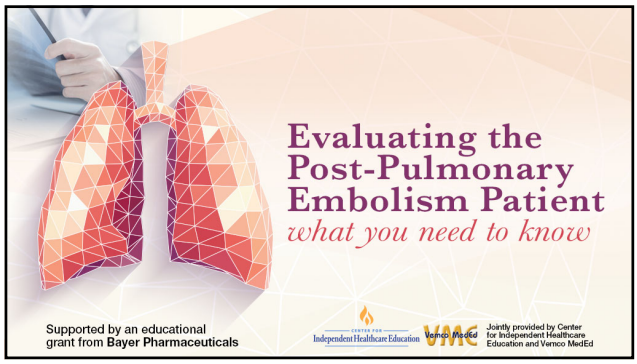


Learning Objectives

By the end of this activity, the participant should be better able to:

- Identify risk factors and early signs of chronic thromboembolic pulmonary hypertension (CTEPH) among post-pulmonary embolism (PE) patients.
- Apply early screening and detection approaches for patients suspected of CTEPH.
- Discuss the role of primary care providers as part of the multi-professional healthcare team in the evaluation and management of the post-PE patient.

Outline

- Case presentation and CTEPH introduction
- Can we prevent CTEPH?
- Basics of CTEPH
- Surgical therapy
- Medical therapy
- Role of the PCP throughout this process

CTEPH, chronic thromboembolic pulmonary hypertension

CTEPH: Practice Guidelines

SPECIAL ARTICLE

Diagnostic evaluation and management of chronic thromboembolic pulmonary hypertension: A clinical practice guideline

Sanjay Mehta MDCM FRCPC FCCP[1], Doug Helmersen MD FRCPC[2], Steeve Provencher MD MSc FRCPC[3], Naushad Hirani MD FRCPC[2], Fraser D Rubens MD MSc FRCSC[4], Marc De Perrot MD MSc[5], Mark Blostein MD FRCPC[6], Kim Boutet MD FRCPC[7], George Chandy MD MSc FRCPC[8], Carole Dennie MD FRCPC[9], John Granton MD FRCPC[10], Paul Hernandez MDCM FRCPC[11], Andrew M Hirsch MD FRCPC[12], Karen Laframboise MD FRCPC[13], Robert D Levy MD FRCPC[14], Dale Lien MD FRCPC[15], Simon Martel MD FRCPC[3], Gerard Shoemaker MD FRCPC[1], John Swiston MD MPH FRCPC[16], Justin Weinkauf MD FRCPC[13]; for the Canadian Thoracic Society Pulmonary Vascular Disease – CTEPH CPG Development Committee, and the Canadian Thoracic Society Canadian Respiratory Guidelines Committee

Mehta S, et al. *Can Respir J*. 2010;17:301-34.

36 y/o Man with Chest Pain and Dyspnea

- Patient presents to the ED with chest pain and dyspnea that started earlier that day.
- History of DVT and was on warfarin but is homeless and ran out of medication 1 week ago.
- Reports severe stabbing chest pain diffusely and is asking for "Dilaudid."
- Dyspnea with any movement; has a dry cough.
- Prior DVT unprovoked, he thinks he may have had a blood clot a few years ago after a surgery.

History

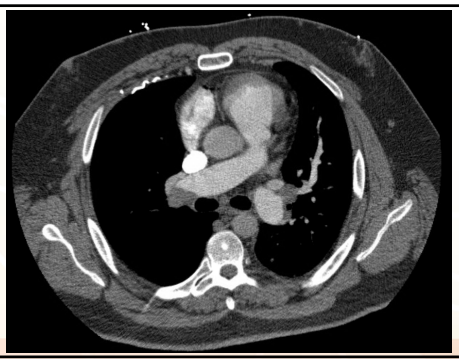
- **Past Medical History**
  - HTN
  - DVT (6 months ago)
- **Past Surgical History**
  - Cholecystectomy 2012
- **Allergy**
  - Daptomycin (unknown reaction)
- **Family History**
  - Estranged from family but mother has lupus and some unknown cancer, sister has had miscarriage
- **Medications**
  - Amlodipine (not taking)
  - Warfarin (not taking)
- **Social History**
  - Smoker
  - IV and inhalational heroin use
  - Denies EtOH
  - Unemployed
  - Homeless (currently living on friend's couch)

