

# **Pulmonary Embolism – It's a Team Sport**

## **Case Presentations and Discussion**

### **Panelists:**

**Christopher Kabrhel, MD, MPH**

**Louis Chu, MD**

**Samuel Goldhaber, MD**

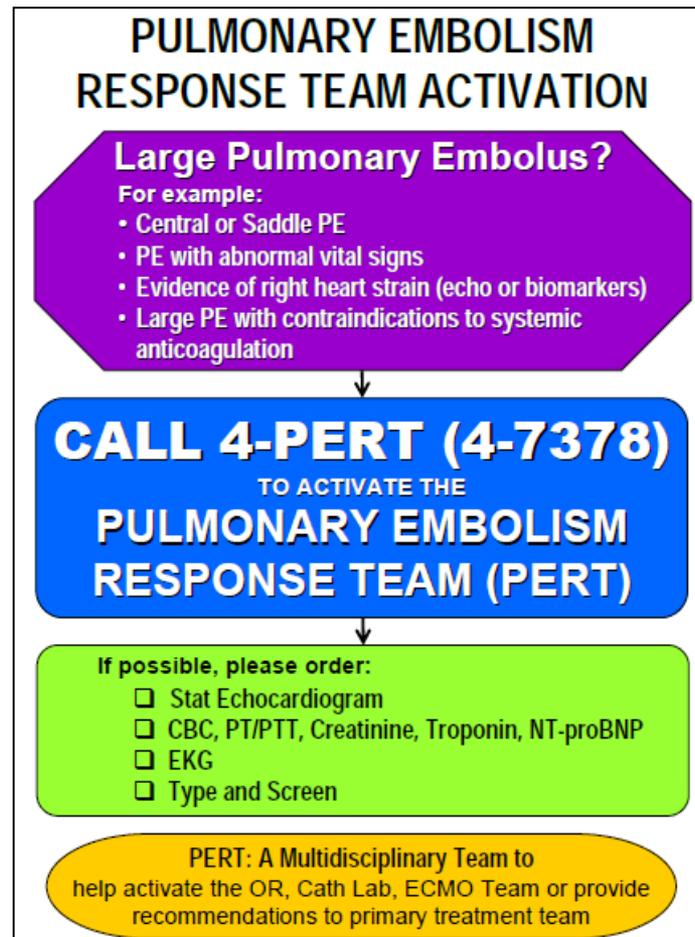
**Jeffrey L. Weinstein, MD**

**Barbara L. LeVarge, MD**

# Case 1

- 25 yo F, otherwise healthy, on oral contraceptives
- Long haul flight 3 days prior
- Sudden onset pleuritic chest pain and dyspnea
- Called EMS, arrives to ED with following VS:
  - BP 90/65, HR 133, RR 30, O2 89% RA, 94% NRB
- CTA chest shows saddle PE with moderate R heart strain

# Pulmonary Embolism Response Team (PERT)

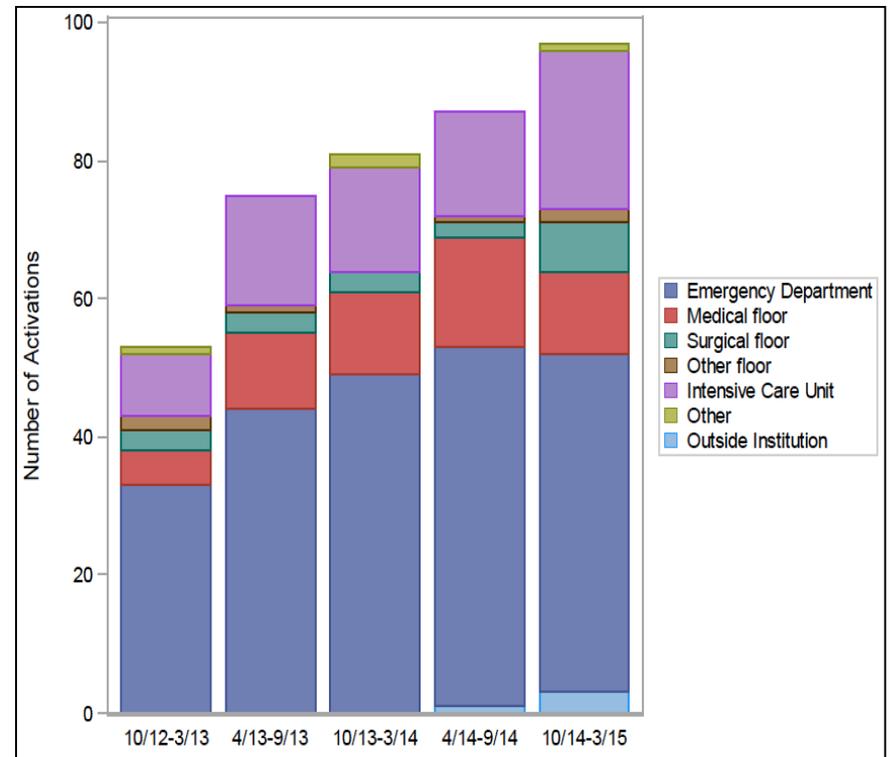


# MGH PERT Activations

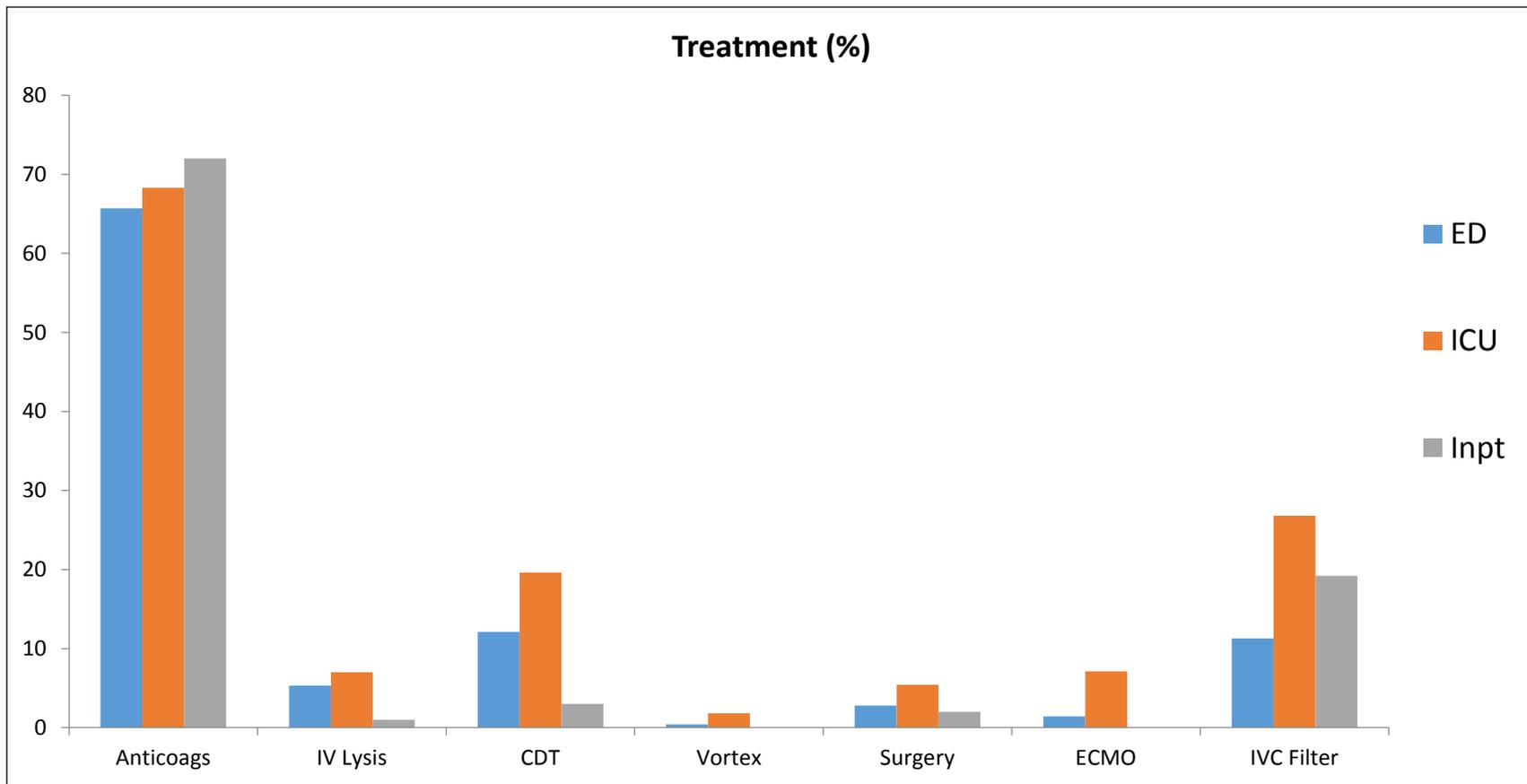
n=394 (initial 30 months)

