Venous Thromboembolism 2020: An Update

Thomas F. Morley, DO, MACOI, FCCP, FAASM
Professor of Medicine
Chairman Department of Medicine
Director of the Division of Pulmonary, Critical Care and Sleep Medicine
Rowan University School of Osteopathic Medicine

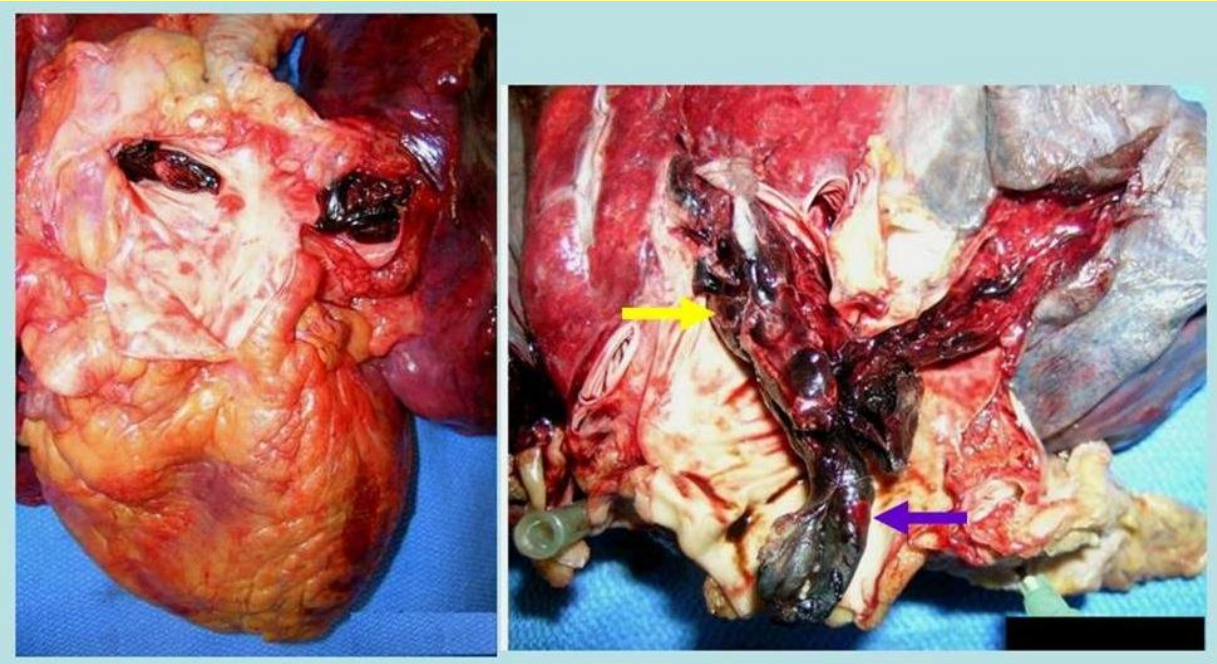
ROWAN UNIVERSITY
School of Osteopathic Medicine

No Disclosures

ROWAN UNIVERSITY
School of Osteopathic Medicine

Pulmonary Embolism

Its severity ranges from asymptomatic, incidentally discovered subsegmental thrombi to massive, pressor-dependent PE complicated by cardiogenic shock and multisystem organ failure.



Risk Factors for Venous Thromboembolism
ACQUIRED

- **Virchow's Triad**
  (stasis, venous injury, hypercoagulable)
- **Prior history of thromboembolic disease**
- **Prior surgical history or trauma**
- **Immobilization/paralysis**
- **Cancer**
- **Estrogen Therapy**
- **Pregnancy/Postpartum**
- **Antiphospholipid antibody syndrome**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Established or Potential Hypercoagulable States

- Activated protein C resistance
- Alpha-macroglobulin deficiency
- Anticardiolipin antibiodies
- Antithrombin deficiency
- Dysfibrinogenemia
- Factor V Leiden
- Factor V deficiency/excess
- Factor VII excess
- Factor VIII excess
- Factor XI excess
- Heparin cofactor II deficiency
- Hyperhomocysteinemia
- Hyperfibrinogenemia
- Lupus anticoagulants
- PAI-1 excess
- Plasminogen deficiency
- Protein C deficiency
- Protein S deficiency
- Prothrombin G20210A
- tPA deficiency
- TFPI deficiency
- Thrombomodulin deficiency

PAI-1=plasminogen activator inhibitor-1; TFPI=tissue factor pathway inhibitor; tPA=tissue plasminogen activator

When to suspect a hypercoagulable state?

- **Clots in low risk patient**
- **Clots in odd locations**
- **Recurrent clots**
- **Family history of clots**
- **Spontaneous abortion**

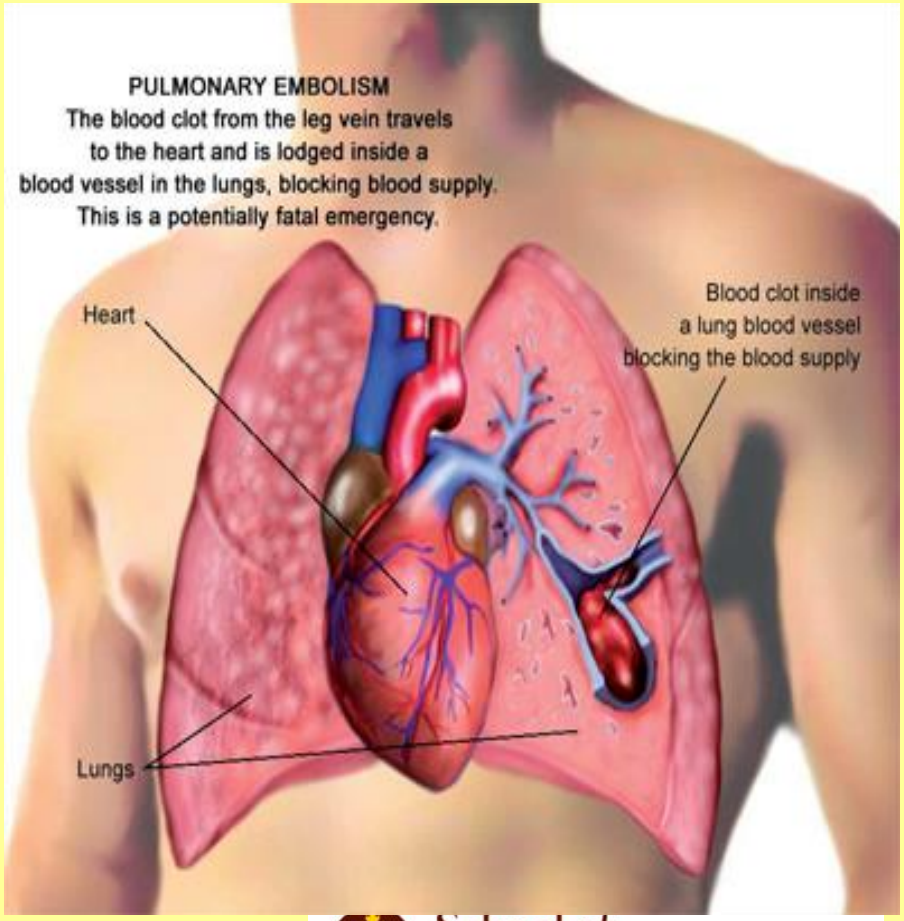
ROWAN UNIVERSITY
School of Osteopathic Medicine

Hypercoagulable states associated with BOTH Arterial and Venous Thrombosis

Cancer
Myeloproliferative syndromes
Antiphospholipid antibodies (APA)
Hyperhomocysteinemia
Heparin-induced thrombocytopenia
Nephrotic syndrome

Pulmonary Embolism Sources

- **Lower extremity DVT**
  - 70% cases of PE
- **Unusual sites**
  - Right heart
  - Upper extremity
  - Renal veins
  - Iliac veins
  - Hepatic veins

