



Post-Traumatic Venous Thromboembolism in 2016

M. Margaret Knudson MD, FACS

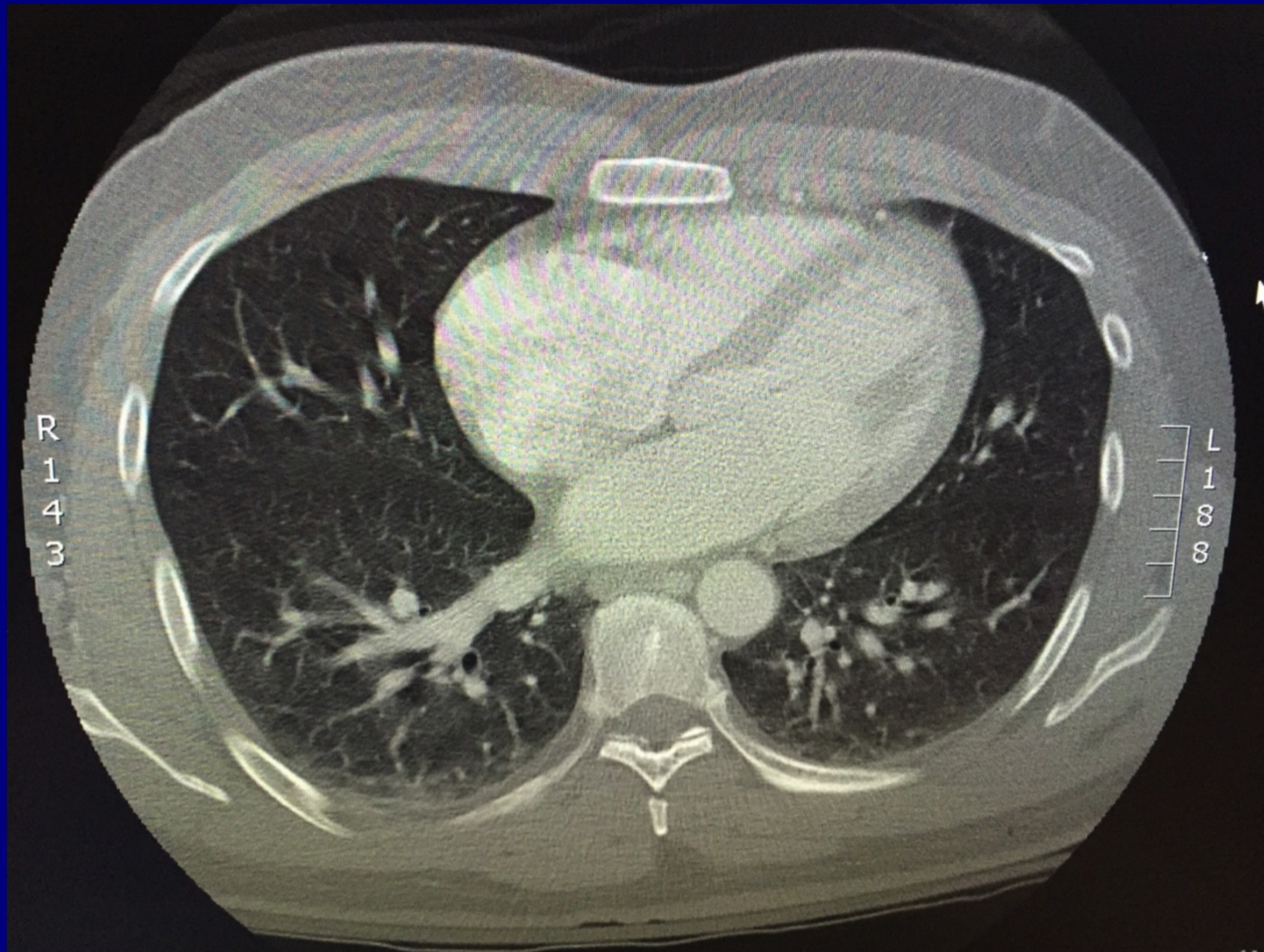
U. Of California, San Francisco

Case Presentation: SFGH 2016

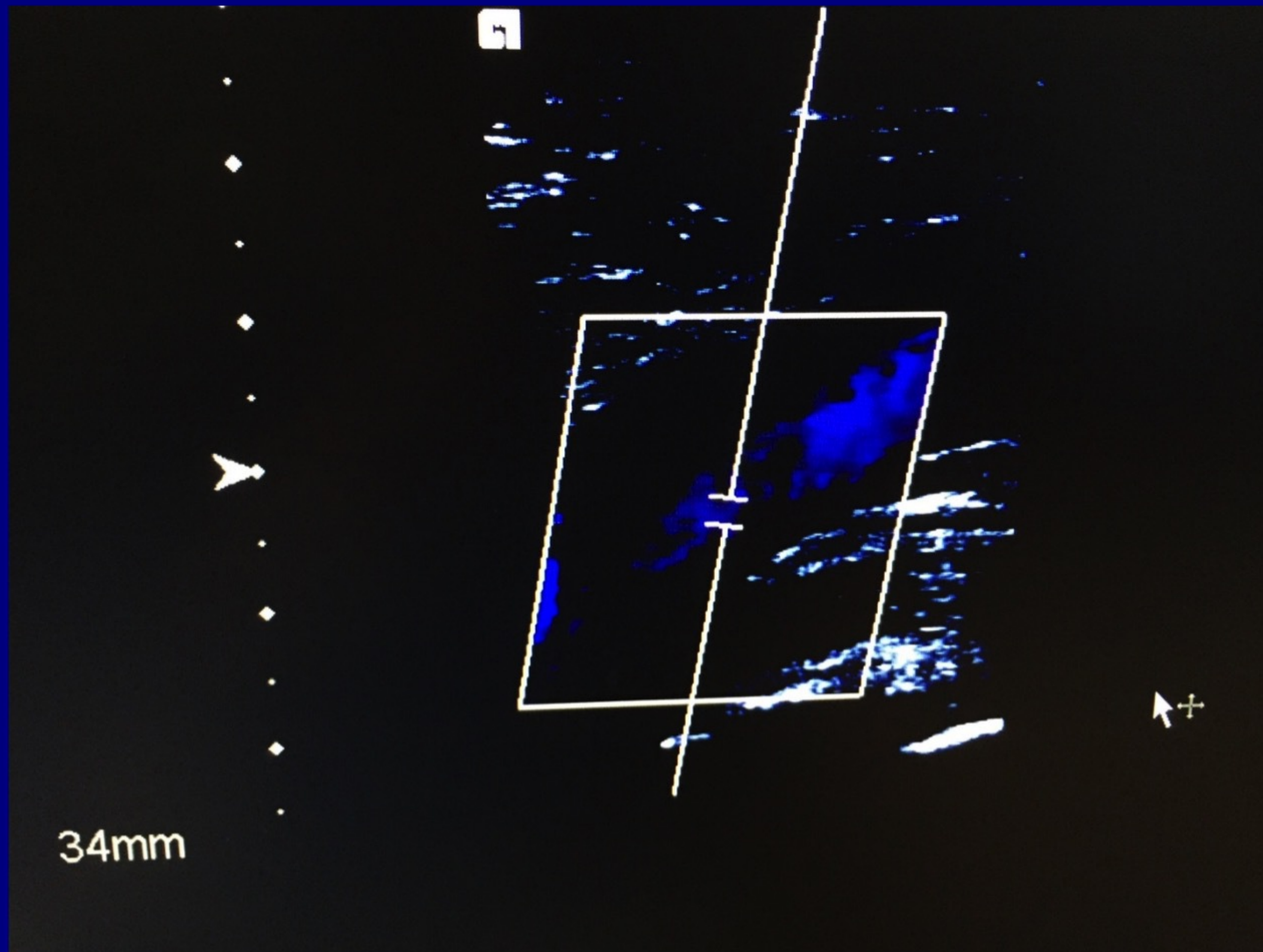
- 24 year old involved in MCC
- Presented to ED with mild hypotension
- Complaining only of severe leg pain
- Underwent full **trauma evaluation**
- Ortho anxious to **“fix the broken bone”**