now, n≈850

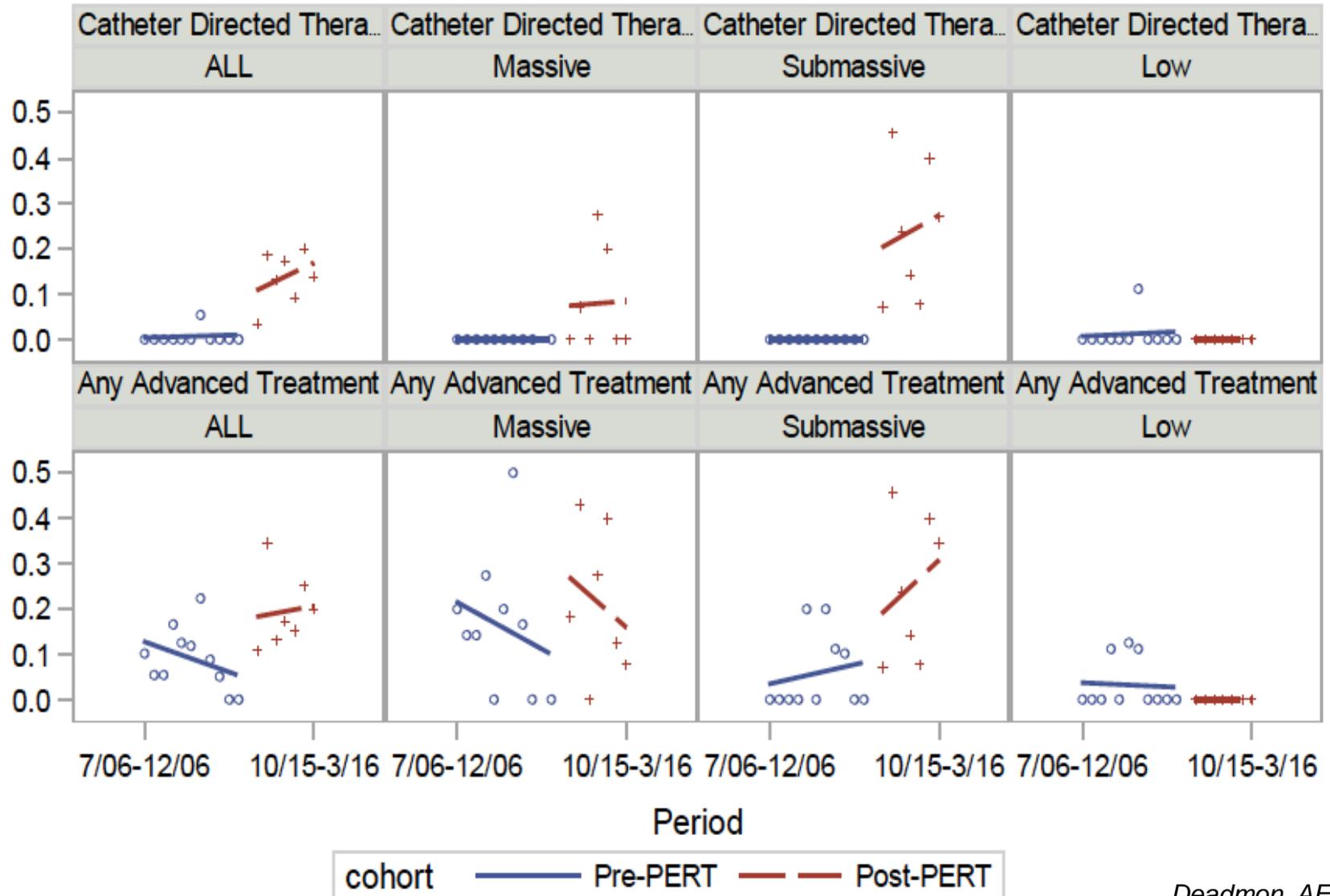
- Multidisciplinary virtual consults
  - Average length: 25 mins.
  - Range 5–15 physicians
  - Off-hours/weekends: 53%



# MGH PERT Treatment



# MGH PERT Treatment



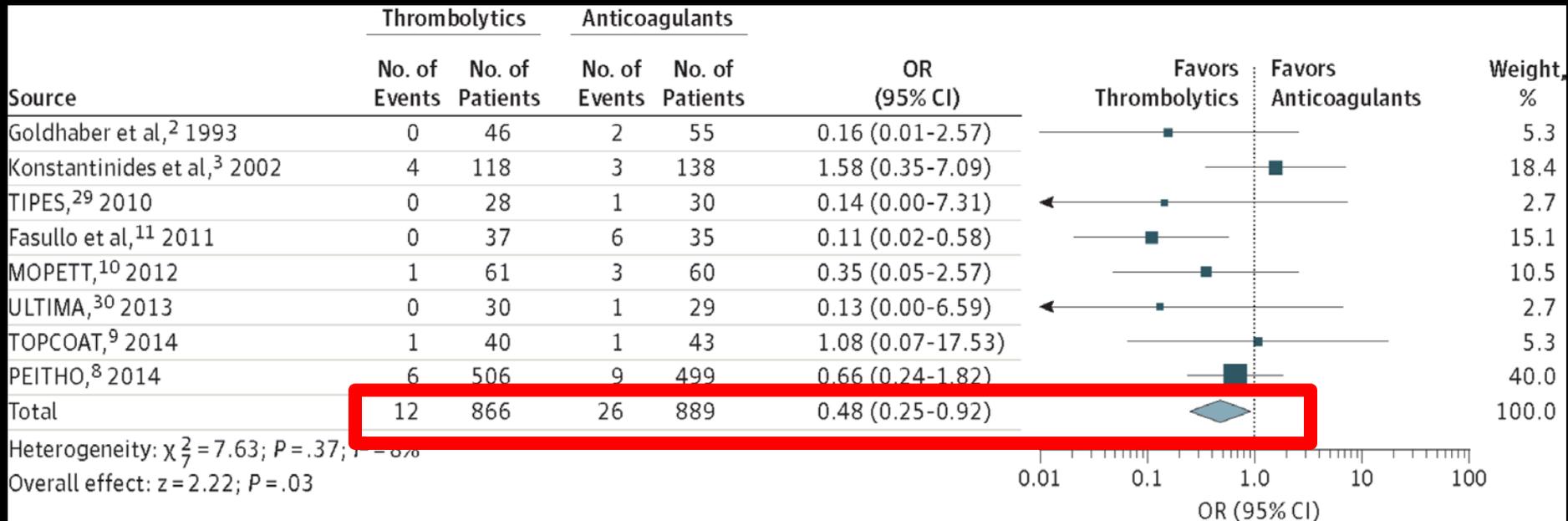
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# ADVANCED MANAGEMENT

- 1) Systemically administered (via peripheral IV) thrombolysis:
  - Full Dose (TPA 100 mg)
  - Half Dose (TPA 50 mg)
- 2) Pharmacomechanical therapy with catheter-directed (ultrasound-facilitated) thrombolysis: TPA 24 mg
- 3) Surgical Embolectomy
- 4) IVC Filter

# LYSIS IN SUBMASSIVE PE: MORTALITY META-ANALYSIS



## Intermediate-risk PE

All-cause mortality (8)	12/866 (1.39)	26/889 (2.92)	NNT = 65	.03
Major bleeding (8) <sup>a</sup>	67/866 (7.74)	20/889 (2.25)	NNH = 18	<.001

(JAMA 2014; 311: 2414-2421)

# PEITHO 38-MONTH FOLLOW-UP: PROMISES FULFILLED?

<u>ENDPOINT</u>	<u>LYSIS</u>	<u>HEPARIN</u>
Long-Term Mortality	20%	18%
Chronic SOB or other symptoms	36%	30%
Incidence of CTEPH	2.1%	3.2%

**(JACC 2017; 69: 1536-1544)**

# FIBRINOLYSIS REPORT CARD: PROMISES FULFILLED?

<u>Promise</u>	<u>Yes</u>	<u>No</u>
Reduced Mortality and Recurrent PE: Short-Term	X X	
Reduced Long-Term Mortality		X
Reduced Long-Term Recurrent PE		X
Improved Function and QOL		X
Reduced Incidence of CTEPH		X

# Case 1

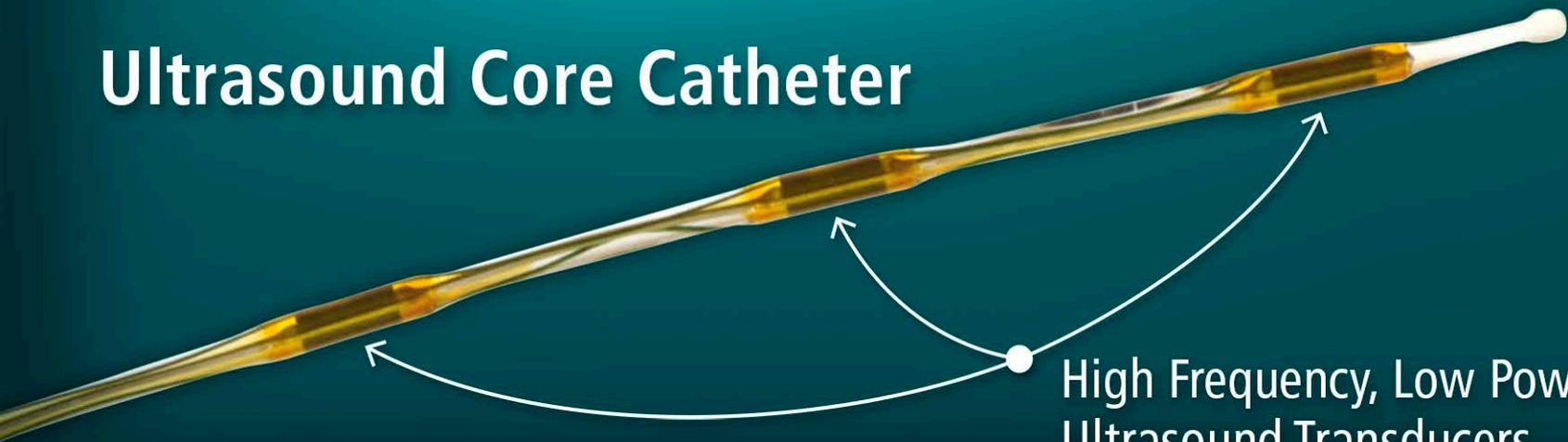
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## Drug Delivery Catheter