Physical Exam

	Temp	BP	HR	RR
08/19 23:00	98.4/36.9	124/87	111	26

- General: NAD, alert & oriented × 4
- HEENT: OP clear, MMM, PERRL, EOMI
- Neck: no LAD, no thyromegaly
- CV: S1 and S2 normal, RRR, no m/r/g
- Lungs: CTA b/l, no W/R/R, on 2L NC
- Abdomen: s/nt/nd + bs, no HSM appreciated
- Skin: track marks on upper extremities
- Extremities: 2+ distal pulses, 1+ pitting edema to knee b/l
- Neuro: CN II-XII intact

NAD, no acute distress; HEENT, head, eyes, ears, nose, throat; OP, oropharynx; MMM, mucous membranes moist; PERRL, pupils equally round and reactive to light; EOMI, extra ocular muscles intact; LAD, lymphadenopathy; RRR, regular rate and rhythm; m/r/g, murmurs, rubs, gallops; CTA b/l, clear to auscultation bilaterally; W/R/R, wheezes/rales/rhonchi; s/nt/nd, soft/non-distended/non-tender; bs, bowel sounds; HSM, hepatosplenomegaly; CN, cranial nerve



Acute and Chronic Complications of PE

- Acute PE incidence 100 per 100,000 patient years[1]
  - Increases with aging
- Incidence has increased over time
  - Aging population and increased sensitivity of testing
- Severity is widely variable[2]
  - Mortality rate in shock approaches 50%
- Chronic Complications are common
  - PE recurrence in 40-50% at 10 years[3]
  - Significant morbidity and mortality with development of PH

PE, pulmonary embolism; PH, pulmonary hypertension
[1]Weiner RS, et al. *Arch Intern Med*. 2011; 171: 831-837. [2]Kucher N, et al. *Circulation*. 2006; 113: 577-582.
[3]Prandoni P, et al. Haematologica. 2007;92:199-205.

Risk Assessment in Acute PE

Early Mortality Risk		Risk Parameters and Scores: Shock or Hypotension	PESI Class III-V or sPESI ≥1	Signs of RV Dysfunction on an Imaging Test	Cardiac Laboratory Biomarkers*
High		+	(+)	+	(+)
Intermediate	Intermediate-high	-	+	Both positive	
	Intermediate-low	-	+	Either 1 (or none) positive	
Low		-	-	Assessment optional: If assessed, both negative	

PESI Criteria*	Age in years
Age > 80 years	+10
Male sex	+30
History of cancer	+10
History of heart failure	+10
History of chronic lung disease	+20
Heart rate ≥ 110 beats/min	+30
Systolic blood pressure < 100 mm Hg	+20
Respiratory rate ≥ 30 breaths/min	+20
Temperature <36°C	+60
Altered mental status	+20
Arterial oxygen saturation <90%	
Simplified PESI† Criteria	
Age > 80 years	+1
History of cancer	+1
History of heart failure or chronic lung disease	+1
Heart rate ≥ 110 beats/min	+1
Systolic blood pressure < 100 mm Hg	+1
Arterial oxygen saturation <90%	+1

Konstantinides S.V., et al. *J Am Coll Cardiol*. 2016; 67(8):976-90.
Goldhaber, S.Z. Braunwald's Heart Disease, 84, 1681-1698.

RV Dysfunction in Acute PE

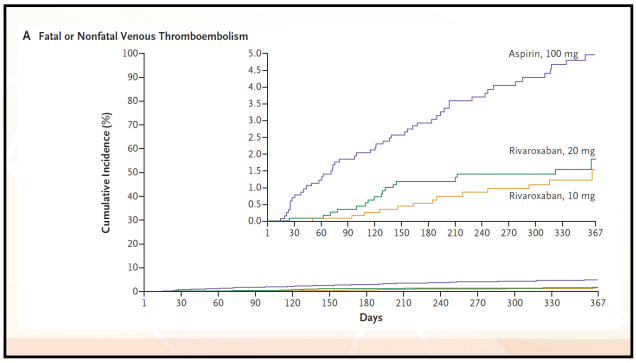
- Obstruction of >30% of pulmonary vasculature correlates with RV dysfunction[1]
- 100% negative predictive value for PE-related death with regards to RV dysfunction on TTE[2]
- RV dysfunction associated with increased mortality[3], though low specificity on TTE
- 24% ↑ risk of recurrent VTE with persistent RV dysfunction[4]

RV, right ventricular; TTE, transthoracic echocardiogram; VTE, venous thromboembolism
[1]Wolfe MW, et al. *Am Heart J*. 1994; 127: 1371-5. [2]Grifoni S, et al. *Circulation*. 2000; 101: 2817-22.
[3]Alpert JS, et al. *JAMA*. 1975; 236: 1477-80. [4]Grifoni S, et al. *ACP J Club*. 2007 Mar-Apr;146:46.

