MHIF FEATURED STUDY:

AKI

Coming soon:
Please Refer Patients!

CONDITION:	PI:	RESEARCH CONTACT:	SPONSOR:
Preventing AKI post OHS	Dr. Shukrallah	Steph Ebnet Stephanie.ebnet@allina.com | 612-863-6286	**Astellas Pharma Inc. (API)**

DESCRIPTION: To evaluate the efficacy of postsurgery treatment with ASP1128 (investigational medication) in subjects at risk for acute kidney injury (AKI) following coronary artery bypass graft (CABG) and/or valve surgery. ASP1128 is a potent and highly selective PPARδ modulator, that is believed to have protective effects on kidney cells that are under cellular stress as a result of ischemia, inflammation and oxidative stress following coronary artery bypass graft and/or valve (CABG/V) surgery. In addition, ASP1128 will reduce inflammatory responses and increased oxidative stress systemically which is expected to reduce the immediate consequences of stress responses following CABG/V surgery.

CRITERIA LIST/ QUALIFICATIONS:

Inclusion

- Subject undergoing non-emergent open chest cardiovascular surgery with use of CPB (i.e., CABG and/or valve surgery [including aortic root and ascending aorta surgery, without circulatory arrest])
- Subject has moderate/high risk of developing AKI following surgery (must have 2 risk factors):
  - Risk factors: age > 70, eGFR < 60, CHF, DM, proteinuria/albuminuria

Exclusion

- On another investigational medication
- GFR < 30
- Prior kidney transplant
- Known or suspected glomerulopephritis
- Endocarditis or active infection
- Surgery off pump
- IV Drug abuse
- Chronic liver disorder
- LVAD

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Minneapolis Heart Institute Foundation®
Creating a world without heart and vascular disease

PULMONARY ARTERY EMBOLISMS

Benjamin Sun, MD
Abbott Northwestern Hospital

History

- Giovanni Battista Morgagni
  - (25 February 1682 – 6 December 1771)
  - Italian Anatomist
  - 'Father of modern pathology'
  - Identified the presence of large clots in the pulmonary arteries found at autopsy in patients who had died suddenly
  - "Where is the disease?"

History

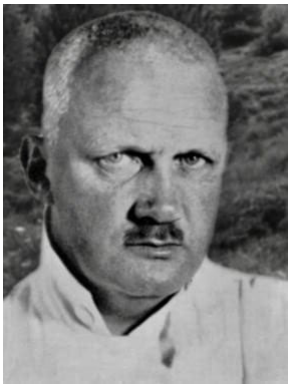
- Rudolph Virchow
  - (13 October 1821 – 5 September 1902)
  - German physician, pathologist
  - Studying Jean Cruveilhier's doctrine
    - "That the essence of inflammation is coagulation of the blood in the veins in the capillaries" i.e phlebitis.
  - 1859: "[T]he detachment of larger or smaller fragments from the end of the softening thrombus which are carried along by the current of blood and driven into remote vessels. This gives rise to the very frequent process on which I have bestowed the name of Embolia."
  - Virchow's Triad
    - Blood stasis
    - Endothelial injury
    - Hypercoagulability

History

- Friedrich Trendelenburg
  - (24 May 1844 – 15 December 1924)
  - German Surgeon
  - Identified the acute mortality of this disease in 9 patients, Leipzig Germany.
  - "Perfected a surgical procedure in a calf using a left parasternal thoracotomy through which the pulmonary artery was opened and the embolus was removed"
  - He treated two patients with this procedure but unfortunately both patients died

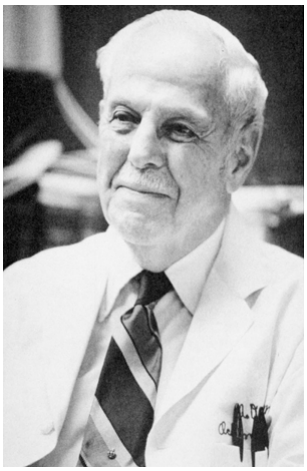
History

- Martin Kirschner
  - (28 October 1879 – 30 August 1942)
  - German Surgeon
    - Student of Trendelenburg
  - March 18, 1924, performed the first successful pulmonary artery embolectomy after a routine hernia operation
  - "Trendelenburg Operation"



History

- Alton Ochsner, Sr.
  - (May 4, 1896 – September 24, 1981)
  - US Thoracic Surgeon
  - Started the Ochsner Clinic
  - Was present at the meeting where Dr. Kirshner presented the Trendelenburg operation.
  - Due to very poor outcomes with only 10 survivors over 300 procedures, he advocated for prophylactic approaches
    - Wrapping the legs
    - Early ambulation
    - Electrical stimulation of calf muscles
    - Head down position
    - Anticoagulation
    - Ligation of the inferior vena cava to prevent pulmonary embolism



Types

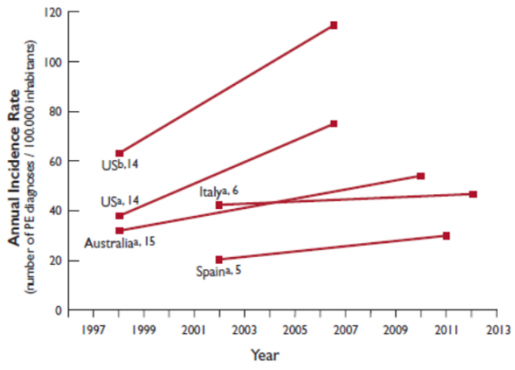
- Infectious
- Occult
- Sub segmental
- Sub Massive
- Massive

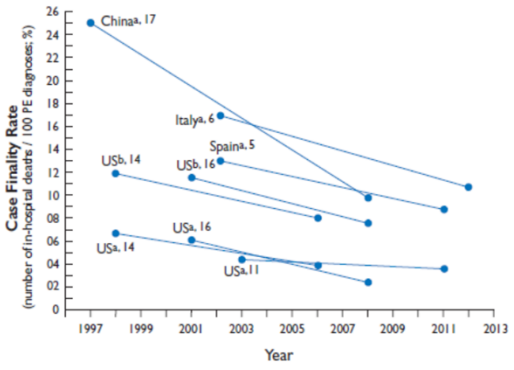
Risk Factors

- Age
- Obesity
- Immobility
  - Air travel
  - Post procedural
  - Orthopedics
- Trauma
  - Orthopedic
  - Vascular
- Hypercoagulability
  - Dehydration
  - Malignancy
  - Oral contraceptives
  - Tobacco use

Incidence

- DVT
  - 53-162 per 100,000 population
- PE
  - 39-115 per 100,000 population
  - Est 300,000 deaths in U.S per year