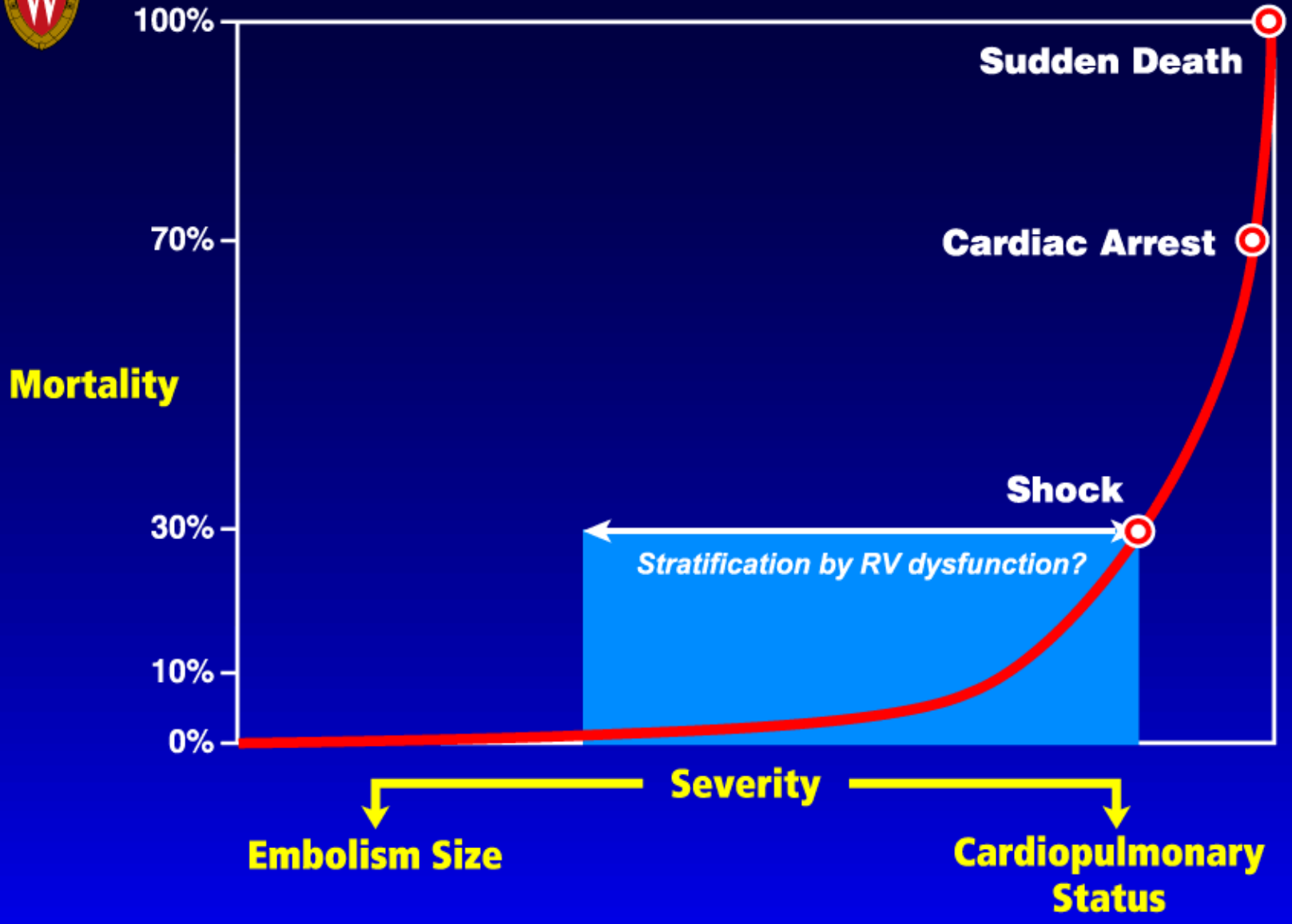


School of Osteopathic Medicine

Pathophysiology

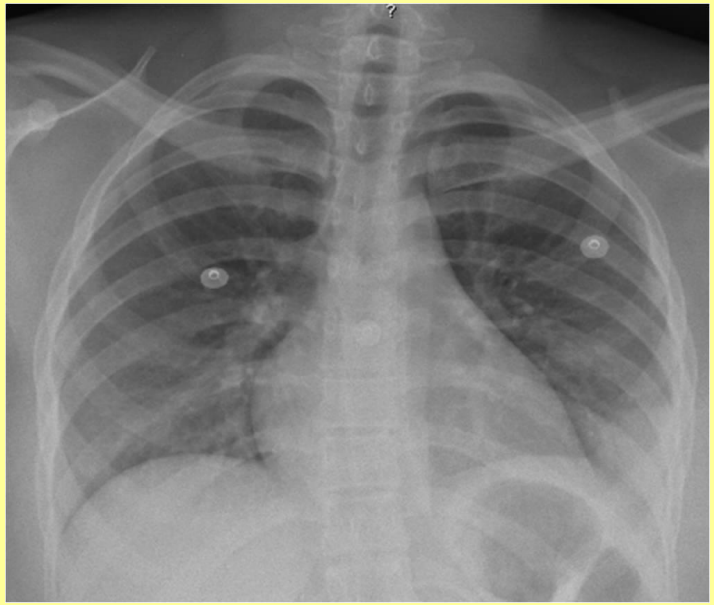
- **Key consequences are hemodynamic**
  - Emboli abruptly increase pulmonary vascular resistance to a level of afterload which cannot be matched by the RV.
- **Sudden death may occur**
  - usually in the form of electromechanical dissociation
- **These effects of depend:**
  - Extent of obstruction
  - Duration over which obstruction accumulates
  - Pre-existing cardiopulmonary state of patient

Outcomes in Pulmonary Embolism



Clinical Definitions

- **The definition of *high-risk* (European classsification) or *massive* (North American classification) PE is usually straightforward and *relies on the presence of clinically overt RV failure which results in haemodynamic compromise.* (i.e. Shock, syncope, PEA)**



ROWAN UNIVERSITY
School of Osteopathic Medicine

Initial Risk Stratification

- High-risk (European classsification)
- Massive (North American classification)
- Patients present with hypotension or syncope or PEA
- Some would add refractory hypoxemia to this group

Torbicki A, et al. Guidelines on the diagnosis and management of acute pulmonary embolism: The Task Force for the Diagnosis and Management of Acute Pulmonary Embolism of the European Society of Cardiology (ESC). *Eur Heart J 2008;*

Jaff MR, et al. Management of massive and submassive pulmonary embolism, iliofemoral deep vein thrombosis, and chronic thromboembolic pulmonary hypertension: a scientific statement from the American Heart Association. *Circulation* 2011;123:1788–1830.

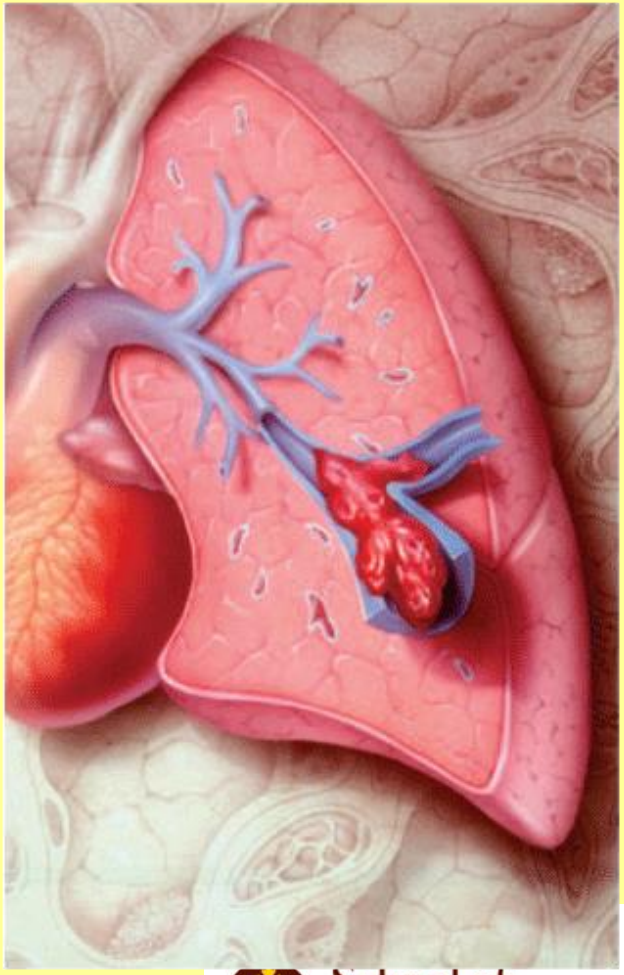
High Risk or Massive PE

- **This condition, which is encountered in <5% of all patients presenting with acute PE constitutes a medical emergency, since it is associated with at least a 15% risk of in-hospital death, particularly during the first hours after admission.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Advanced Risk Stratification: Clinical Scores

- **Some of the (initially) normotensive patients with acute PE may have an elevated risk of death or major complications (intermediate-risk PE in Europe; submassive PE in North America) which warrants further risk stratification and possibly specific advanced therapy.**

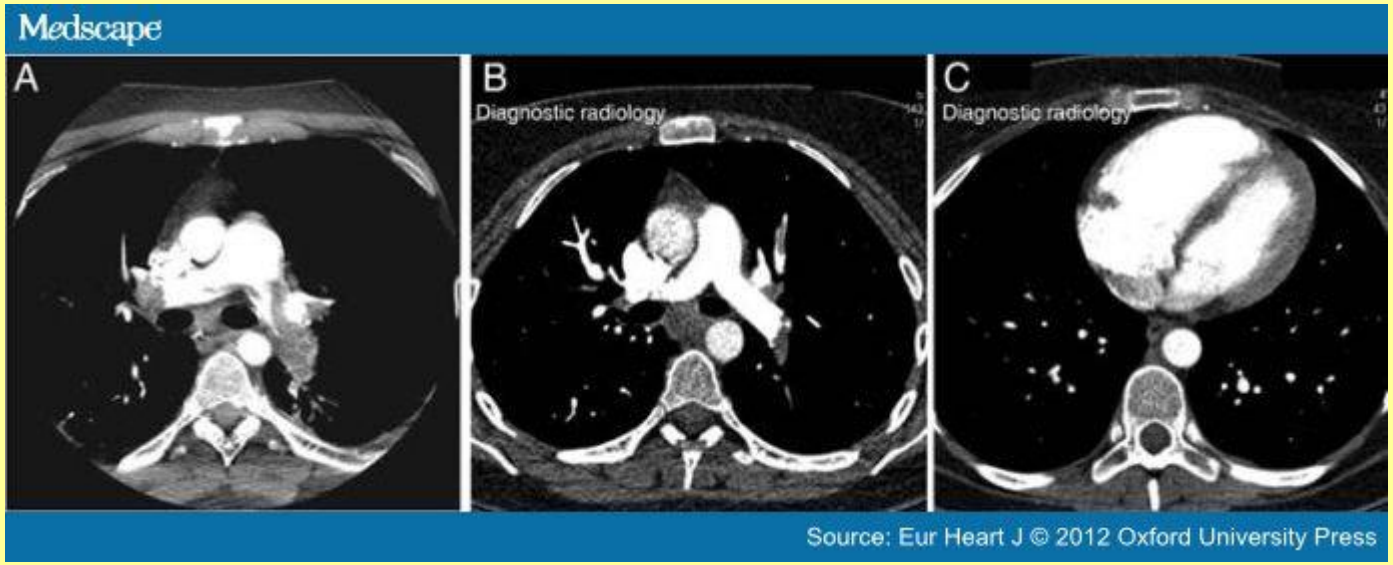


School of Osteopathic Medicine

Risk Stratification Parameters

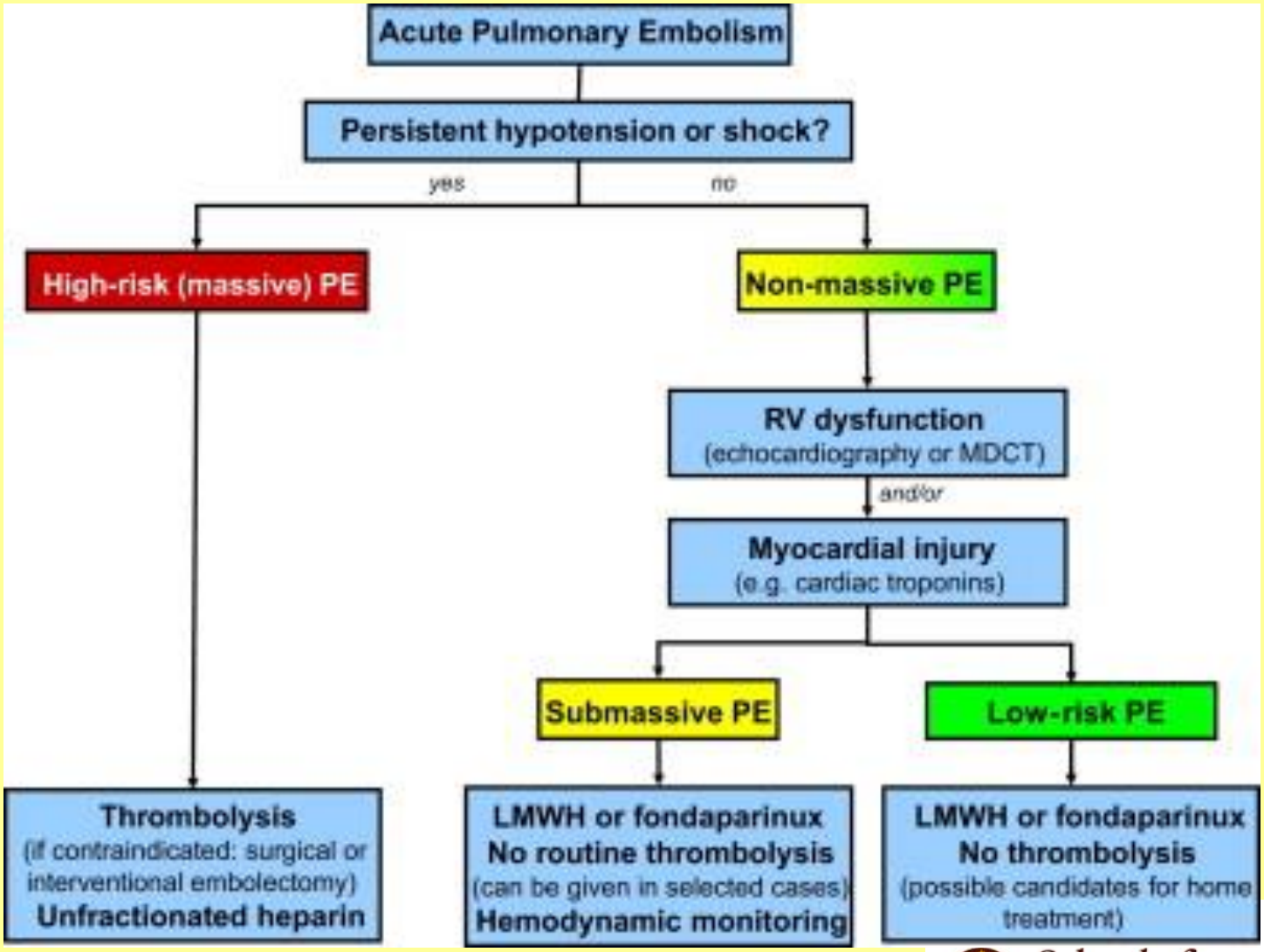
- **BNP and proBMP**
- **Troponin**
- **RV dilation, hypokinesia,**

ROWAN UNIVERSITY
School of Osteopathic Medicine



The extent of thrombotic load on computed tomography does not always correlate with the clinical severity of acute pulmonary embolism or its impact on right ventricular function. (*A*) A straightforward case in which massive thrombi are present in both the right and the left pulmonary artery of a patient presenting with haemodynamic instability (persistent tachycardia, systolic blood pressure between 90 and 100 mmHg). (*B*) However, a patient presenting with similar clinical findings had an apparently much smaller thrombotic load on computed tomography; in this latter patient, the size of thrombi was also in discordance with the impressive enlargement (as a surrogate for dysfunction) of the right ventricle (*C*).

