients with free-floating thrombus. Pacouret,[9] in a well-conducted prospective trial, reported no significant difference in the occurrence of PE in patients with and without free-floating thrombus on anticoagulation. Vena caval filters have not been demonstrated to be superior to anticoagulation alone in this group of patients.

Chronic thrombo-embolic pulmonary hypertension

For patients with chronic thrombo-embolic pulmonary hypertension, ACCP guidelines recommend placement of a permanent vena caval filter in those patients undergoing pulmonary thrombo-endarterectomy (grade 2C), either before or at the time of surgery.[13] Grade 2C is a weak recommendation based on low-quality evidence. All other patients with chronic pulmonary hypertension should be managed with anticoagulation alone (grade 1C).

Special situations (patients at high risk for VTE)

Venous thrombo-embolism and oncology

Patients with malignancy have long been recognised to have increased risk of VTE and its complications. Prothrombotic state associated with malignancy, venous compression as well as older age and immobility all predispose patients to VTE. Treatment failure and recurrent VTE rates of 10 - 20% among surgical oncology patients despite standard anticoagulation have resulted in some authors advocating vena caval filter placement.[10] Several series have however questioned the validity of this statement. With one series[11] demonstrating a doubling of mortality of cancer patients with filter placement, we cannot recommend vena caval filter placement routinely in this group of patients. Any recommendation will have to be prospectively validated.

Bariatric surgery

With the increasing number of bariatric surgical procedures performed, there has been debate regarding prevention and management of VTE in this group of patients. Obesity has been demonstrated to be an independent risk factor for VTE as well as fatal and non-fatal PE. This risk combined with surgery, prolonged immobility and difficulty in dosing these patients with thromboprophylaxis has resulted in the increasing use of filters. In a study of 5 554 bariatric procedures, risk factors for VTE and PE were indentified and recommended as indications for filter placement. These included body mass index of >60.[12] High technical success rates for filter placement and the increasing availability of retrievable filters may justify the temporary deployment of filters in this group of patients.

Vena caval filters and the ICU patient (critically ill)[17]

Inferior vena caval filters are indicated in this group of patients with confirmed VTE and contraindication to anticoagulation, bleeding while on anticoagulation and PE despite anticoagulation. However, the risks and benefit of filter insertion as an adjunct to anticoagulation and thrombolytic therapy in this group of patients remain uncertain.[13]

Filter use concomitant with thrombolysis for DVT[18]

Pulmonary embolisation of small fragments during catheter-directed or systemic thrombolysis is common and perhaps justifies the concomitant use of filters. Antagonists argue that these emboli are clinically insignificant with these events being asymptomatic. There is no consensus on this indication for filter placement. This supposition will need to be confirmed by prospective randomised data.

Additional controversies

Anticoagulation after filter placement

The use of an IVC filter does not change the need for anticoagulation. Therapeutic anticoagulation in patients with a filter should be initiated as soon as it is safe to do so (grade 1C, ACCP 8th edition).[13] The duration of anticoagulation is not affected by filter placement.

Supra-renal inferior vena caval filters

Supra-renal deployment of filters is often considered in patients with juxta-renal vena caval thrombus, stenosis of the infra-renal IVC due to extrinsic compression and gonadal/renal vein thrombosis. The risk of caval filter thrombosis and renal vein thrombosis precipitating renal failure is of concern. Kalva *et al.*, in one of the larger experiences of supra-renal filter placement, revealed these filters to be safe in preventing PE without any added risk of complications.[14]

Table V. Complications

Complication	Rate (%)
Clinically significant pulmonary embolism	2 - 5
Fatal pulmonary embolism	0.3 - 1.9
Complications from insertion (haematoma, infection, pneumothorax, stroke, air embolism, misplacement, tilting)	4 - 11
Venous access site thrombosis	2 - 28%
Filter migration	3 - 69
IVC thrombosis	0 - 28
Post-thrombotic syndrome	13 - 41
Deep vein thrombosis	0 - 36