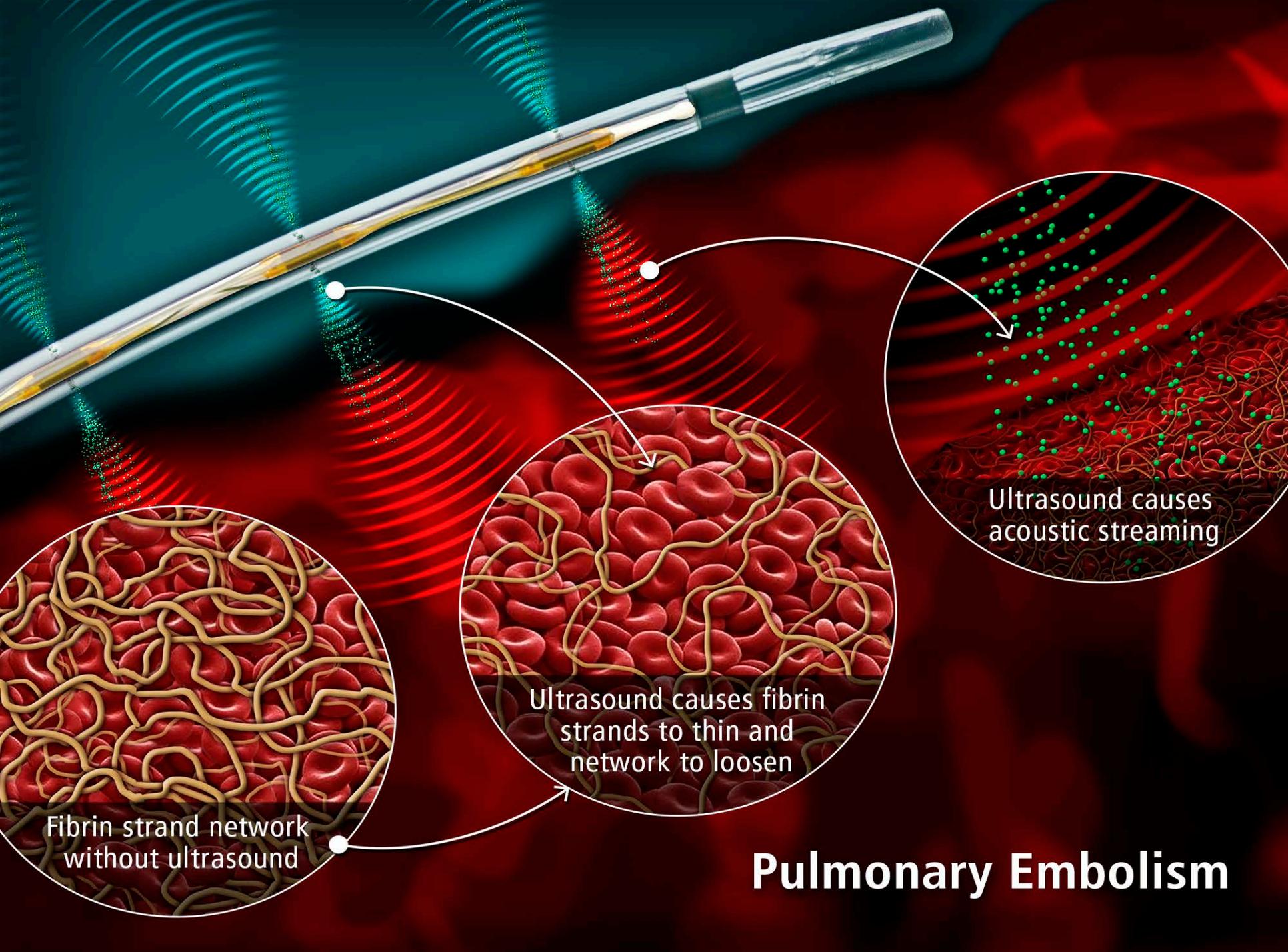


Sideholes for Delivery of Fibrinolytic Agent

## Ultrasound Core Catheter



High Frequency, Low Power Ultrasound Transducers



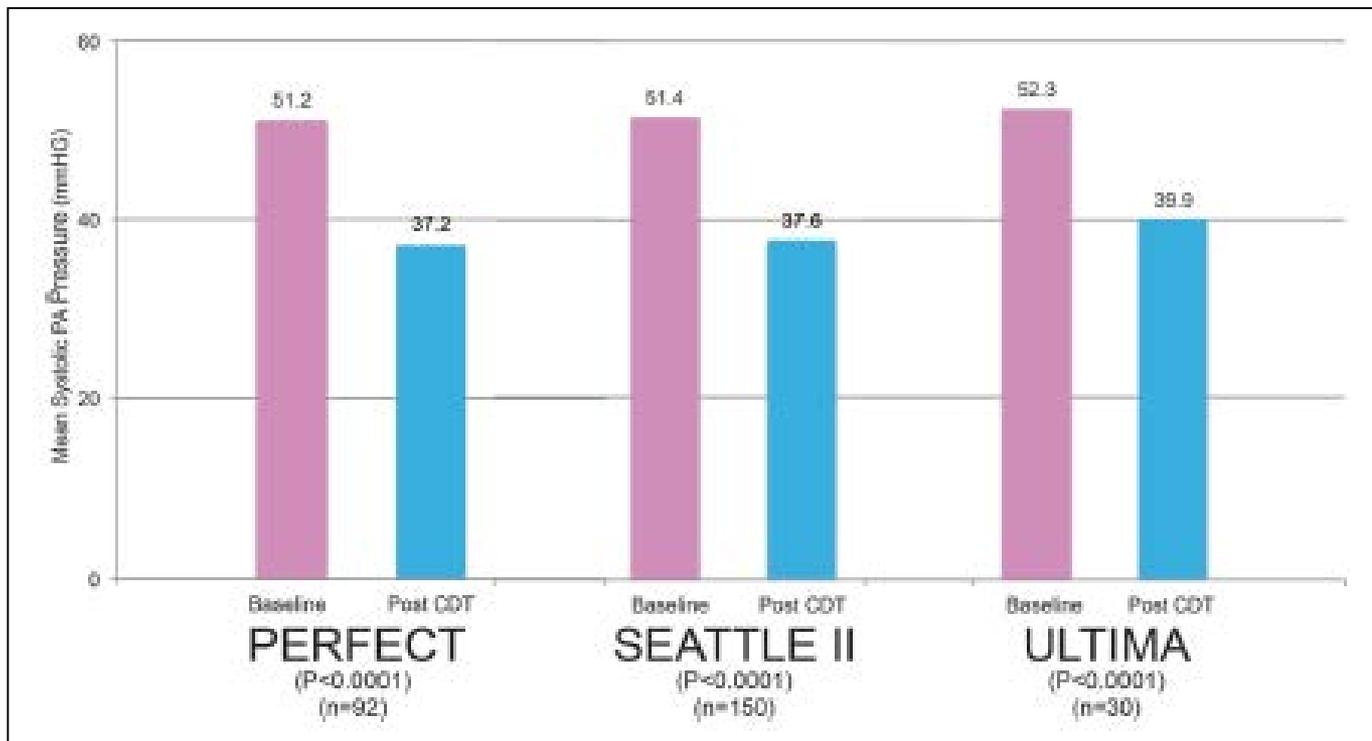
Fibrin strand network  
without ultrasound

Ultrasound causes fibrin  
strands to thin and  
network to loosen

Ultrasound causes  
acoustic streaming

# Pulmonary Embolism

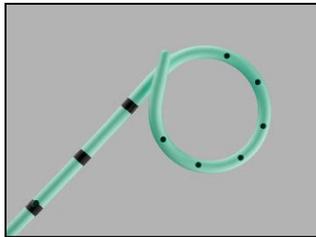
# Catheter Directed Thrombolysis



# Catheter Directed Thrombolysis



EKOS®



- Proximal infusion of thrombolytic
- Mechanical Fragmentation
- Ultrasonic acceleration
- 12-24 hour treatment
- Theoretical benefits:
  - lower drug dose (10-20mg tPA)
  - Drug acts faster, clearing clot sooner
  - Less hemolysis
  - Monitor PA pressure



Cleaner®

# Questions for our experts related to thrombolysis

# Case 2

- 63 yo M with small cell lung cancer
- Sent from Oncology clinic to Radiology to evaluate for LLE DVT
- US confirms DVT
- Code Blue called to Radiology as pt exiting
- VS: BP 74/46, HR 152, RR 32, O2 86%
- Point of care ultrasound shows a moderate pericardial effusion but no evidence tamponade with RV dilatation and McConnell's sign

# Contraindications to Thrombolysis

- Absolute
  - Prior intracranial hemorrhage
  - Intracranial malignant neoplasm or cerebrovascular disease (i.e. AVM)
  - Ischemic stroke within 3 months
  - Active bleeding or bleeding diathesis
  - Recent surgery involving brain or spinal canal
  - Recent significant closed-head trauma
  - Suspected aortic dissection
- Relative
  - Age >75 years
  - Pregnancy
  - Remote ischemic stroke (>3 months)
  - Major surgery within 3 weeks
  - Recent internal bleeding
  - Traumatic or prolonged CPR (>10 minutes)
  - Non-compressible vascular puncture
  - Current use of anticoagulation
  - Severe uncontrolled hypertension at presentation (>SBP 180 or DBP >110) or history of chronic, severe, poorly controlled hypertension
  - Dementia

# Case 2

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# Who to treat

- Team sport – Multidisciplinary teams
- Guidelines lag
- Massive PE often = IV TPA
- Stable, submassive PE = anticoagulation
- Hi-risk submassive PE = ? CDT
  - RV strain (echo, CT)
  - Symptomatic patient
  - Elevated troponins, BNP
  - PESI Score?