Initial “Pan Scan”



Pre-operative Duplex Scan

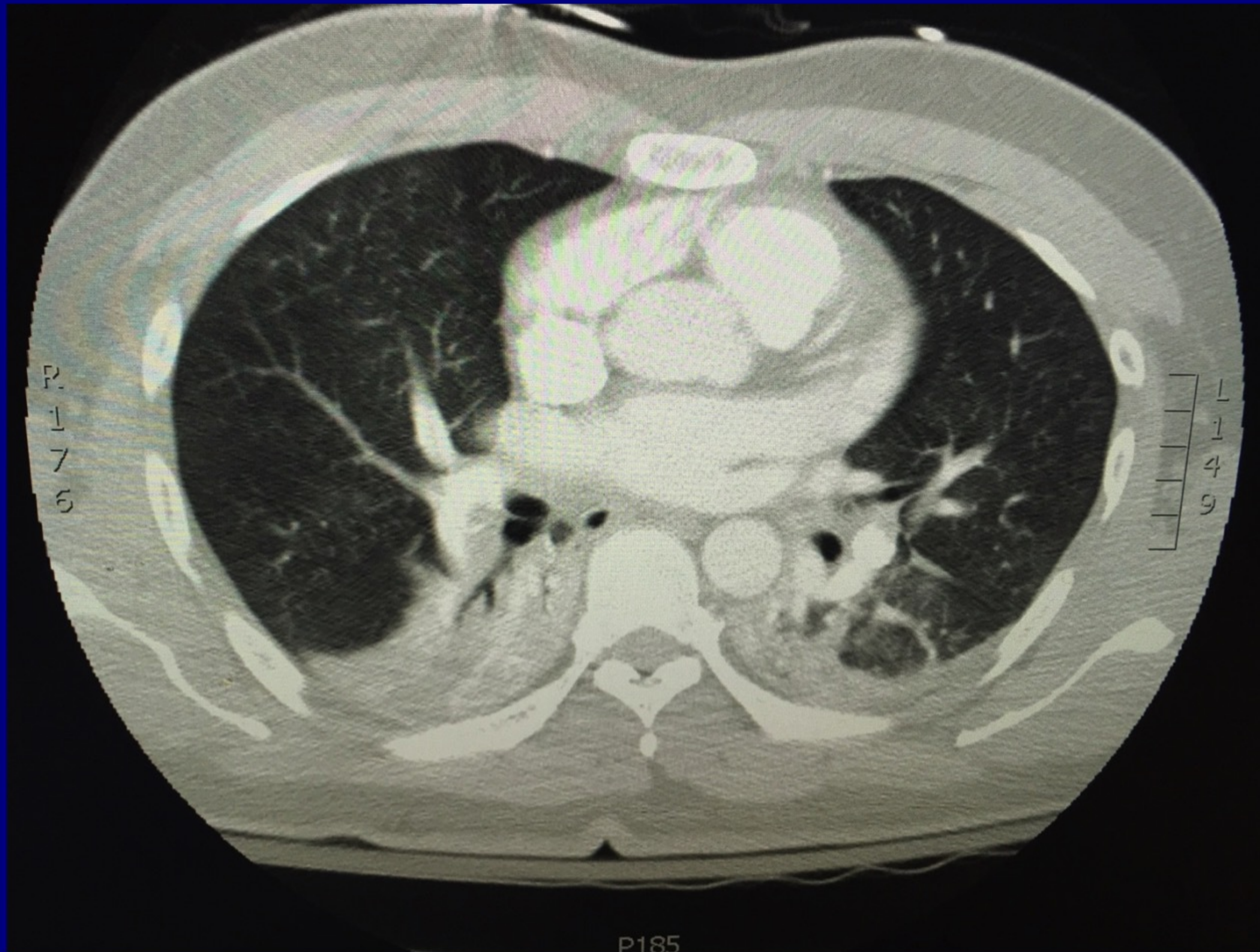


Case Presentation Continued

- Decision made to perform immediate orthopedic procedure
- Patient did well during surgery
- Developed **acute desaturation** in the recovery area
- **PaO₂= 40 mmHg!**