ROWAN UNIVERSITY
School of Osteopathic Medicine



Advanced Risk Stratification: Clinical Scores

- **The Pulmonary Embolism Severity Index (PESI) is the most extensively validated prognostic clinical score to date.**
- **Its major strength lies in excluding (ruling out) an adverse outcome as indicated by the high negative predictive value (NPV) of the lowest PESI classes I and II.**
- **The main limitation of the index is that it requires numerous variables and is relatively complex to calculate, which may reduce its practicability in high-volume centres.**

Wells' Criteria for Assessment of Pretest Probability

The Wells Criteria for assessing pretest probability is important for diagnosing DVT and PE. Below describes the criteria and scoring system:

Criteria	Points
Suspected DVT	3.0
An alternative diagnosis is less likely than PE	3.0
Heart rate > 100 beats per minute	1.5
Immobilization or surgery in the previous four weeks	1.5
Previous DVT or PE	1.5
Hemoptysis	1.0
Malignancy (on treatment, treated in the past six months or palliative)	1.0

Score range	Mean probability of PE	% with this score	Interpretation of risk
<2 points	3.6%	40	Low
2 to 6 points	20.5%	53	Moderate
>6 points	66.7%	7	High

Source: Adapted with permission from Wells PS, Anderson DR, Rodger M, et al. Derivation of a simple clinical model to categorize patients' probability of pulmonary embolism: Increasing the models utility with the SimpliRED D-dimer. *Thromb Haemost*. 2000;83:416-420.

D-dimer

- **Plasma D-dimer degradation product of crosslinked fibrin**
- **Useful in ruling out clot**
  - High negative predictive value (NPV)
- **Fibrin present in many other disorders**
  - Low positive predictive value (PPV)
- **ELISA-derived assays have highest sensitivity**
  - Latex-derived & whole-blood agglutination assays have lower sensitivity

ROWAN UNIVERSITY
School of Osteopathic Medicine

Techniques for Diagnosis of PE

EKG

Chest Radiographs

Echocardiogram

V/Q Scans

Helical CT

MRI

ROWAN UNIVERSITY
School of Osteopathic Medicine

EKG Findings of Pulmonary Embolism

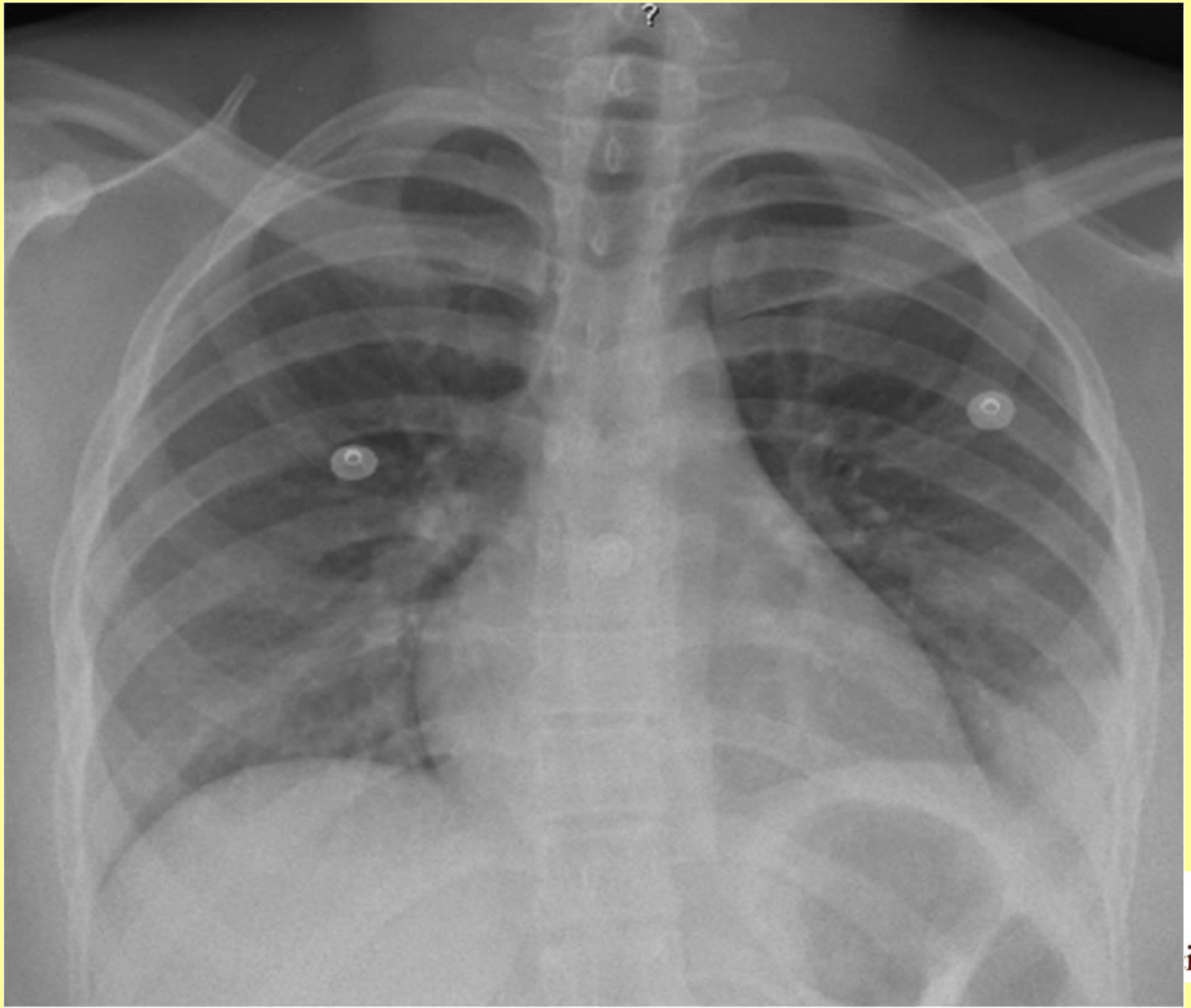
- Tachycardia
- T-wave changes
- ST-segment changes
- Right axis deviation
- S1-Q3-T3
- RBBB
- p-pulmonale

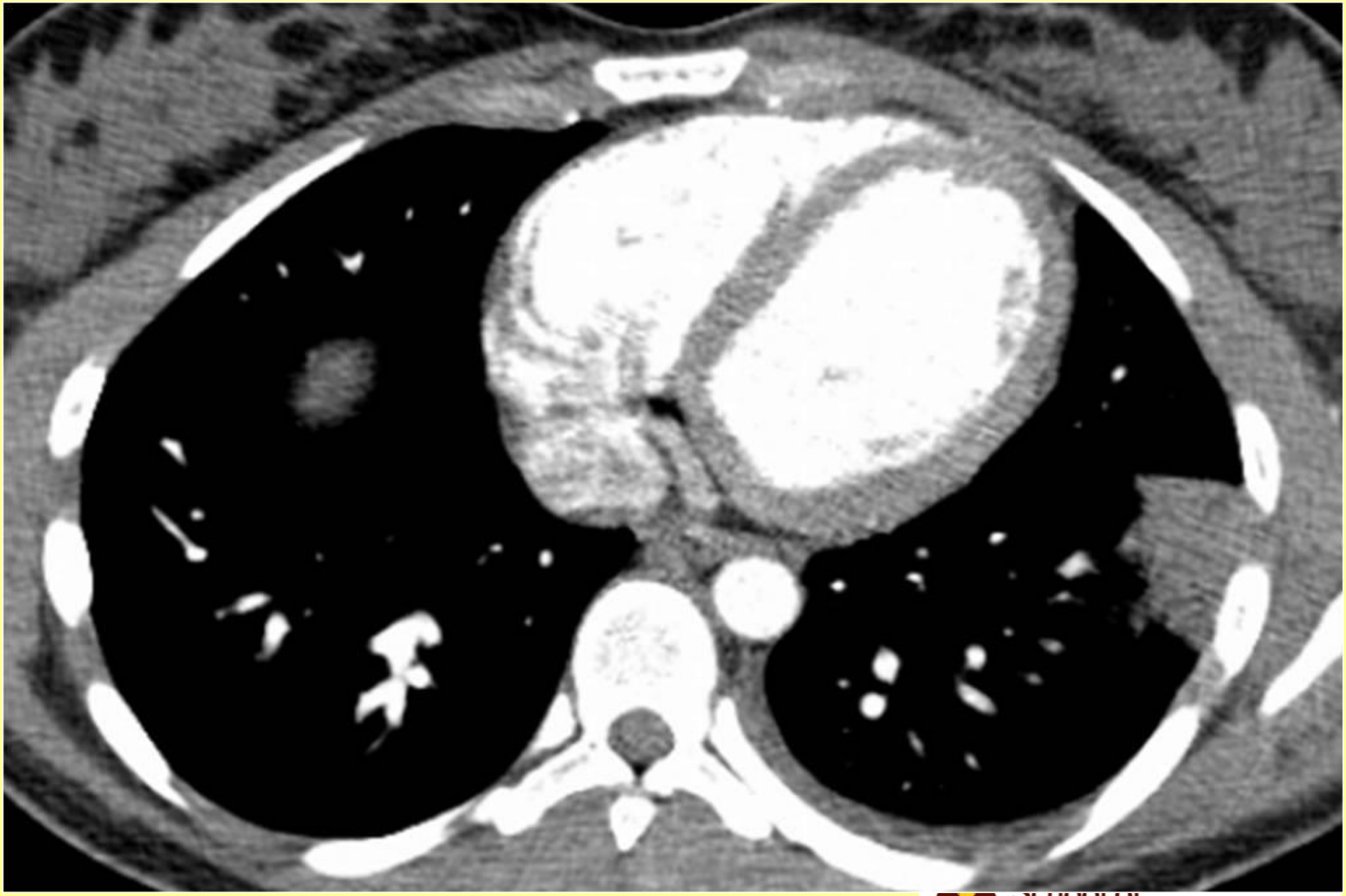
ROWAN UNIVERSITY
School of Osteopathic Medicine

Chest Radiography

- **Valuable in excluding other diagnoses**
  - Pneumothorax, Pneumonia, CHF, tumor, rib fx
- **Aids in interpreting V/Q scan**
- **Radiographic signs suggest PE:**
  - Hampton's hump
  - Westermark sign
  - Fleischner sign