Treatment of Acute PE

- Low Risk → Anticoagulation
  - ACCP recommend NOAC rather than warfarin
    - Less bleeding risk and greater convenience
  - Duration of anticoagulation remains unclear
    - Minimum 3 months, consider long term (24 months or more)
    - Unprovoked VTE has highest risk of recurrence

PE, pulmonary embolism; ACCP, American College of Chest Physicians; NOAC, novel oral anticoagulants; VTE, venous thromboembolism
Kearon C, et al. *Chest*. 2016;149:315-352.



Treatment of Acute PE (cont.)

- High Risk → Anticoagulation + Thrombolysis
  - 30-50% reduction in mortality with systemic thrombolysis, ~ 3 fold increase in major bleeding[1]
  - Catheter-directed thrombolysis and reperfusion
    - Appears efficacious, decreasing thrombus burden by > 50% [2]
    - Phase 3 trials are lacking and requires local expertise
- Intermediate Risk → Anticoagulation + ?

PE, pulmonary embolism
[1]Chatterjee S, et al. *JAMA*. 2014;311:2414-2421. [2]Kuo WT, et al. *Chest*. 2015;148:667-673.

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Fibrinolysis for Patients with Intermediate-Risk Pulmonary Embolism

Outcome	Tenecteplase (N=506)	Placebo (N=499)	Odds Ratio (95% CI)	P Value
Primary outcome — no. (%)	13 (2.6)	28 (5.6)	0.44 (0.23–0.87)	0.02
Death from any cause	6 (1.2)	9 (1.8)	0.65 (0.23–1.85)	0.42
Hemodynamic decompensation	8 (1.6)	25 (5.0)	0.30 (0.14–0.68)	0.002
Bleeding between randomization and day 7				
Major extracranial bleeding	32 (6.3)	6 (1.2)	5.55 (2.3–13.39)	<0.001
Minor bleeding	165 (32.6)	43 (8.6)		
Major bleeding†	58 (11.5)	12 (2.4)		

Meyer G, et al. *NEJM*. 2014;370:1402-1411.

Table 2 Outcomes of Stable Patients with Acute RVF Who Received Thrombolysis

	Alive	Died	LOS
Thrombolytics	394	33	8.8 d
No thrombolytics	2580	245	9.57 d
P-value		.5094	.5

LOS = hospital length of stay; RVF = right ventricular failure.

Table 3 Outcomes of Unstable Patients with Acute RVF Who Received Thrombolysis

	Alive	Died	LOS
Thrombolytics	113	25	9.8 d
No thrombolytics	189	88	11 d
P-value		.003	.7

LOS = hospital length of stay; RVF = right ventricular failure.

Desai H, et al. *Am J Med*. 2017;130:e29-e32.

Chronic Complications of PE: CTEPH

What is Pulmonary Hypertension?

- Diagnosed by RHC with mPAP ≥25 mm Hg
  - Normal mPAP ≤20 mm Hg at rest
- Precapillary PH defined with PAWP ≤15 mm Hg
  - Normal ≤12 mm Hg
- PAH defined by PVR >3 Woods units
  - (PVR = ΔPressure/CO)
  - Normal PVR in some secondary PH

RHC, right heart catheterization; mPAP, mean pulmonary arterial pressure; PH, pulmonary hypertension; PAWP, pulmonary arterial wedge pressure; PAH, pulmonary arterial hypertension; PVR, pulmonary vascular resistance; CO, cardiac output
Hoeper MM, et al. *J Am Coll Cardiol*. 2013;62:D42-50.