Immediate Post-Op CTA



Historical Perspectives

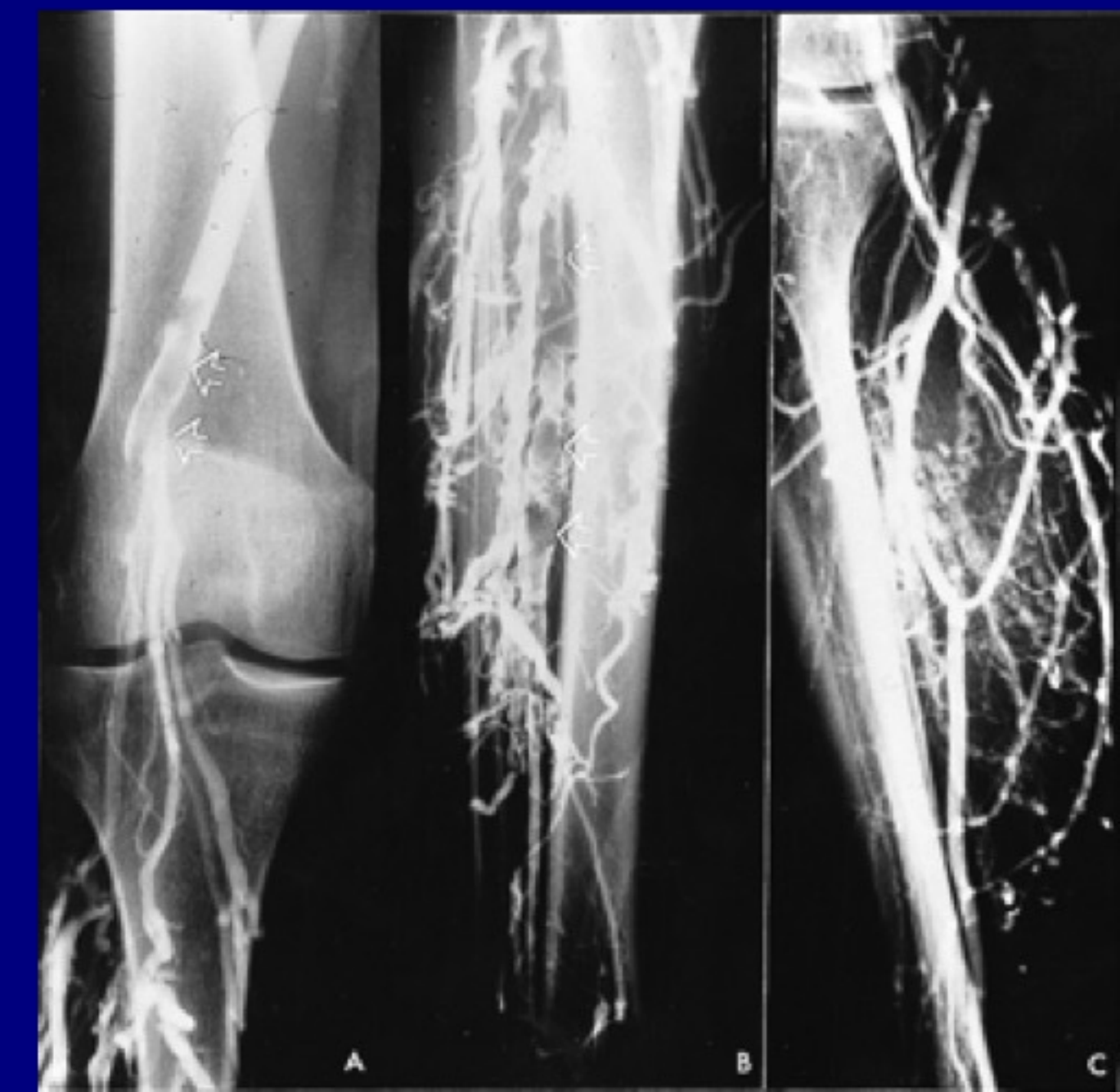
“A study of protocols of 9,882 postmortem exams including death from injury...in the traumatic group embolisms were found in 61 cases(3.8%) and in the non-traumatic group in 222 cases (2.6%). Statistically, this appears to be a significant difference.”

J.S. McCartney, 1934

Historical Perspectives

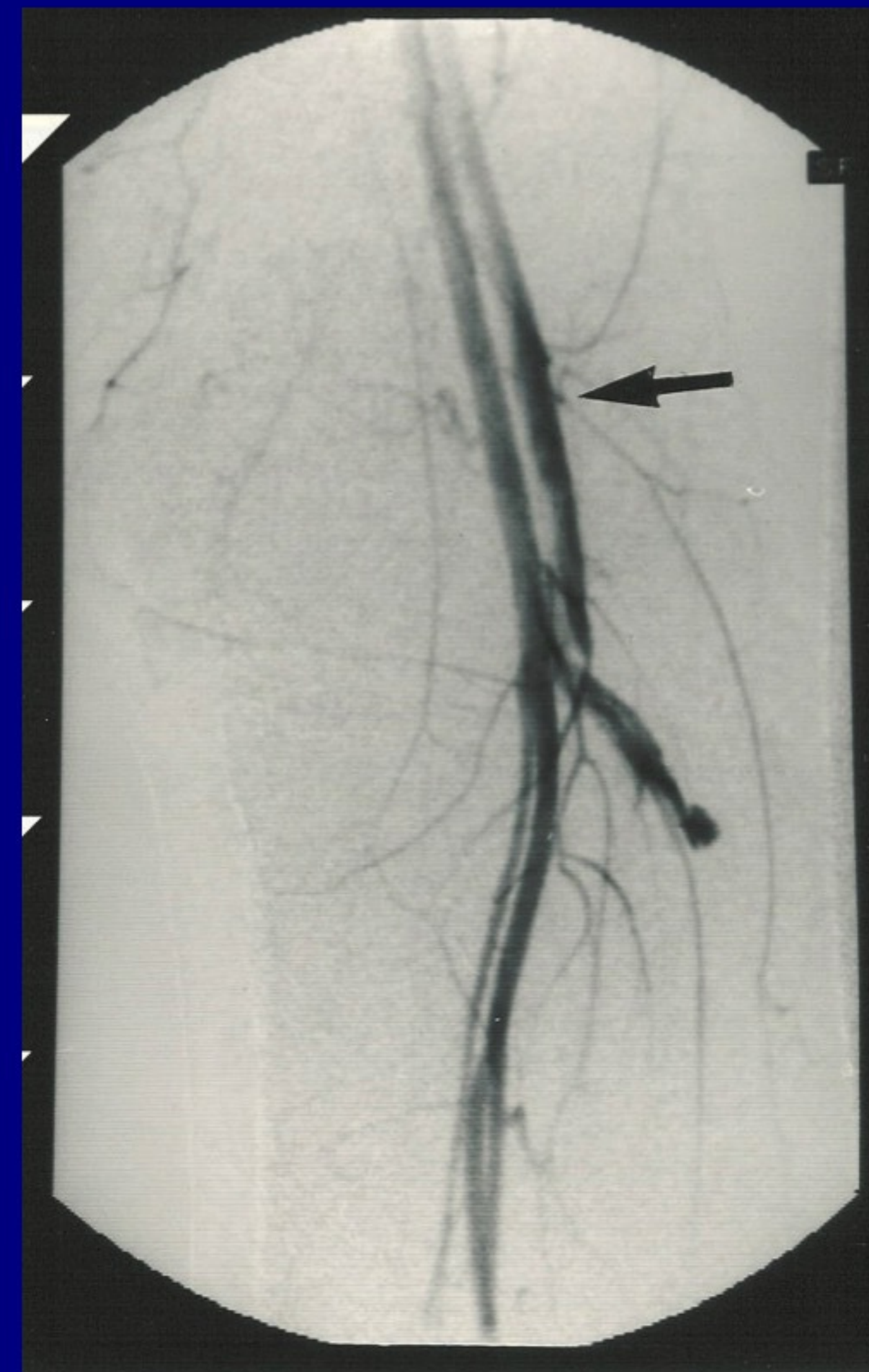
- 124 trauma patients: venograms
- Fracture patients: 35% venous thrombosis
- Thrombus found within 24 hours of injury
- Both injured/uninjured extremity
- 2/3rds with DVT-asymptomatic

