

Deep Vein Thrombosis

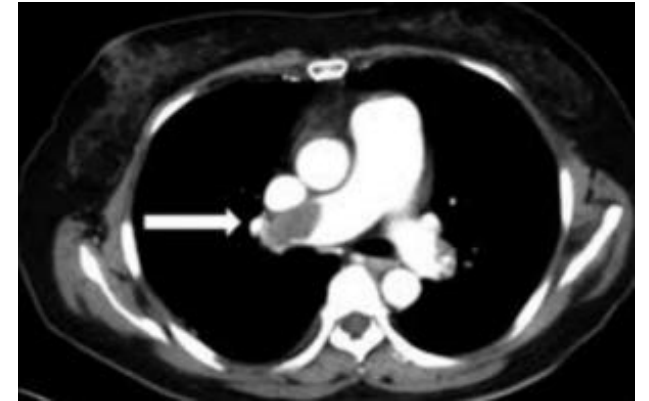
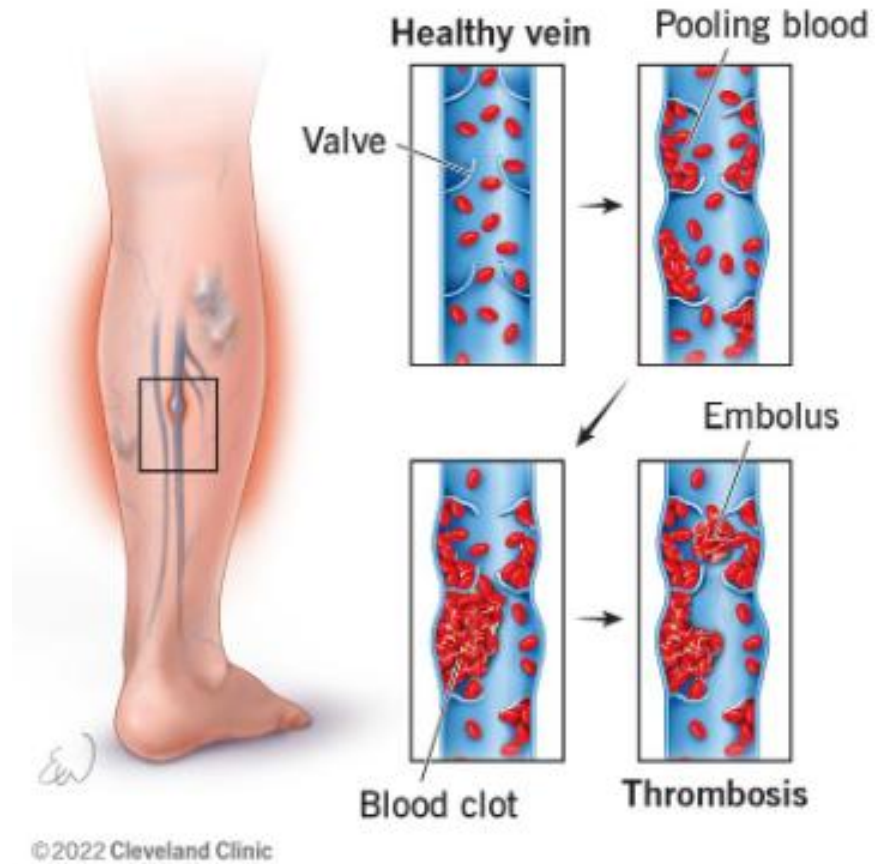
Diagnosis, Anticoagulation, and Thrombus Removal

대한심장혈관흉부외과학회 제18차 전공의 연수교육 · 혈관 세션

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Venous thromboembolism



Why We Treat DVT: Two Complications

Pulmonary Embolism

Acute — it can kill

1 in 3

DVT patients already have silent PE

9.7%

30-day case fatality after PE

34%

of PE deaths: sudden or within hours

Post-thrombotic Syndrome

Chronic — it disables

20–50%

develop PTS despite anticoagulation
≈ 5% severe

≈ **50%**

after iliofemoral DVT
≈ 25% moderate–severe · up to 10% severe with ulcer

No cure

pain, heaviness, swelling, skin change, ulcer
→ lifelong loss of quality of life

Treat DVT early and well — prevent PE now and PTS later

Epidemiology of VTE

1 in 12

Adults develop VTE in their lifetime

**60% VTE
In > 65 ages**

African > Caucasians > Asians

Surgery / hospitalization (<3months) 50–60%

**Active cancer
~20%**

Unprovoked 20–30%

VTE in Korea (HIRA database 2014~2018)

Table 2. Reported VTE incidence in studies conducted over the past two decades

Studies and Locations		Study period	Study design	Size of population	VTE	DVT	PE
Region	VTE per 100,000 person-years						
Western countries	114 – 184						
Asian countries	13.8 – 57						
Korea	32.8 (2014) → 53.7 (2018)						
Sakuma et al. ³	Japan	Aug-Sep 2006	Quest				
Molina et al. ⁴ (2011)	Singapore	2006	Cohort (3 m				
Lee et al. ⁵	Taiwan	2002	Population-based	Around 22.5 million/year	16.5		4.8
Law et al. ⁷	Hong Kong	2010–2011	Population-based	2,898,107 admissions	41.7	30.0	11.7
Cheuk et al. ⁶	Hong Kong	2000–2001	Retrospective	2,082,245 admissions	21	17.1	3.9

VTE = venous thromboembolism, DVT = deep vein thrombosis, PE = pulmonary embolism with or without DVT.

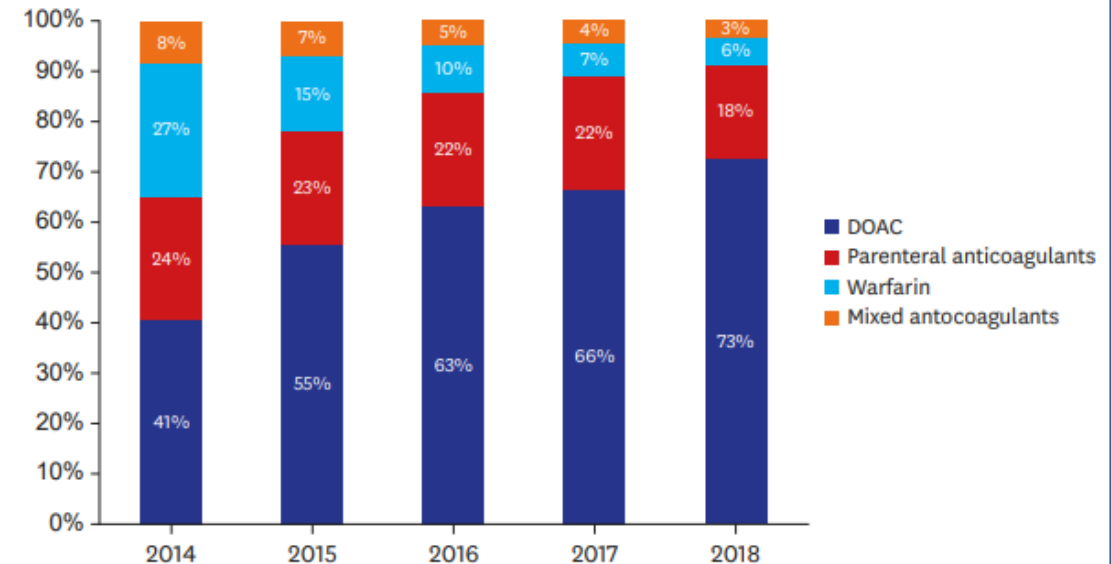


Fig. 1. Anticoagulation trend for venous thromboembolism from 2014 to 2018.
DOAC = direct oral anticoagulants.

Risk factors for VTE (Provoked)

Persistent/ transient	Inherited	Acquired
Persistent	Antithrombin deficiency Protein C deficiency Protein S deficiency Factor V Leiden Prothrombin gene polymorphism Non-O blood group Sickle cell disease	Malignancy (until remission) ± chemotherapy Myeloproliferative disorders Paroxysmal nocturnal hemoglobinuria Antiphospholipid syndrome Inflammatory bowel disease Systemic lupus erythematosus Nephrotic syndrome Obesity HIV infection

Cox C W, Roberts, LN. JTH Educational 2024

Duffett, L. Annals of Internal Medicine 2022

Table 1. Transient Risk Factors for Venous Thrombosis

Strong risk factor (odds ratio >10)

Hip or leg fracture
Hip or leg joint replacement
Major general surgery
Major trauma
Spinal cord injury

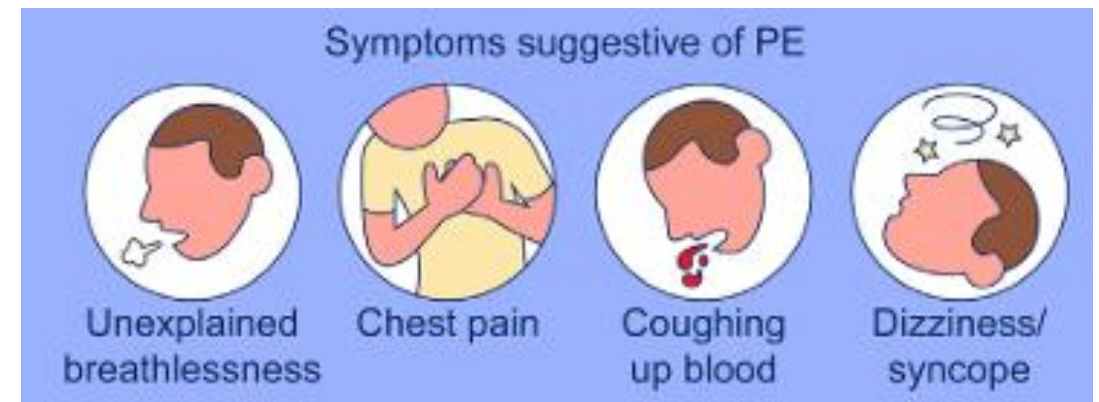
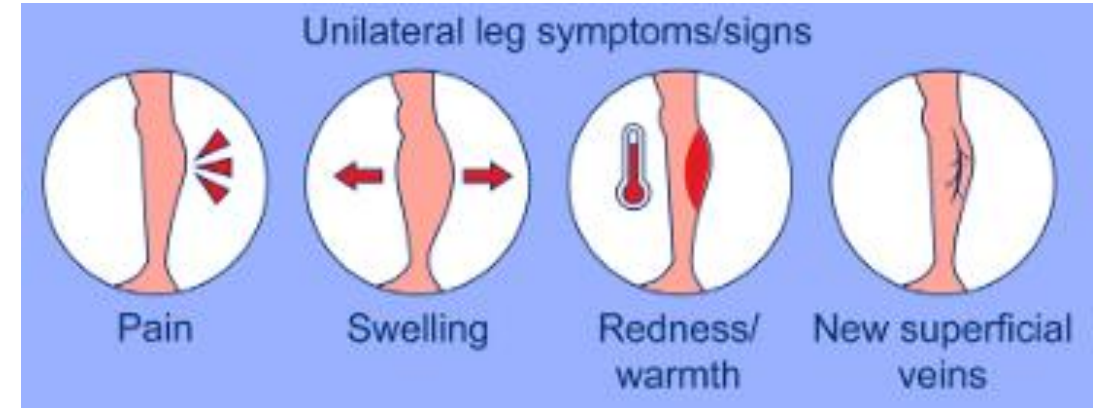
Moderate risk factor (odds ratio of 2 to 9)

Arthroscopic knee surgery
Cancer
Central venous lines
Congestive heart or respiratory failure
Hormone replacement therapy
Oral contraceptive therapy
Paralytic stroke
Postpartum
Previous venous thromboembolism
Thrombophilia

Weak risk factor (odds ratio <2)

Bed rest >3 d
Immobility due to sitting (e.g., prolonged road or air travel)
Increasing age
Laparoscopic surgery (e.g., cholecystectomy)
Obesity
Pregnancy (antepartum)
Varicose veins