Classification of Pulmonary Hypertension

1. Pulmonary arterial hypertension
   - 1.1 Idiopathic PAH
   - 1.2 Heritable PAH
   - 1.2.1 BMPR2
   - 1.2.2 ALK-1, ENG, SMAD9, CAV1, KCNK3
   - 1.2.3 Unknown
   - 1.3 Drug and toxin induced
   - 1.4 Associated with:
   - 1.4.1 Connective tissue disease
   - 1.4.2 HIV infection
   - 1.4.3 Portal hypertension
   - 1.4.4 Congenital heart diseases
   - 1.4.5 Schistosomiasis
   - 1' Pulmonary veno-occlusive disease and/or pulmonary capillary hemangiomatosis
   - 1''. Persistent pulmonary hypertension of the newborn (PPHN)
2. Pulmonary hypertension due to left heart disease
   - 2.1 Left ventricular systolic dysfunction
   - 2.2 Left ventricular diastolic dysfunction
   - 2.3 Valvular disease
   - 2.4 Congenital/acquired left heart inflow/outflow tract obstruction and congenital cardiomyopathies
3. Pulmonary hypertension due to lung diseases and/or hypoxia
   - 3.1 Chronic obstructive pulmonary disease
   - 3.2 Interstitial lung disease
   - 3.3 Other pulmonary diseases with mixed restrictive and obstructive pattern
   - 3.4 Sleep-disordered breathing
   - 3.5 Alveolar hypoventilation disorders
   - 3.6 Chronic exposure to high altitude

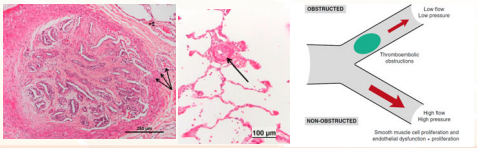
4. Chronic thromboembolic pulmonary hypertension (CTEPH

- disorders, splenectomy
- 5.2 systemic disorders: sarcoidosis, pulmonary histiocytosis, lymphangioleiomyomatosis
- 5.3 Metabolic disorders: glycogen storage disease, Gaucher disease, thyroid disorders
- 5.4 Others: tumoral obstruction, fibrosing mediastinitis, chronic renal failure, segmental PH

Simonneau G, et al. *J Am Coll Cardiol*. 2013;62:D34-41.

Group 4 Pulmonary Hypertension

- Chronic thromboembolic PH
- Estimated ~3% incidence after acute PE
- Obstruction + arteriopathy
- Treatment both surgical and medical



Lang IM, et al. *Ann Am Thorac Soc*. 2016;13(Suppl 3):S215-21.

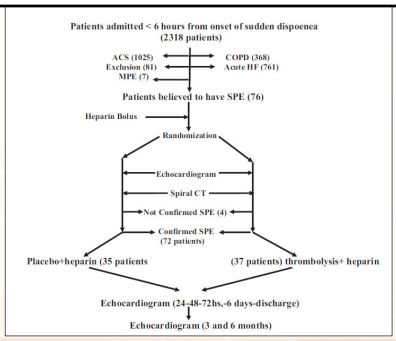
Can We Prevent CTEPH?

Six-Month Echocardiographic Study in Patients With Submassive Pulmonary Embolism and Right Ventricle Dysfunction: Comparison of Thrombolysis With Heparin

Sergio Fasullo, MD, Sebastiano Scalzo, MD, Giorgio Maringhini, MD, Filippo Ganci, MD, Sergio Cannizzaro, MD, Ivana Basile, MD, Debora Cangemi, MD, Gabriella Terrazzino, MD, Gaspare Parrinello, MD, Filippo M. Sarullo, MD, Roberto Baglini, MD, Salvatore Paterna, MD and Pietro Di Pasquale, MD

Fasullo S, et al. *Am J Med Sci*. 2011;341:33-9.

Thrombolysis to Prevent CTEPH



Fasullo S, et al. *Am J Med Sci*. 2011;341:33-9.

TABLE 6. Total events during hospitalization and follow-up

	Heparin, n (%)	Thrombolysis, n (%)	*P*
Death	6 (17.1)	0	0.027
Recurrent PE (fatal)	4 (11.4)	0	
Irreversible RVD	2 (5.7)	0	
Major bleedings	1 (2.85)	2 (5.4)	NS
Minor bleedings	8 (22)	16 (43.2)	0.005
Recurrent PE (not fatal)	1 (2.85)	0	NS
RVD	3 (8.6)	0	NS
Deep venous thrombosis: persistence	5 (14.2)	0	0.055
Total events	16 (45.7)	2 (5.4)	0.005

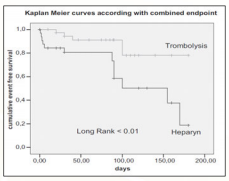
RVD, right ventricle dysfunction; PE, pulmonary embolism.

TABLE 5. Events after discharge and during follow-up (180 d)

	Heparin, n (%)	Thrombolysis, n (%)	*P*
Death	1 (2.85)	0	NS
Recurrent PE (fatal)	1 (2.85)	0	NS
Recurrent PE (not fatal)	1 (2.85)	0	NS
RVD	3 (8.5)	0	NS
Bleedings (minor)	4 (11.4)	5 (13.5)	NS
Deep vein thrombosis: persistence	5 (14.2)	0	0.055

RVD, right ventricle dysfunction; PE, pulmonary embolism.