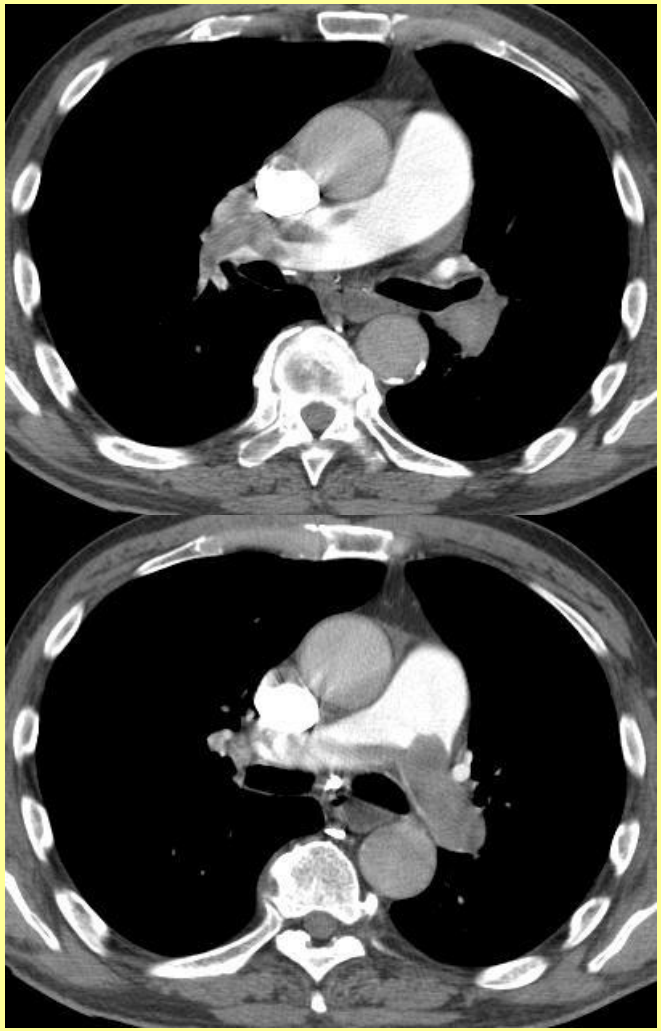
ROWAN UNIVERSITY
School of Osteopathic Medicine

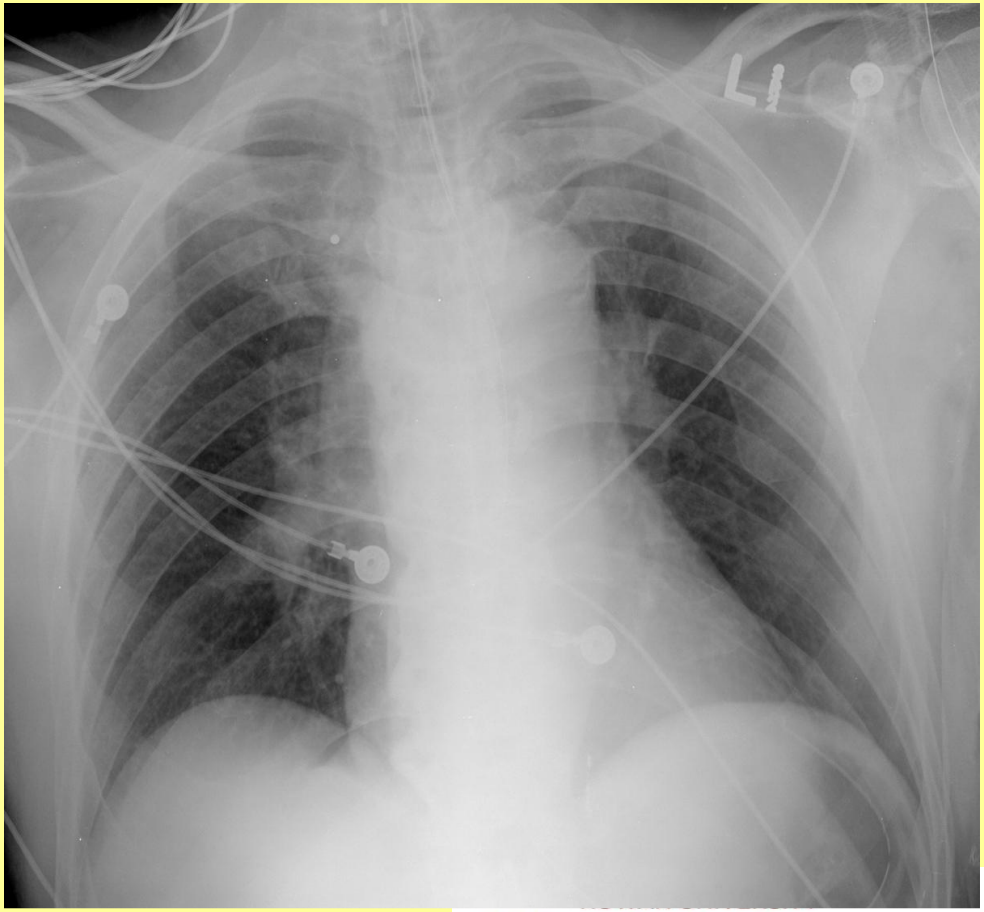




Westermark's Sign

Fleischner sign





School of Osteopathic Medicine

Echocardiogram

- Useful for rapid triage of pts
- Assess right and left ventricular function
- Diagnostic of PE if echo findings are consitent with clinical hx

ROWAN UNIVERSITY
School of Osteopathic Medicine

Echocardiogram

- **TEE more sensitive than TTE**
- **Demonstrate intracardiac clot or signs of right ventricular failure**

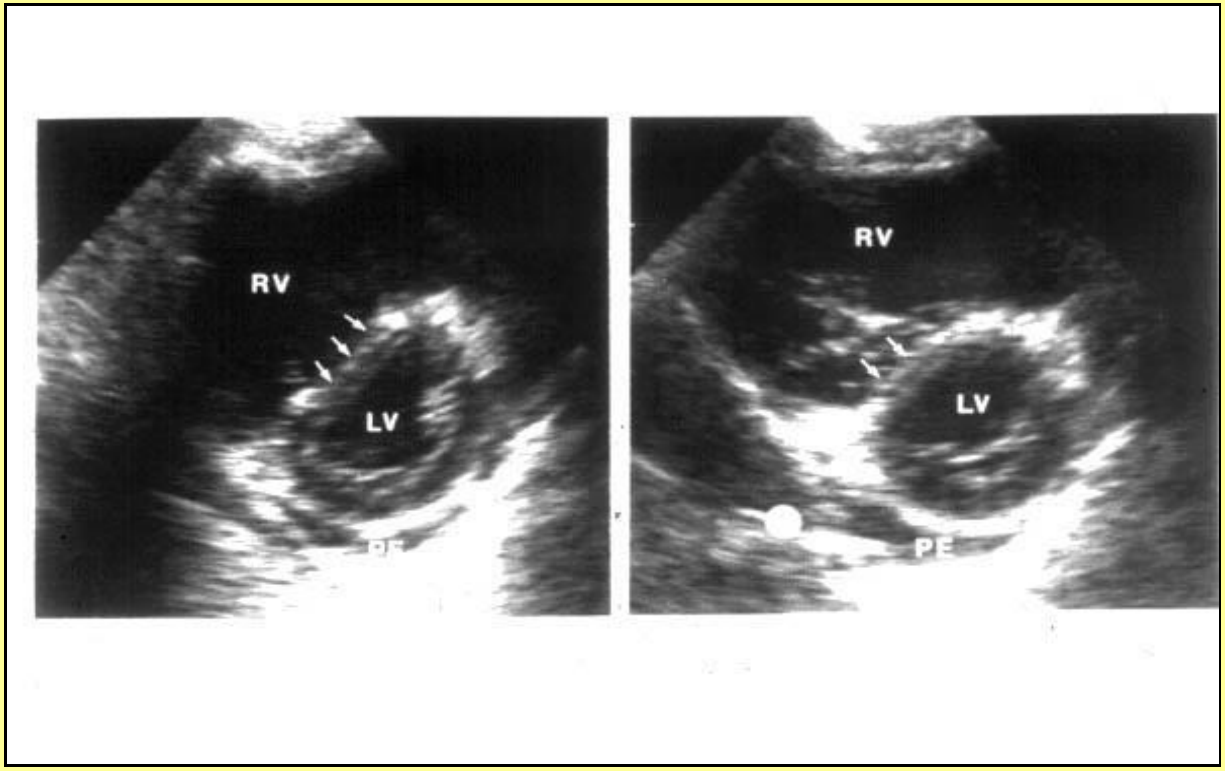
- **Indirect evidence**
  - right ventricular dilation
  - dilated pulmonary artery
  - abnl right ventricular wall motion
  - dilated vena cava

ROWAN UNIVERSITY
School of Osteopathic Medicine

Right Ventricular Dysfunction

- **Progressive right heart failure is the usual immediate cause of death from PE**
- **As pulmonary vascular resistance increases, right ventricular wall tension rises and perpetuates further right ventricle dilation and dysfunction**
- **Interventricular septum bulges into and compresses the normal left ventricle**

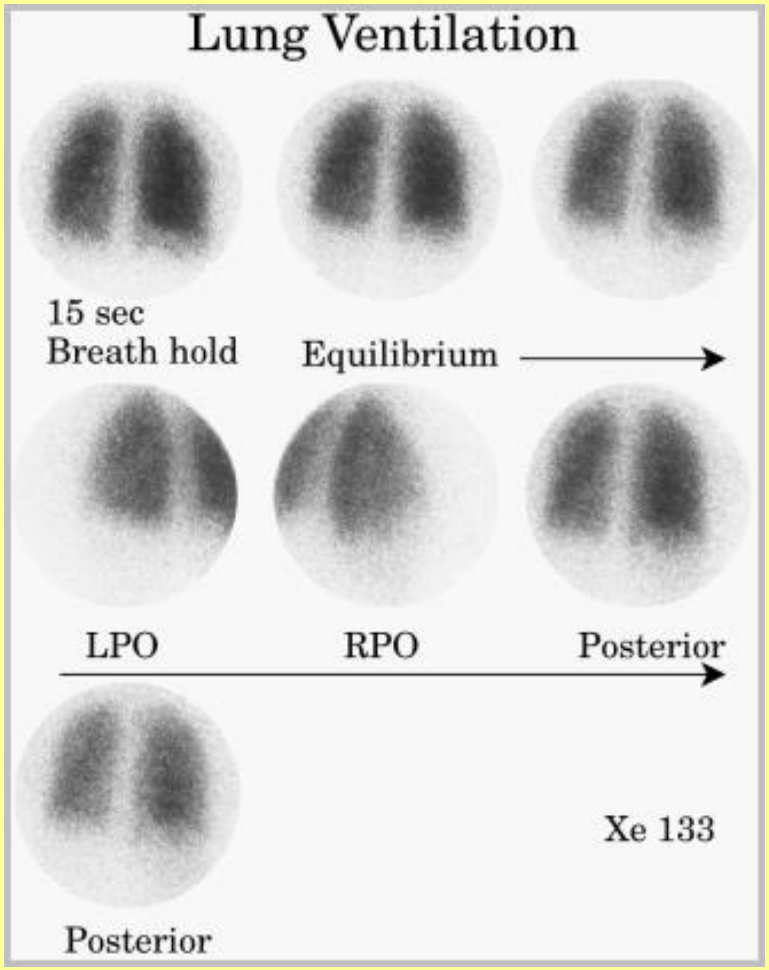
ROWAN UNIVERSITY
School of Osteopathic Medicine