Clinical manifestations of VTE



- Most DVT is asymptomatic, especially in distal DVT

Differential diagnosis of DVT

Table 3. Differential Diagnosis of DVT

Disease	Characteristics	Notes
Venous insufficiency (venous reflux)	Usually due to venous hypertension from such causes as venous reflux or obesity	Obtain ultrasonography of venous reflux
Superficial thrombophlebitis	Firm, tender, varicose vein	Superficial thrombosis is rarely associated with DVT
Muscle strain, tear, or trauma	Pain occurring with a range of motion more characteristic of orthopedic problem due to trauma; usually a history of leg injury	Perform appropriate orthopedic evaluation
Swelling in a paralyzed leg	History of paraplegia	Patients with paralyzed limb may develop edema without DVT
Baker cyst	Pain localized to popliteal region of leg	Seen on ultrasonography
Cellulitis	Skin erythema and warmth	Consider antibiotic treatment
Lymphedema	Toe edema is more characteristic of lymphedema than of venous edema	Lymphedema can occur in 1 or both legs

Duffett, L. *Annals of Internal Medicine* 2022

Wells score for deep vein thrombosis^{52,53}

Active cancer	+1
Paralysis, paresis, or recent plaster cast on lower extremities	+1
Recent immobilisation >3 days or major surgery within the past 4 weeks	+1
Localised tenderness of deep venous system	+1
Swelling of entire leg	+1
Calf swelling >3 cm compared with asymptomatic side	+1
Unilateral pitting oedema	+1
Collateral superficial veins	+1
Previously documented deep vein thrombosis	+1
Alternative diagnosis at least as likely as deep vein thrombosis	-2
Clinical pretest probability	
Unlikely	Total score ≤2 (prevalence 4%)
Likely	Total score >2 (prevalence 27%)

Wells PS et al. *NEJM* 2003

D-dimer: A Rule-out Test

95%

sensitivity

99%

negative predictive value

False negatives

During Anticoagulation
Symptoms lasting 2~3wks

35–55%

specificity

Raised without DVT

Pneumonia

Surgery

Infection

Malignancy

Pregnancy

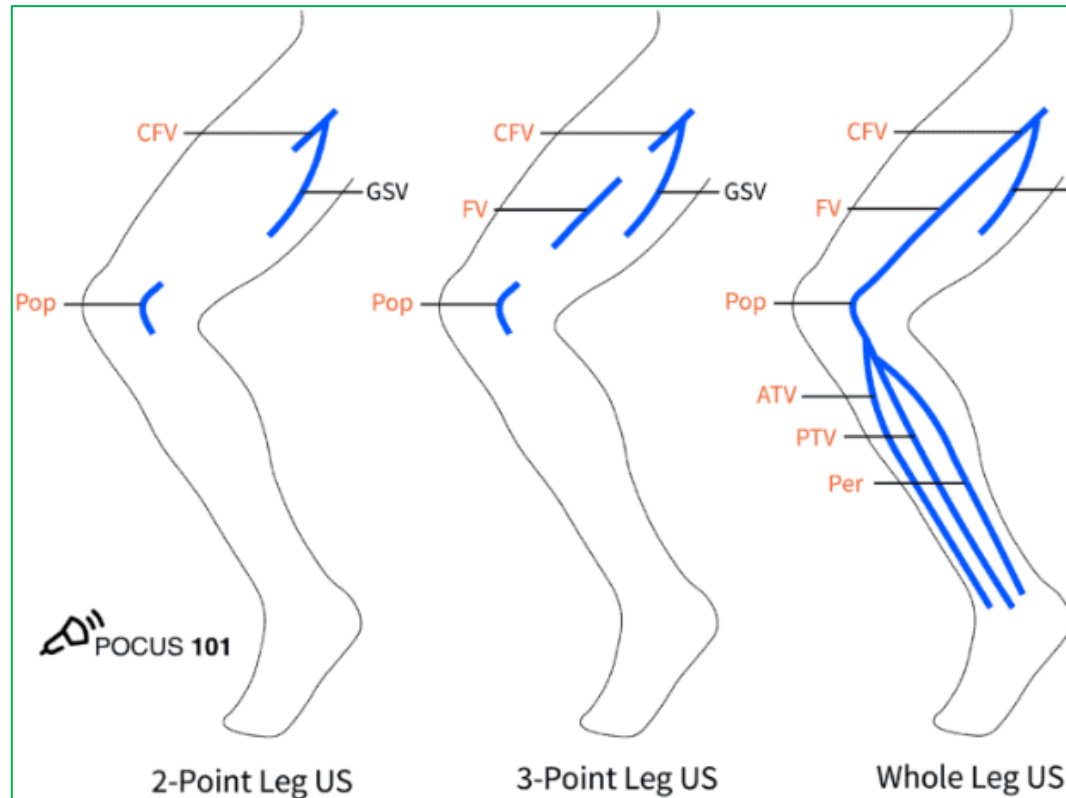
Old age

Heart failure

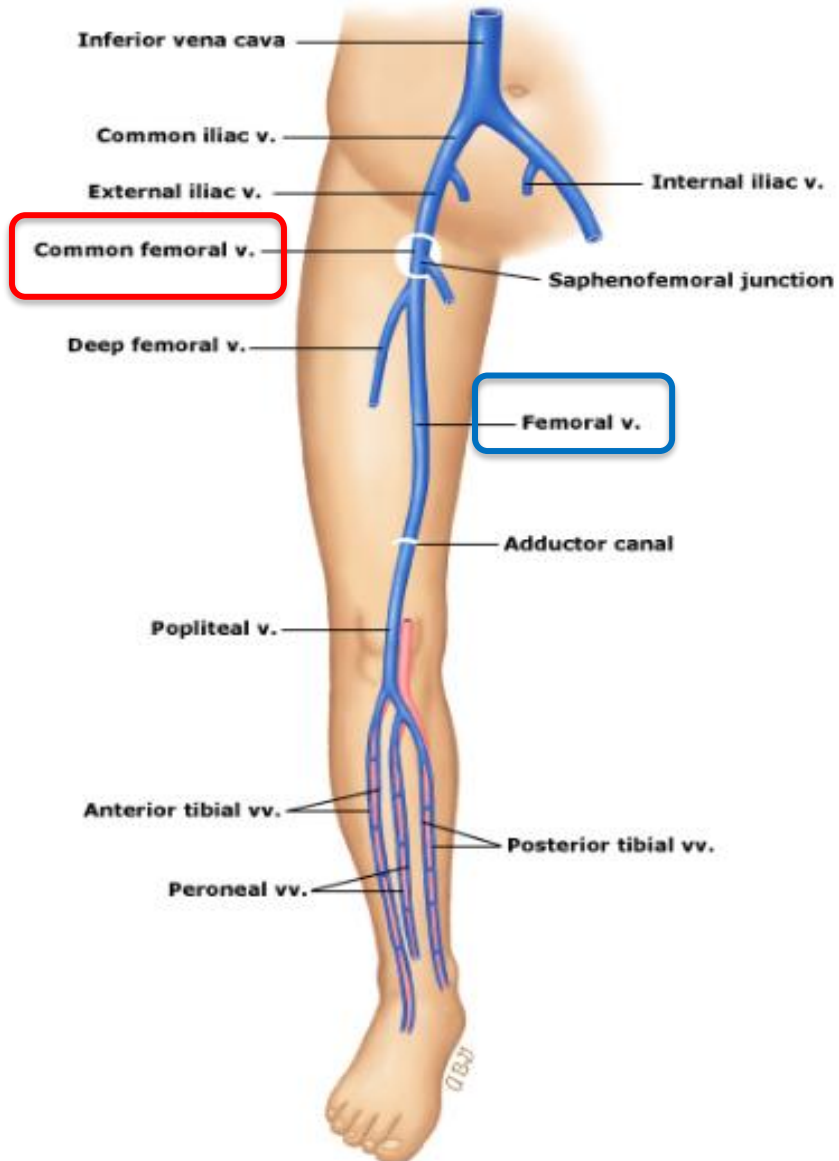
Compression Ultrasound – Gold standard



Frog Leg Position



Venous Anatomy and Anatomical Classification



The anatomical level decides the treatment

Proximal DVT

Iliofemoral DVT

Iliac vein and/or **common femoral vein** ($\pm$ distal veins)

Femoropopliteal DVT

Femoral and/or popliteal vein, without CFV or iliac involvement

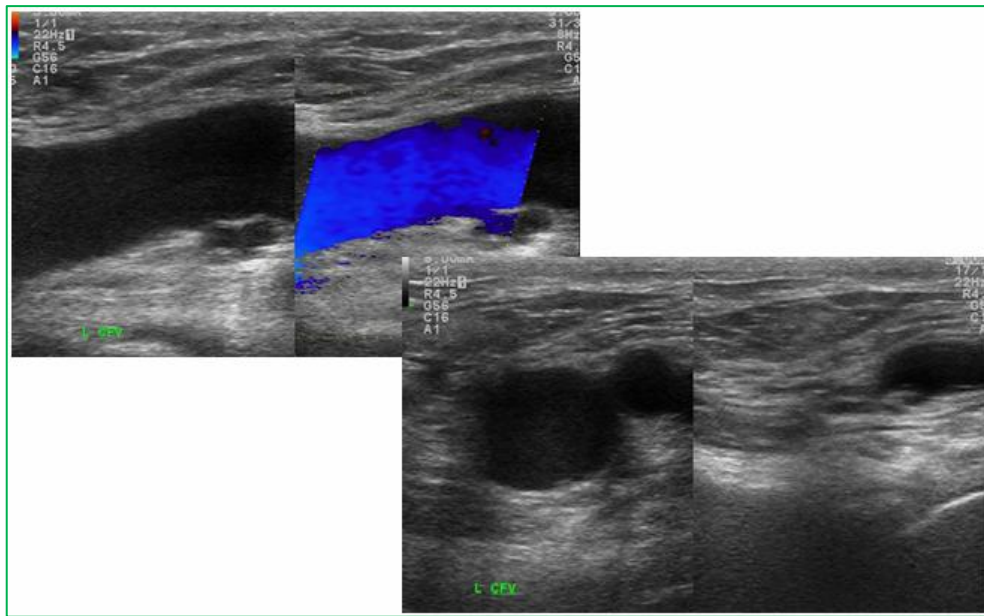
Distal DVT

Isolated calf DVT

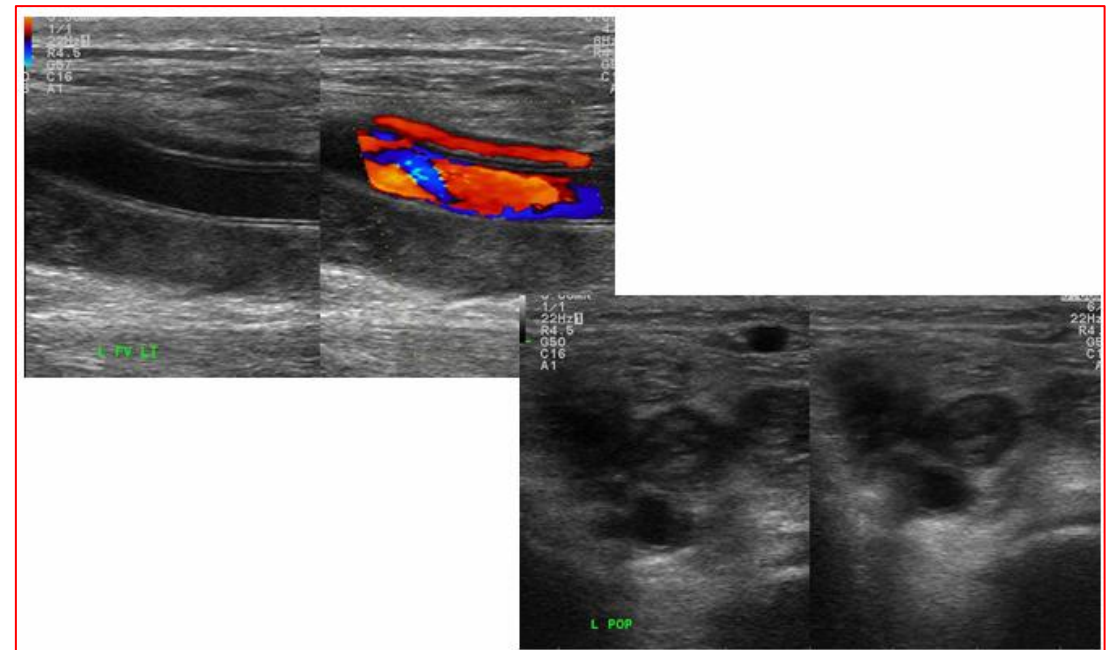
Anterior tibial, Peroneal, posterior tibial vein, below the popliteal vein