Superior vena caval (SVC) filters

The incidence of upper extremity DVT is increasing, particularly with the liberal use of central venous lines and dialysis catheters. Conservative estimates are that upper limb DVT accounts for 5% of all cases of DVT. Series have suggested a higher rate of PE of 11 - 36% following upper limb DVT.[15] Indications for filter use in the SVC are the same as those for the IVC. Ascher in 2004 reported the largest series of SVC filter placement. Indications were contraindication or failure of anticoagulation in the setting of upper limb DVT. Mortality was high, with 47% of patients dying of unrelated causes during the same hospitalisation. Follow-up of the survivors revealed no PE, SVC thrombosis or perforation.[16] In patients with acute upper limb DVT the ACCP 8th edition recommends placement of an SVC filter only in those patients for whom anticoagulation is contraindicated and if there is clear evidence of DVT progression or clinically significant PE (grade 2C).[13]

Complications[18]

The overall complication rate associated with filters is 4 - 11% with a low mortality rate of 0.12% (Table V).

Conclusion

It is difficult to draw definite conclusions based on published data. Randomised comparison of the various filters is not available. The only randomised trial (Decousus *et al.*[5]) on the subject of filters does provide valuable information. The placement of filters is of little value in patients who have no contraindication to the use of anticoagulation.

IVC filter placement is recommended with a high quality of evidence in those patients with proven acute VTE and a current contraindication to anticoagulation, with a major complication resulting from anticoagulation and with recurrent VTE despite adequate anticoagulation. The grade 2 recommendations for filters justify their use in clinical practice but one must be cognisant of the fact that these desirable effects of filter use are closely balanced with their undesirable effects.

There is currently no evidence to justify the use of IVC filters as primary treatment for VTE outside of indications recommended in this evidence-based review. Randomised comparison of IVC filter use with pharmacological prophylaxis is required in high-risk patient groups.

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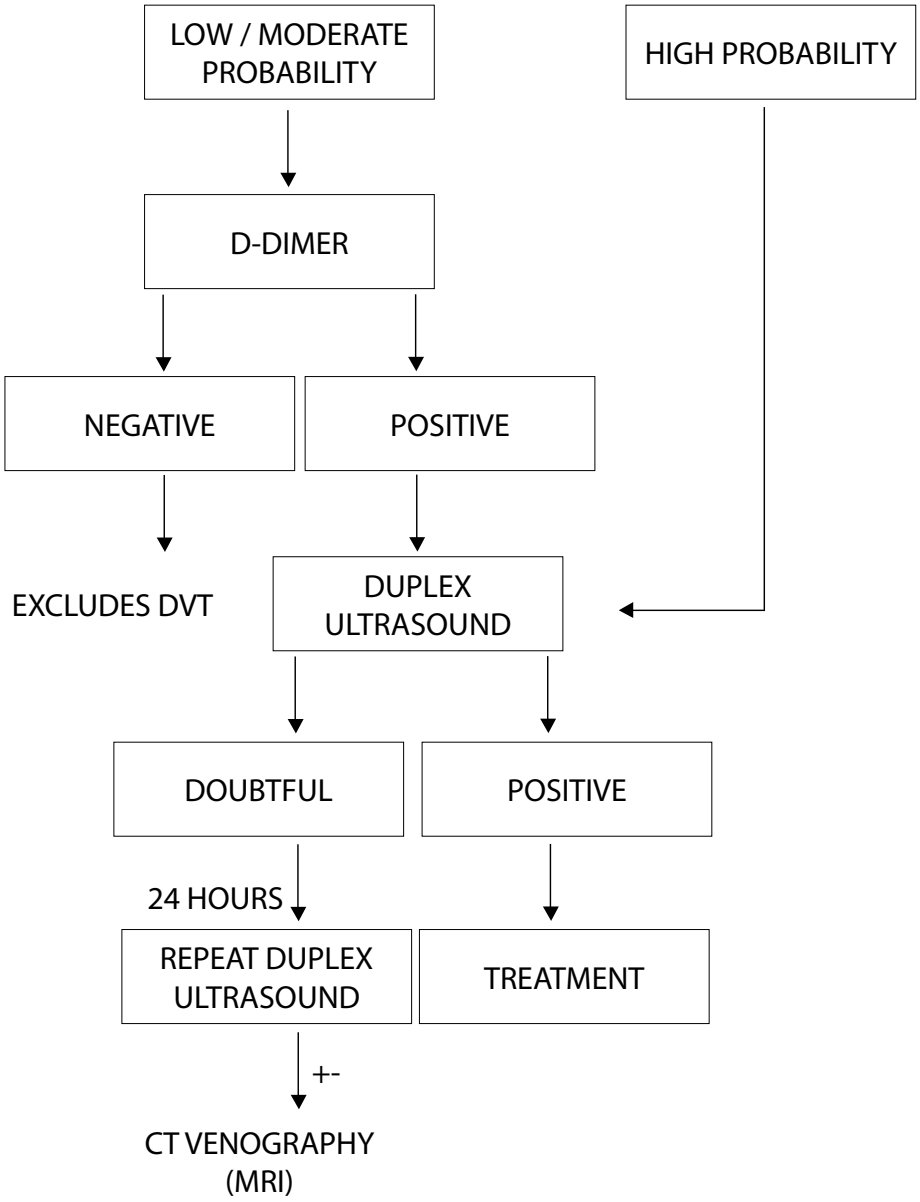
SUMMARY AND GUIDELINES FOR MANAGEMENT OF ESTABLISHED LOWER LIMB DVT