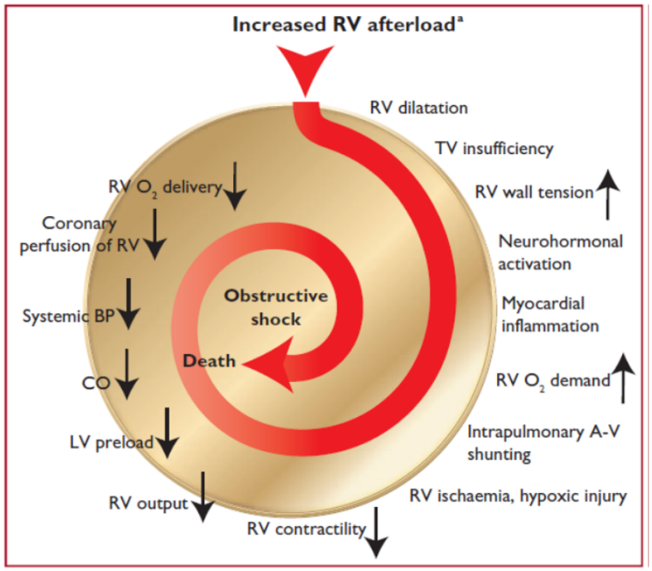
Predisposing Factors

Strong risk factors (OR > 10)
Fracture of lower limb
Hospitalization for heart failure or atrial fibrillation/flutter (within previous 3 months)
Hip or knee replacement
Major trauma
Myocardial infarction (within previous 3 months)
Previous VTE
Spinal cord injury
Weak risk factors (OR < 2)
Bed rest >3 days
Diabetes mellitus
Arterial hypertension
Immobility due to sitting (e.g. prolonged car or air travel)
Increasing age
Laparoscopic surgery (e.g. cholecystectomy)
Obesity
Pregnancy
Varicose veins

Moderate risk factors (OR 2–9)
Arthroscopic knee surgery
Autoimmune diseases
Blood transfusion
Central venous lines
Intravenous catheters and leads
Chemotherapy
Congestive heart failure or respiratory failure
Erythropoiesis-stimulating agents
Hormone replacement therapy (depends on formulation)
In vitro fertilization
Oral contraceptive therapy
Post-partum period
Infection (specifically pneumonia, urinary tract infection, and HIV)
Inflammatory bowel disease
Cancer (highest risk in metastatic disease)
Paralytic stroke
Superficial vein thrombosis
Thrombophilia

Pathophysiology of PE

- Acute PE interferes with both circulation and gas exchange
- Right ventricular failure due to acute pressure overload is the primary cause of death in severe PE
- A nonpreconditioned thin-walled RV is generally unable to generate a mean PAP>40 mmHg
- Anatomical obstruction and hypoxic vasoconstriction in the affected lung area leads to an increase in PVR
- PE-induced vasoconstriction, mediated by thromboxane A2 and serotonin release contributes to additional increase in pulmonary vascular resistance
- RV strain and systemic hypotension can result in elevated cardiac biomarkers and systemic epinephrine levels



Presentation

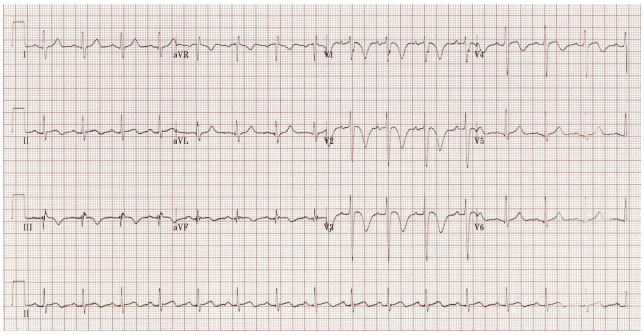
- Acute pleuritic chest pain
- Acute shortness of breath
- Concomitant syncope
- Hemoptysis
- Shock
- Cardiac arrest

Differential Diagnosis

- Acute coronary syndrome
- Arrythmia
- Acute dissection
- Pneumonia
- Pleurisy
- Pericarditis
- Diaphragmatic hernia
- Achalasia
- Esophageal Spasm

Diagnostics

- Vitals
  - HR: usually tachycardic
  - BP: usually lower
  - O_2Sat: usually lower
- Physical Exam
  - May or may not have a history or ongoing swelling in a lower extremity
  - Upper extremity thrombus rarely leads to clinically significant PE
  - Isolated calf DVT rarely leads to clinically significant PE
  - Often does not have pleuritic chest pain
  - Anxious
- EKG:
  - Inversion of T waves in V1-V4
  - Right bundle branch block
  - New onset atrial fibrillation
  - Often is non diagnostic
- ECHO
- CT Scan
  - Timing of dye infusion
  - Pulmonary artery
  - Aorta



The revised Geneva clinical prediction rule for PE

Items	Clinical decision rule points	
	Original version[91]	Simplified version[87]
Previous PE or DVT	3	1
Heart rate		
75–94 b.p.m.	3	1
≥95 b.p.m.	5	2
Surgery or fracture within the past month	2	1
Haemoptysis	2	1
Active cancer	2	1
Unilateral lower-limb pain	3	1
Pain on lower-limb deep venous palpation and unilateral oedema	4	1
Age >65 years	1	1
Clinical probability		
Three-level score		
Low	0–3	0–1
Intermediate	4–10	2–4
High	≥11	≥5
Two-level score		
PE-unlikely	0–5	0–2
PE-likely	≥6	≥3

b.p.m. = beats per minute; DVT = deep vein thrombosis; PE = pulmonary embolism.

The Wells Clinical Prediction Rule for PE

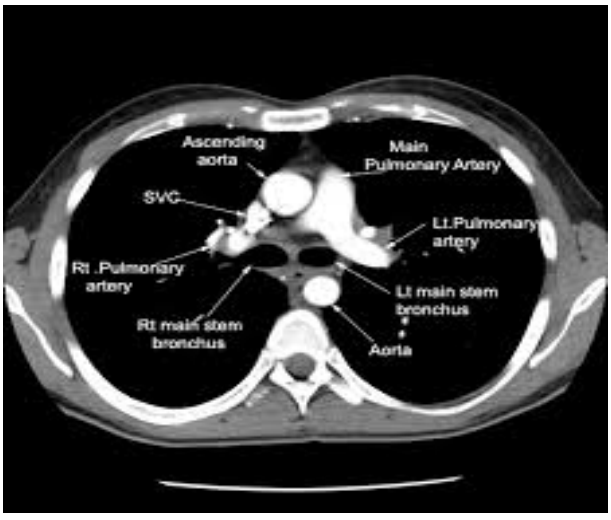
Items	Clinical decision rule points	
	Original version[1]	Simplified version[2]
Previous PE or DVT	1.5	1
Heart rate >100 b.p.m.	1.5	1
Surgery or immobilization within the past 4 weeks	1.5	1
Haemoptysis	1	1
Active cancer	1	1
Clinical signs of DVT	3	1
Alterative diagnosis less likely than PE	3	1
Clinical probability		
Three-level score		
Low	0–1	N/A
Intermediate	2–6	N/A
High	≥7	N/A
Two-level score		
PE unlikely	0–4	0–1
PE likely	≥5	≥2

b.p.m. = beats per minute; DVT = deep vein thrombosis; N/A = not applicable; PE = pulmonary embolism.