Freeark et al, 1967



INCIDENCE: OCCULT DVT

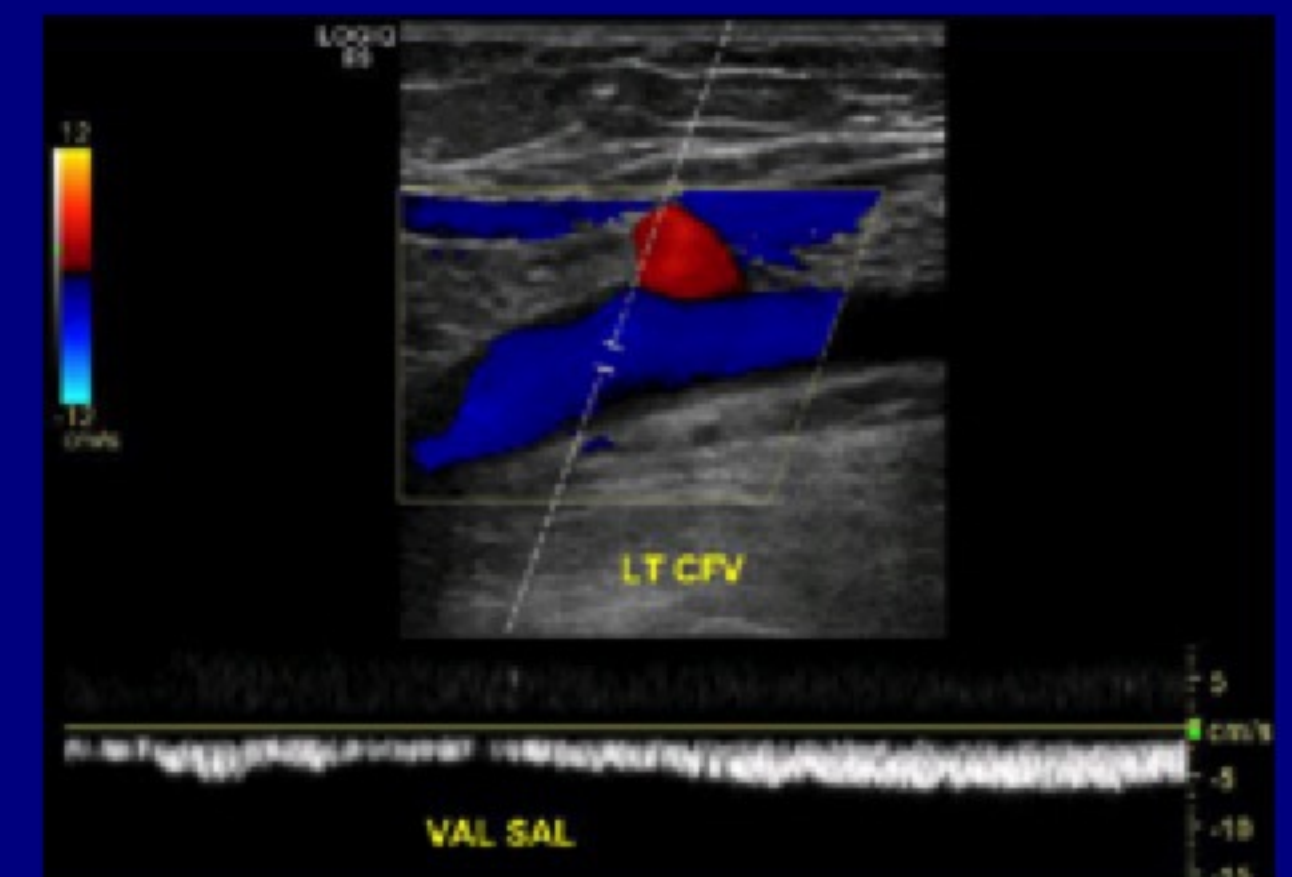
- 349 injured patients: screening venography*
- **None receiving prophylaxis**
- Proximal DVT rate: 18%
- PE rate: 2% (43% mortality!!)



*Geerts et al, NEJM 1994

Current Data on Surveillance Bias

- 17 Trauma Centers involved in “CLOTT”
- Incidence of Clinically recognized DVT: 1-2%
- Routine Surveillance with Duplex
- **Occult DVT: 9%**
- Should they all be treated????
- Quality measure tied to reimbursement



Incidence of Occult PE after Trauma

- 90 consecutive patients; ISS ≥ 9
- Asymptomatic; no DVT
- Chest CT: between 3-7 days
- **22 had clot on CT; 4 were major!**
- 30% were receiving prophylaxis



THROMBOEMBOLISM AFTER TRAUMA

AN ANALYSIS OF 1602 EPISODES FROM THE ACS NATIONAL
TRAUMA DATA BANK

Annals of Surgery 2004

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The University of California, San Francisco

RESULTS

- 450,375 patients included
- 84% blunt injuries
- 31% ISS>10
- 998 pts: DVT (0.36%)
- 522 pts: PE (0.13%)
- 82 pts: both DVT/PE
- PE mortality: 18.7%



RISK FACTOR ANALYSIS

Risk Factor *	Odds Ratio
Shock on admission (BP < 90 mHg)	1.95
Age \geq 40 yrs.	2.29
Head injury (AIS \geq 3)	2.59
Pelvic fracture	2.93
Lower extremity fracture	3.16
Spinal cord injury with paralysis	3.39

* Greenfield 1997, 2000; Knudson 1994, 1996

p < .0001 for all factors

RISK FACTOR ANALYSIS (CONT')

Risk Factor	Odds Ratio
Major surgical procedure	4.32
Venous injury	7.93
Ventilator days > 3	10.62