Compression Ultrasound – Gold standard

- Duplex USG; Compressible CFV



- Duplex USG; Non compressible POPV in DVT



Other Dx. Tools for DVT

CT venography

Iliac and IVC extent · May-Thurner

When ultrasound is inconclusive, needed intervention

MR venography

No radiation

When ultrasound is inconclusive or not feasible

Venography

During intervention

Thrombus burden · outflow · collaterals

IVUS

During intervention in acute iliofemoral DVT

Stenosis · landing zones · stent sizing

Goals of DVT Treatment

- Diminish the severity and duration of symptoms
- Prevent Pulmonary embolism
- Minimize the risk of recurrent venous thrombosis
- Prevent the Post thrombotic syndrome (PTS)

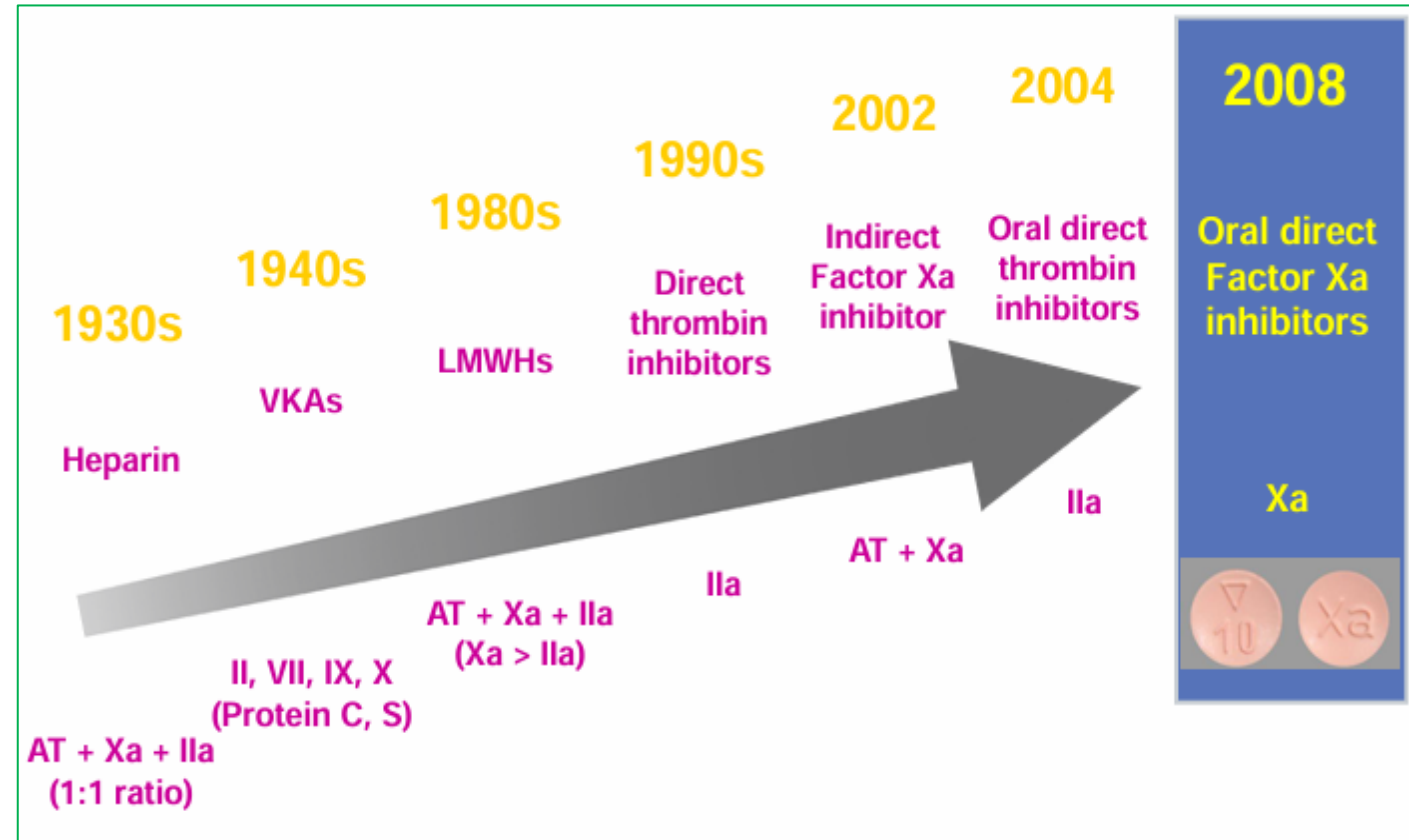


Treatment options of DVT

- **Anticoagulation**
- **Endovascular thrombolysis/thrombectomy**
- **Surgical thrombectomy**
- **IVC filter**
- **Compression therapy**

Anticoagulation of DVT

- **Heparin (IV)**
 - Intervention planned, Renal failure
- **Vitamin K Antagonist**
 - Antiphospholipid antibody syndrome, renal failure (CrCl <15)
- **LMWH (SC)**
 - Parenteral, Pregnancy
- **DOAC – 1st choice for most pts**
 - Less major bleeding(RR=0.61) or ICH(RR=0.37) vs LMWH/VKA



DOAC in DVT

apixaban (Eliquis)



initial: 10 mg PO BID x7 days
≥3 months: 5mg PO BID

rivaroxaban (Xarelto)



initial: 15 mg PO BID with food x21 days
≥3 months: 20 mg PO daily with food
(for CrCl ≥ 15 ml/min)

dabigatran (Pradaxa)



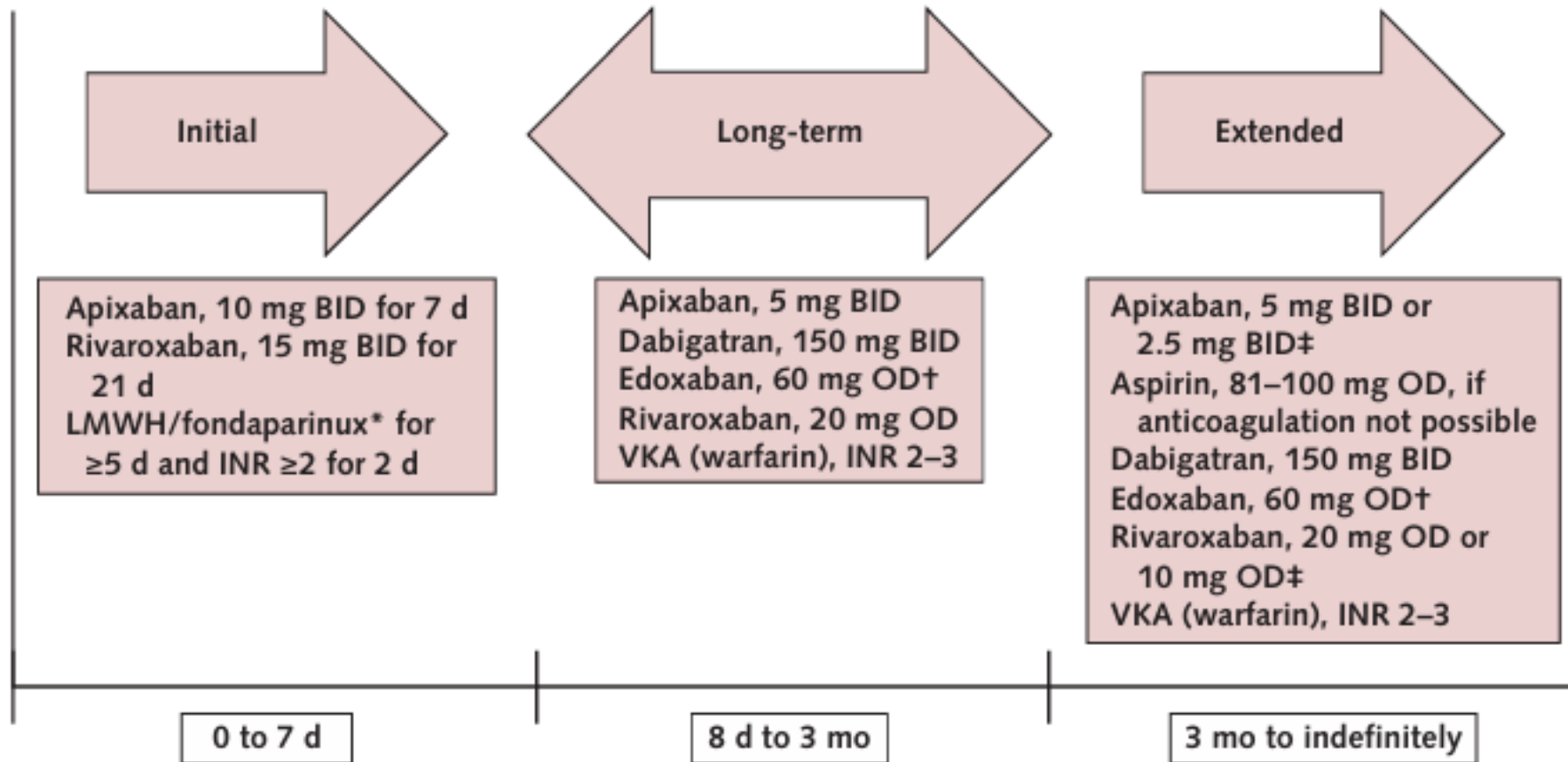
initial: 5 days of parenteral anticoagulation*
≥3 months: 150 mg PO BID
(for CrCl ≥ 30 ml/min)

edoxaban (Savaysa)



initial: 5 days of parenteral anticoagulation*
≥3 months: 60 mg daily
(30 mg daily if CrCl 15-50 ml/min or <60 kg)

Duration and dose of anticoagulation in DVT



Duration of anticoagulation in DVT

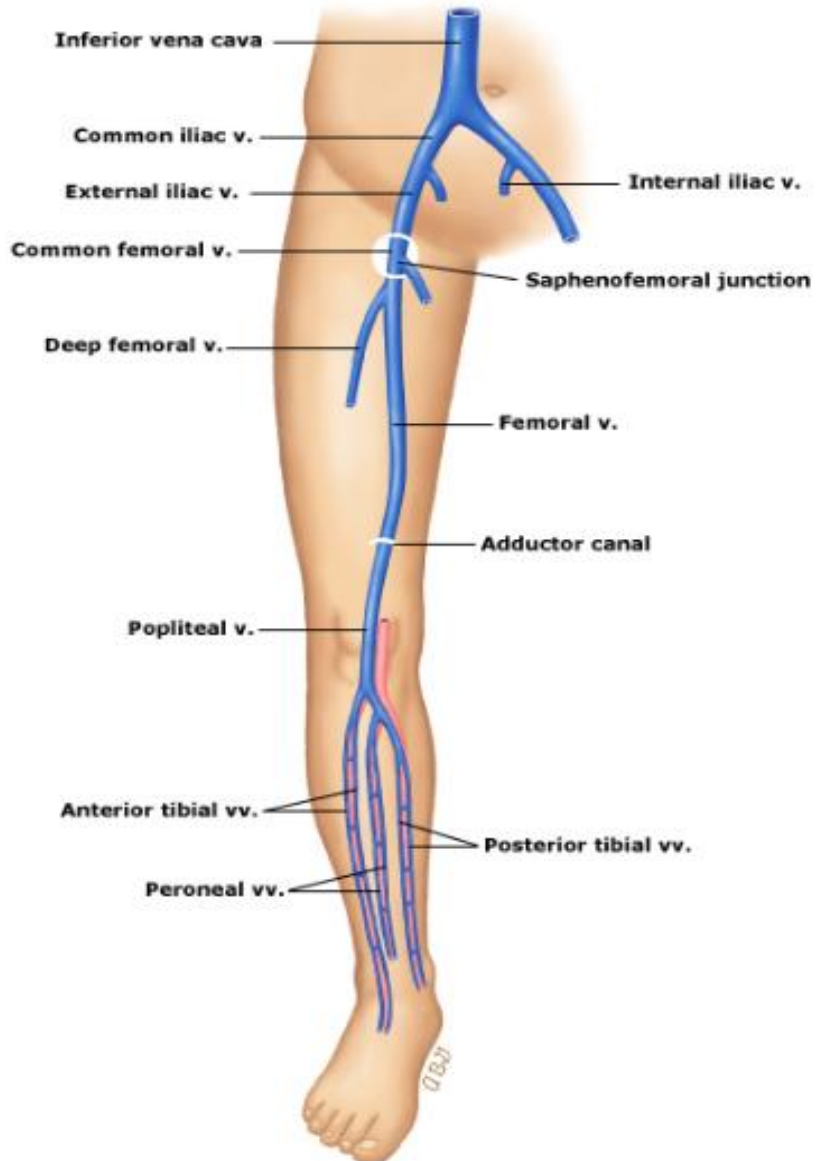
VTE risk factors		Estimated recurrence risk/year	Recommended duration of anticoagulation
MAJOR TRANSIENT	Examples: - surgery with general anaesthesia >30min - hospitalised with acute medical illness & ↓ mobility ≥3 days - trauma with fractures	3% LOW	3 months and stop
MINOR TRANSIENT	- minor surgery with general anaesthesia <30min - hospitalised with acute medical illness <3days - acute illness and bedbound at home ≥3 days - combined hormonal contraception - oral hormone replacement therapy - pregnancy/post partum - lower limb injury with ≥3 days - long haul travel	3-8% INTERMEDIATE	Consider longterm at 3 months
UNPROVOKED	no identifiable risk factor		
MAJOR PERSISTENT	- inflammatory bowel disease or active autoimmune disease - active cancer - antiphospholipid syndrome ≥1 prior VTE without major provoking factor	>8% HIGH	Continue longterm unless ↑ bleeding risk