Imaging tests for diagnosis of pulmonary embolism

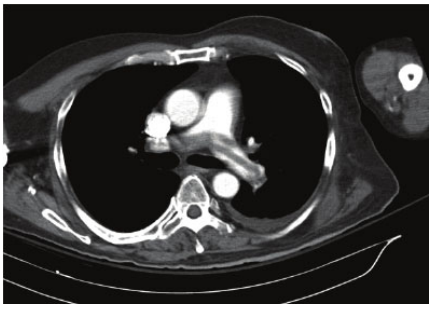
	Strengths	Weaknesses/limitations	Radiation issues[a]
CTPA	• Readily available around the clock in most centres • Excellent accuracy • Strong validation in prospective management outcome studies • Low rate of inconclusive results (3–5%) • May provide alternative diagnosis if PE excluded • Short acquisition time	• Radiation exposure • Exposure to iodine contrast: ○ limited use in iodine allergy and hyperthyroidism ○ risks in pregnant and breastfeeding women ○ contraindicated in severe renal failure • Tendency to overuse because of easy accessibility • Clinical relevance of CTPA diagnosis of subsegmental PE unknown	• Radiation effective dose 3–10 mSv[b] • Significant radiation exposure to young female breast tissue
Planar V/Q scan	• Almost no contraindications • Relatively inexpensive • Strong validation in prospective management outcome studies	• Not readily available in all centres • Interobserver variability in interpretation • Results reported as likelihood ratios • Inconclusive in 50% of cases • Cannot provide alternative diagnosis if PE excluded	• Lower radiation than CTPA, effective dose ~2 mSv[b]
V/Q SPECT	• Almost no contraindications • Lowest rate of non-diagnostic tests (<3%) • High accuracy according to available data • Binary interpretation ('PE' vs. 'no PE')	• Variability of techniques • Variability of diagnostic criteria • Cannot provide alternative diagnosis if PE excluded • No validation in prospective management outcome studies	• Lower radiation than CTPA, effective dose ~2 mSv[b]
Pulmonary angiography	• Historical gold standard	• Invasive procedure • Not readily available in all centres	• Highest radiation, effective dose 10–20 mSv[b]