DIAGNOSIS: CLINICAL SUSPICION OF DVT (WELLS CRITERIA)



IVC FILTERS INDICATIONS

ABSOLUTE

- VTE } ANTICOAGULATION
  PE } CONTRAINDICATION
- VTE COMPLICATIONS ON ANTICOAGULATION

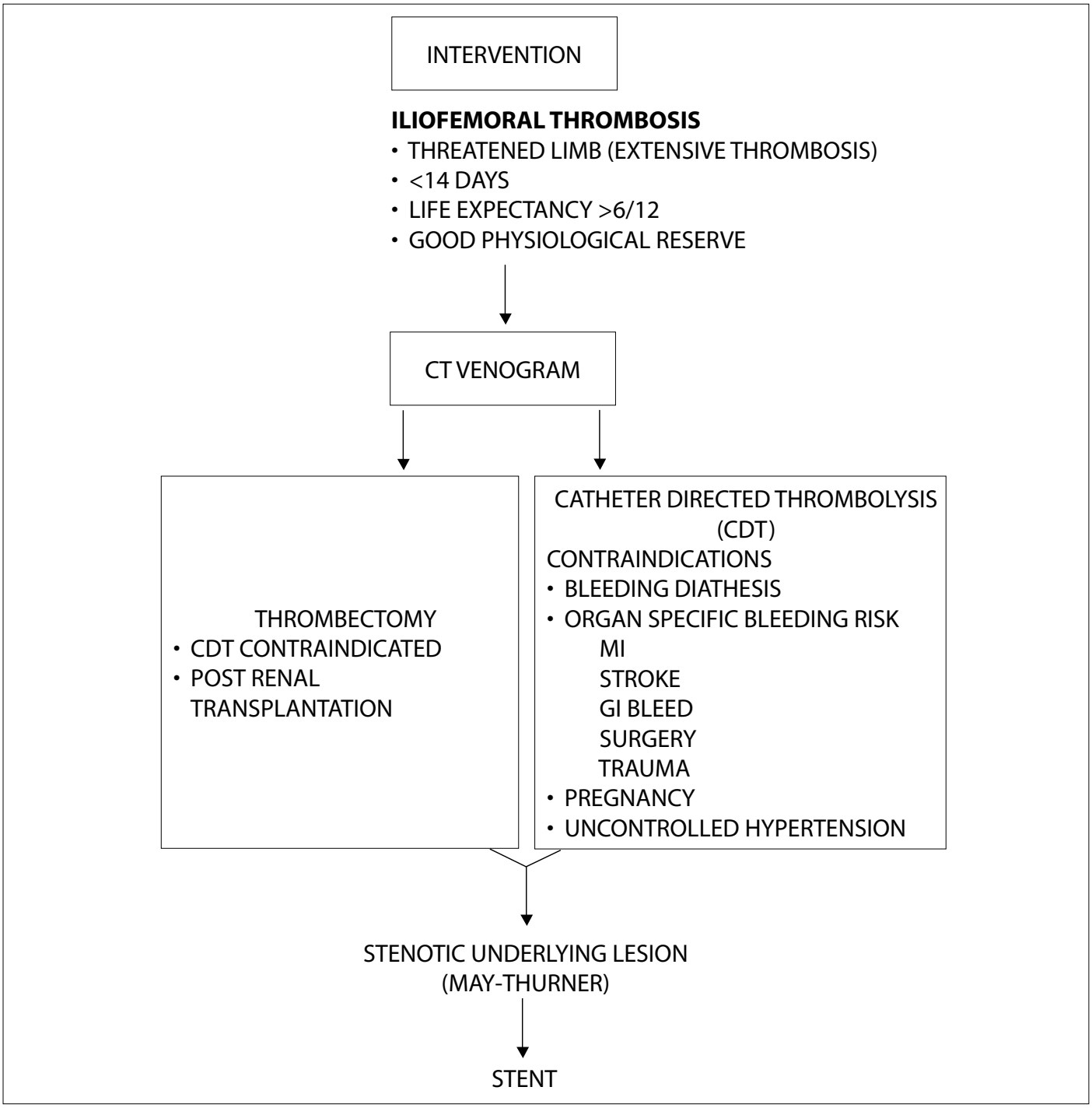
- RECURRENT PULMONARY EMBOLISM

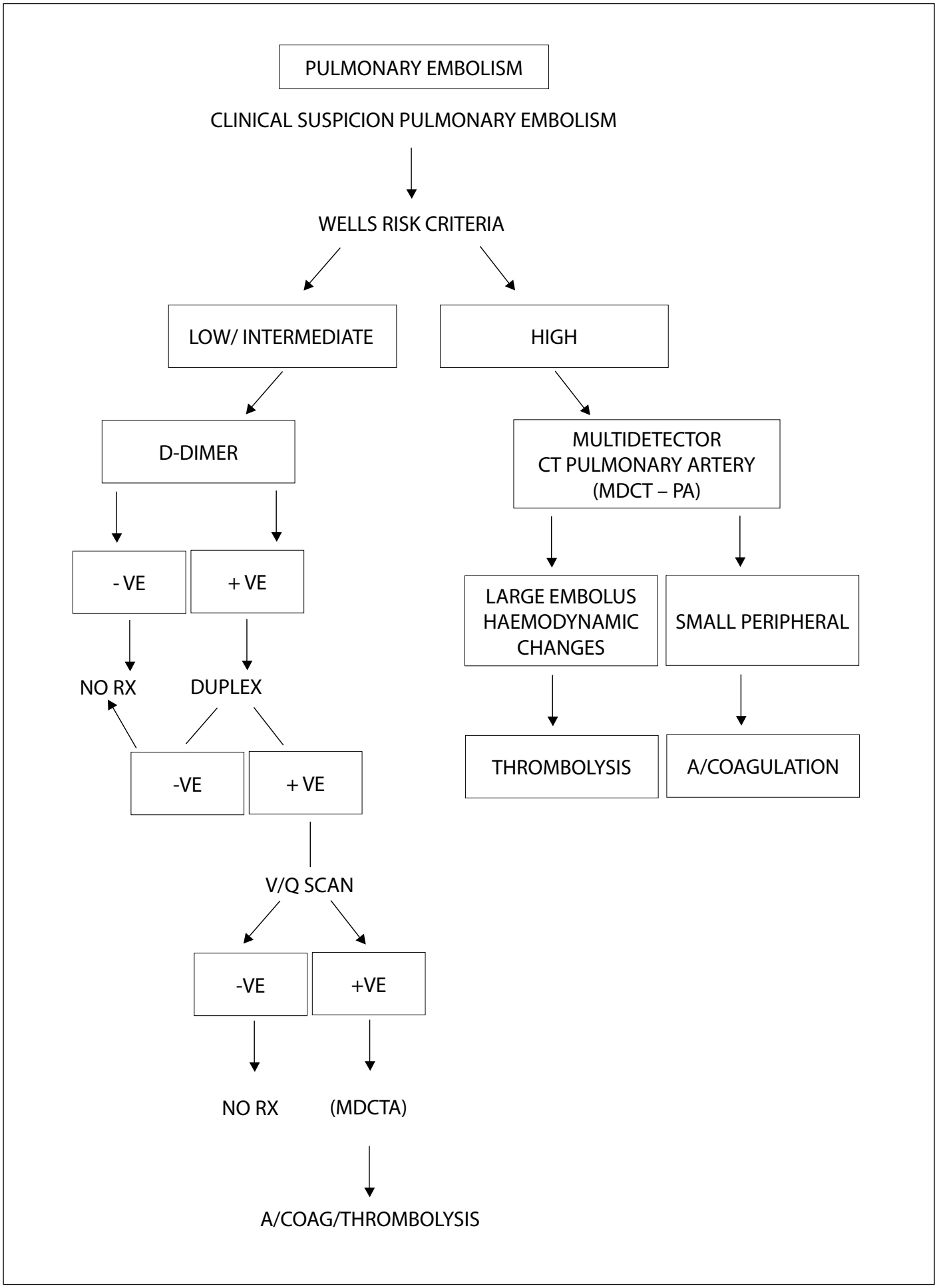
- PROGRESSION DVT

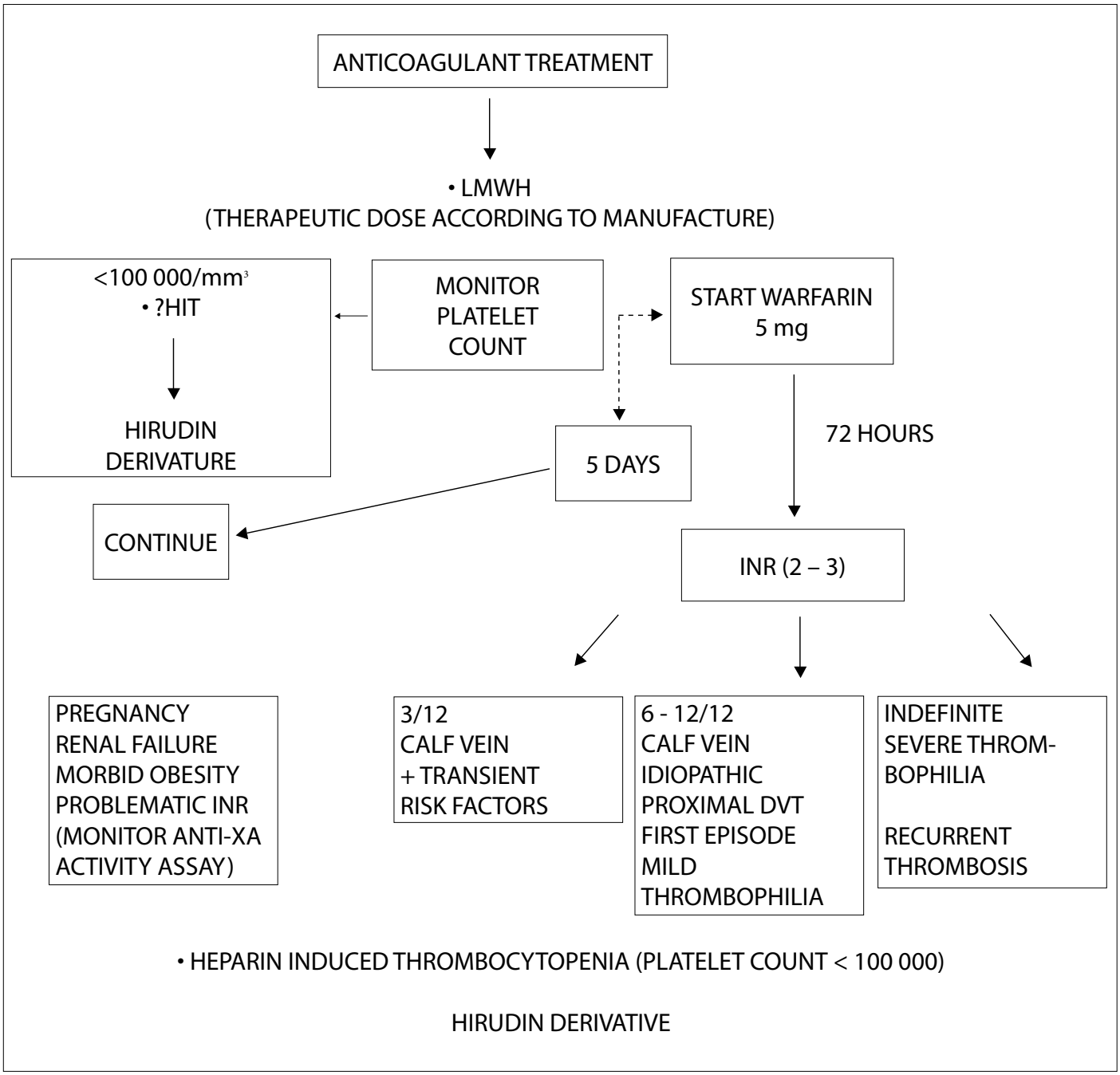
- HAEMORRHAGE

DEBATABLE

- FLOATING THROMBUS
- POOR LUNG FUNCTION
- BARIATRIC SURGERY