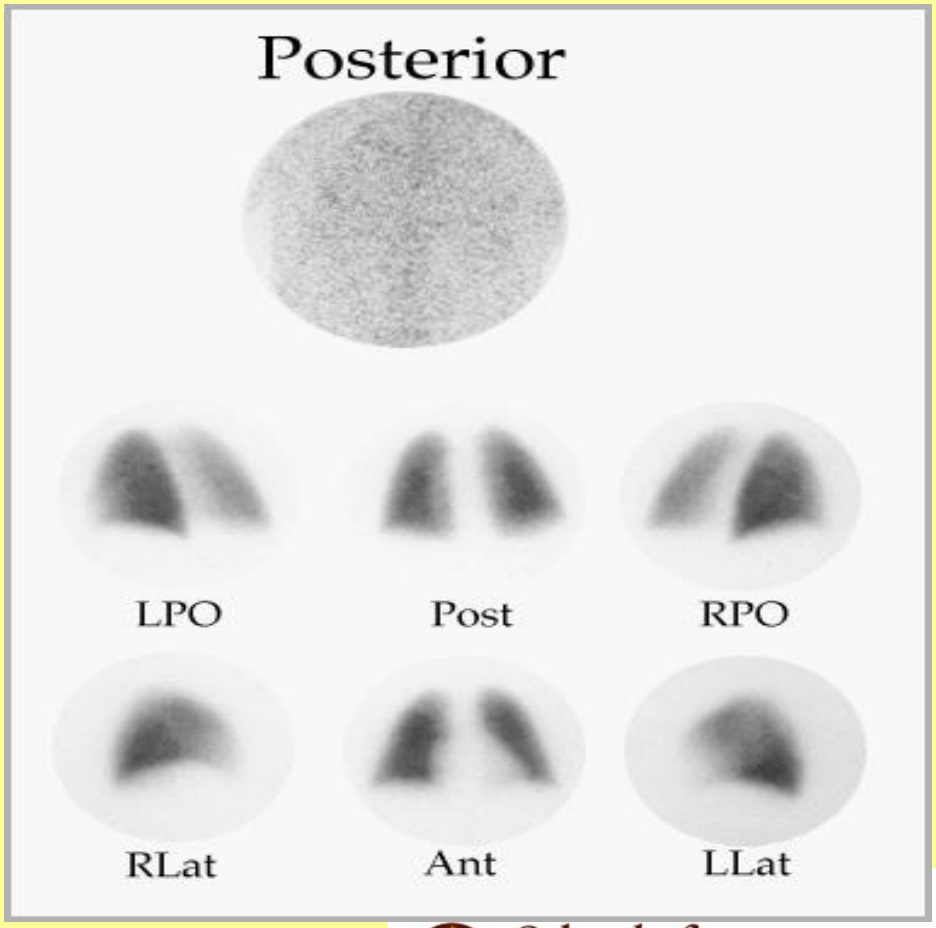


Echocardiogram suggesting a PE. Diastole on the left, systole on the right

ROWAN UNIVERSITY
School of Osteopathic Medicine

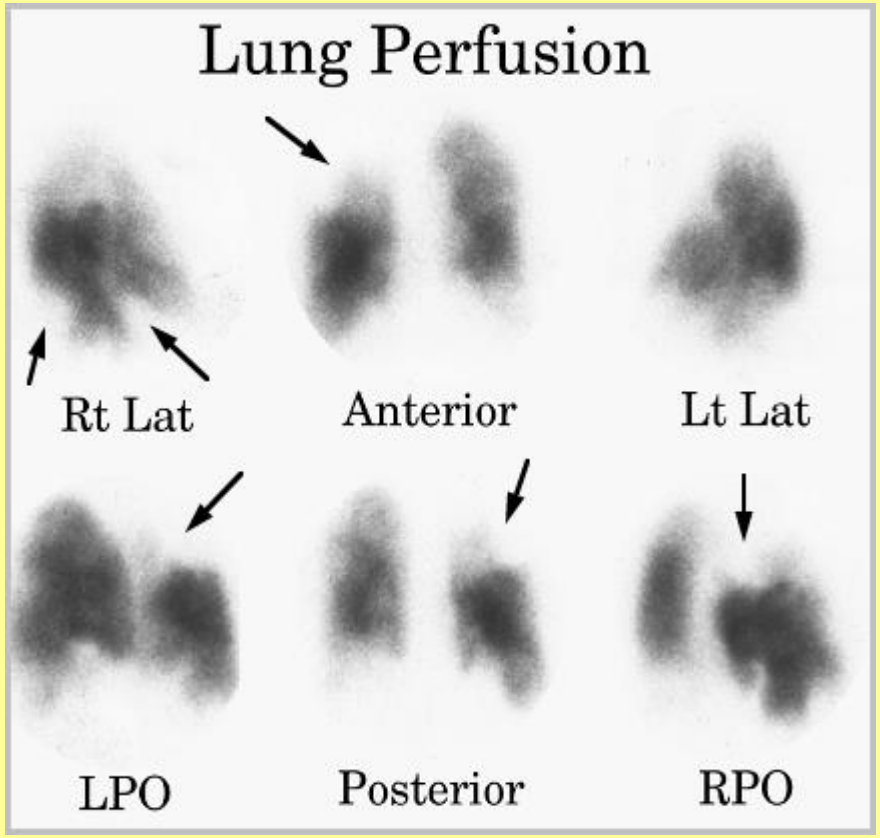
Ventilation-Perfusion (V/Q) Scans

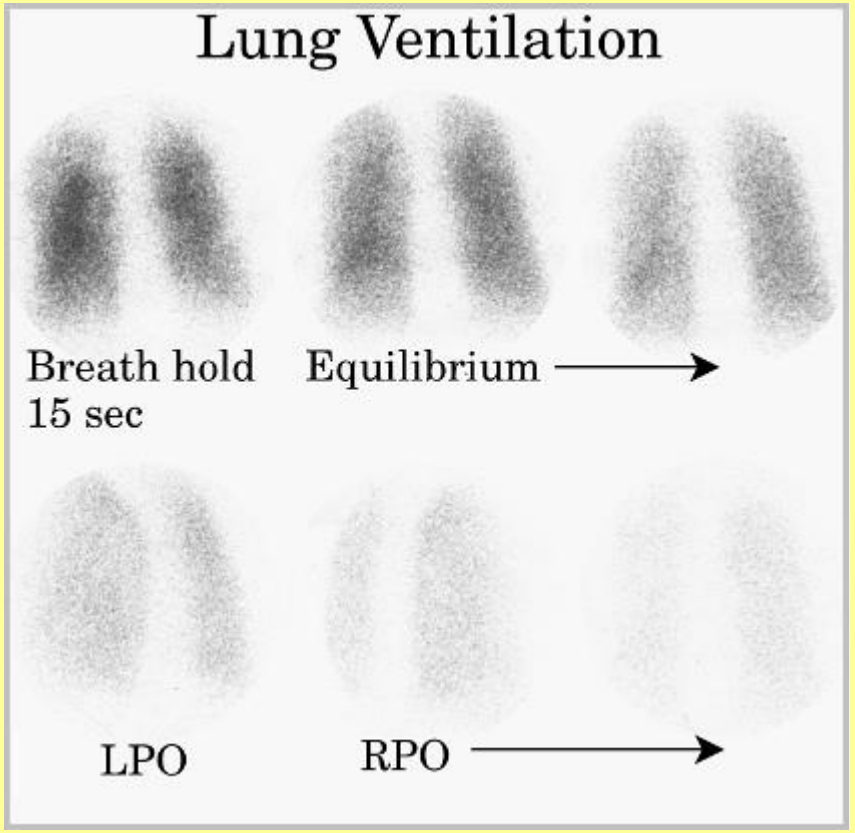




School of Osteopathic Medicine

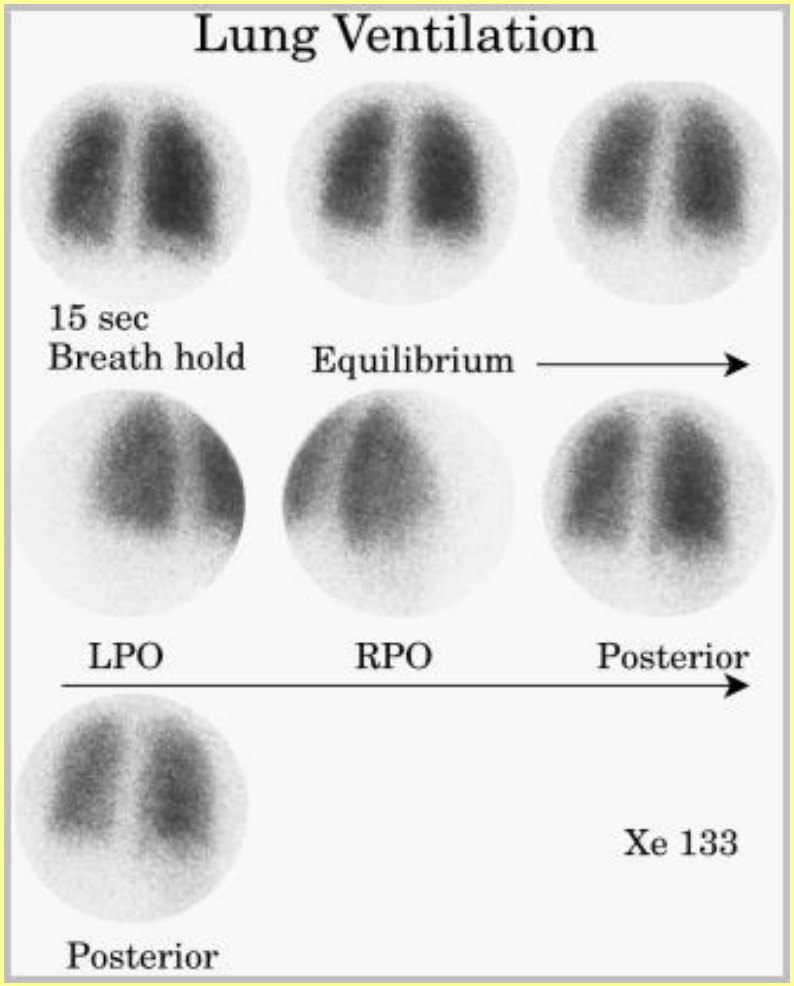
High Probability V/Q Scan

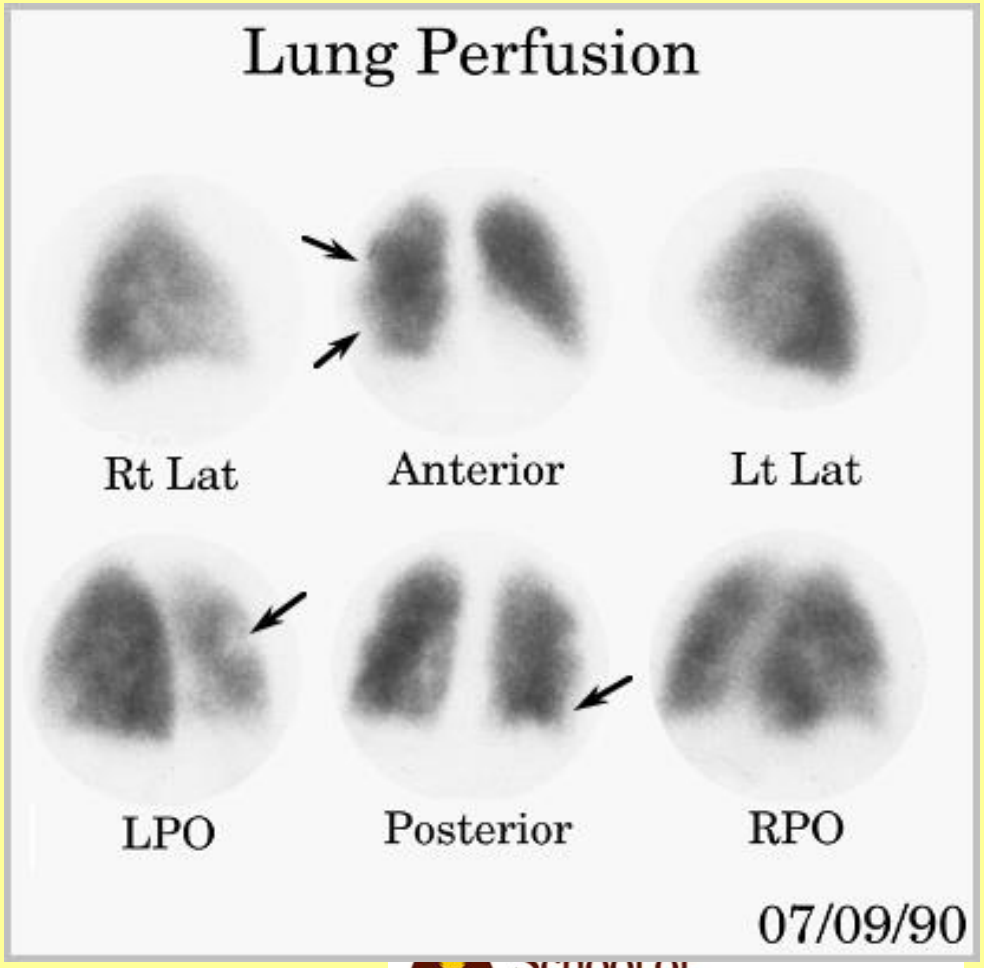




ROWAN UNIVERSITY
School of Osteopathic Medicine

V/Q with Subsegmental Defects





School of Osteopathic Medicine

V/Q Lung Scan

- **Normal V/Q Sensitivity 99%**
  - –Rules *out* PE
- **High Prob V/Q Specificity 96%**
  - –Rules *in* PE
- **But, >60% nondiagnostic**
- **Takes >2 hr to perform**
- **Not available at all times**

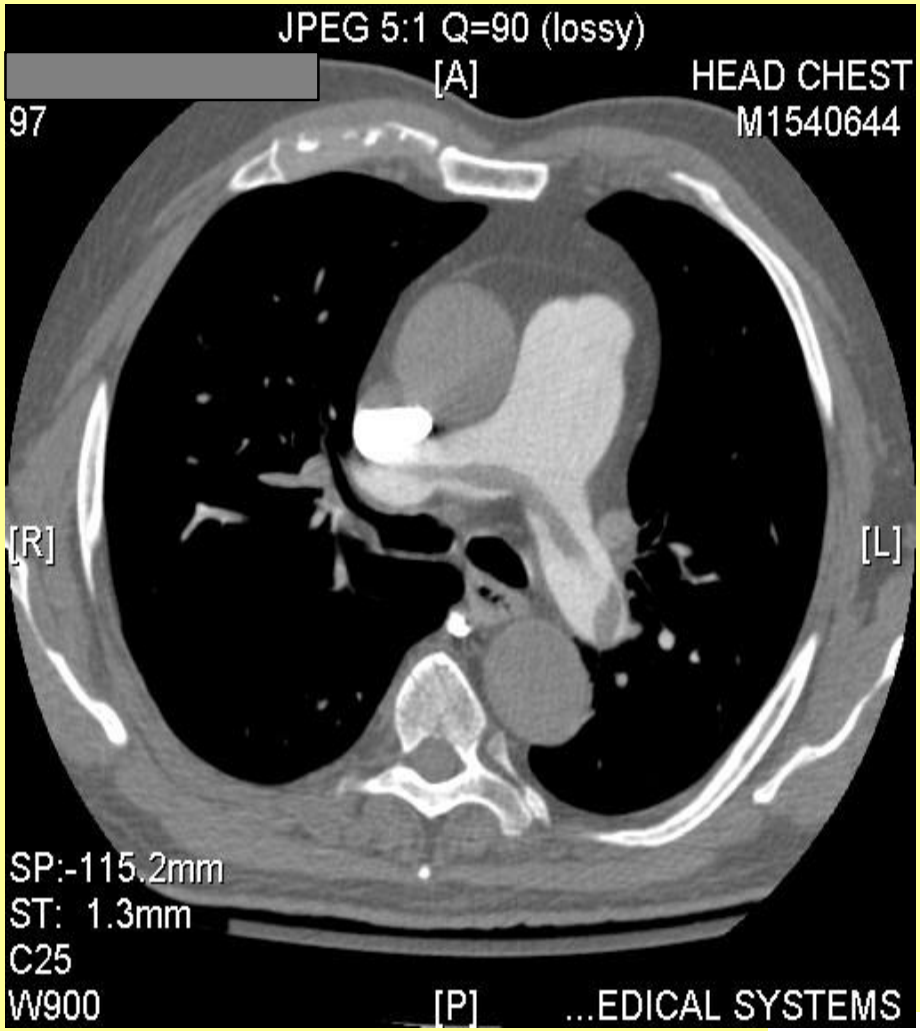
ROWAN UNIVERSITY
School of Osteopathic Medicine

CT Pulmonary Angiogram