CT Chest Anatomy

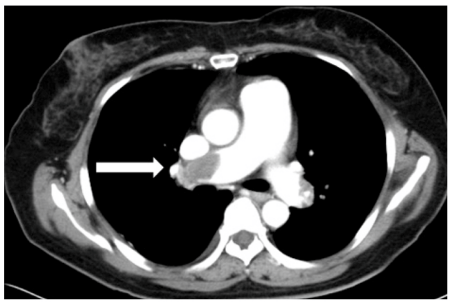


Pulmonary Embolisms

Saddle

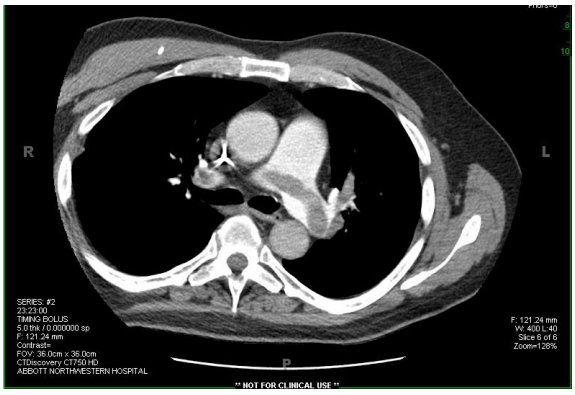


Right Side

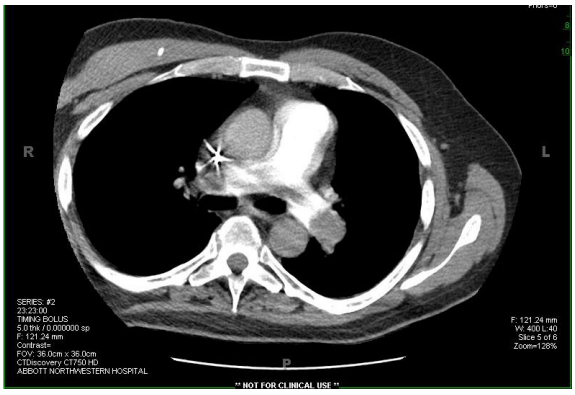


Patient

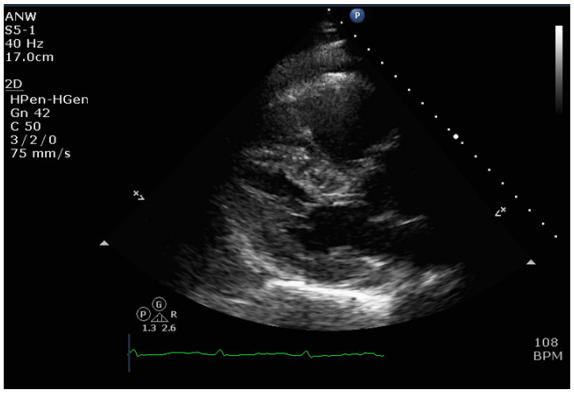
Saddle

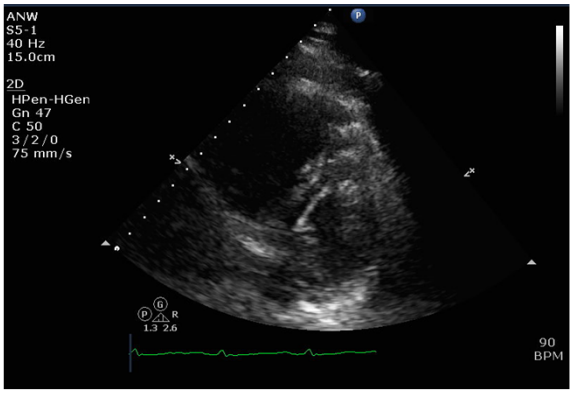


Left PA



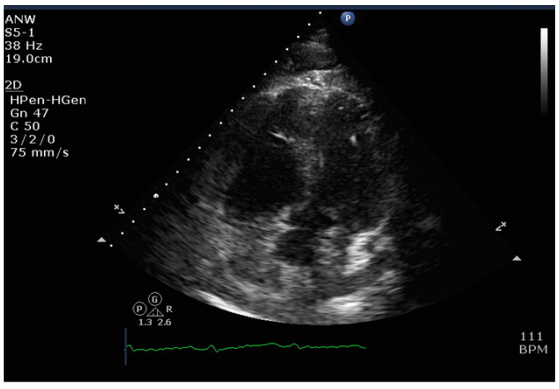
ECHO



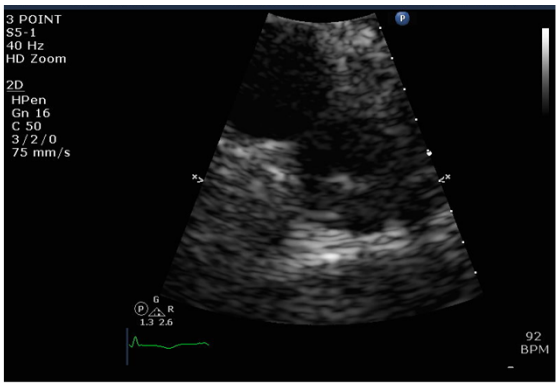


ECHO

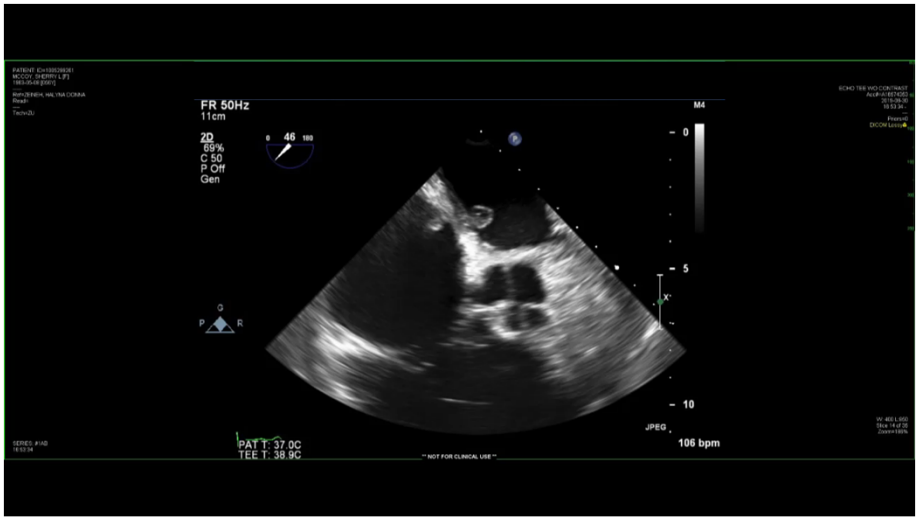
McConnell's Sign



Clot in IVC



Clot in transit



Pulmonary Embolism Severity Index

Parameter	Original version[226]	Simplified version[229]
Age	Age in years	1 point (if age >80 years)
Male sex	+10 points	–
Cancer	+30 points	1 point
Chronic heart failure	+10 points	1 point
Chronic pulmonary disease	+10 points	
Pulse rate ≥110 b.p.m.	+20 points	1 point
Systolic BP <100 mmHg	+30 points	1 point
Respiratory rate >30 breaths per min	+20 points	–
Temperature <36°C	+20 points	–
Altered mental status	+60 points	–
Arterial oxyhaemoglobin saturation <90%	+20 points	1 point

	Risk strata[a]	
	Class I: ≤65 points very low 30 day mortality risk (0–1.6%) **Class II: 66–85 points** low mortality risk (1.7–3.5%)	**0 points** = 30 day mortality risk 1.0% (95% CI 0.0–2.1%)
	Class III: 86–105 points moderate mortality risk (3.2–7.1%) **Class IV: 106–125 points** high mortality risk (4.0–11.4%) **Class V: >125 points** very high mortality risk (10.0–24.5%)	**≥1 point(s)** = 30 day mortality risk 10.9% (95% CI 8.5–13.2%)

Classification of pulmonary embolism severity and the risk of early (in-hospital or 30 day) death

Early mortality risk		Indicators of risk			
		Haemodynamic instability[a]	Clinical parameters of PE severity and/or comorbidity: PESI class III–V or sPESI ≥I	RV dysfunction on TTE or CTPA[b]	Elevated cardiac troponin levels[c]
High		+	(+)[d]	+	(+)
Intermediate	Intermediate–high	-	+[e]	+	+
	Intermediate–low	-	+[e]	One (or none) positive	
Low		-	-	-	Assesment optional; if assessed, negative

Clinical Classifications of PE

Sub Massive

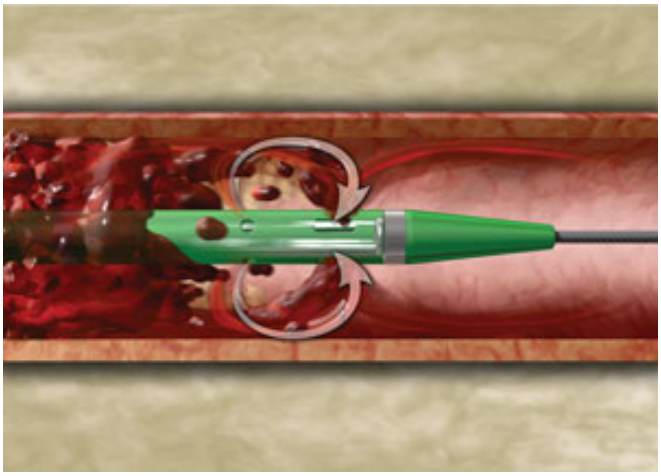
- Acute PE without systemic hypotension
  - (systolic blood pressure >90 mm Hg)
- With either RV dysfunction or myocardial necrosis
- RV dysfunction means the presence of at least 1 of the following:
  - —RV dilation (apical 4-chamber RV diameter divided by LV diameter >0.9) or RV systolic dysfunction on echocardiography
  - —RV dilation (4-chamber RV diameter divided by LV diameter >0.9) on CT
  - —Elevation of BNP (>90 pg/mL)
  - —Elevation of N-terminal pro-BNP (>500 pg/mL); or
  - —Electrocardiographic changes (new complete or incomplete right bundle-branch block, anteroseptal ST elevation or depression, or anteroseptal T-wave inversion)
- Myocardial necrosis is defined as either of the following:
  - —Elevation of troponin I (>0.4 ng/mL) or
  - —Elevation of troponin T (>0.1 ng/mL)

Massive

- Acute PE with sustained hypotension
  - (systolic blood pressure <90 mm Hg for at least 15 minutes
- Requiring inotropes
- Pulselessness
- Persistent profound bradycardia
  - (heart rate <40 bpm with signs or symptoms of shock).

Therapeutic Options

- Resuscitation
  - ECMO
- Anticoagulation
- Thrombolytics
- Percutaneous catheter-directed treatment
- Surgery



Treatment Approach

- Clot Burden
- Location
  - Central
  - Peripheral
- Hemodynamic Stability
  - RV strain
  - Hypoxia (intubation)
  - Inotropes
  - ECMO
- Ability to tolerate thrombolytics
  - Recent surgery
  - Recent bleeding
- What options are available
  - Catheter based
  - Surgery

Thrombolytic regimens, doses, and contraindications

Molecule	Regimen	Contraindications to fibrinolysis
rtPA	100 mg over 2 h	**Absolute**
	0.6 mg/kg over 15 min (maximum dose 50 mg)[a]	History of haemorrhagic stroke or stroke of unknown origin
Streptokinase	250 000 IU as a loading dose over 30 min, followed by 100 000 IU/h over 12–24 h	Ischaemic stroke in previous 6 months
	Accelerated regimen: 1.5 million IU over 2 h	Central nervous system neoplasm
Urokinase	4400 IU/kg as a loading dose over 10 min, followed by 4400 IU/kg/h over 12–24 h	Major trauma, surgery, or head injury in previous 3 weeks
	Accelerated regimen: 3 million IU over 2 h	Bleeding diathesis
		Active bleeding
		Relative
		Transient ischaemic attack in previous 6 months
		Oral anticoagulation
		Pregnancy or first post-partum week
		Non-compressible puncture sites
		Traumatic resuscitation
		Refractory hypertension (systolic BP >180 mmHg)
		Advanced liver disease
		Infective endocarditis
		Active peptic ulcer