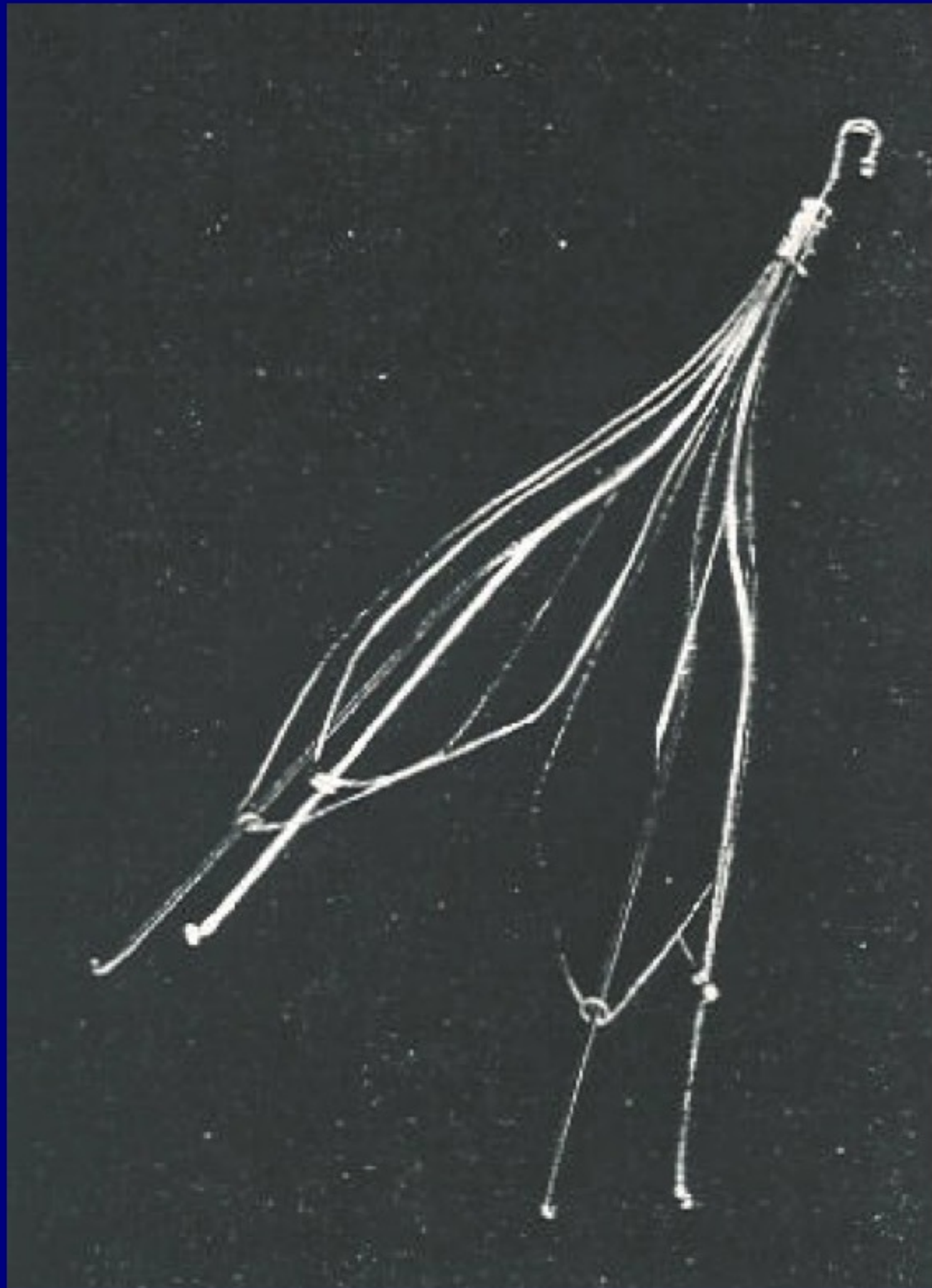
p < .0001 for all factors

MULTIVARIATE ANALYSIS

Risk Factor	Odds Ratio
Head injury (AIS ≥ 3)	1.24
Major operative procedure	1.53
Lower extremity fracture (AIS ≥ 3)	1.92
Age ≥ 40 years	2.01
Venous injury	3.56
Ventilator days > 3	8.08

$p \leq 0.0125$ for all factors

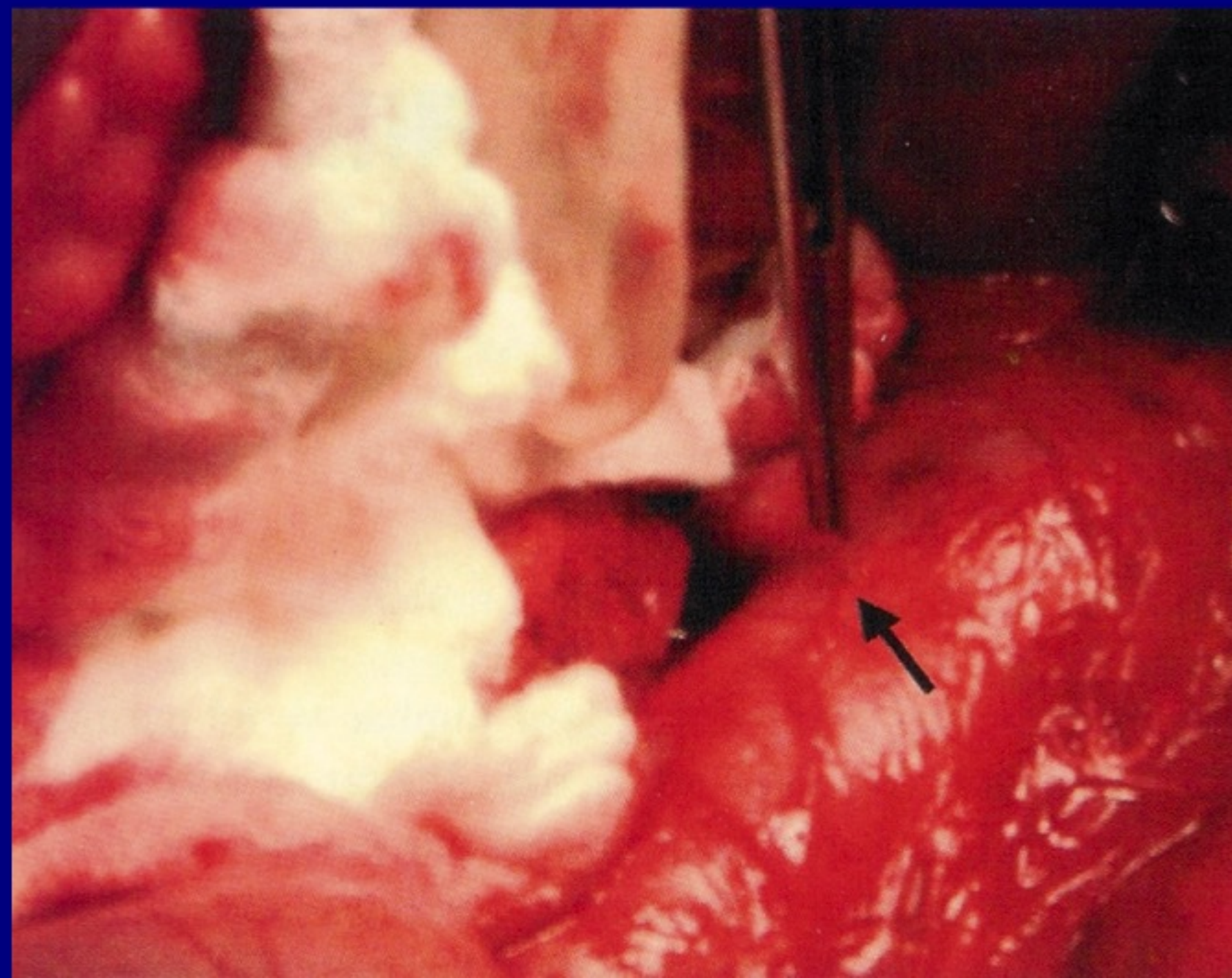
VENA CAVA FILTERS



- Procedure code: “IVC plication”
- 3,883 patients
- 86%: prophylaxis (no VTE)
- PE rate in filter group: 4.7%
- 410 patients: no risk factors
- Permanent IVC filters

CONCLUSIONS

- Clinically significant VTE rates: low
- 90% VTE pts. have at least 1 risk factor
- VTE risk- varies with each factor
- **Role of IVC filters: re-examined**



PROPOSED ALGORITHM

Injured Patient

High Risk Factor
(OR for VTE = 2-3)

- Age ≥ 40
- Pelvic fx
- Lower extremity fx
- Shock
- Spinal cord injury
- Head trauma (AIS ≥ 3)

Contraindication for heparin?