Endovascular procedure for DVT

Acute Iliofemoral DVT, Phlegmasia cerulea dolens

- Catheter directed thrombolysis (CDT)
- Pharmaco-Mechanical Thrombolysis (PCDT or PMT)
- Mechanical Thrombectomy (MT)
- Adjuvant venous angioplasty and stenting

Venous Anatomy and Anatomical Classification



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Anterior tibial, Peroneal, posterior tibial vein, below the popliteal vein

DVT Below the Groin: Anticoagulation Is the Treatment

Femoropopliteal DVT

femoral ± popliteal vein, CFV and iliac clear

Anticoagulation alone

3 months if provoked · longer if unprovoked

Early thrombus removal: not recommended

no PTS benefit, more bleeding

Isolated Calf DVT

calf veins only, below the popliteal vein

Decide by symptoms, risk of extension and bleeding risk

Anticoagulate

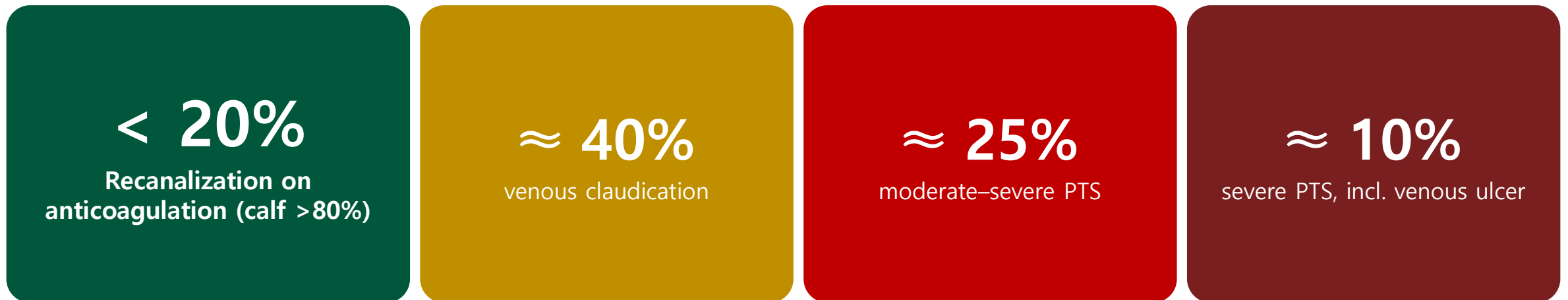
3 months
cancer → longer

Or watch

repeat whole-leg
ultrasound at 1 week

Iliofemoral DVT: A High-risk Subset (25% of DVT)

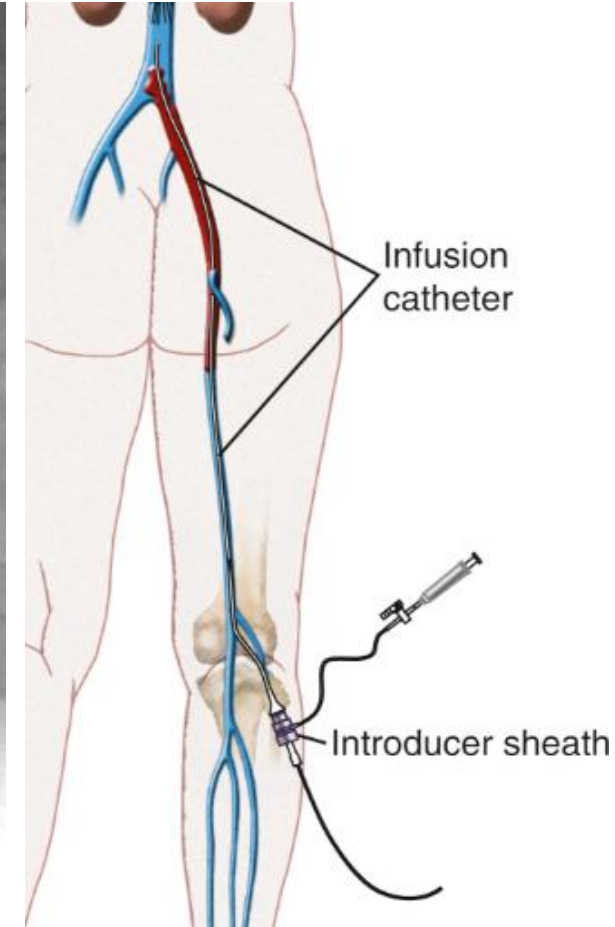
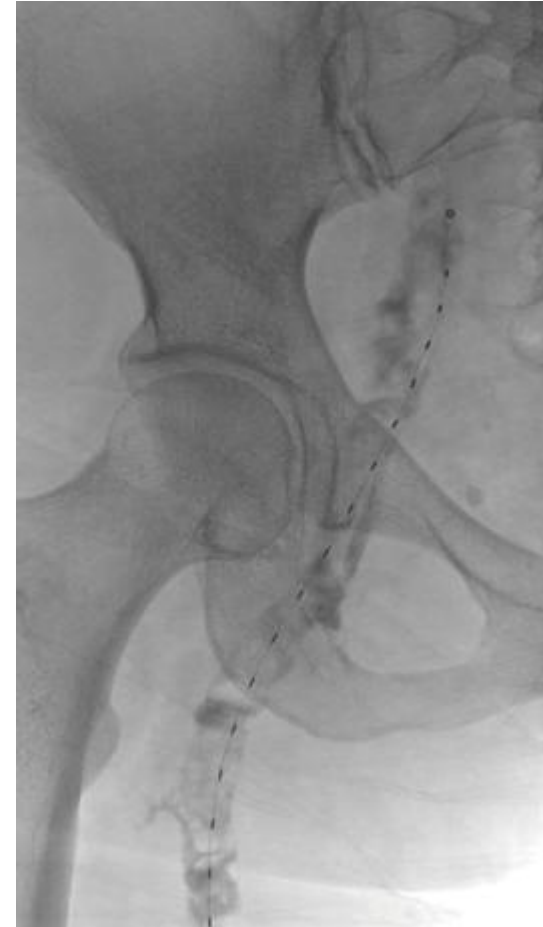
Long-term outcomes after acute iliofemoral DVT



More PE, recurrence and severe post-thrombotic syndrome than less extensive DVT

Catheter directed thrombolysis (CDT)

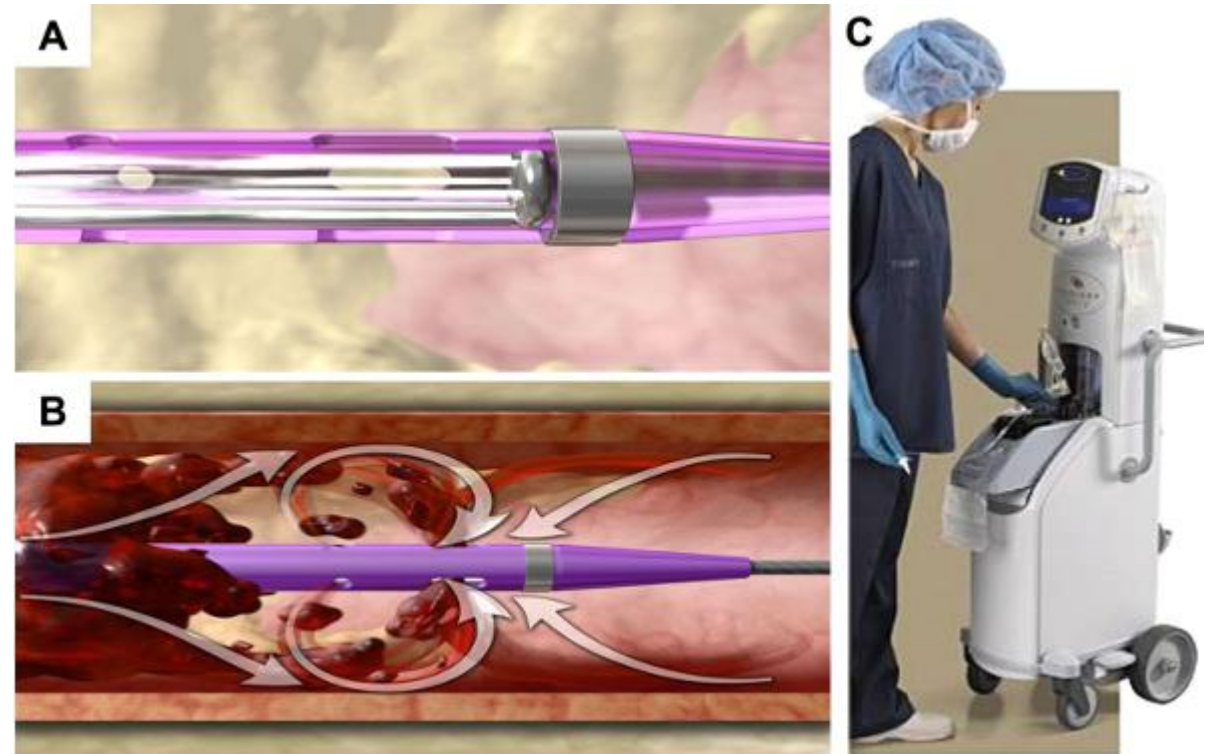
- Lytic therapy infused in area of thrombus burden
- 6Fr sheath Popliteal approach
- 5Fr multi-sideport catheter
- *Urokinase, Streptokinase, tPA*
- Risk of hemorrhage
- Tx time: 24~72hrs
- Prolonged immobilization ICU care



Pharmaco-mechanical thrombolysis/thrombectomy (PCDT/PMT)

Angiojet Rheolytic thrombectomy system and innovation for power pulse infusion

- 8Fr sheath popliteal approach
- Infusion tPA at thrombus using *power pulse spray* and 30min waiting
- *Rheolytic Thrombectomy* (<480sec)
- Reduce dosage of thrombolytic Tx.
- Reduce treatment time
- Decrease ICU stay
- *Hypertension, Hemolysis, Bradycardia*



The Open Vein Hypothesis; 3 multicenter RCTs (2007~2018)

Li W, et al. Circulation 2025

- **Rapid thrombus removal will decrease PTS risk**
via reducing venous HTN after Acute Proximal DVT