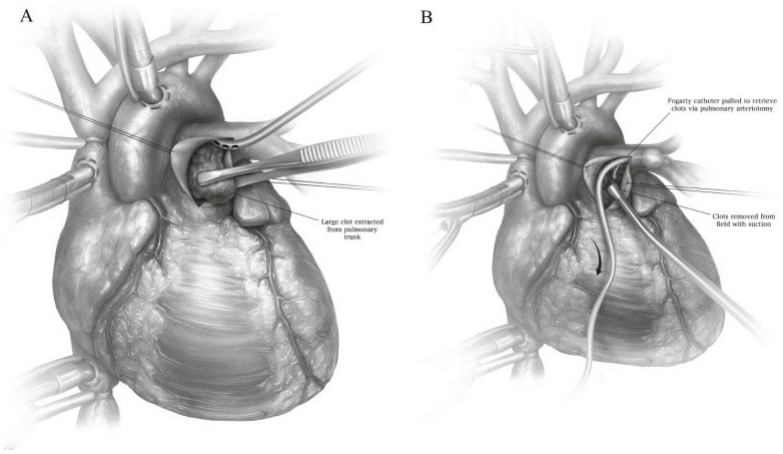
- 9.9 % risk of severe bleeding
- 1.7% of cerebral hemorrhage

Percutaneous catheter-directed treatment

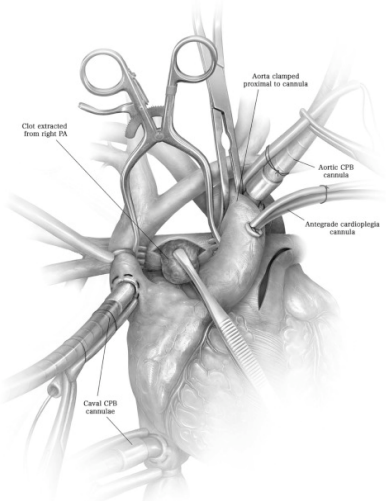
- Some encouraging results but mostly case series
- Survival to hospital discharge up to 87%
- One randomized to thrombolytics in intermediate-risk PE

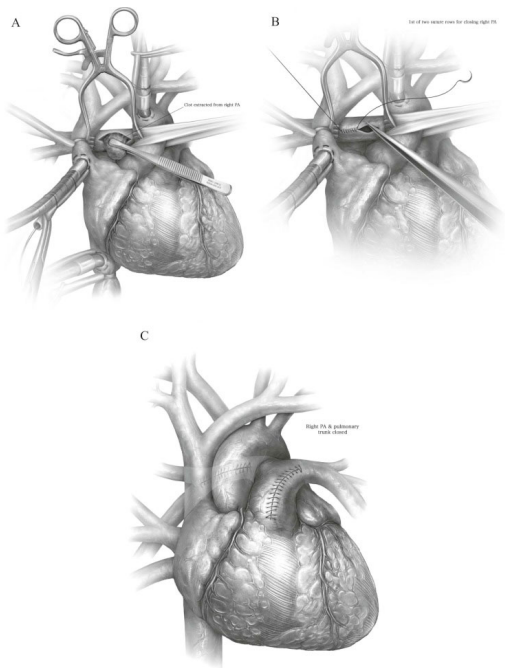
Catheter interventions with thrombolysis		Catheter interventions without thrombolysis	
Technique	**Device examples**	**Technique**	**Device examples**
Catheter-directed thrombolysis	UniFuse® (AngioDynamics, Latham, NY) Cragg-McNamara® (ev3 Endovascular, Plymouth, MN) 4–5 F infusion catheters, with 10–20 cm infusion length	Aspiration thrombectomy	Aspirex® 8 F or 10 F catheter (Straub Medical, Switzerland): rotational thrombectomy[a]
			Angiovac suction cannula® (AngioDynamics, Latham, NY): veno-venous bypass system, with 26 F access for inflow and 16–20 F access for outflow
			Indigo® Mechanical Thrombectomy System (Penumbra, Alameda, CA): 8 F vacuum-assisted aspiration with mechanical clot engagement
			Sheath with detachable haemostatic valve 8–9 F (Argon Medical Devices, Athens, TX), multi-purpose guide catheter (8–9 F), aspiration syringe (60 mL)
Ultrasound-assisted catheter-directed thrombolysis	EkoSonic 5.2® F 12 cm treatment zone device (EKOS, Bothell, WA)	Mechanical thrombectomy	Flowtriever® (Inari Medical, Irvine, CA): 20 F device with three self-expanding nitinol discs entrapping the thrombus with simultaneous aspiration
Rheolytic thrombectomy plus catheter-directed thrombolysis	AngioJet 6 F PE® thrombectomy with Power Pulse™ thrombolysis (Boston Scientific, Minneapolis, MN)[a]	Rheolytic thrombectomy	AngioJet 6 F PE® catheter (Boston Scientific, Minneapolis, MN)[a]
Combined techniques	For example, pigtail fragmentation (5 F) plus AngioJet 6 F PE® thrombectomy with Power Pulse™ thrombolysis	Thrombus fragmentation	Pigtail catheter (5–6 F) or peripheral balloon catheters (6–7 F, balloon diameter 5–10 mm)
		Combined techniques	Pigtail fragmentation (5 F) plus thrombectomy with Aspirex® 8/10 F

Surgical Embolectomy



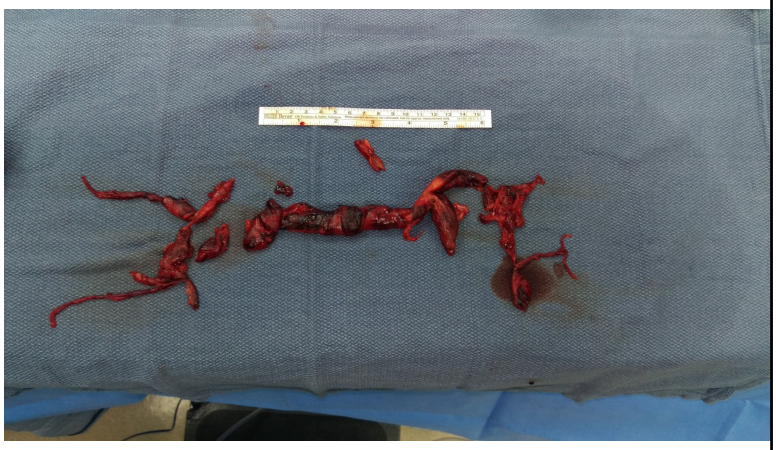
Surgical Embolectomy





Surgery

- Sternotomy
- Cardiopulmonary Bypass
- Warm and beating
- Open the PA and extract the clot



Survival and recurrence after acute pulmonary embolism treated with pulmonary embolectomy or thrombolysis in New York State, 1999 to 2013

Timothy Lee, BS,[a] Shinobu Itagaki, MD, MS,[a] Yuting P. Chiang, MD, MS,[b] Natalia N. Egorova, PhD,[c] David H. Adams, MD,[a] and Joanna Chikwe, MD[a,d]

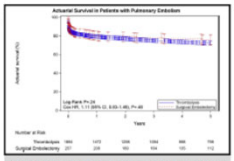
ABSTRACT

Background: Pulmonary embolism (PE) results in more than 250,000 hospitalizations annually in the United States, with high mortality. Outcome data are limited, and reperfusion strategies remain controversial. Here we evaluated the outcomes of thrombolysis and surgical embolectomy in patients with acute PE using a statewide database.