No

LMWH*

Yes

Mechanical
compression

VERY High Risk Factor
(OR for VTE = 4-10)

- Major operative procedure
- Venous injury
- Ventilator days > 3
- 2 or more high risk factors

Contraindication for heparin?

No

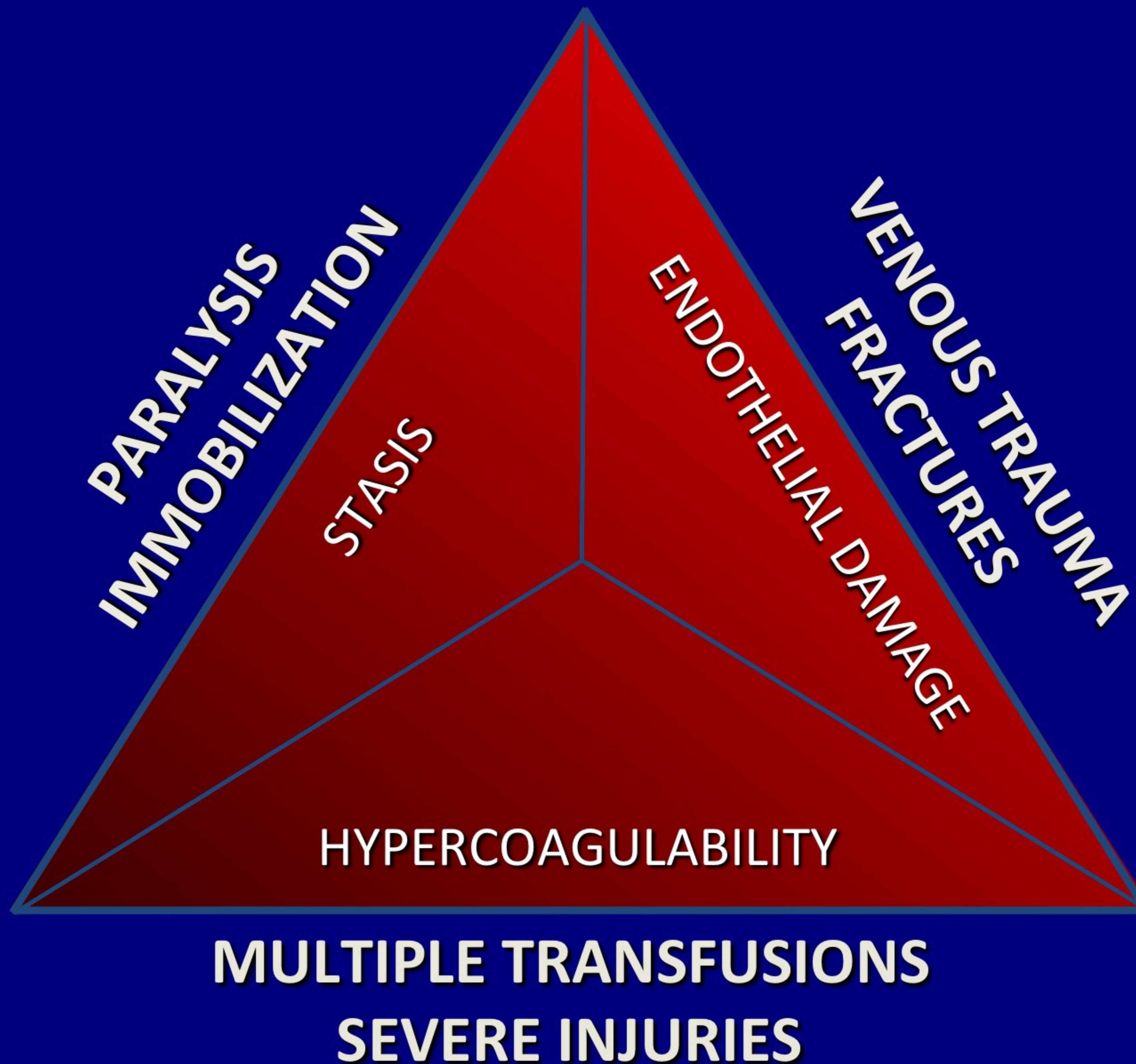
LMWH* and
mechanical
compression

Yes

Mechanical
compression
and serial CFD
OR temporary
IVC filter

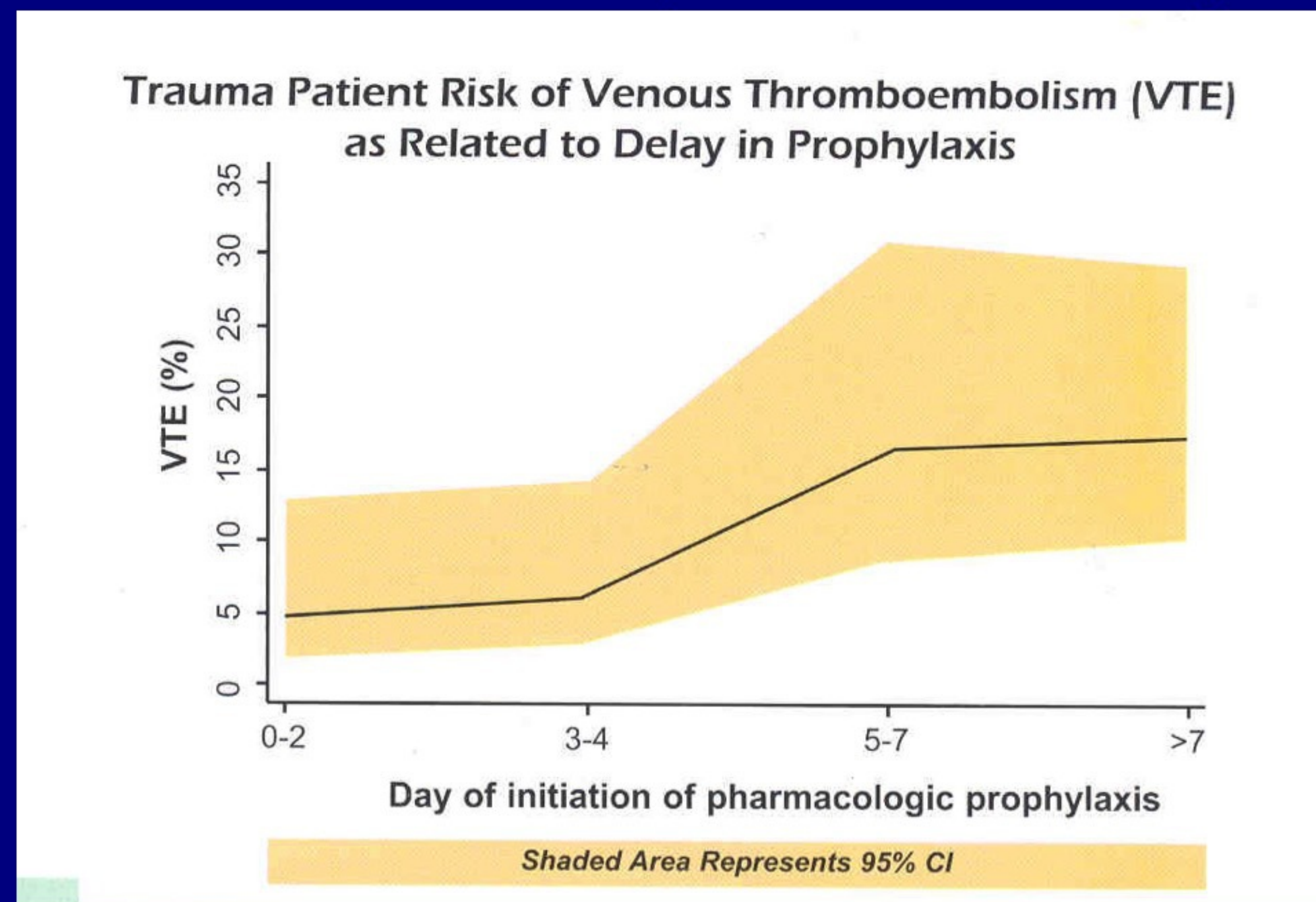
*Prophylactic dose

Knudson's Trauma Triad