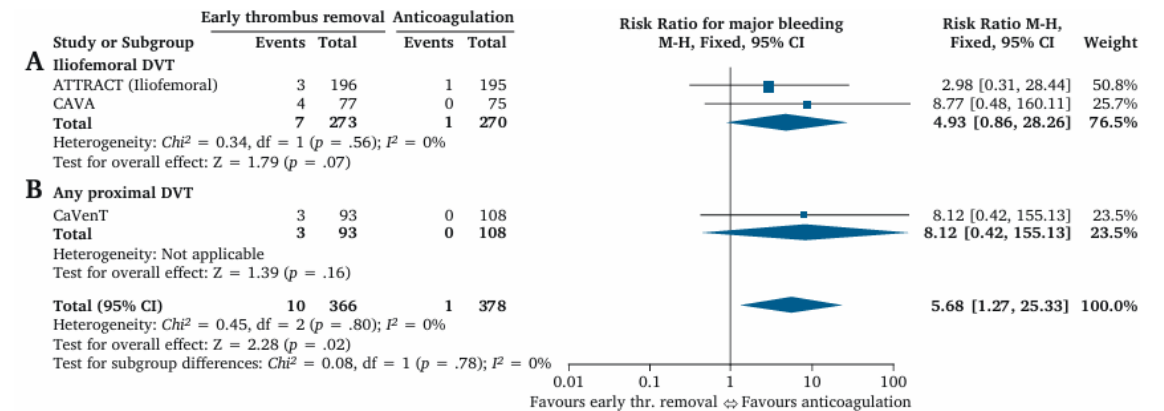
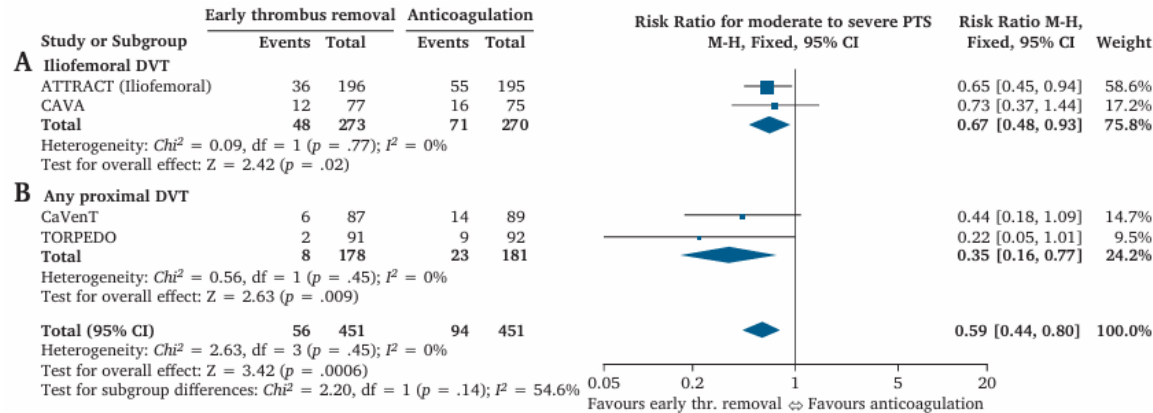
	CaVenT [9] <i>CDT</i>	ATTRACT [11] <i>PCDT/PMT</i>	CAVA [12] <i>CDT</i>
Level of evidence	B <i>Enden T, et al. Lancet 2012</i>	B <i>Noten P, et al. NEJM 2017</i>	B <i>Noten P, et al. Lancet 2020</i>
No of patients	209	692	184
Objective	To examine whether CDT in addition to anticoagulation reduces risk of PTS compared with anticoagulation alone	To examine whether PMT in addition to anticoagulation reduces risk of PTS compared with anticoagulation alone	To examine whether US-CDT in addition to anticoagulation reduces risk of PTS compared with anticoagulation alone
Key results	CDT reduced PTS occurrence at 2 yr (41% CDT vs 56% no-CDT; $P = .047$) and 5 yr (42% CDT vs 70% no-CDT; $P < .01$)	CDT did not reduce PTS compared to anticoagulation (47% CDT vs 48% no-CDT; $P = 0.56$)	US-CDT did not reduce PTS compared to anticoagulation (29% US-CDT vs 35% no-US-CDT; $P = .42$)
Included iliofemoral DVT	Yes	Yes	Yes
Included femoro-popliteal DVT	Yes	Yes	No
Fibrinolytic drug	Alteplase	Alteplase	Urokinase
Maximum dose	80 mg	35 mg	9.85 million IU
Single-session therapy	No	Yes (if popliteal open)	No
Thrombectomy devices	No	AngioJet, Trellis	No

Plotnik AN, et al. CIRSE 2024

Early thrombus removal using lytic agent: Benefit and Bleeding

Moderate-severe PTS
RR 0.59

Major bleeding
RR 5.68



Benefit: fewer and milder PTS
Cost: bleeding

The Bleeding Cost of Thrombolysis



lytic dose ↓ · procedure time ↓ · ICU stay ↓

OR 4.9

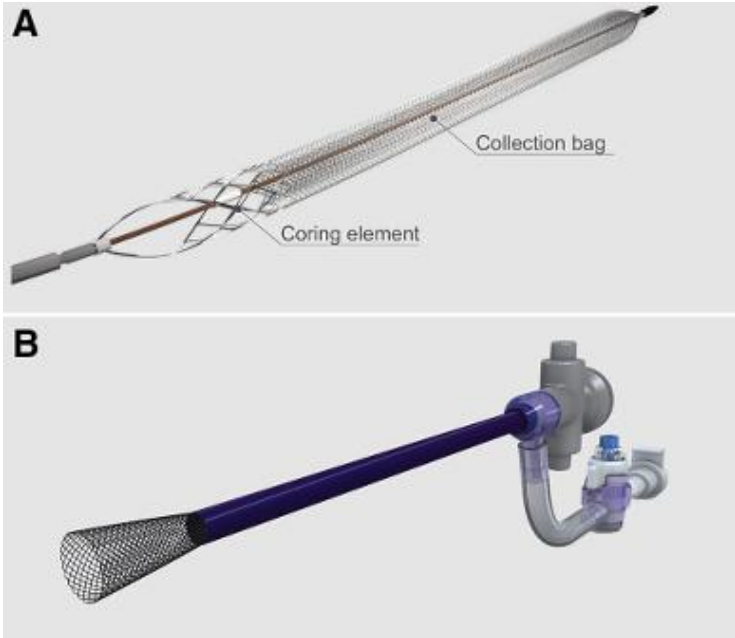
major bleeding with lytic thrombus removal in RCTs (NNH 33)

Goal of new devices

Remove the thrombus **without lytics**, in one session, without an ICU stay

Mechanical Thrombectomy (MT, Lytic free)

Principle	Example	Note
Rheolytic: jet + aspiration	AngioJet	6–8 F · optional lytic power pulse · hemolysis → hemoglobinuria, AKI
Large-bore coring + bag	ClotTrievers	13 F / 16 F sheath · no lytic · single session
Large-bore continuous aspiration	Indigo Lightning (Penumbra)	12–16 F · computer-aided vacuum
Large-bore manual aspiration	8~11F catheter	No lytic · single session



Evidence for Mechanical Thrombectomy

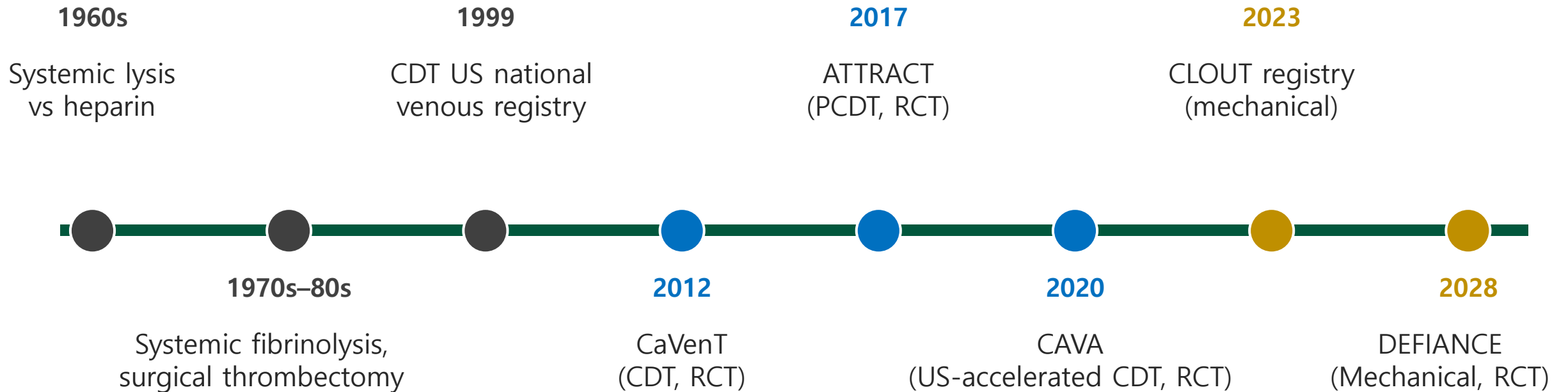
Study	Result	Caveat
CLOUT registry (n = 500)	30-day mortality 0.9% · device-related SAE 0.2% · Villalta median 9 → 1	Single-arm, industry-sponsored
CLOUT by thrombus age	No lytics · single session 99.6% · near-complete removal 91% / 82% / 84% (acute / subacute / chronic)	Single-arm
CLOUT vs ATTRACT controls (PSM)	PTS at 12 months 17% vs 38%	Indirect comparison
CLOUT vs ATTRACT PCDT arm (PSM, 130 pairs)	No PTS at 12 months 83% vs 64% · ICU 2% vs 53%	Indirect comparison
Turner 2026 meta-analysis	MT: no major bleeding · efficacy data from 1 observational study	Low certainty

Safety signal is good — efficacy is not yet proven

Mechanical Thrombectomy c ClotTrievers



History: From Systemic Lysis to Mechanical Thrombectomy



From dissolving the clot to removing it — less lytic, shorter procedures

Guidelines recommendations on early thrombus removal

Guideline	Position on early thrombus removal
ASH 2020 (미국혈액학회)	Anticoagulation alone, except limb-threatening DVT and young, low-bleeding-risk iliac or CFV DVT
CHEST 2021 (미국흉부 의사협회)	Suggests anticoagulation alone over thrombolysis or thrombectomy
ESVS 2021 (유럽혈관외과학회)	Consider in selected symptomatic iliofemoral DVT (IIa A) · not for femoral, popliteal or calf DVT (III B)
SIR 2023 (인터벤션영상의학회)	An acceptable option in selected patients with acute iliofemoral DVT
ESVM 2025 (유럽혈관의학회)	Consider for severe iliofemoral DVT (IIa A) · mechanical thrombectomy preferred over CDT (IIa B) · IVUS (IIa B)

ESVS 2021; Vedantham S, et al. JVIR 2023 (SIR); Schlager O, et al. Vasa 2025 (ESVM); CHEST 2021 and ASH 2020 as summarized in Duffett L. Ann Intern Med 2022

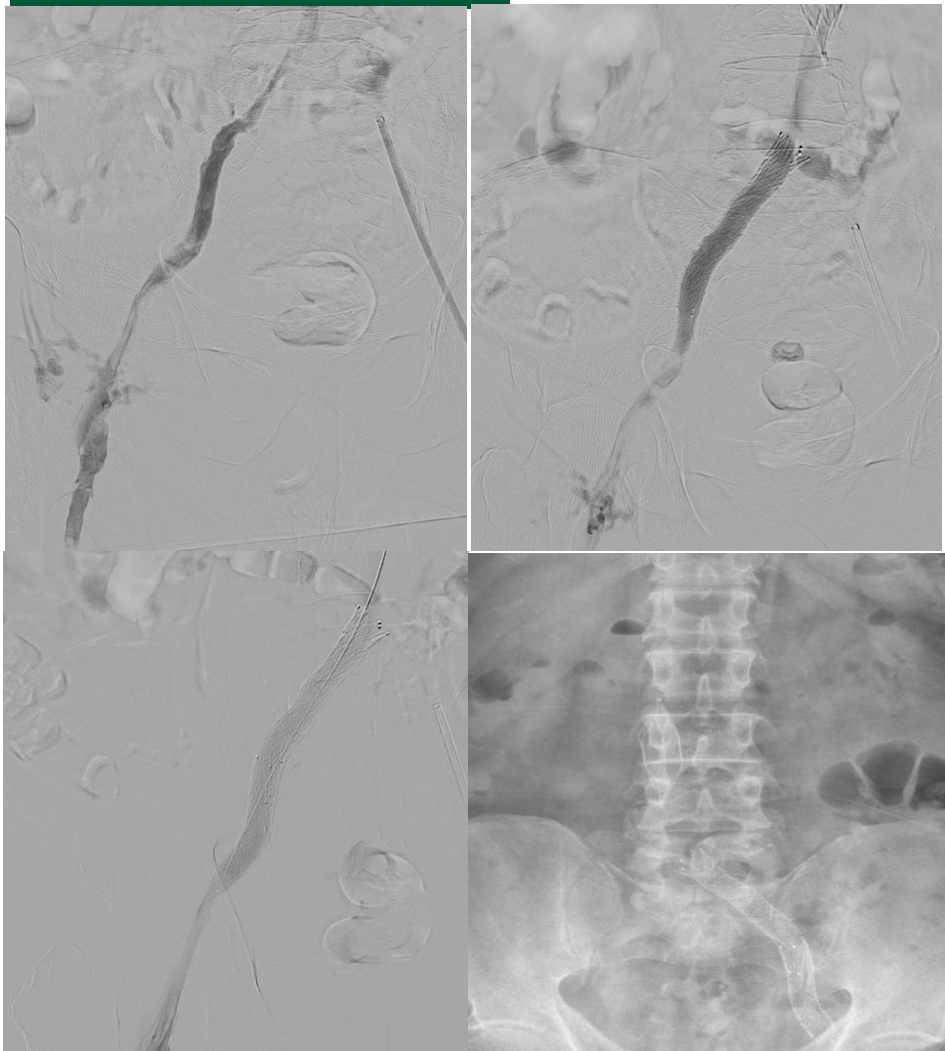
Patient Selection for intervention: Practical Criteria