Methods: Among 174,322 patients hospitalized with PE in New York State between 1999 and 2013, we performed a retrospective comparison of 2111 adults with acute PE who underwent either thrombolysis (n = 1854; 88%) or surgical embolectomy (n = 257; 12%) as first-line therapy. Patients were identified using a mandatory database. The median follow-up was 4.2 years (range, 0-16.3 years). The primary study endpoint was all-cause mortality; secondary outcomes included recurrent PE, recurrent deep vein thrombosis, reintervention, and stroke.

Results: In 2111 patients who underwent reperfusion, there was no difference in 30-day mortality between those who underwent thrombolysis and those who underwent surgical embolectomy (15.2% vs 13.2%; odds ratio [OR], 1.12, 95% confidence interval [CI], 0.72-1.73). Thrombolysis was associated with higher risk of stroke (1.9% vs 0.8%; OR, 4.70; 95% CI, 1.08-20.42) and reintervention (3.8% vs 1.2%; OR, 7.16; 95% CI, 2.17-23.62) at 30 days. Five-year actuarial survival was similar in the 2 groups (72.4% [95% CI, 70.3%-74.5%] vs 76.1% [95% CI, 70.2%-81.0%]; hazard ratio (HR) for death, 1.11; 95% CI, 0.83-1.49). Thrombolysis was associated with a higher rate of recurrent PE necessitating inpatient readmission (7.9% [95% CI, 6.9%-9.4%] vs 2.8% [95% CI, 1.1%-5.8%]; HR, 3.38; 95% CI, 1.48-7.73).

Conclusions: Pulmonary embolectomy and thrombolysis are associated with similar early and long-term survival, supporting guideline recommendations for embolectomy when thrombolysis is contraindicated. (J Thorac Cardiovasc Surg 2018;155:1084-90)



Actuarial survival after thrombolysis or surgical embolectomy in New York State, 1999 to 2013.

Central Message

Pulmonary embolectomy is associated with similar early and long-term survival compared to thrombolysis, supporting guideline recommendations for embolectomy when thrombolysis is contraindicated.

Perspective

Pulmonary embolism results in more than 250,000 hospitalizations annually in the United States, with high mortality. Outcome data are limited, and choice of reperfusion strategy remains controversial. We provide the first multicenter data evaluating early and long-term outcomes after pulmonary embolectomy and thrombolysis.

See Editorial Commentaries pages 1091 and 1093.

See Editorial page 1080.

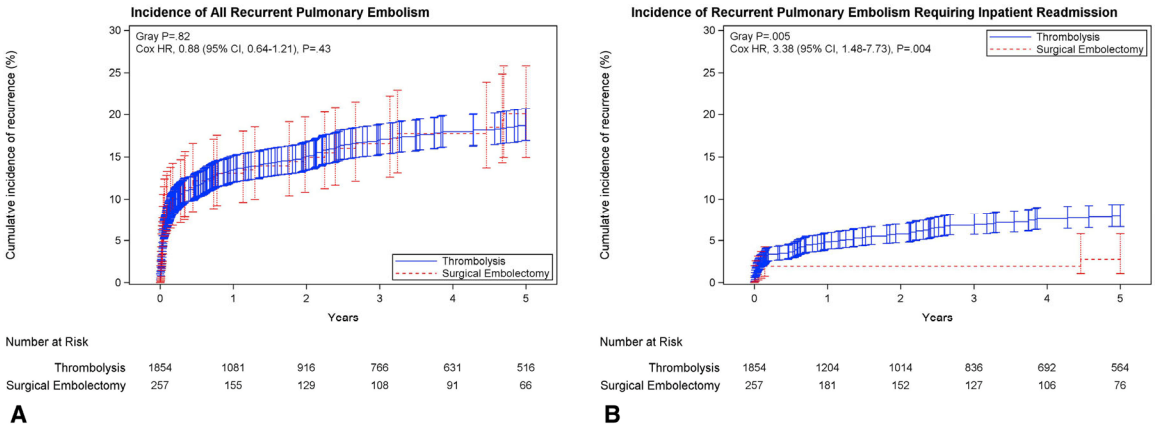
Surgery vs Thrombolysis 30 day Outcomes

Outcome	Thrombolysis (n = 1854), n (%)	Surgery (n = 257), n (%)	OR (95% CI)*	*P* value
Mortality	282 (15.2)	34 (13.2)	1.12 (0.72-1.73)	.62
Recurrent pulmonary embolism	137 (7.4)	22 (8.6)	0.99 (0.61-1.61)	.97
Recurrent pulmonary embolism necessitating inpatient readmission	46 (2.5)	3 (1.2)	1.20 (0.81-1.76)	.37
Recurrent deep vein thrombosis	73 (4.9)	12 (4.7)	1.03 (0.53-1.99)	.93
Reoperation or reintervention†	71 (3.8)	3 (1.2)	7.16 (2.17-23.62)	.001
Stroke	35 (1.9)	2 (0.8)	4.70 (1.08-20.42)	.039
Major bleed	67 (3.6)	23 (9.0)	0.53 (0.31-0.92)	.024
Blood transfusion	225 (12.1)	51 (19.8)	0.73 (0.49-1.07)	.11

OR, Odds ratio; *CI*, confidence interval. *Adjusted using logistic regression analysis, with all patient demographics and baseline characteristics entered as covariates into initial model, and covariates in the final model determined via stepwise selection with $P = .25$ for entry into the model and $P = .15$ to stay in the model. †Reoperation or reintervention

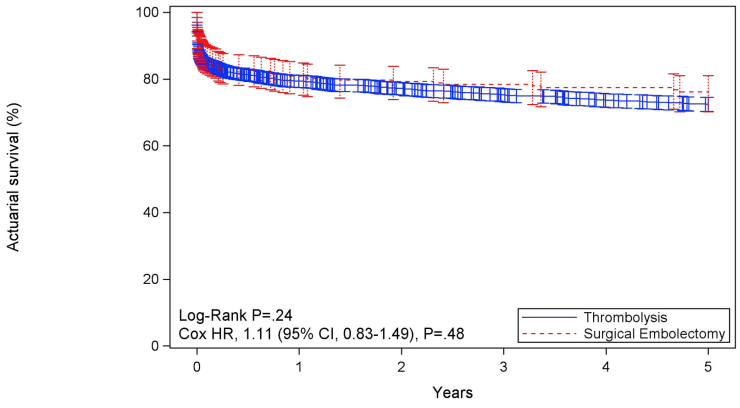
Figure 2

Surgery vs Thrombolysis Recurrent PE



The Journal of Thoracic and Cardiovascular Surgery 2018 155, 1084-1090.e12DOI: (10.1016/j.jtcvs.2017.07.074)

Surgery vs Thrombolysis Survival



Number at Risk

Thrombolysis	1854	1472	1298	1094	956	795
Surgical Embolectomy	257	208	189	164	135	112

The Journal of Thoracic and Cardiovascular Surgery 2018 155, 1084-1090.e12DOI: (10.1016/j.jtcvs.2017.07.074)

Surgical pulmonary embolectomy and catheter-based therapies for acute pulmonary embolism: A contemporary systematic review

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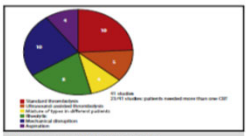
ABSTRACT

Objectives: Mortality in acute pulmonary embolism (PE) is believed to be principally due to the subgroup of PEs that are massive. Systemic thrombolysis is the therapeutic mainstay for acute massive PE, despite evidence suggesting limited survival benefits. Both catheter-based therapies (CBT) and surgical pulmonary embolectomy (SE) are well-accepted alternatives to treat acute PE. However, the comparative effectiveness of these approaches is difficult to study. We conducted a systematic review of CBT and SE for acute PE.