- **Identifies proximal PE (which are the ones usually hemodynamically important)**
- **Not as accurate with peripheral PE**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Spiral CT for Dx PE



ROWAN UNIVERSITY
School of Osteopathic Medicine

Pulmonary Angiogram

- **Most specific test available for diagnosis of PE**
- **Can detect emboli as small as 1-2 mm**
- **Most useful when the clinical likelihood of PE differs substantially from the lung scan or CTPA results**

Pulmonary Angiography

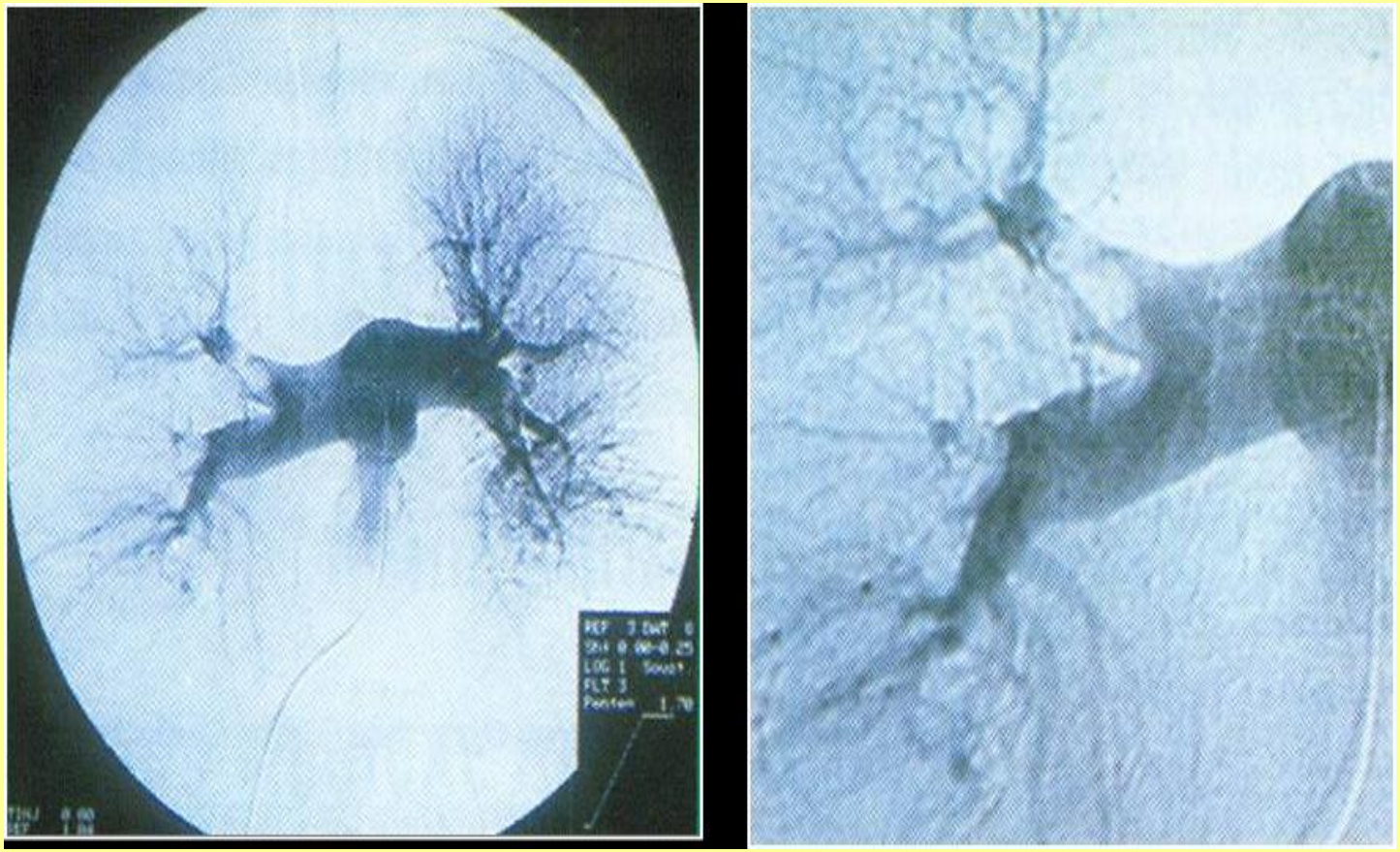
Diagnostic Findings

O.5 % Mortality **1 % Major Morbidity**

Diagnostic Findings	
	Intraluminal filling defects **Vascular Cutoffs**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Pulmonary angiogram



ROWAN UNIVERSITY
School of Osteopathic Medicine

Antithrombotic Therapy for VTE Disease: CHEST Guideline and Expert Panel Report

Chest. 2016;149(2):315-352.