# PESI Score

**Table 8**

Pulmonary embolism severity index (PESI) score

Predictors	Points assigned
Age, years	Age, in years
Altered mental status*	+60
Systolic blood pressure <100 mmHg	+30
History of cancer	+30
Arterial oxygen saturation <90 % <sup>‡</sup>	+20
Temp < 36 °C	+20
Respiratory rate ≥ 30/min	+20
Pulse ≥ 110/min	+20
Male sex	+10
History of heart failure	+10
History of chronic lung disease <sup>†</sup>	+10

A total point score for a given patient is obtained by summing the patient's age in years and the points for each applicable predictor. Points assignments correspond with the following risk classes: Class I (very low risk): ≤65; Class II (low risk): 65–85; Class III (intermediate risk): 86–105; Class IV (high risk): 106–125; Class V (very high risk): >125

<sup>†</sup> Chronic obstructive pulmonary disease

<sup>‡</sup> With and without supplemental oxygen administration

\* Altered mental status was defined as confusion, disorientation, somnolence, lethargy, stupor, or coma

Streiff MB, Agnelli G, Connors JM, Crowther M, Eichinger S, Lopes R, McBane RD, Moll S, Ansell J. J Thromb Thrombolysis . 2016; 41: 32-67.



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# Simplified PESI

- Age > 80
- History of Cancer
- Chronic Cardiopulmonary Disease
- Pulse > 110
- CHF
- SBP < 100
- SaO<sub>2</sub> < 90%

0 factors is low risk, everything else is high risk



## Case 2

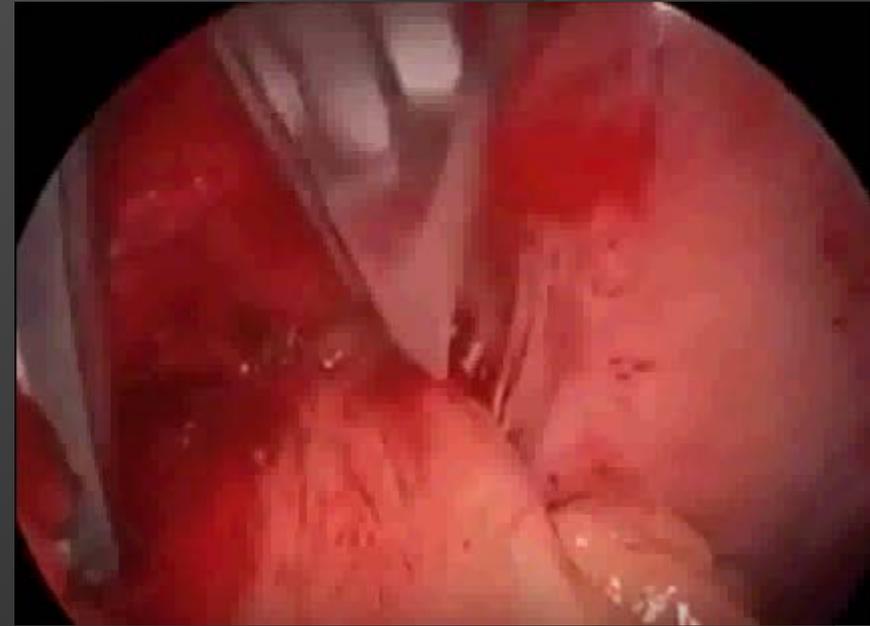
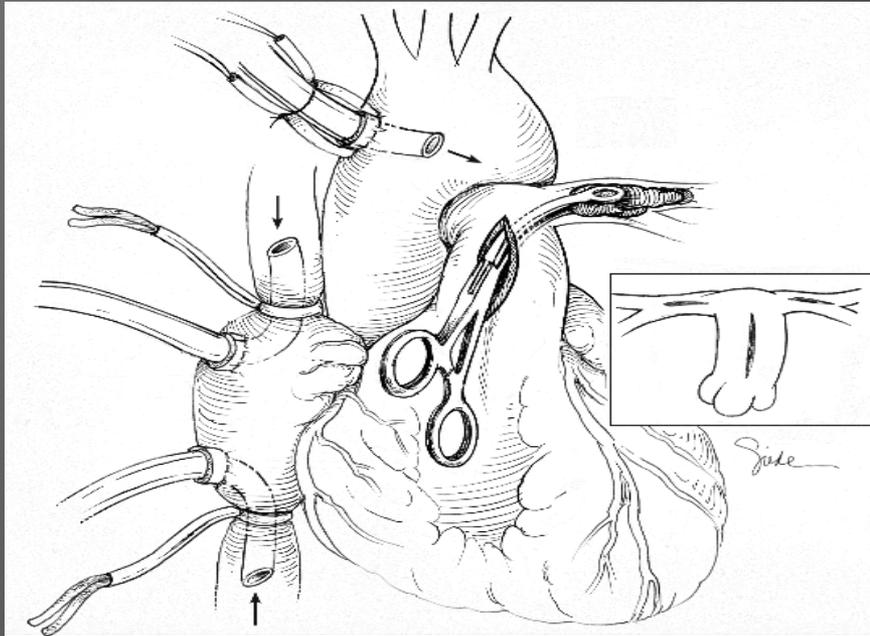
- 63 yo M with small cell lung cancer
- Confirmed LLE DVT
- Code Blue called to Radiology
- VS: BP 74/46, HR 152, RR 32, O2 86%
- Moderate pericardial effusion on ultrasound
- Patient brought to the ED and started on IVF and Levophed for blood pressure support.
- The pt received 2 L crystalloids and is on maximum dose of Levophed with continued hypotension, current 80/57.

# Patient Selection

- Classic Indications:
  - Hemodynamic instability despite 2 pressors
  - Failed thrombolytic therapy
  - Contraindication to thrombolytic therapy
- Expanded indications:
  - Good surgical candidates with submassive PE and significant RV strain



# Surgical Embolectomy



# Surgical Embolectomy



Right



Left



# Outcomes

## Outcomes After Surgical Pulmonary Embolectomy for Acute Pulmonary Embolus: A Multi-institutional Study

W. Brent Keeling, MD, Thor Sundt, MD, Marzia Leacche, MD, Yutaka Okita, MD, Jose Binongo, PhD, Yi Lasajanak, MSPH, Lishan Aklog, MD, and Omar M. Lattouf, MD, for the SPEAR Working Group

Division of Cardiothoracic Surgery, Emory University, Atlanta, Georgia; Division of Cardiothoracic Surgery, Massachusetts General Hospital, Boston; Division of Cardiothoracic Surgery, Brigham and Women's Hospital, Boston, Massachusetts; Division of Cardiothoracic Surgery, Kobe University, Kobe, Japan; and Pavilion Holdings Group, New York, New York

Table 3. Postoperative Outcomes

Outcome	All (n = 214), n (%)	Massive (n = 38), n (%)	Submassive (n = 176), n (%)	OR	95% CI	p Value
Postoperative transfusion	93 (43.5)	29 (76.3)	64 (36.4)	5.42	2.43–12.08	<0.01
Septicemia	8 (3.7)	3 (7.9)	5 (2.8)	3.01	0.76–12.48	0.12
Permanent Stroke	10 (4.7)	3 (7.9)	7 (4.0)	2.23	0.59–8.44	0.24
Atrial fibrillation	26 (12.1)	7 (18.4)	19 (10.8)	1.92	0.76–4.90	0.17
Pneumonia	14 (6.5)	4 (10.5)	10 (5.7)	2.07	0.64–6.70	0.23
Prolonged ventilation	60 (28.0)	16 (42.1)	44 (25.0)	2.18	1.054–4.52	0.04
Postoperative dialysis	3 (1.4)	0	3 (1.7)	0.64	0.03–13.18	0.77
Renal failure	24 (11.2)	5 (13.2)	19 (10.8)	1.33	0.48–3.71	0.59
Reexploration for hemorrhage	18 (8.4)	6 (15.8)	12 (6.8)	2.63	0.94–7.37	0.07
In-hospital Mortality	25 (11.7)	9 (23.7)	16 (9.1)	3.13	1.28–7.69	0.01

# Outcomes

## Midterm benefits of surgical pulmonary embolectomy for acute pulmonary embolus on right ventricular function



William Brent Keeling, MD,<sup>a</sup> Bradley G. Leshnowar, MD,<sup>a</sup> Yi Lasajanak, MSPH,<sup>b</sup> Jose Binongo, PhD,<sup>b</sup> Robert A. Guyton, MD,<sup>a</sup> Michael E. Halkos, MD,<sup>a</sup> Vinod H. Thourani, MD,<sup>a</sup> and Omar M. Lattouf, MD<sup>a</sup>

- Improvement in RV function/hemodynamics

**TABLE 4. Postoperative echocardiographic data**

	Preoperative (n = 21)	Postoperative (n = 21)	<i>P</i> value
Moderate or greater ventricular dysfunction	17 (81.0%)	9 (42.9%)	.01
Moderate or greater tricuspid regurgitation	6 (28.6%)	1 (4.8%)	.03
Pulmonary artery systolic pressure (mm Hg)	51.2 ± 21.6 (n = 17)	36.6 ± 10.1 (n = 6)	.21
Tricuspid valve regurgitant velocity (m/s)	3.1 ± 0.8 (n = 16)	2.8 ± 0.7 (n = 7)	.20

**TABLE 5. Midterm echocardiographic follow-up**

	Preoperative value (n = 21)	Midterm value (n = 12)	<i>P</i> value
Moderate or greater ventricular dysfunction	17 (81.0%)	1 (8.3%)	<.0001
Moderate or greater tricuspid regurgitation	6 (28.6%)	0 (0)	.0005
Pulmonary artery systolic pressure (mm Hg)	51.2 ± 21.6 (n = 17)	37.2 ± 14.2 (n = 9)	.01
Tricuspid valve regurgitant velocity (m/s)	3.1 ± 0.8 (n = 16)	2.4 ± 0.7 (n = 11)	.03



Questions?