Methods: The PubMed database was queried for CBT- and SE-related publications between January 1998 and June 2017. A minimum of 10 patients undergoing intervention(s) was required for inclusion, and studies must not have excluded patients with massive PE. End points examined included hospital mortality, and additionally for CBT, procedural success rate.

Results: A total of 75 studies (41 of CBT, 34 of SE) were identified, with 1650 patients undergoing CBT and 1101 undergoing SE. Patients undergoing SE were more critically ill than those undergoing CBT (massive PE, 545 out of 975 [55.9%] for SE vs 742 out of 1553 [47.8%] for CBT). Cardiopulmonary resuscitation (CPR) was required in 217 out of 1015 patients undergoing SE (21.4%) versus 38 out of 983 patients undergoing CBT (4.0%). The hospital mortality of SE was 14.0%, versus 5.6% for CBT, in the entire patient group. However, the hospital mortality of SE in patients with pre-SE CPR was 46.3%, whereas it was 6.8% in those patients without pre-SE CPR. Although CPR was associated with an increased risk of mortality both for CBT and SE, it accounted for all of the mortality effect on SE (the adjusted odds ratio for CPR in a random effects model with treatment considered was 9.79 (95% confidence interval, 4.98-19.17; $P < .0001$). The adjusted odds ratio for mortality for SE relative to CBT was 1.36 (95% confidence interval, 0.80-2.32; $P = .84$). Moreover, CBT was associated with a procedural failure rate of 8.3%.

Conclusions: Both CBT and SE were associated with satisfactory published outcomes. SE is associated with greater absolute postprocedure mortality than CBT, but has been undertaken in more critically ill populations. The markedly higher incidence of CPR in SE accounts for the differential mortality between the patients undergoing SE and those undergoing CBT. Decision making with respect to best therapy must take into account potential needs for periprocedure artificial mechanical right ventricle and lung support, institutional experience and outcomes, anticipated therapeutic efficacy and benefit, and approach-specific risks.
(J Thorac Cardiovasc Surg 2018;156:2155-67)



Heterogeneity of CBTs for acute PE.

Central Message

Outcomes of appropriately selected patients undergoing SE are at least equivalent to those undergoing CBTs to treat large-burden (ie, massive and submassive) PE.

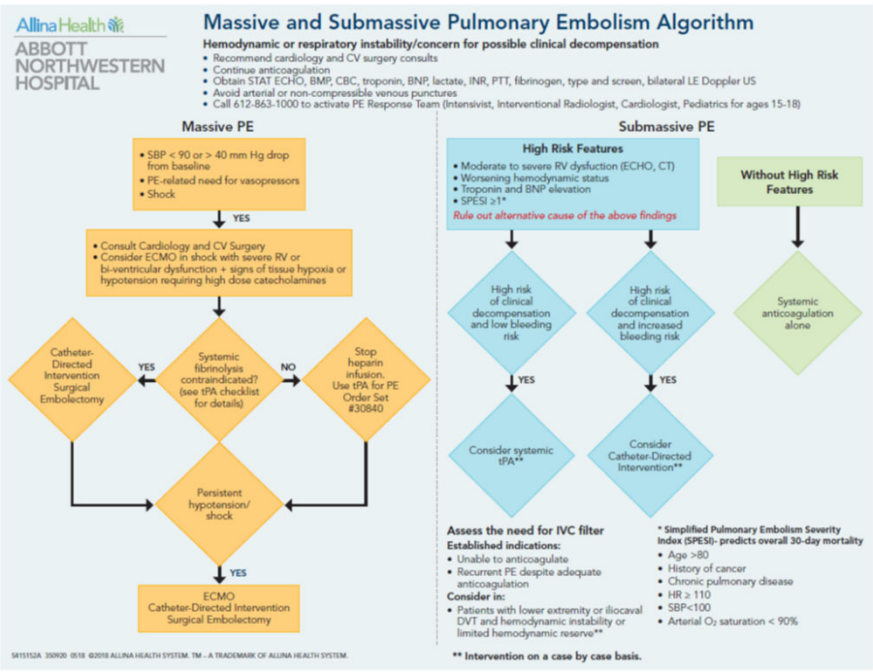
Perspective

Both CBTs and SE have satisfactory published outcomes. Surgical therapy is associated with greater absolute postprocedure mortality than CBT, but has been undertaken in more critically ill populations. This accounts for the differential mortality of patients undergoing SE versus CBT.

See Editorial Commentary page 2168.

Conclusions

- Both had satisfactory outcomes
- Surgical embolectomy
  - Sicker population
    - 21% had preop CPR vs 4% in catheter based (46% mortality with CPR)
  - Advantage for people who may need mechanical support
  - Advantage for central PE and larger embolic burden
- Catheter based Therapy
  - Surgery is contraindicated
  - More peripheral disease
  - Failure rate of 8.3% requiring reintervention



Abbott Northwestern Data 2018-2019

- In 2018 ANW had 372 PE patients, of those patients:
- 8% required PERT Activation.
- 38% had an ICU stay.
- 16 Catheter directed intervention
  - Survival rate of 19%.
    - 2 PEA arrest during procedure
    - Hemorrhage into brain mass on iv heparin
- 3 underwent surgical Embolectomy
  - Survival rate of 66%.
  - Complications included:
    - Confirmed massive PE. E-CPR, VA ECMO followed by surgical embolectomy. Decannulated next day. Survived.
    - Confirmed massive PE. S/p surgical embolectomy and Protek Duo. Recurrent episodes of hypotension and resp failure. Made comfort care eventually and expired.
    - Massive PE, s/p recent spine surgery. Surgical embolectomy. Survived, d/c'd home
- 4 received ECMO

- In 2019 ANW had 384 PE patients, of those patients:
- 9% required PERT Activation.
- 35% had an ICU stay.
- 9 Catheter directed intervention
  - Data not complete yet
- 7 underwent surgical Embolectomy
  - Survival rate of 43%.
  - 3 patients had preoperative EF of 10-15%
  - One received CDI and TPA prior to surgery
- 9 received ECMO

IVC Filter

- Long term anticoagulation is contraindicated
- Recurrence for DVT on anticoagulation
- Anticipated need to stop anticoagulation
- Residual clot burden (in IVC or legs) with tenuous pulmonary reserve
- Most will not benefit from an IVC filter
- Retrievable filters preferred