- ✓ Acute iliofemoral DVT (usually < 2–4 weeks)
- ✓ Threatened limb, or severe symptoms (pain, swelling, difficulty walking)
- ✓ Physically active, life expectancy $\geq$ 5 years
- ✓ Bleeding risk chooses the technique — lytic or lytic-free

Adjuvant venous angioplasty and stenting

A stent treats the culprit lesion (May-Thurner compression) and the residual stenosis

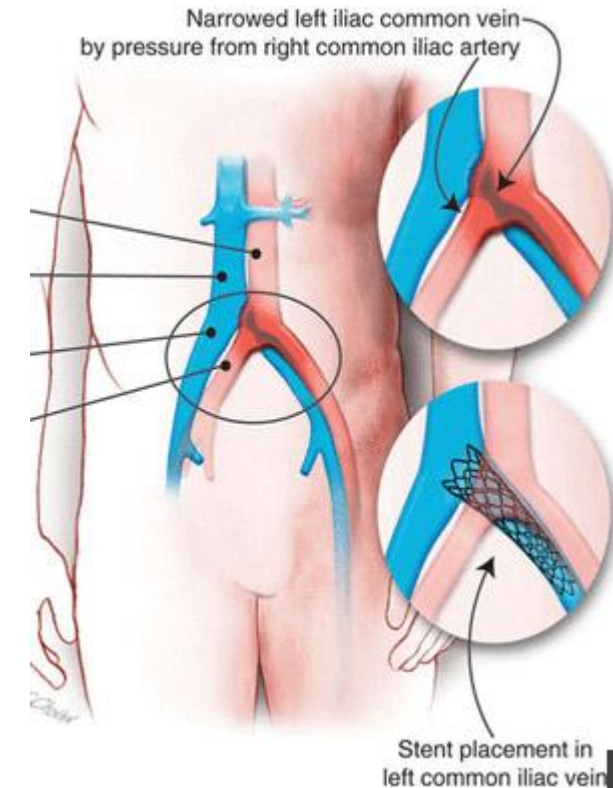
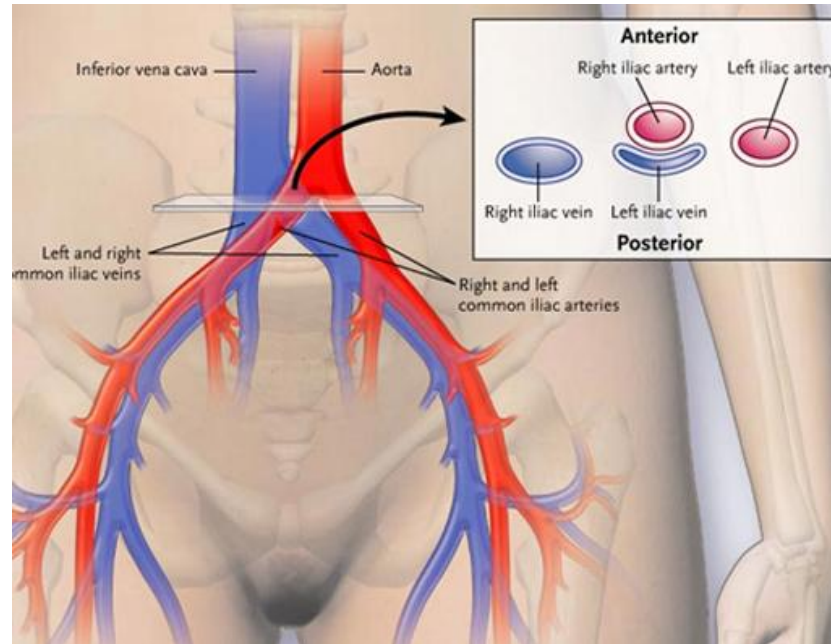
- 8~9Fr sheath Popliteal approach
- Venoplasty using ballon (8~12mm)
- Self-expanding Venous stent (10~16mm)



Author (year)	N	Success rate	Primary patency				Sx resolution	Complication
			6 mts	1 yr	2 yrs	4 yrs		
O'Sullivan GJ (2000)	39	87%		92% (A) 94% (C)			85%	17%
Hurst DR (2001)	18		89%	79%				
Kwak HS (2005)	22	96%		95%	95%			9%
Husmann MJ (2007)	11	100%		90%	82%		90%	
Oguzkurt L (2008)	36	94%		85%		80%	85% (A) 25% (C)	3%

May-Thurner Anatomy

- Right common iliac artery compresses the left common iliac vein
- Left-sided predominance of iliofemoral DVT
- The compression often remains after the thrombus is removed
- **Venous stent needed for patency**



Phlegmasia Cerulea Dolens: **Only Emergency** in DVT



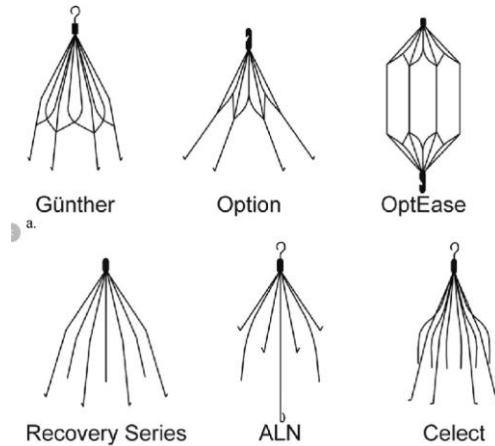
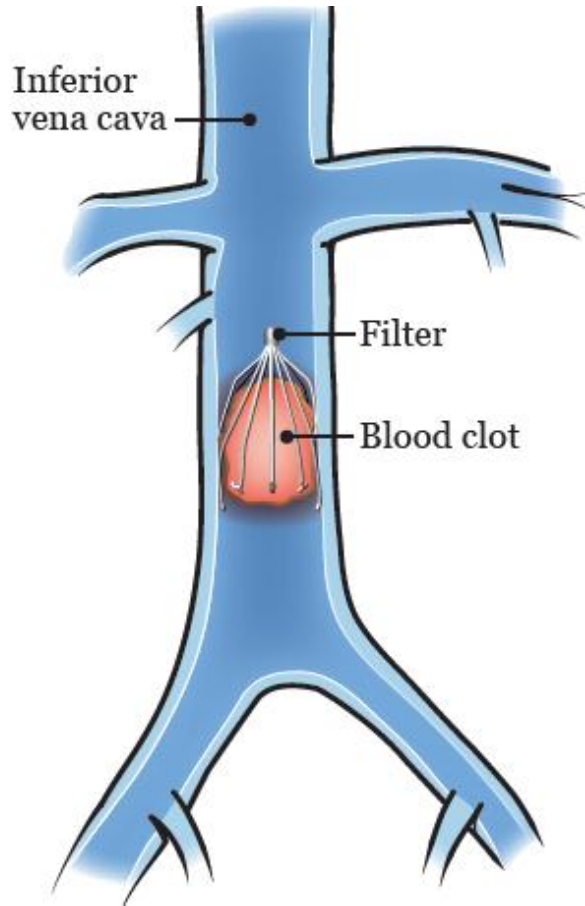
Outflow including collaterals is blocked
→ ischemic pain, cyanosis, bullae, shock
→ venous gangrene

Anticoagulation alone
amputation up to 50% · mortality up to 40%

Immediately: weight-based heparin ·
aggressive leg elevation · fluid resuscitation

Emergency thrombus removal: CDT, PCDT or
surgical thrombectomy

IVC Filter



- **Contraindications to anticoagulation**
- **Anticoagulation failure**
- **Not considered indicated for routine thrombolysis intervention**
- **Considered in case of loose thrombi or patients with poor cardiopulmonary reserve, filter placement before thrombolysis or mechanical thrombectomy with Retrievable filters**

Iliofemoral DVT CT



- 38/F Postpartum period c
Maythurner syndrome

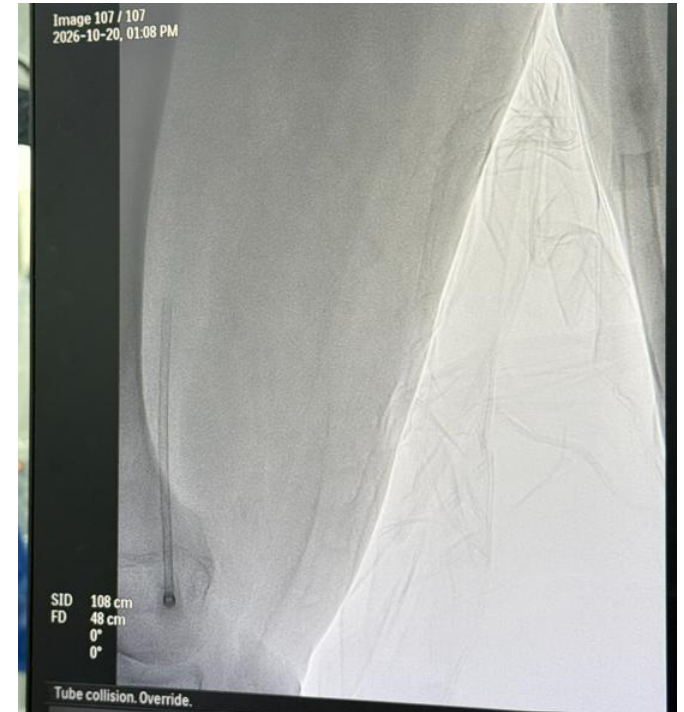
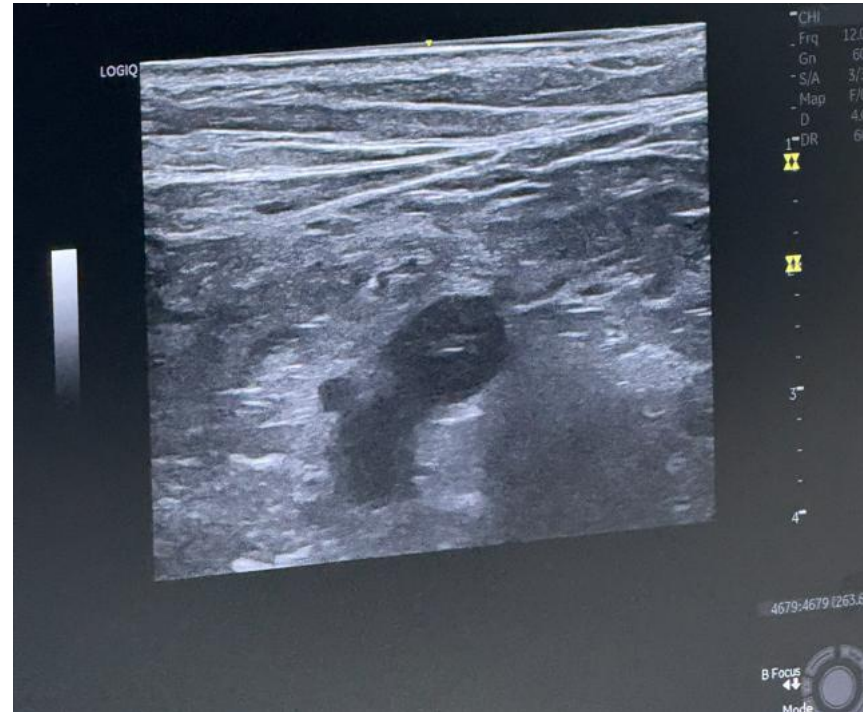