ROWAN UNIVERSITY
School of Osteopathic Medicine

Initial Treatment of Pulmonary Embolism

- **Anticoagulant treatment should be administered to all patients with high or intermediate clinical probability of acute PE, without awaiting definitive confirmation by imaging procedures.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Initial Treatment of Pulmonary Embolism

- **Unfractionated heparin is the preferred mode of initial anticoagulation for a limited group of patients with severe renal impairment (creatinine clearance <20–30 mL/min)**
- **for those at high risk of bleeding**
- **for high-risk hypotensive patients**
- **as a rule, for extremely overweight, underweight, or old patients**

Initial Treatment of Pulmonary Embolism

- With the exception of these circumstances
- LMWH or fondaparinux is given subcutaneously at weight-adjusted doses
- Anticoagulation with unfractionated heparin or LMWH/fondaparinux should be continued for at least 5 days

ROWAN UNIVERSITY
School of Osteopathic Medicine

Initial Treatment of Pulmonary Embolism

- **Oral anticoagulants (vitamin K antagonists) should be initiated as soon as possible in hemodynamically stable patients, preferably on the same day as heparin**

- **Parenteral anticoagulation can be stopped as soon as the international normalized ratio (INR) has been in the therapeutic range (between 2.0 and 3.0) on 2 consecutive days.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

For VTE and no cancer, as long-term anticoagulant therapy

- **we suggest**
  - dabigatran (Grade 2B) Pradaxa
  - rivaroxaban (Grade 2B) Xarelto
  - apixaban (Grade 2B), or Eliquis
  - edoxaban (Grade 2B) Savaysa
  - over vitamin K antagonist (VKA) therapy,

ROWAN UNIVERSITY
School of Osteopathic Medicine

For VTE and Cancer as long-term anticoagulant therapy

- **we suggest LMWH over VKA (Grade 2B),**
  - dabigatran (Grade 2C)
  - rivaroxaban (Grade 2C)
  - apixaban (Grade 2C), or
  - edoxaban (Grade 2C).

ROWAN UNIVERSITY
School of Osteopathic Medicine

Initial Therapy

- **Initial parenteral anticoagulation is given before dabigatran (Pradaxa) and edoxaban (Savaysa), is not given before rivaroxaban (Xarelto) and apixaban (Eliquis), and is overlapped with VKA therapy.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

First VTE that is an unprovoked proximal DVT of the leg or PE and who have a (i) low or moderate bleeding risk

- **We suggest extended anticoagulant therapy (no scheduled stop date) over 3 months of therapy (Grade 2B),**
- **For high bleeding risk we recommend 3 months of anticoagulant therapy over extended therapy (no scheduled stop date)**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Proximal DVT of the leg or PE provoked by surgery

- **We recommend treatment with anticoagulation for 3 months over (i) treatment of a shorter period (Grade 1B), (ii) treatment of a longer time-limited period (eg, 6, 12, or 24 months) (Grade 1B), or (iii) extended therapy (no scheduled stop date) (Grade 1B).**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Proximal DVT of the leg or PE provoked by a nonsurgical transient risk factor

- **We recommend treatment with anticoagulation for 3 months over (i) treatment of a shorter period (Grade 1B) and (ii) treatment of a longer time-limited period (eg, 6, 12, or 24 months) (Grade 1B).**

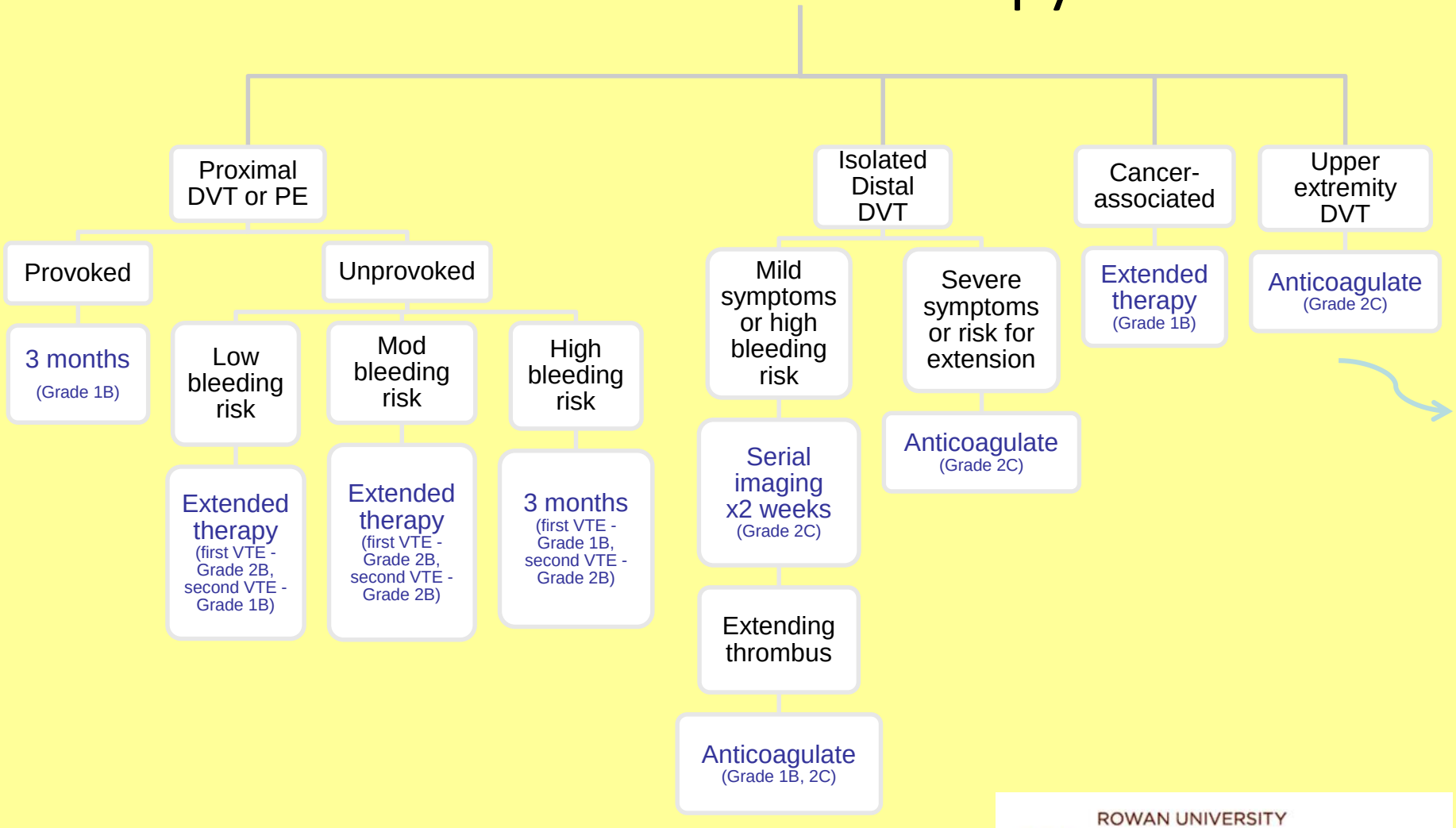
ROWAN UNIVERSITY
School of Osteopathic Medicine

Subsegmental PE

- **In patients with subsegmental PE (no involvement of more proximal pulmonary arteries) and no proximal DVT in the legs who have a (i) low risk for recurrent VTE (see text), we suggest clinical surveillance over anticoagulation (Grade 2C) or (ii) high risk for recurrent VTE (see text), we suggest anticoagulation over clinical surveillance**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Duration of Therapy



ROWAN UNIVERSITY
School of Osteopathic Medicine

Risk Factors for Bleeding on Anticoagulant Therapy

- Age >65
- Age >75
- Previous bleeding
- Cancer
- Metastatic cancer
- Renal failure
- Liver failure
- Thrombocytopenia
- Previous stroke
- Diabetes
- Anemia
- Antiplatelet therapy
- Poor anticoagulant control
- Comorbidity and reduced functional capacity
- Recent surgery
- Frequent falls
- Alcohol abuse
- NSAID use

Low risk	0 risk factors
Moderate risk	1 risk factor
High risk	≥2 risk factors

ROWAN UNIVERSITY
School of Osteopathic Medicine

Outpatient Tx for PE

- **Normotensive patients without serious comorbidity or signs of (right) heart failure belong to a low-risk group which could be treated out of hospital.**

Davies CW, et al. Early discharge of patients with pulmonary embolism: a two-phase observational study. *Eur Respir J* 2007;30:708–714.

Zondag W, et al. Outpatient treatment in patients with acute pulmonary embolism: the Hestia Study. *J Thromb Haemost* 2011;9:1500–1507.

Agterof MJ, et al. Out of hospital treatment of acute pulmonary embolism in patien with a low NT-proBNP level. *J Thromb Haemost* 2010;8:1235–1241.

Outpatient Tx for PE

- **A randomized study reported that low-risk patients as defined by the PE severity index can safely be discharged within 24 h and treated as outpatients.**

Aujesky D, et al. Outpatient versus inpatient treatment for patients with acute pulmonary embolism: an international, open-label, randomised, non-inferiority trial.
***Lancet* 2011;378:41–48.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Other Approved Oral Agents

- **Apixaban (Eliquis)**
  - 10 mg PO BID for 7 days then 5 mg BID
- **Dabigatran (Pradaxa)**
  - 150 mg PO BID
  - 75 mg PO BID for renal disease patients

ROWAN UNIVERSITY
School of Osteopathic Medicine

Other Approved Oral Agents

- **Edoxaban (Savaysa)**
  - 60 mg PO once daily
  - 30 mg PO daily with renal disease

Reverse Dabigatran (Pradaxa)

Possible interventions
▪ Idarucizumab ▪ Activated PCC* (eg, FEIBA) ▪ Antifibrinolytic agent (eg, tranexamic acid, epsilon-aminocaproic acid) ▪ Anticoagulant discontinuation ▪ Oral activated charcoal (if last dose within prior two hours) ▪ Hemodialysis ▪ RBC transfusions if needed for anemia ▪ Platelet transfusions if needed for thrombocytopenia or impaired platelet function (eg, due to aspirin) ▪ Surgical/endoscopic intervention if appropriate

Reverse
Rivaroxaban (Xarelto), apixaban (Eliquis), edoxaban (Lixiana), betrixaban (Bevyxxa)

- Andexanet alfa (AndexXa) **or** a 4-factor unactivated PCC (eg, Kcentra)
- Antifibrinolytic agent (eg, tranexamic acid, epsilon-aminocaproic acid)
- Anticoagulant discontinuation
- Oral activated charcoal (if last dose recent enough)
- RBC transfusions if needed for anemia
- Platelet transfusions if needed for thrombocytopenia or impaired platelet function (eg, due to aspirin)
- Surgical/endoscopic intervention if appropriate

ROWAN UNIVERSITY
School of Osteopathic Medicine

Duration of Anticoagulation

- **Patients who have pulmonary embolism and preexisting irreversible risk factors, such as deficiency of antithrombin III, protein S and C, factor V Leiden mutation, or the presence of antiphospholipid antibodies, should be placed on long-term anticoagulation.**

Thrombolytic Therapy

- Thrombolytic therapy is clearly indicated for hemodynamically unstable patient who lack contraindication
- In only one randomized thrombolysis trial with clinical endpoints, early thrombolytic treatment given to normotensive patients with evidence of RV dysfunction significantly reduced the need for emergency escalation of therapy during the hospital stay

Konstantinides S, et al. Heparin plus alteplase compared with heparin alone in patients with submassive pulmonary embolism. *N Engl J Med* 2002;347:1143–1150.

Thrombolytic Therapy

- Overall, >90% of patients with PE appear to respond favourably to thrombolysis as indicated by clinical and echocardiographic improvement within the first 36 h.
- The greatest benefit is observed when treatment is initiated within 48 h of symptom onset, but thrombolysis can still be useful in patients who have had symptoms for 6–14 days.

Meneveau N, et al. Management of unsuccessful thrombolysis in acute massive pulmonary embolism. *Chest* 2006;129:1043–1050.

Daniels LB, et al. Relation of duration of symptoms with response to thrombolytic therapy in pulmonary embolism. *Am J Cardiol* 1997;80:184–188.