INTERVENTION
ILIOFEMORAL THROMBOSIS
• THREATENED LIMB (EXTENSIVE THROMBOSIS)
• <14 DAYS
• LIFE EXPECTANCY >6/12
• GOOD PHYSIOLOGICAL RESERVE
CT VENOGRAM
THROMBECTOMY
• CDT CONTRAINDICATED
• POST RENAL TRANSPLANTATION
CATHETER DIRECTED THROMBOLYSIS (CDT)
CONTRAINDICATIONS
• BLEEDING DIATHESIS
• ORGAN SPECIFIC BLEEDING RISK
MI
STROKE
GI BLEED
SURGERY
TRAUMA
• PREGNANCY
• UNCONTROLLED HYPERTENSION
STENOTIC UNDERLYING LESION (MAY-THURNER)
STENT


PULMONARY EMBOLISM
CLINICAL SUSPICION PULMONARY EMBOLISM
WELLS RISK CRITERIA
LOW/ INTERMEDIATE
HIGH
D-DIMER
MULTIDETECTOR CT PULMONARY ARTERY (MDCT – PA)
- VE
+ VE
LARGE EMBOLUS HAEMODYNAMIC CHANGES
SMALL PERIPHERAL
NO RX
DUPLEX
THROMBOLYSIS
A/COAGULATION
-VE
+ VE
V/Q SCAN
-VE
+VE
NO RX
(MDCTA)
A/COAG/THROMBOLYSIS


ANTICOAGULANT TREATMENT
• LMWH
(THERAPEUTIC DOSE ACCORDING TO MANUFACTURE)
<100 000/mm3
• ?HIT
HIRUDIN DERIVATURE
MONITOR PLATELET COUNT
START WARFARIN 5 mg
72 HOURS
5 DAYS
CONTINUE
INR (2 – 3)
PREGNANCY
RENAL FAILURE
MORBID OBESITY
PROBLEMATIC INR
(MONITOR ANTI-XA ACTIVITY ASSAY)
3/12
CALF VEIN
+ TRANSIENT
RISK FACTORS
6 - 12/12
CALF VEIN
IDIOPATHIC
PROXIMAL DVT
FIRST EPISODE
MILD
THROMBOPHILIA
INDEFINITE
SEVERE THROM-
BOPHILIA
RECURRENT
THROMBOSIS
• HEPARIN INDUCED THROMBOCYTOPENIA (PLATELET COUNT < 100 000)
HIRUDIN DERIVATIVE