- 60/M Immobility 2wks d/t
femur necrosis

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion

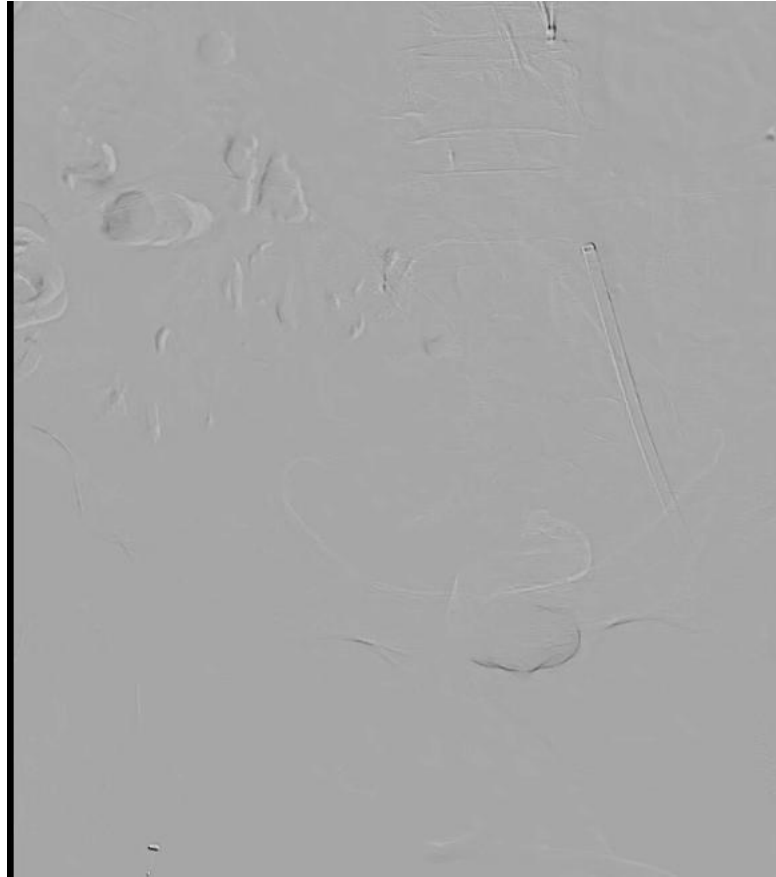


Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



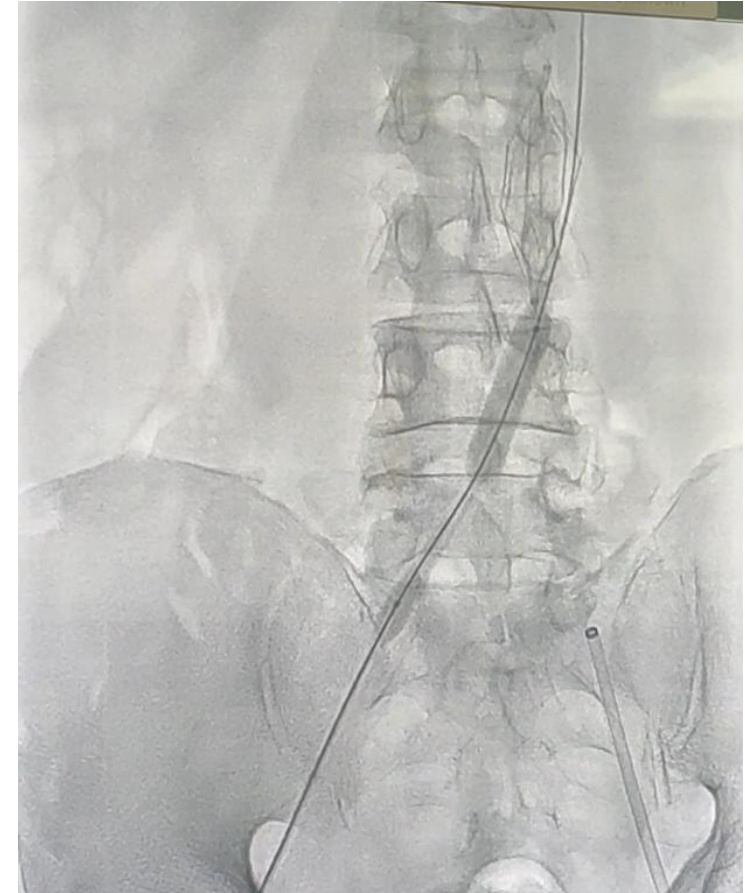
US guided Popliteal puncture, 8Fr angiosheath insertion

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



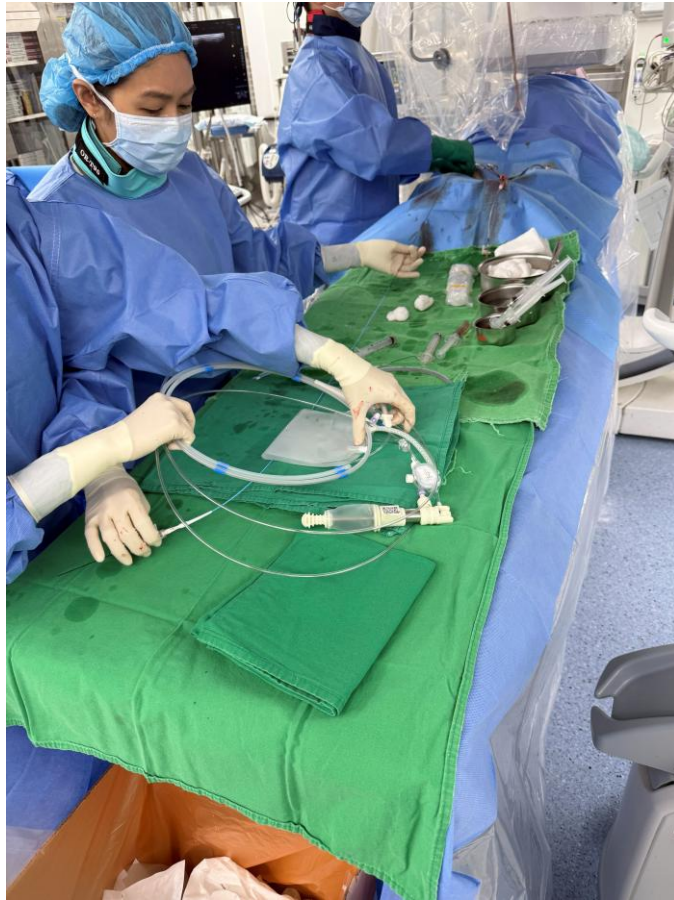
Venography: Occluded Deep vein from LCIV-LPOPV

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



Retrievable IVC filter insertion via contralateral popliteal

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



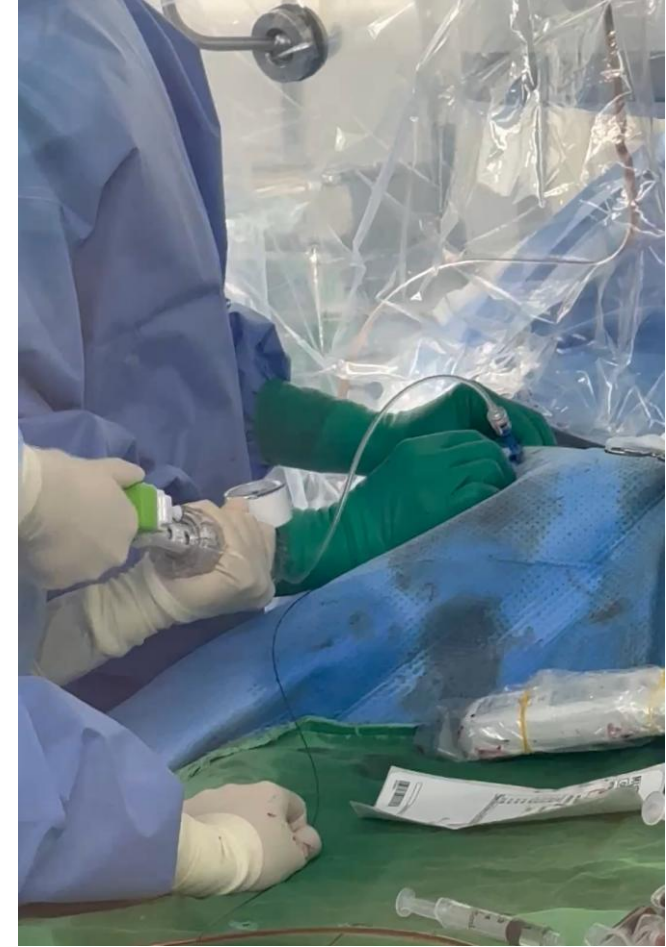
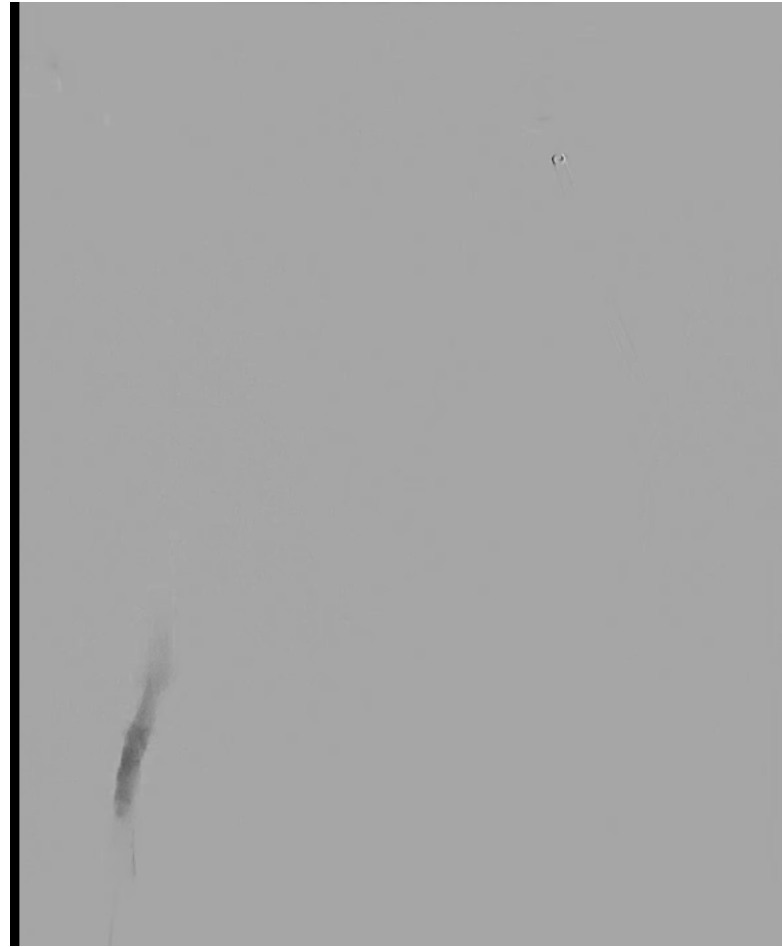
AngioJet priming with tPA 20mg/100ml