Thrombolysis to Prevent CTEPH



Fasullo S, et al. *Am J Med Sci*. 2011;341:33-9.

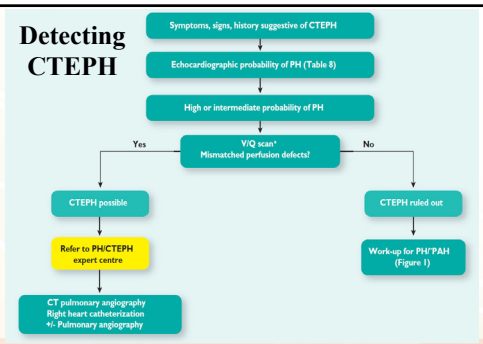
Identification of CTEPH

Incidence and Risk Factors of CTEPH in Patients After Acute PE

Age (years)/sex	Time from symptoms to diagnosis (days)	Unprovoked PE	ESC risk stratification	Initial therapy*	Dyspnea	Time to CTEPH (months)
68/F	20	No	Intermediate	Anticoagulation	Yes	11
75/F	3	No	Low	Anticoagulation	Yes	33
68/M	0	Yes	Low	Anticoagulation	Yes	13
73/F	7	Yes	Intermediate	Thrombolysis	Yes	12
74/F	7	No	Low	Anticoagulation	No	23
44/F	31	No	Intermediate	Anticoagulation	Yes	15
65/M	7	Yes	Low	Anticoagulation	Yes	6
67/F	2	No	Intermediate	Thrombolysis	Yes	7
69/M	20	Yes	Intermediate	Anticoagulation	Yes	9
80/F	1	No	Intermediate	Anticoagulation	Yes	31

Yang S, et al. *J Thorac Dis.* 2015;7:1927-38.

Detecting CTEPH



Galie N, et al. *Eur Heart J.* 2016;37:67-119.

Screen Appropriately

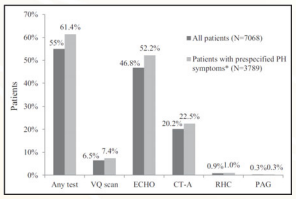
- Screening all patients 1 year after PE resulted in <1% diagnosis of CTEPH
- Targeted screening has better yield

Post PE patients screened for CTEPH with echocardiography.

Article	Number of patients screened with echocardiography	Number of patients with an abnormal echocardiography result	Number of patients diagnosed with CTEPH (n, %)
Giuliani et al. 2014 [59]	111	15	5 (33)
Guerin et al. 2014 [37]	146	8	7 (88)
Kayaalp et al. 2014 [61]	85	31	5 (6)
Klok et al. 2015 [60]	134	25	4 (16)
Klok et al. 2010 [19]	459	44	6 (14)
Marti et al. 2010 [62]	110	23	10 (44)
Total	1045	146	37 (25)

Ende-Verhaar YM, et al. *Thromb Res.* 2017;151:1-7.

Monitoring for PH Following PE: The INFORM Study

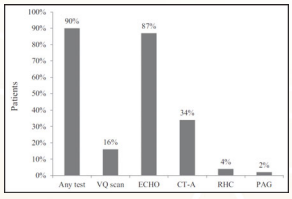


	Echo	
	n	%
Total Number of Patients	3309	46.8%
Probable CTEPH symptoms		
Syncope	360	74.4%
Malaise and fatigue	1231	57.9%
Dyspnea	1835	67.3%
Hemoptysis	67	69.1%
Chest pain, unspecified	1619	63.9%
Dizziness/vertigo, not otherwise specified	627	65.6%
Gait abnormality	355	64.0%
Cardiomegaly (429.3)	510	85.3%
Ascites (789.3)	119	62.6%
Peripheral edema (782.3)	846	61.3%

Tapson VF, et al. *Am J Med.* 2016;129:978-985.e2.