# Case 3

- 56 yo male with history of DVTs on lifelong anticoagulation for underlying pro-thrombotic state presented to ED with traumatic SDH
- Coumadin reversed with prothrombin complex concentrate
- Taken emergently to OR for SDH evacuation
- Peri-Arrest in ICU POD 1

# Damage control: shock in acute PE

## \*\*Definitive therapy\*\*

### Preload optimization:

- RV dilation → leftward septal shift → cardiovascular collapse
- Minimize fluid resuscitation unless clearly hypovolemic

### RV afterload reduction:

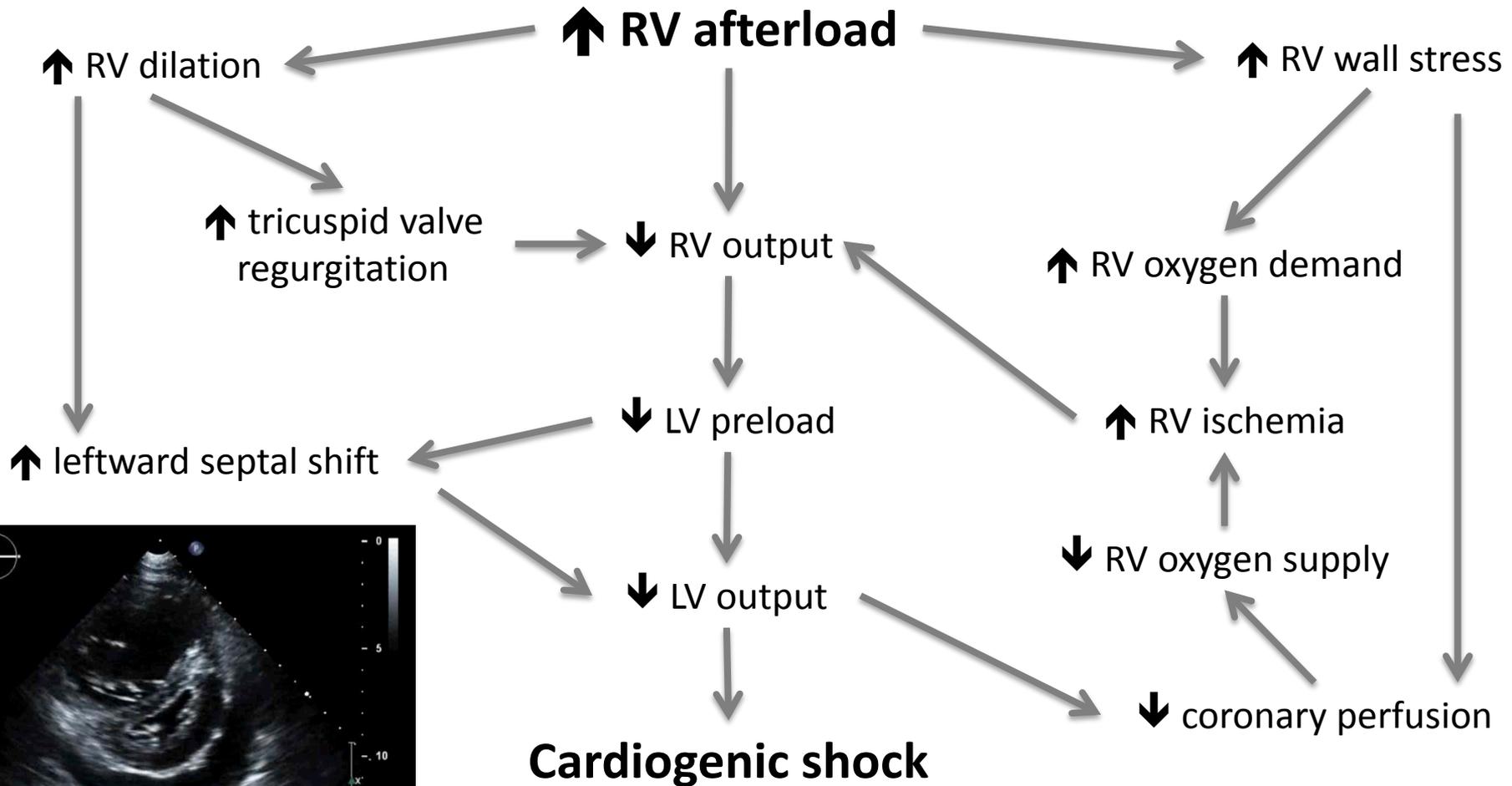
- Intubation is a high risk event (be prepared for cardiac arrest)
- Do not allow hypoxemia/hypercarbia, but high alveolar pressure is bad
- Inhaled nitric oxide or epoprostenol might help

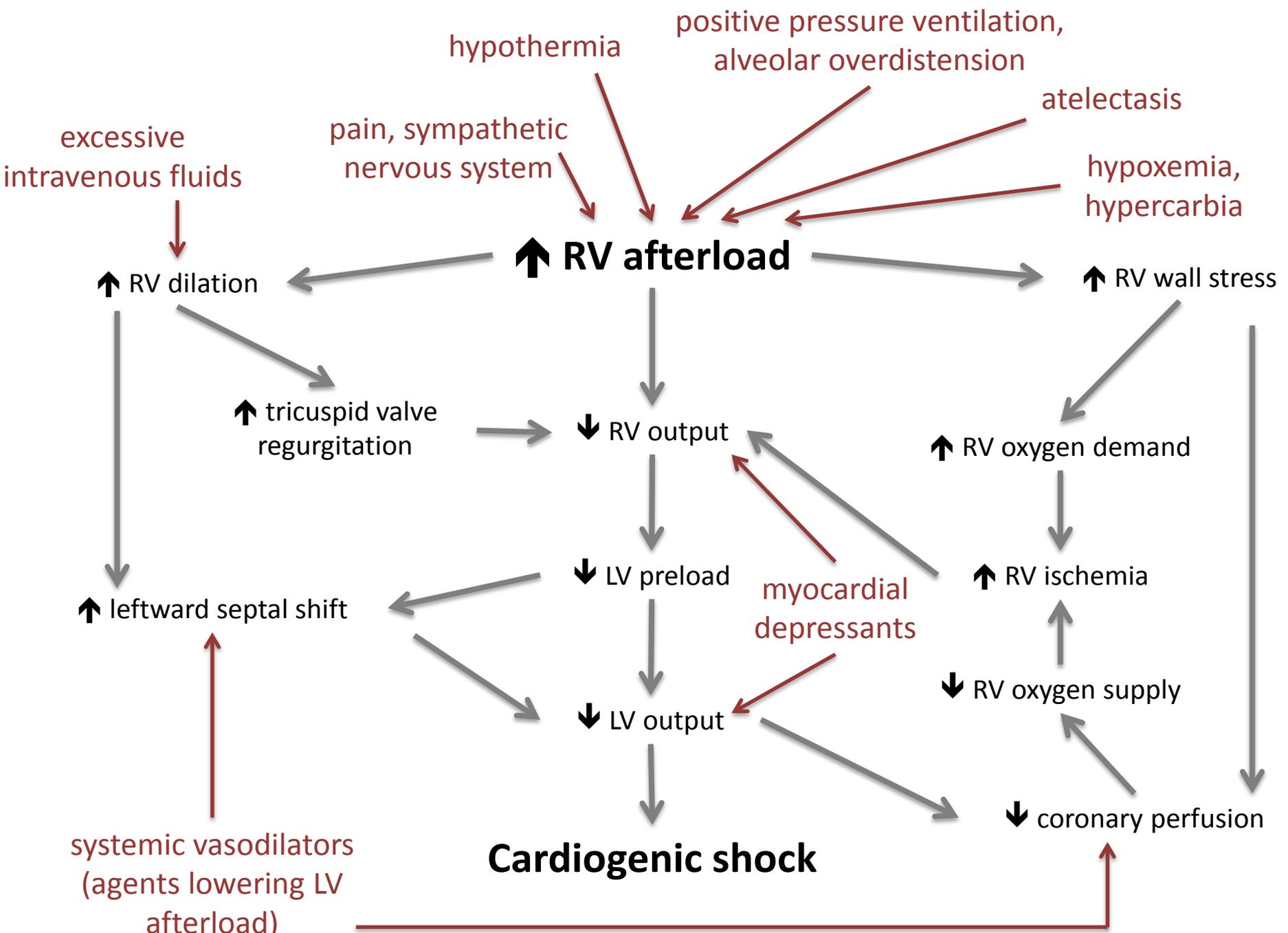
### Inotropy support

### Maintain aortic/RCA perfusion pressure

- Low SVR is poorly tolerated (more septal shift, poor coronary perfusion)
- Support SVR with vasopressors (usually mixed  $\alpha/\beta$ )