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



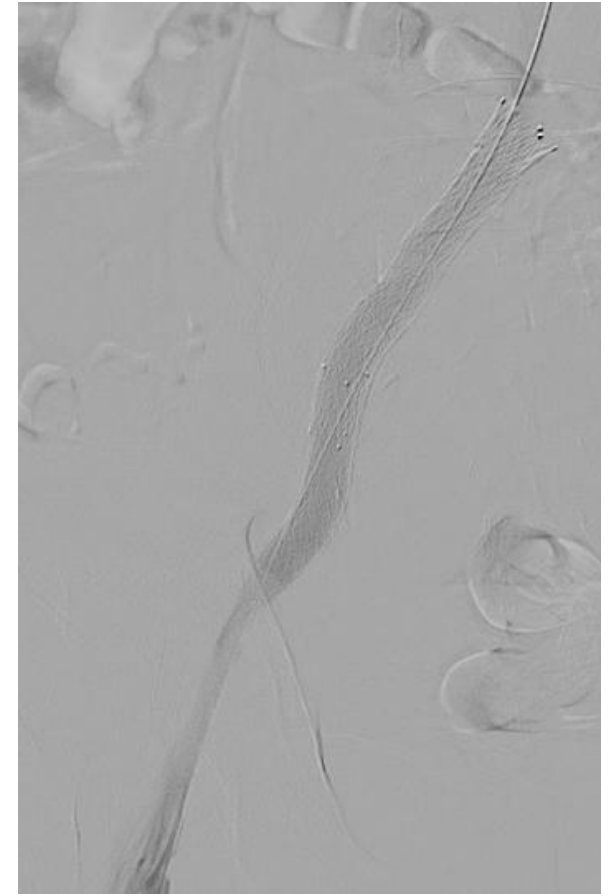
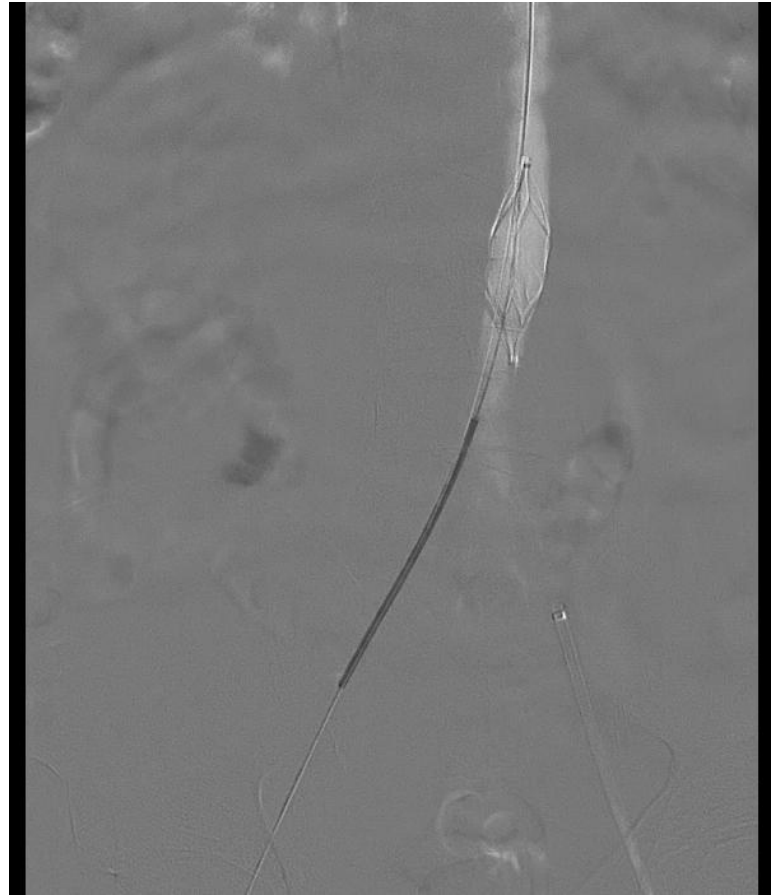
tPA infusion at thrombus with PowerPulse mode

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion



**Rheolytic thrombectomy with thrombectomy mode
Venous angioplasty (Mustang 12mm-8cm)**

Pharmaco-mechanical thrombolysis using Angiojet IVC filter insertion, Stent insertion

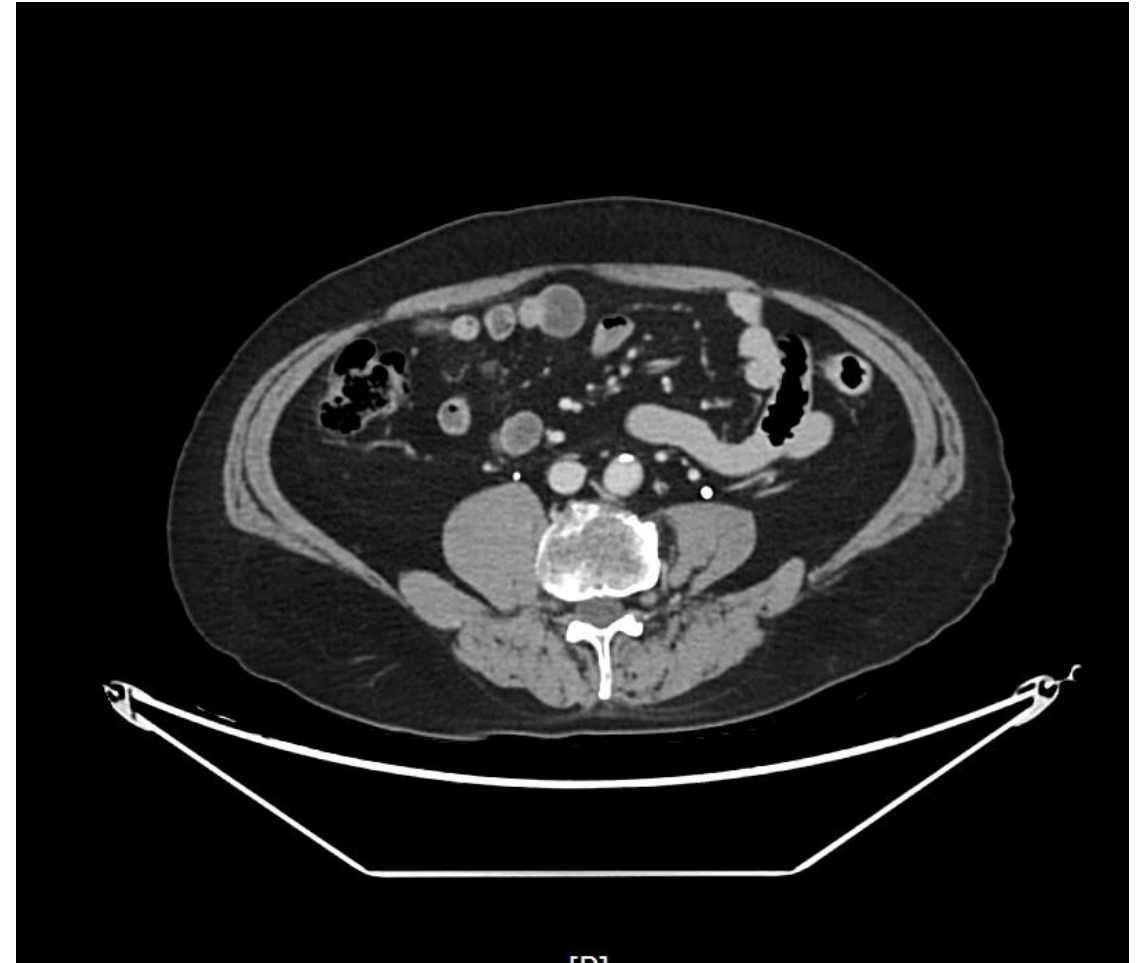


Stent insertion (Venovo 12mmx8cm x2)

- 38/F Postpartum(C/sec) period
c Maythunner syndrome



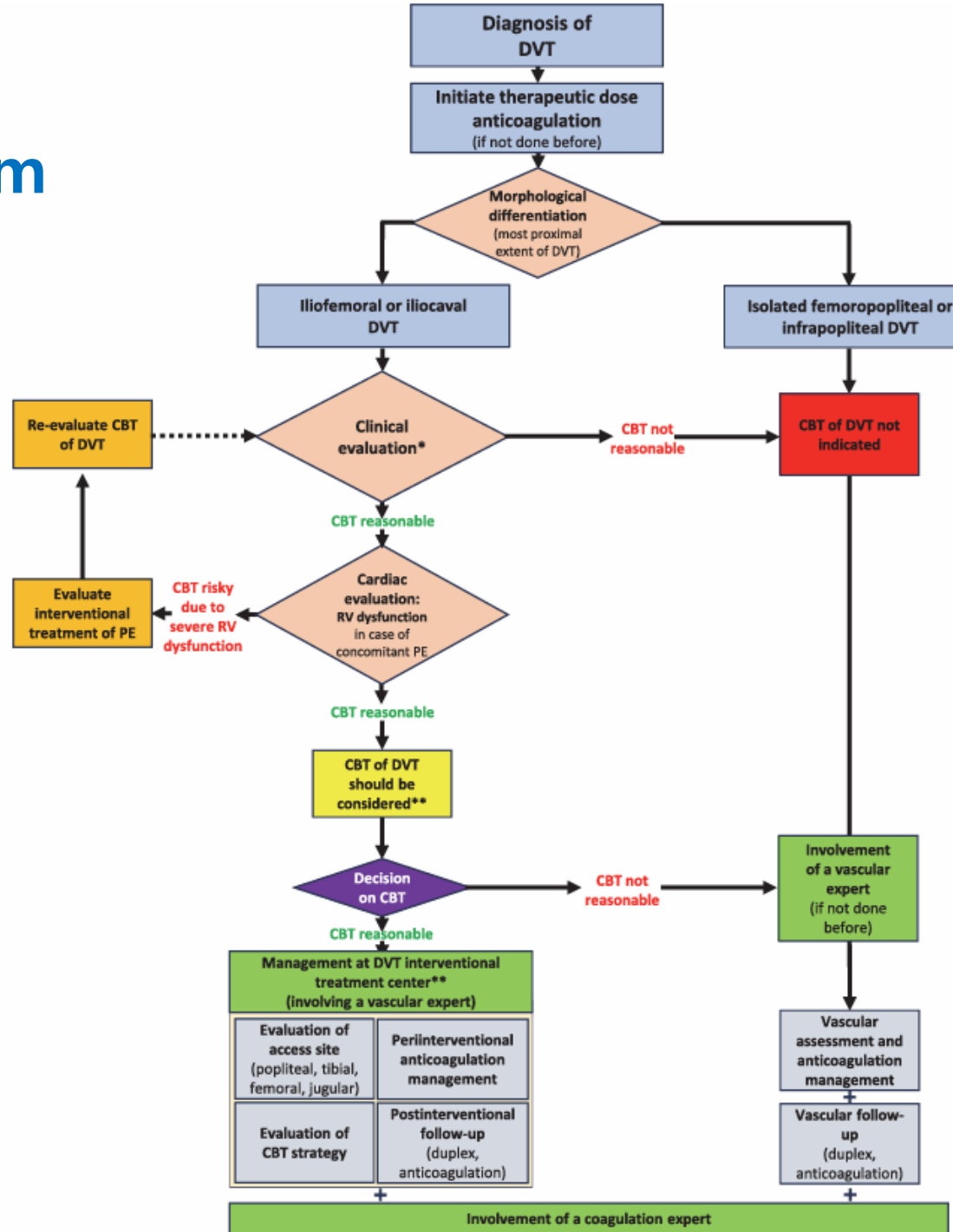
- 60/M Immobility 2wks d/t
femur necrosis



- MT using AngioJet (x2)
- PCDT using AngioJET c LCIV Stent (Venovo 12mm)

- PCDT using AngioJet (x2)

DVT Treatment algorithm



VTE Prophylaxis in Surgical Patients

≈ 50%

of VTE follows hospitalization or surgery within 3 months

Caprini risk	Score	Prophylaxis
Very low	0	Early ambulation
Low	1–2	Mechanical (Pneumatic compression)
Moderate	3–4	Pharmacologic or mechanical
High	≥ 5	Pharmacologic + mechanical

Thoracic cancer surgery (lung resection, esophagectomy): LMWH + mechanical prophylaxis

AATS/ESTS 2022 · conditional recommendations, low-certainty evidence

But, East Asian VTE rates are lower → individualize by VTE and bleeding risk

Take-home Message

- Anticoagulation is the foundation of DVT treatment; its duration depends on the risk factor.
- Below the groin (femoropopliteal or calf DVT), anticoagulation is the treatment — no early thrombus removal.
- In selected acute iliofemoral DVT, early thrombus removal with stenting of residual lesions is a reasonable option.
- Phlegmasia cerulea dolens is a limb-threatening emergency that requires immediate thrombus removal.
- Lytic-free mechanical thrombectomy is promising, but ongoing RCTs will define its role.

Thank you for your attention