Monitoring for PH Following PE: The INFORM Study

Patients with subsequent diagnosis of pulmonary hypertension



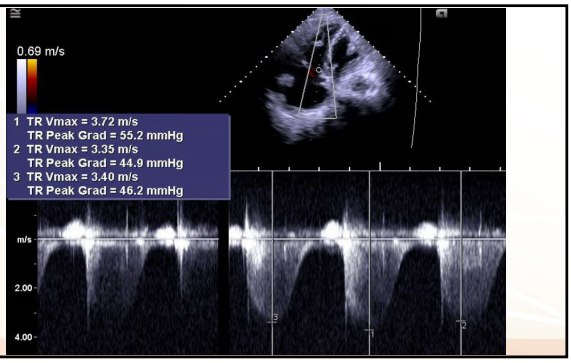
Tapson VF, et al. *Am J Med.* 2016;129:978-985.e2.

V/Q Scan vs. CT Angiography

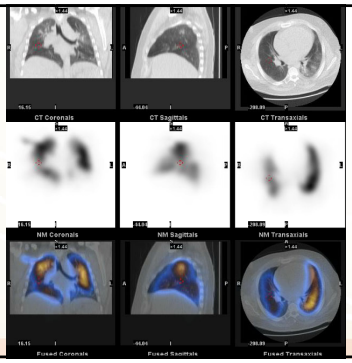
Indicator	Scintigraphy V/Q (1)*	Scintigraphy V/Q (2)†	CTPA
Sensitivity (%)	97.4	96.2	51.3
Specificity (%)	90	94.6	99.3
Accuracy (%)	92.5	95.2	82.8
NPV (%)	98.5	97.9	79.7
PPV (%)	83.5	90.3	97.6

- False positive V/Q in 15/149
  - PAH, PVOD, PH with parenchymal lung disease
- CT poor at identifying distal thromboembolic disease

PVOD, pulmonary venoocclusive disease
Tunariu N, et al. *J Nucl Med.* 2007;48:680-4.



V/Q Scan



Our Patient Gets RHC

HEMODYNAMIC DATA:

	Pressure (mm Hg)	O_2 Saturations
AORTA:	132/87 (105)	94%
LV:	143 / 9	
PCW:	Poor quality tracing despite multiple attempts	
PA:	84/29 (49)	57.8%
RV:	88/13	
RA:	15	

CARDIAC OUTPUT (L/MIN) by Thermodilution: 4.5; by Estimated Fick: 4.8

CARDIAC INDEX (L/MIN/M²) by Thermodilution: 1.8; by Estimated Fick: 1.9

RESISTANCE (WOOD units = dynes-sec/cm⁵)

PULMONARY VASCULAR RESISTANCE (NL 20–130) Thermodilution: 824
Estimated Fick: 771

LV, left ventricle; PCW, pulmonary capillary wedge; PA, pulmonary artery; RV, right ventricle; RA, right atrium

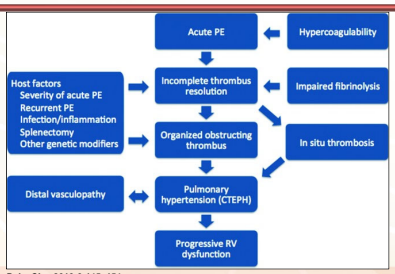
The Basics of CTEPH

CTEPH

Fig 2. (A) Right and (B) left pulmonary angiograms from a patient with severe pulmonary hypertension secondary to thromboembolic disease.

Madani MM, et al. *Ann Thorac Surg.* 2012;94:97–103.

Pathogenesis of CTEPH



Matthews DT, Hemnes AR. *Pulm Circ.* 2016;6:145–154.

Risk Factors for CTEPH

- Recurrent PE
- Proximal disease
- Antiphospholipid syndrome
- Hemostatic Factors
  - Elevated Factor VIII, vW factor
- Splenectomy
  - Erythrocytosis and thrombocytosis
- Non-O blood group

Kim NH, Lang IM. *Eur Respir J*. 2012;21:27-31.

Our Patient Gets Lab Results

LUPUS INHIBITOR	
* H 42.5	
ANCA-CYTOPLAS STAIN	
* <1:20	
HIV AB SCRN	
NON REACTIVE	
BLOOD CULT	
BLDCT	
SPUTUM	
SPUCT	
ABO/RH(D)	AB SCREEN
O Rh Positive	Negative
ANA	SCL70 AB
* None Detected	
	* 1
RHEUM FACTOR	CYCLIC CITRUL PEPTIDE AB,IG
* <10	* 4
ACA IGM	ACA IGG
* H 72	* H >150
ANTI B2 GLYCOPROTEIN 1 IGA	
* H 26	

Therapies for CTEPH

Pulmonary Endarterectomy

- Performed through median sternotomy
- Circulatory arrest for ~20 minutes at a time
- Unilateral endarterectomy at each arrest
- Can be successful to subsegmental branches
- Jamieson Classification:
  - Type I – Acute or subacute proximally
  - Type II – Chronic disease proximally
  - Type III – Segmental and subsegmental only

Pulmonary Endarterectomy

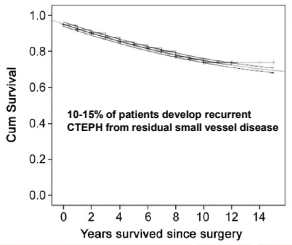
Fig 3. Thromboembolic specimen removed from the patient described in Fig 2. The disease type is type III on both sides.