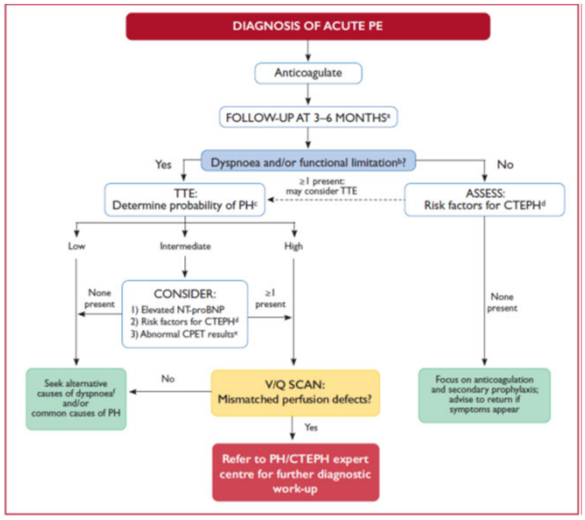
Anticoagulation in patients after PE (without cancer)

Recommendations	Class[a]	Level[b]
Therapeutic anticoagulation for ≥ 3 months is recommended for all patients with PE.[347]	I	A
Patients in whom discontinuation of anticoagulation after 3 months is recommended		
For patients with first PE/VTE secondary to a major transient/reversible risk factor, discontinuation of therapeutic oral anticoagulation is recommended after 3 months.[331,340,341]	I	B
Patients in whom extension of anticoagulation beyond 3 months is recommended		
Oral anticoagulant treatment of indefinite duration is recommended for patients presenting with recurrent VTE (that is, with at least one previous episode of PE or DVT) not related to a major transient or reversible risk factor.[358]	I	B
Oral anticoagulant treatment with a VKA for an indefinite period is recommended for patients with antiphospholipid antibody syndrome.[359]	I	B
Patients in whom extension of anticoagulation beyond 3 months should be considered[c,d]		
Extended oral anticoagulation of indefinite duration should be considered for patients with a first episode of PE and no identifiable risk factor.[330,331,347,351–353]	IIa	A
Extended oral anticoagulation of indefinite duration should be considered for patients with a first episode of PE associated with a persistent risk factor other than antiphospholipid antibody syndrome.[330,352,353]	IIa	C
Extended oral anticoagulation of indefinite duration should be considered for patients with a first episode of PE associated with a minor transient or reversible risk factor.[330,331,352]	IIa	C
NOAC dose in extended anticoagulation[e]		
If extended oral anticoagulation is decided after PE in a patient without cancer, a reduced dose of the NOACs apixaban (2.5 mg b.i.d.) or rivaroxaban (10 mg o.d.) should be considered after 6 months of therapeutic anticoagulation.[352,353]	IIa	A
Extended treatment with alternative antithrombotic agents		
In patients who refuse to take or are unable to tolerate any form of oral anticoagulants, aspirin or sulodexide may be considered for extended VTE prophylaxis.[355–357]	IIb	B
Follow-up of the patient under anticoagulation		
In patients who receive extended anticoagulation, it is recommended that their drug tolerance and adherence, hepatic and renal[f] function, and bleeding risk be reassessed at regular intervals.[359]	I	C

Prognosis

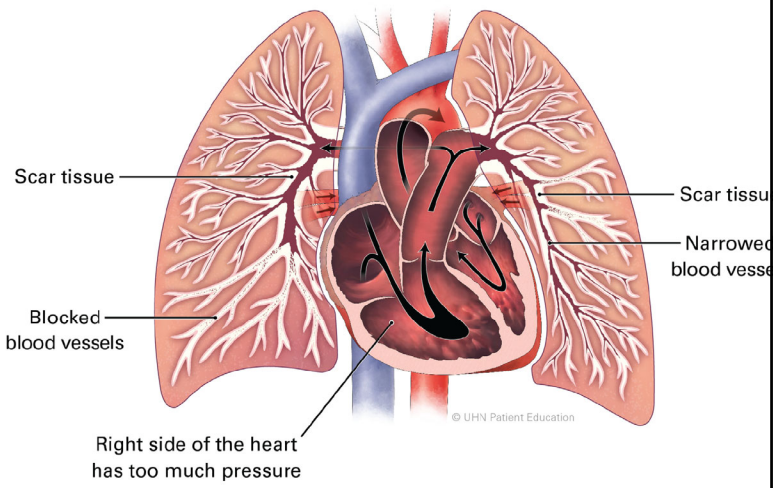
- Dependent on the severity of the PE
- Overall mortality:
  - 1023 patients=32% at 5 yrs
  - 5% due to PE or recurrent PE
  - 31% due to cardiovascular causes (MI, CHF, CVA)
  - 64% due to non cardiovascular causes (malignancy, sepsis, etc)
- Sub Segmental PE do better

Follow up



Chronic Pulmonary Embolism

- CTEPH: chronic thromboembolic pulmonary hypertension
- Very different entity
- Incidence 0.1-9.1% within 2 years after symptomatic PE event
  - Referral bias
  - Switzerland registry 0.8% within 2 yrs

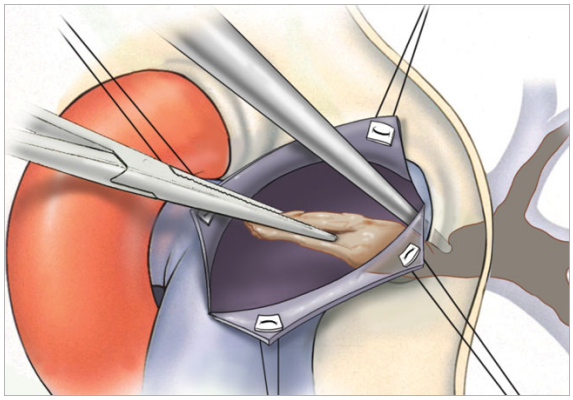


Risk Factors for CTEPH

Findings related to the acute PE event (obtained at PE diagnosis)	Concomitant chronic diseases and conditions predisposing to CTEPH (documented at PE diagnosis or at 3–6 month follow-up)
Previous episodes of PE or DVT	Ventriculo-atrial shunts
Large pulmonary arterial thrombi on CTPA	Infected chronic i.v. lines or pacemakers
Echocardiographic signs of PH/RV dysfunction[a]	History of splenectomy
CTPA findings suggestive of pre-existing chronic thromboembolic disease[b]	Thrombophilic disorders, particularly antiphospholipid antibody syndrome and high coagulation factor VIII levels
	Non-O blood group
	Hypothyroidism treated with thyroid hormones
	History of cancer
	Myeloproliferative disorders
	Inflammatory bowel disease
	Chronic osteomyelitis

CTEPH Surgery

- Highly selective patient population with favorable anatomy
- Elective
- Sternotomy
- Cardiopulmonary bypass
- Deep hypothermia and intermittent circulatory arrest
- Heart is arrested
- Technically demanding surgery
- Pulmonary artery endarterectomy



CTEPH Surgery

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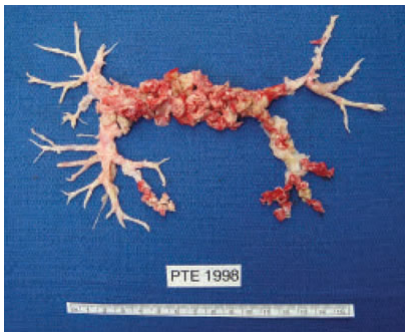

Final Thoughts

- Growing population of acute PE
- More will need advanced therapies
- More with circulatory collapse
  - ECMO before needing CPR
- ?Earlier surgery?
- ?Role of catheter based interventions?
- Should we be moving into CTEPH?