# Right ventricular auto-aggravation





# Case 3

- 56 yo male with history of DVTs on lifelong anticoagulation for underlying pro-thrombotic state presented to ED with traumatic SDH
- Coumadin reversed with prothrombin complex concentrate
- Taken emergently to OR for SDH evacuation
- Peri-Arrest in ICU POD 1- markedly dilated RV on bedside ECHO

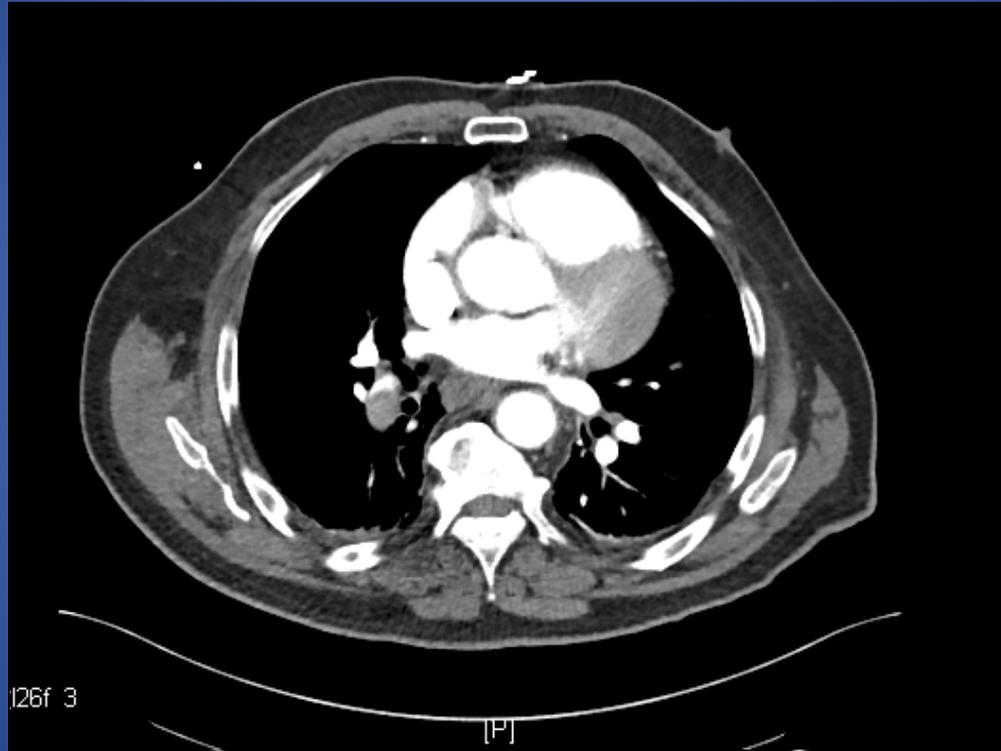
# Which Catheter to Choose?

- PERFECT registry did not find statistically significant difference USAT vs Regular lysis catheters\*
  - PA pressure reduction
  - Infusion time
  - Total tPA dose
- Only EKOS is FDA approved for pulmonary lysis
  - Uses Ultrasound to facilitate/accelerate lysis, fibrin disaggregation
  - ULTIMA, SEATTLE II used USAT

\* Kuo W T, Banerjee A, Kim PS, DeMarco F J, Levy J R, Facchini F R, Unver K, Bertini M J, Sista A K, Hall M J, Rosenberg J K, De Gregorio M A. Pulmonary embolism response to fragmentation, embolectomy, and catheter thrombolysis (PERFECT). Chest 2015; 148(3): 667-673.



# Massive PE



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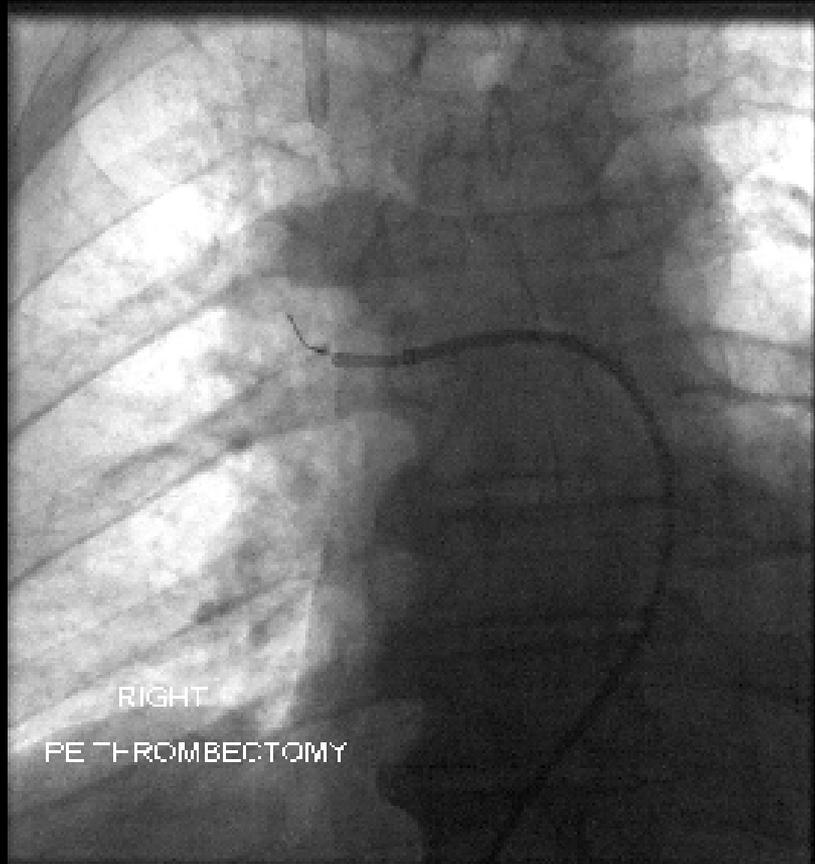
RIGHT  
PE THROMBECTOMY