Outcomes of PEA

Variable	Group 1 (n = 1000)	Group 2 (n = 500)	*p* Value
PVR (dynes/sec/cm^{-5})			
Preoperative	861.2 ± 446.2	719.0 ± 383.2	< 0.001[a]
Postoperative	294.8 ± 204.2	253.4 ± 148.6	< 0.001[a]
Cardiac output (L/min)			
Preoperative	3.9 ± 1.3	4.3 ± 1.4	< 0.001[a]
Postoperative	5.4 ± 1.5	5.6 ± 1.4	< 0.001[a]
Mean pulmonary artery pressure (mm Hg)			
Preoperative	46.1 ± 11.4	45.5 ± 11.6	0.3854
Postoperative	28.7 ± 10.1	26.0 ± 8.4	< 0.001[a]

PEA, pulmonary endarterectomy
Madani MM, et al. *Ann Thorac Surg* 2012;94:97–103.

Outcomes of PEA



Madani MM, et al. *Ann Thorac Surg* 2012;94:97–103.

Our Patient is Referred to Cleveland Clinic for PTE Evaluation

ADMISSION DIAGNOSIS CTEPH (chronic thromboembolic pulmonary hypertension) (HCC) [416 8, 415 19)
History of Present Illness

36 y/o Caucasian M with a medical history significant for
- HTN on amlodipine 5 mg daily
- Antiphospholipid antibody syndrome diagnosed by hematology, positive B2 glycoprotein Ab, lupus anticoagulant and anticardiolipin Ab, non compliant/ failed previous anticoagulation
- recurrent DVT/ PE most recent prior to admission 5/5
- CTEPH diagnosed on VQ right heart cath and CTPE protocol scans was on riociguat at OSH
- IVC filter in place inserted appx 3 yrs ago per patient
- Heroin abuse most recent a couple of months ago per patient OM of foot with amputation of right first toe and left second metatarsal head
- Unclear history of HIT

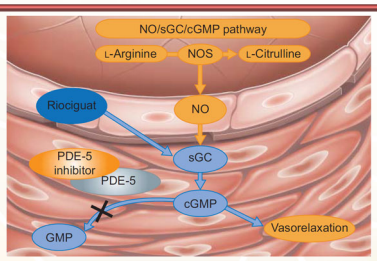
Who is transferred from University of Illinois for evaluation of pulmonary thromboembolectomy for his CTEPH

Cleveland Clinic

Our Patient: Operative Findings

- Large amount of chronic scarring and organizing thrombus throughout both pulmonary arterial trees
- Were able to open up all lobar and segmental vessels
- Pulmonary pressures were not substantially different post-operatively, but PVR decreased over two-fold

Riociguat for the Treatment of CTEPH



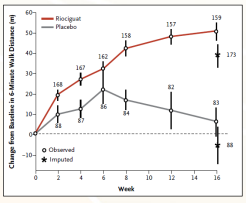
N.H. Kim. *Eur Respir Rev.* 2010 19: 68-71.

Riociguat for the Treatment of CTEPH

- Phase 3, randomized, placebo-controlled trial
- 261 patients with inoperable CTEPH
- 66% women, 71% white, 22% Asian
- 95% functional class II-III
- 2:1 riociguat:placebo
- Up to 2.5 mg riociguat TID × 16 weeks

Ghofrani HA, et al. *N Engl J Med.* 2013;369:330-40.