Thrombolytic Therapy for Submassive PE

- **Hemodynamically stable patients usually *DO NOT* *require thrombolytic therapy.***
- ***Occasionally thrombolytic therapy may be considered on case by case basis.***
- ***Cases that might be considered include:***

ROWAN UNIVERSITY
School of Osteopathic Medicine

Indications and potential indications for thrombolytic therapy in venous thromboembolism

Indication
High-risk (massive) PE (ie, presence of hypotension related to PE)*
Potential indication
Patients with severe right ventricular dysfunction due to PE (ie, intermediate risk PE)
Others:
Presence of severe hypoxemia (particularly in those with a contribution from concomitant cardiopulmonary disease)
Patients with acute PE who appear to be decompensating but are not yet hypotensive
Extensive clot burden

* This indication is widely accepted; the other potential indications require careful review of the risks of thrombolytic therapy and potenti

Reduced Dose TPA for Submassive PE

- **QUESTION: Could reduced dose TPA (50 mg over 2 Hrs) expedite the resolution pulmonary hypertension due to “moderate” acute PE without adverse effects?**

  - **Moderate pulmonary embolism treated with thrombolysis (from the "MOPETT" Trial).**
  - ***Sharifi M, Bay C, Skrocki L, Rahimi F, Mehdipour M,“MOPETT”Investigators***
  - ***Am J Cardiol. 2013;111(2):273. Epub 2012 Oct 24.***

ROWAN UNIVERSITY
School of Osteopathic Medicine

MOPETT Trial

- **The purpose of the study was to evaluate the role of "safe dose" thrombolysis in the reduction of pulmonary artery pressure in moderate PE.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

MOPETT Trial

- **During a 22-month period, 121 patients with moderate PE were randomized to receive a "safe dose" of tissue plasminogen activator plus anticoagulation (thrombolysis group [TG], n = 61 patients) or anticoagulation alone (control group [CG], n = 60).**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Varable	TG(N=58)	CG(N=56)	P-value
PH (>40 syst)	9 (16%)	32 (57%)	<0.001
PH and Recurrent PE	9 (16%)	35 (63%)	<0.001

MOPETT Trial Conclusions

- *The results from the prospective randomized trial suggests that "safe dose" thrombolysis is safe and effective in the treatment of moderate PE, with a significant immediate reduction in the pulmonary artery pressure that was maintained at 28 months.*

ROWAN UNIVERSITY
School of Osteopathic Medicine

Bolus Injections of Thrombolytics

- **Bolus injections of ofthrombolytics may be effective without excessive bleeding complications.**

- **PROBLEM: most bolus regimens have not been directly compared to routine 100 mg TPA over two hours.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Bolus Injections of Thrombolytics

- **An important exception re bolus thrombolytics is for cardiac arrest or impending arrest due to PE.**

- **It is faster and more practical to administer 50mg of TPA IV over two minutes and repeat after 15 minutes if no adequate response is obtained.**

ROWAN UNIVERSITY
School of Osteopathic Medicine

Thrombolysis for pulmonary embolism

Agents and regimens	
Streptokinase[a]	
250 000 U as a loading dose over 30 min, followed by 100 000 U/h over 12–24 h	
Accelerated regimen: 1.5 million IU over 2 h[b]	
Urokinase[a,c]	
4400 U per kg of body weight as a loading dose over 10 min, followed by 4400 U/kg/h over 12–24 h	
Accelerated regimen: 3 million U over 2 h[b]	
Alteplase[a]	
100 mg over 2 h[d]	
Accelerated regimen: 0.6 mg/kg for 15 min	
Reteplase[a,e]	
Two bolus injections of 10 U 30 min apart	
Tenecteplase[f]	
30–50 mg bolus for 5–10 s adjusted for body weight	
<60 kg	30 mg
≥60 to <70 kg	35 mg
≥70 to <80 kg	40 mg
≥80 to <90 kg	45 mg
≥90 kg	50 mg

Contraindications
Absolute
History of haemorrhagic stroke or stroke of unknown origin
Ischaemic stroke in previous 6 months
Central nervous system neoplasms
Major trauma, surgery, or head injury in previous 3 weeks
Relative
Transient ischaemic attack in previous 6 months
Oral anticoagulation
Pregnancy or first postpartum week
Non-compressible puncture sites
Traumatic resuscitation
Refractory hypertension (systolic blood pressure >180 mmHg)
Advanced liver disease
Infective endocarditis
Active peptic ulcer

Indications for Vena Caval Interruption

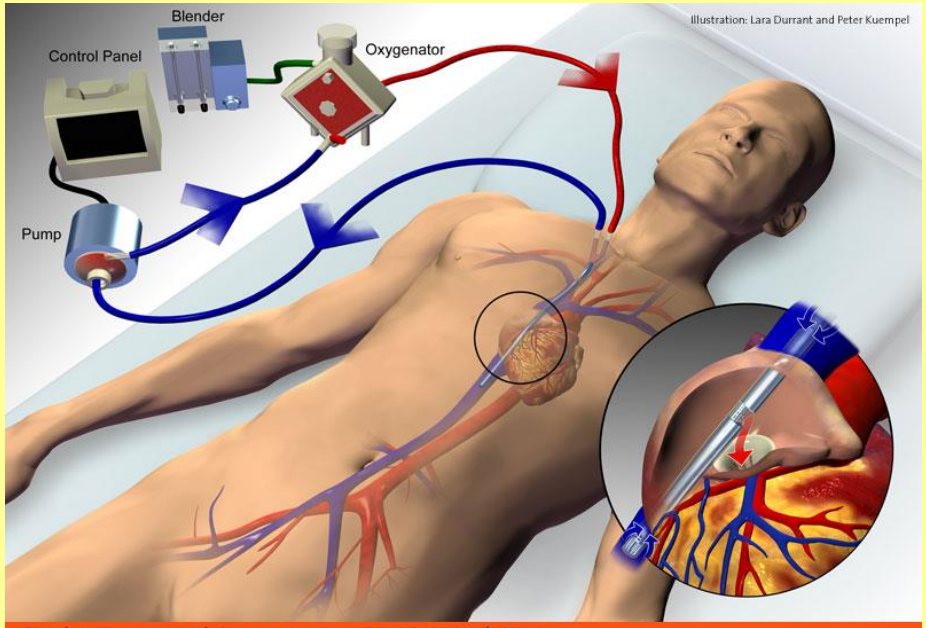
1. **Contraindication to anticoagulation**
2. **Recurrent emboli on adequate Tx**
3. **Serious bleeding on anticoagulation**
4. **Massive pulmonary embolism**
5. **Psychosocial reasons**

In patients with acute DVT or PE who are treated with anticoagulants, we recommend against the use of an inferior vena cava (IVC) filter

ROWAN UNIVERSITY
School of Osteopathic Medicine

Surgical Treatment

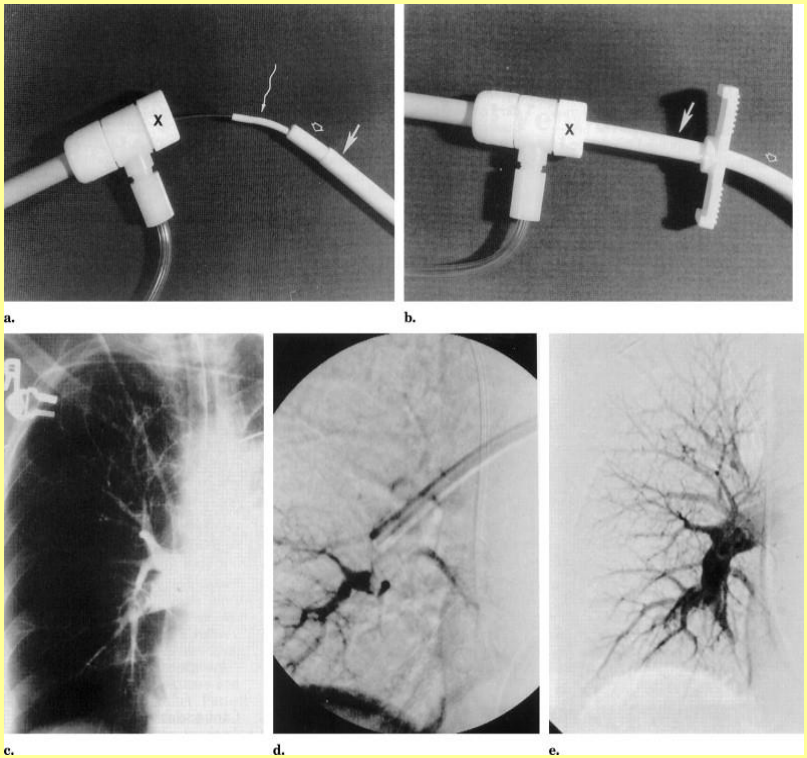
- Pulmonary embolectomy is a recommended therapeutic option in patients with high-risk PE in whom there are absolute contraindications to thrombolysis, or if thrombolysis has failed.[5,53]
- Recent technical advances in transportable extracorporeal assist systems, and particularly the timely early involvement of the cardiac surgeon as part of an interdisciplinary approach to high-risk PE before haemodynamic collapse, have contributed to improved postoperative outcomes and case fatality rates as low as 23%.[58]



Single-site approach to venovenous ECMO cannulation:
A dual-lumen cannula is inserted in the internal jugular vein (extending through the right atrium and into the inferior vena cava). Venous blood is withdrawn through one "drainage" lumen with ports in both the superior and inferior vena cava. Reinfusion of oxygenated blood occurs through the second lumen, with a port situated in the right atrium. Inset: The two ports of the "drainage" lumen are situated in the superior and inferior vena cavae, distant from the reinfusion port. The reinfusion port is positioned so that oxygenated blood is directed across the tricuspid valve and directly into the right ventricle. This arrangement significantly reduces recirculation of blood when the cannula is properly positioned.

ROWAN UNIVERSITY
School of Osteopathic Medicine

Interventional Treatment



In case of absolute contraindications to thrombolysis:

thrombus fragmentation

rheolytic thrombectomy

suction thrombectomy

rotational

Catheter-Directed Embolectomy, Fragmentation, and Thrombolysis for the Treatment of Massive Pulmonary Embolism After Failure of Systemic Thrombolysis*

CHEST. 2008;134(2):250-254. doi:10.1378/chest.07-2846

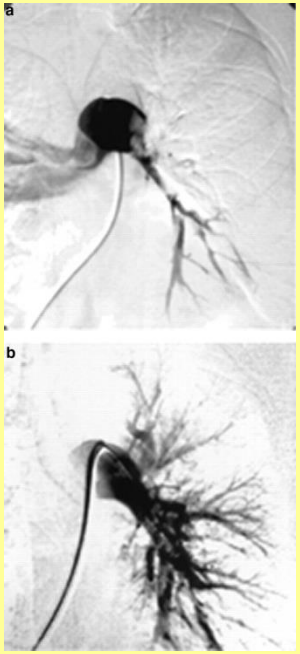


Figure Legend:

A 57-year-old woman presented in extremis from massive bilateral PE. The patient was referred to the Interventional Radiology Department when there was no response to IV infusion of 100 mg of tPA. Both lungs were treated emergently with CDI, including 20 mg of local TNK. Pulmonary angiograms of the left lung, before and after CDI, are shown. Top, a: left pulmonary angiogram demonstrates a persistent massive PE, despite treatment with systemic TPA, and flow into the left lung is severely compromised. Bottom, b: following CDI, left lung perfusion is improved. Similar maneuvers were performed in the right lung (not shown) with good results and resolution of shock. Reproduced with permission from Sze et al.[13]

ROWAN UNIVERSITY
School of Osteopathic Medicine