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RIGHT  
PE THROMBECTOMY

RIGHT  
POST  
THROMBECTOMY

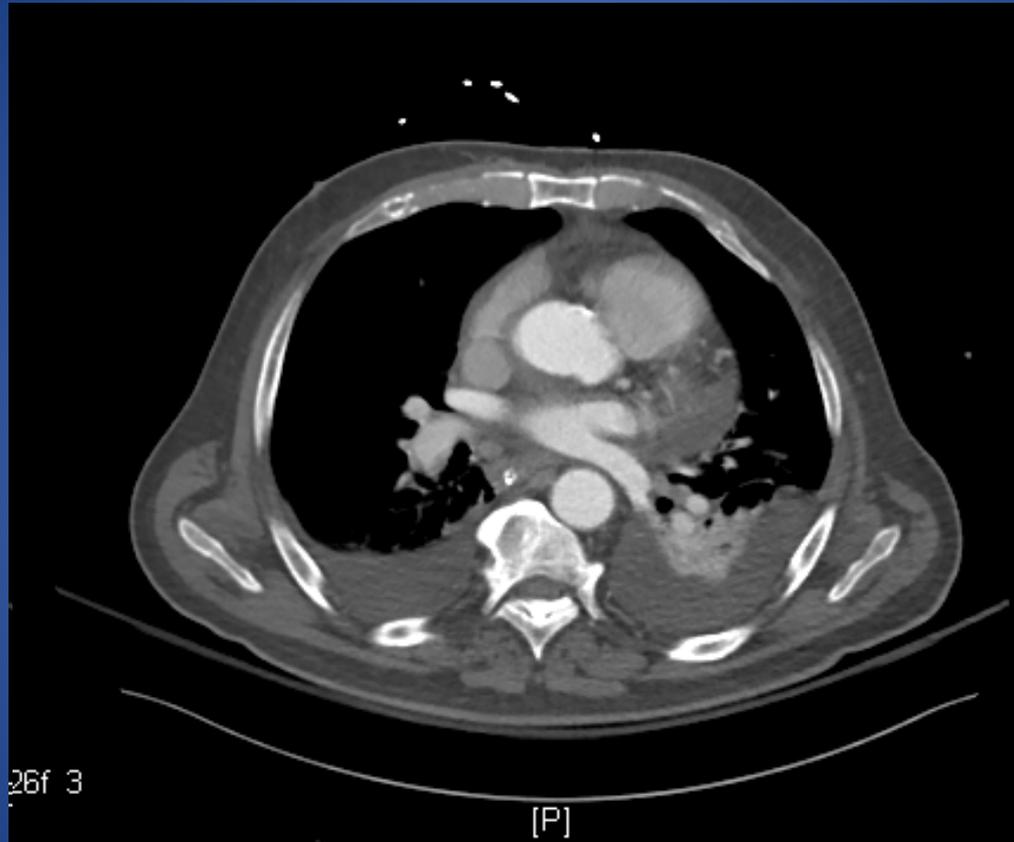


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# Post CT

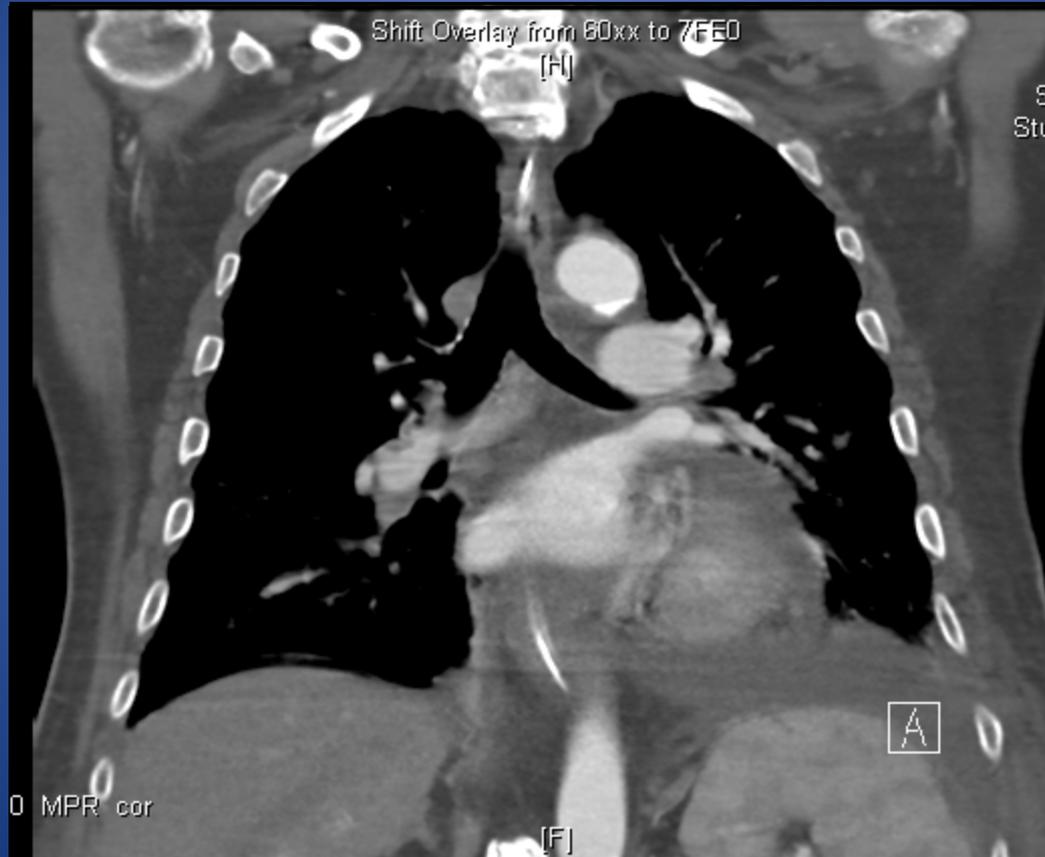


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# Post CT



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# Post CT



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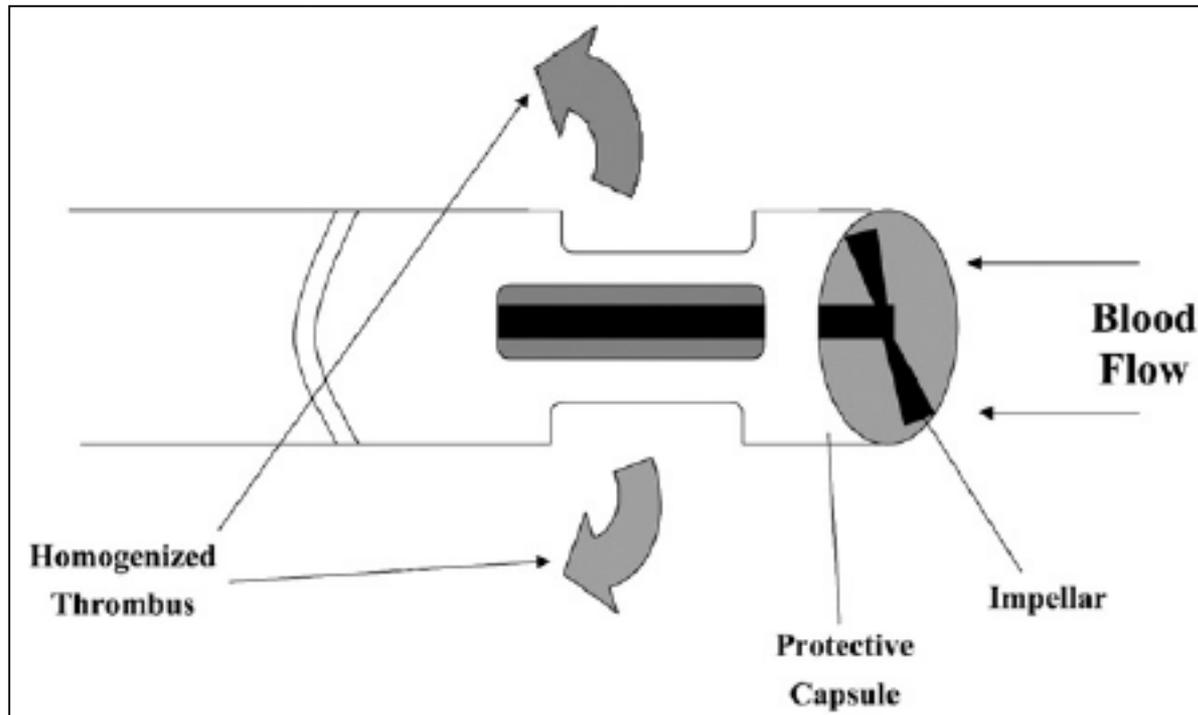


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Questions for our panel?