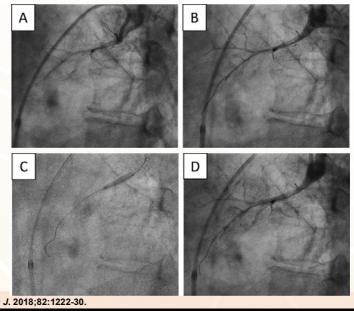
Riociguat for the Treatment of CTEPH



Event	Placebo (N = 88)	Riociguat (N = 173)
	number of patients (percent)	
Adverse events		
Any	76 (86)	159 (92)
Headache	12 (14)	43 (25)
Dizziness	11 (12)	39 (23)
Dyspepsia	7 (8)	31 (18)
Peripheral edema	18 (20)	27 (16)
Nasopharyngitis	8 (9)	26 (15)
Nausea	7 (8)	19 (11)
Vomiting	3 (3)	17 (10)
Diarrhea	4 (5)	17 (10)
Hypotension	3 (3)	16 (9)‡
Upper respiratory tract infection	4 (5)	10 (6)
Increase in international normalized ratio	4 (5)	10 (6)
Constipation	1 (1)	10 (6)
Prolonged activated partial-thromboplastin time	2 (2)	8 (5)
Cough	16 (18)	9 (5)
Chest pain	4 (5)	7 (4)
Dyspnea	12 (14)	8 (5)
Back pain	5 (6)	7 (4)
Increase in serum creatinine level	5 (6)	3 (2)
Pain in extremity	5 (6)	3 (2)
Insomnia	6 (7)	4 (2)
Syncope	3 (3)	4 (2)

Ghofrani HA, et al. *N Engl J Med.* 2013;369:330-40.

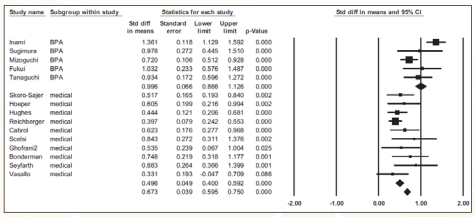
Balloon Pulmonary Angioplasty



Ogawa A, Matsubara H. *Circ J.* 2018;82:1222-30.

Medical Therapy Versus Balloon Angioplasty for CTEPH: A Systematic Review and Meta-Analysis

6-Minute Walk Distance



Phan K, et al. *Heart Lung Circ.* 2018;27:89-98.

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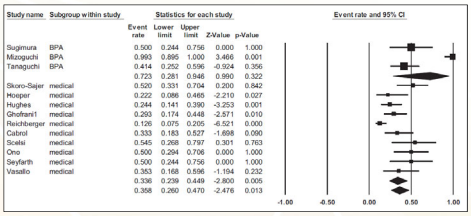
Functional Class



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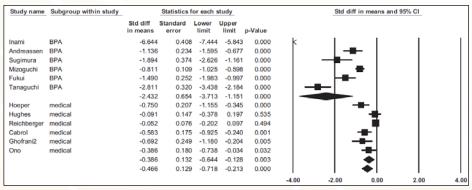
Mean PA Pressure



Phan K, et al. *Heart Lung Circ.* 2018;27:89-98.

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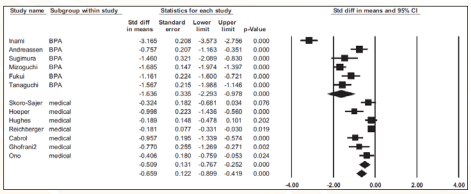
Pulmonary Vascular Resistance



No RCTs have been performed for balloon pulmonary angiography

Phan K, et al. *Heart Lung Circ.* 2018;27:89-98.

Our Patient Returns to University of Illinois at Chicago

Hospital Course

- Maintained on anticoagulation with rivaroxaban and on sildenafil for persistent PH
- A 6MWT revealed mild desaturation on exertion, qualifying him for 3L of oxygen on exertion
- Patient remained stable with no acute issues
- Social work was consulted regarding homelessness
- Sister agreed to take patient to her residence in Wyoming following discharge
- On discharge, patient was well appearing and hemodynamically stable
- The pharmacy was able to provide him with a supply of medication prior to discharge

The Role of the PCP in Evaluation and Management of the Post-PE Patient

- **CTEPH needs to be on your radar**
  - Minority of post-PE patients, but carries serious morbidity and mortality consequences
- **Screen when appropriate**
  - Identify key risk factors
  - Recognize symptoms and signs
- **Refer probable or likely subjects**
  - RHC will be necessary to confirm, but early referral is key
- **Maintain communication with multi-professional team**
  - Surgical treatment associated with 10–15% recurrence rate
  - Medical therapies require routine monitoring

Conclusions

- Differentiating acute and chronic thromboembolic disease is important
  - Though it can be difficult
- CTEPH is a rare complication but identifying risk factors is essential
- All CTEPH patients should be evaluated for PEA
- Medical therapy has been shown to improve morbidity of CTEPH
- The PCP is important in each step of this process