Practice Patterns VTE Prophylaxis in Trauma

- 315 patients: 11% VTE
- Early prophylaxis: 4% risk
- Prophylaxis after 4 days: **3 times greater!**



Filter Fever!



Prophylactic Vena Cava Filters?

- Problems:
 - Recurrent PE: 3%
 - No protection against DVT
 - 10%: caval thrombosis
 - permanence: leg edema
 - migration/IVC perforation
 - timing: 6% PE within 24 hours

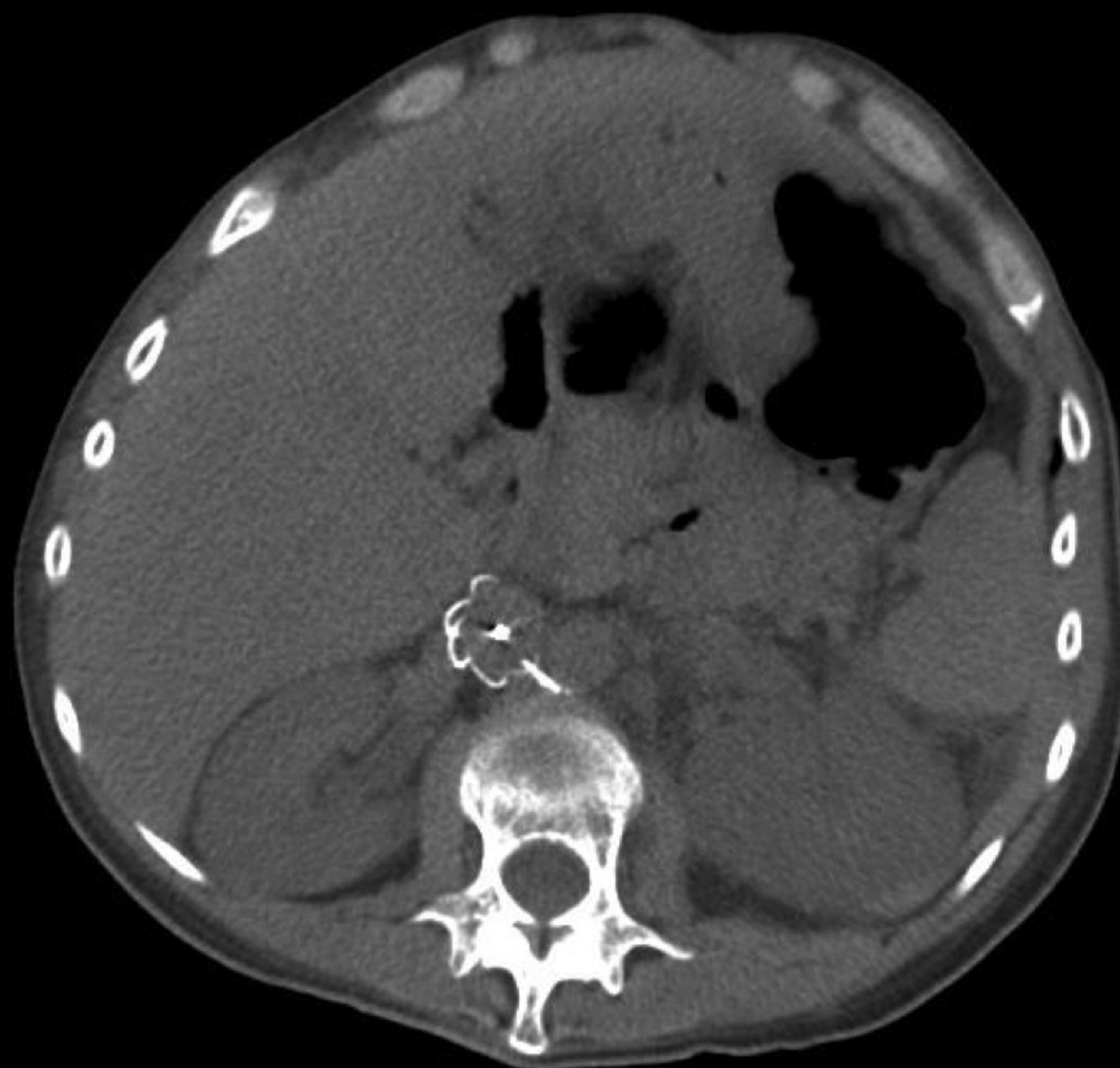
Retrievable Filters: “NOT”