# Additional Slides

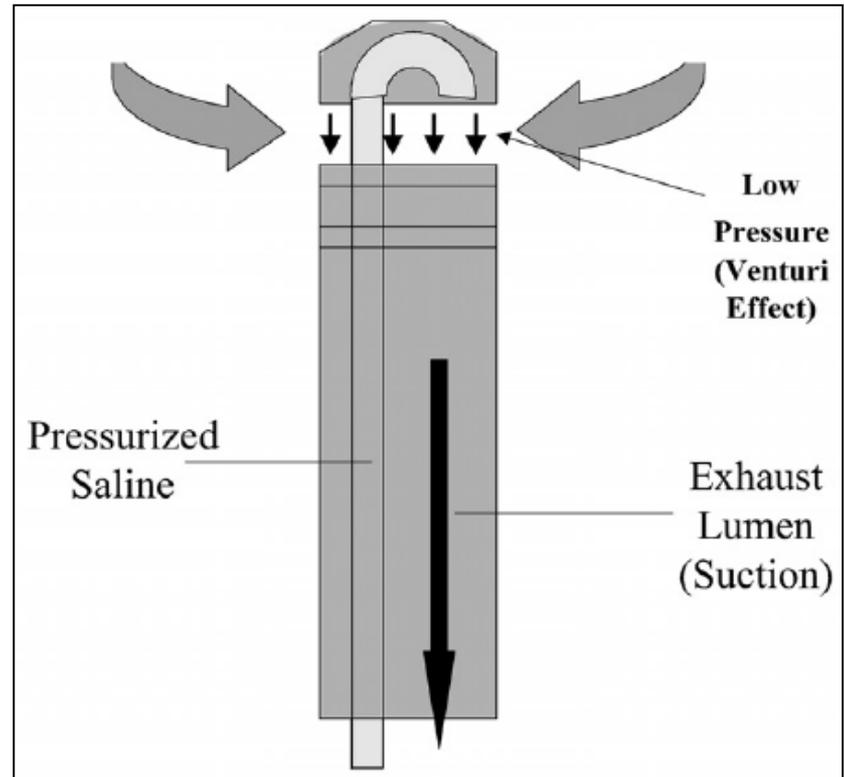
# Impeller System



Amplatz<sup>®</sup> Catheter

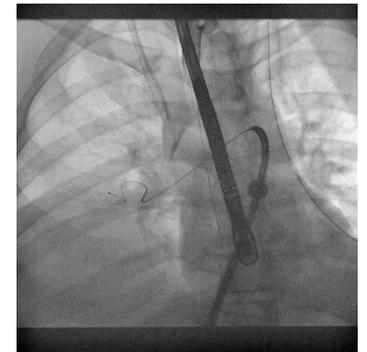
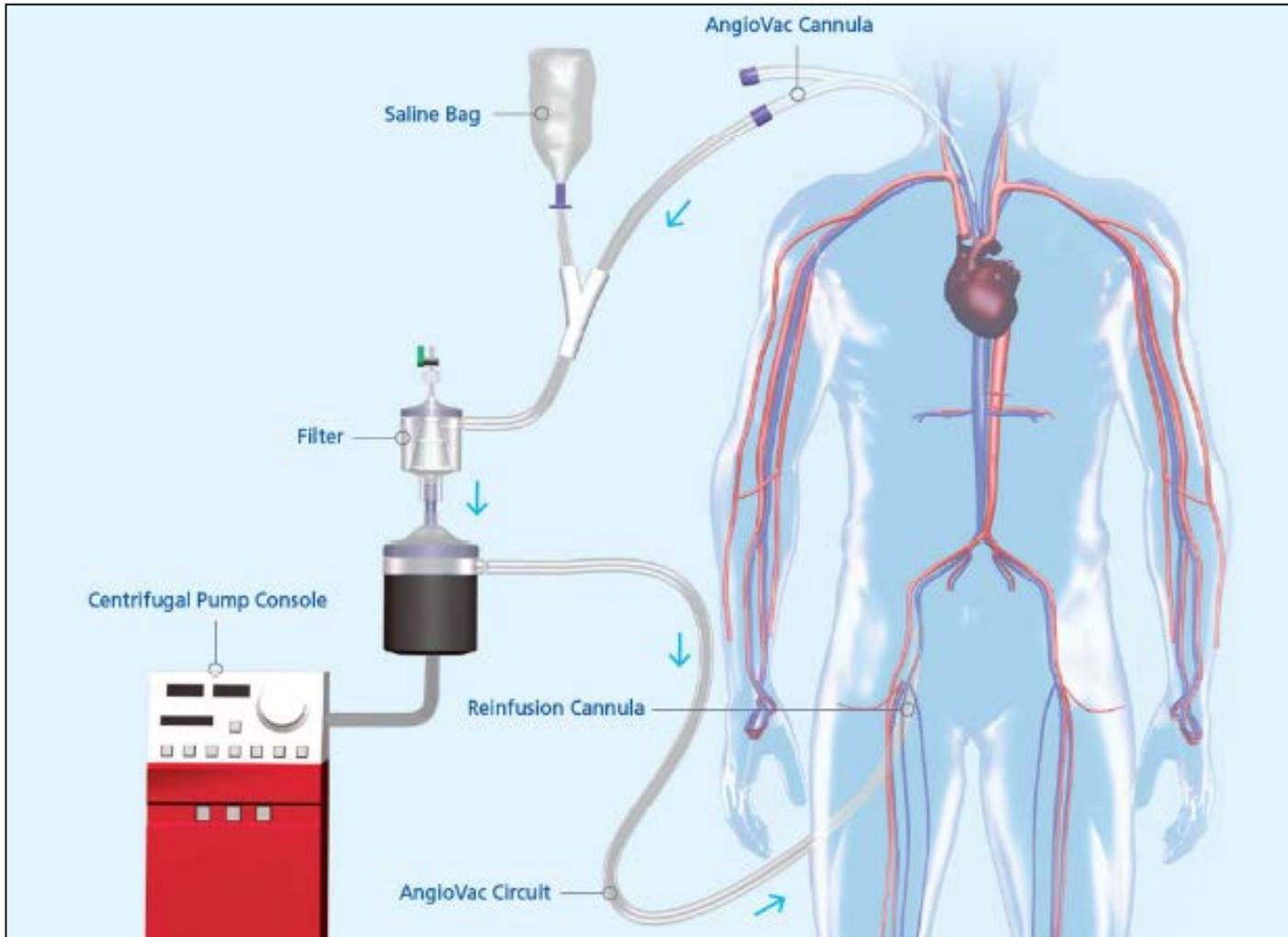
# Rheolytic Thrombectomy

- AngioJet®
- Hydrolyzer®
- Oasis®



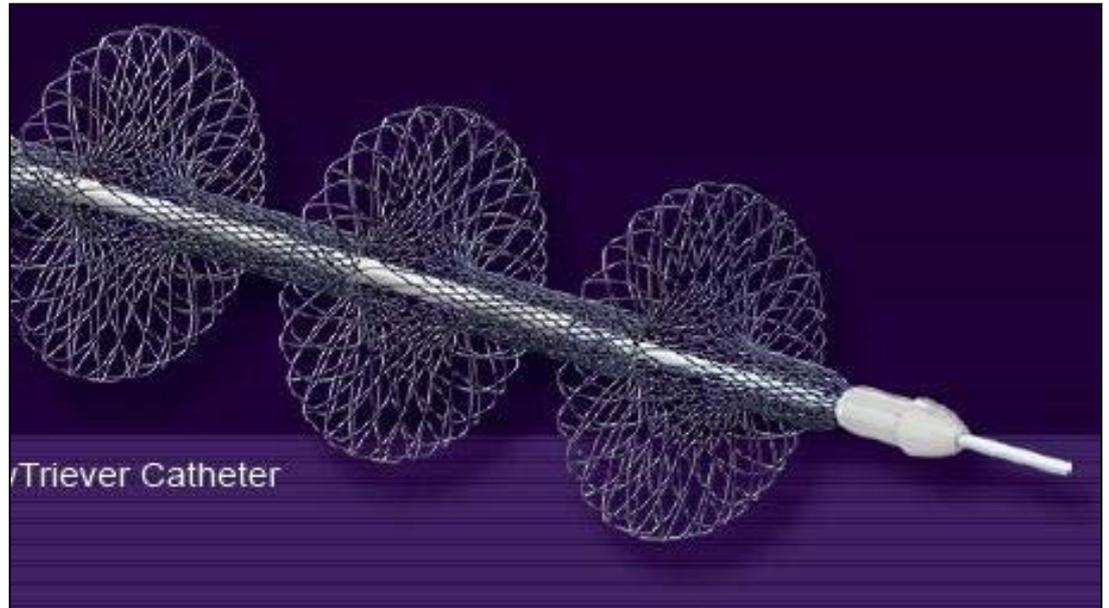
Venturi Effect

# Angiovac<sup>®</sup> / Vortex<sup>®</sup>



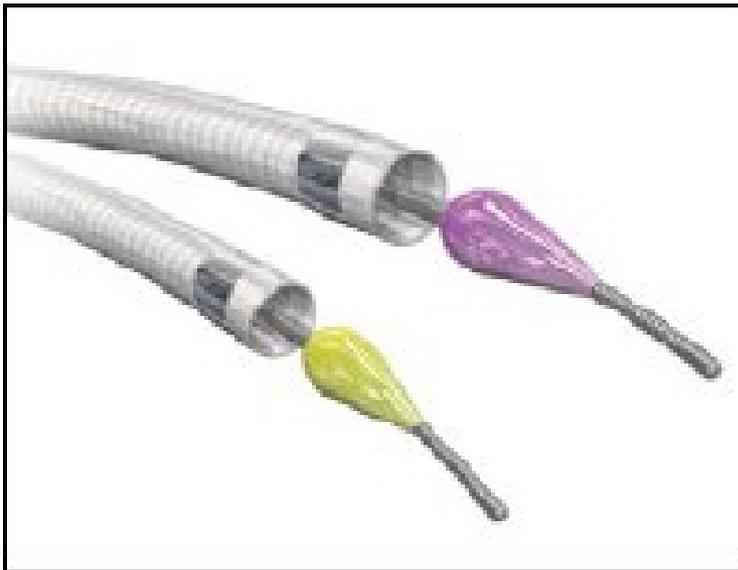
# Inari<sup>®</sup> Flowtriever<sup>®</sup>

- 22 F sheath
- 3 Nitinol discs
- FLARE Study Ongoing



# Penumbra<sup>®</sup> Indigo<sup>®</sup>

- 6F and 8F Aspiration catheter
- Suction pump
- Separator wire
- 3 different tips



# EKOS

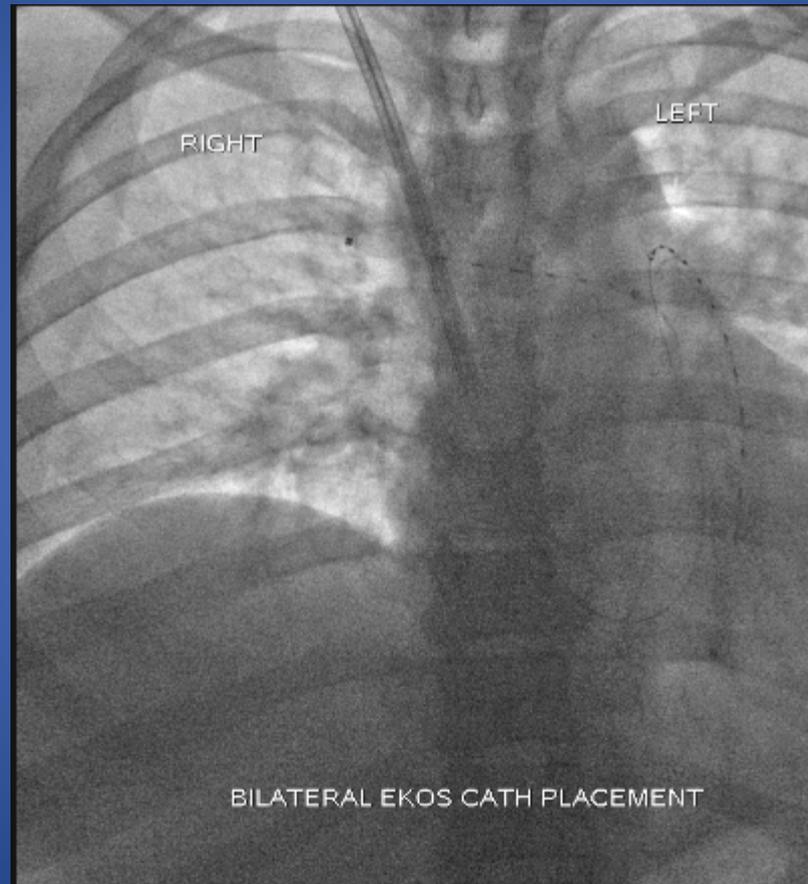


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# EKOS



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