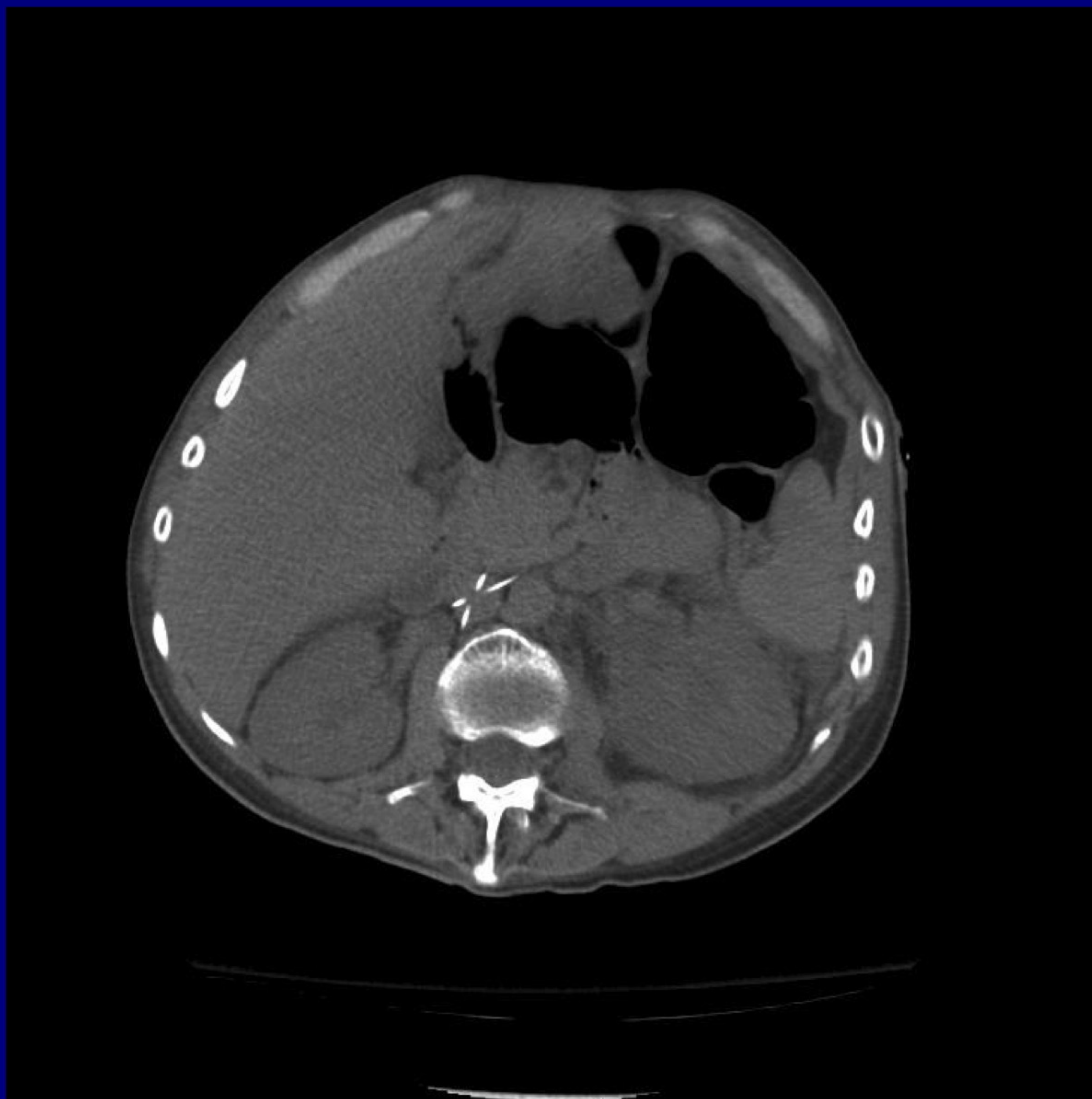
- May be retrieved within 5 days
- May be left in place: 30 days?
- Solution for high risk patients?
- Leads to 3-fold increase use
- AAST study: >400 patients
- Only 22% were retrieved!
- \$100,000/ PE prevented

Antevil J Trauma 2006

Karmy-Jones J Trauma 2007









3738 POST-TRAUMATIC PULMONARY EMBOLI

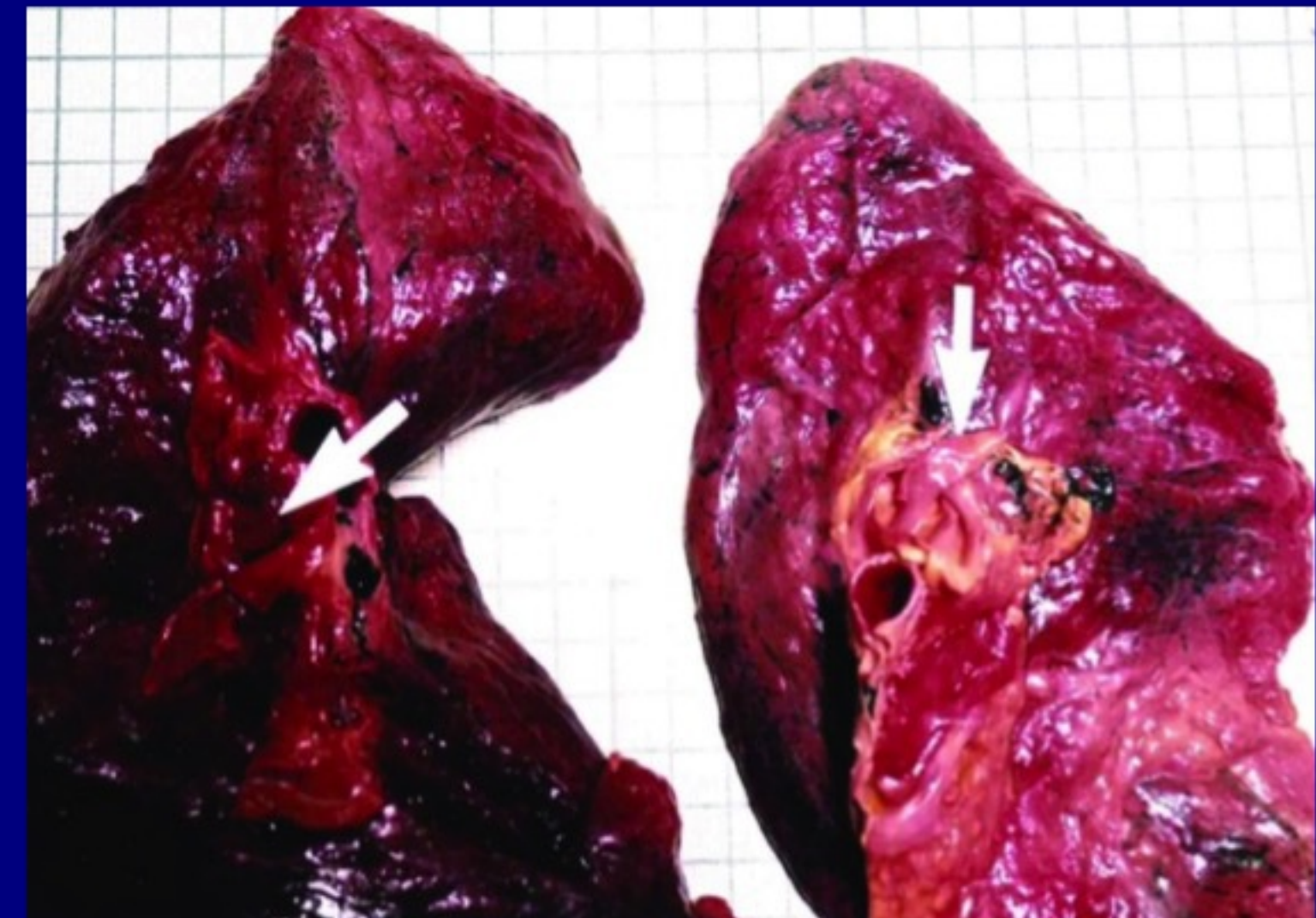
A NEW LOOK AT AN OLD DISEASE

M.M.Knudson, D. Gomez, B.Haas, MJ Cohen,
AB Nathens

U. California San Francisco, U. Toronto

Historical Perspective: Pulmonary Emboli

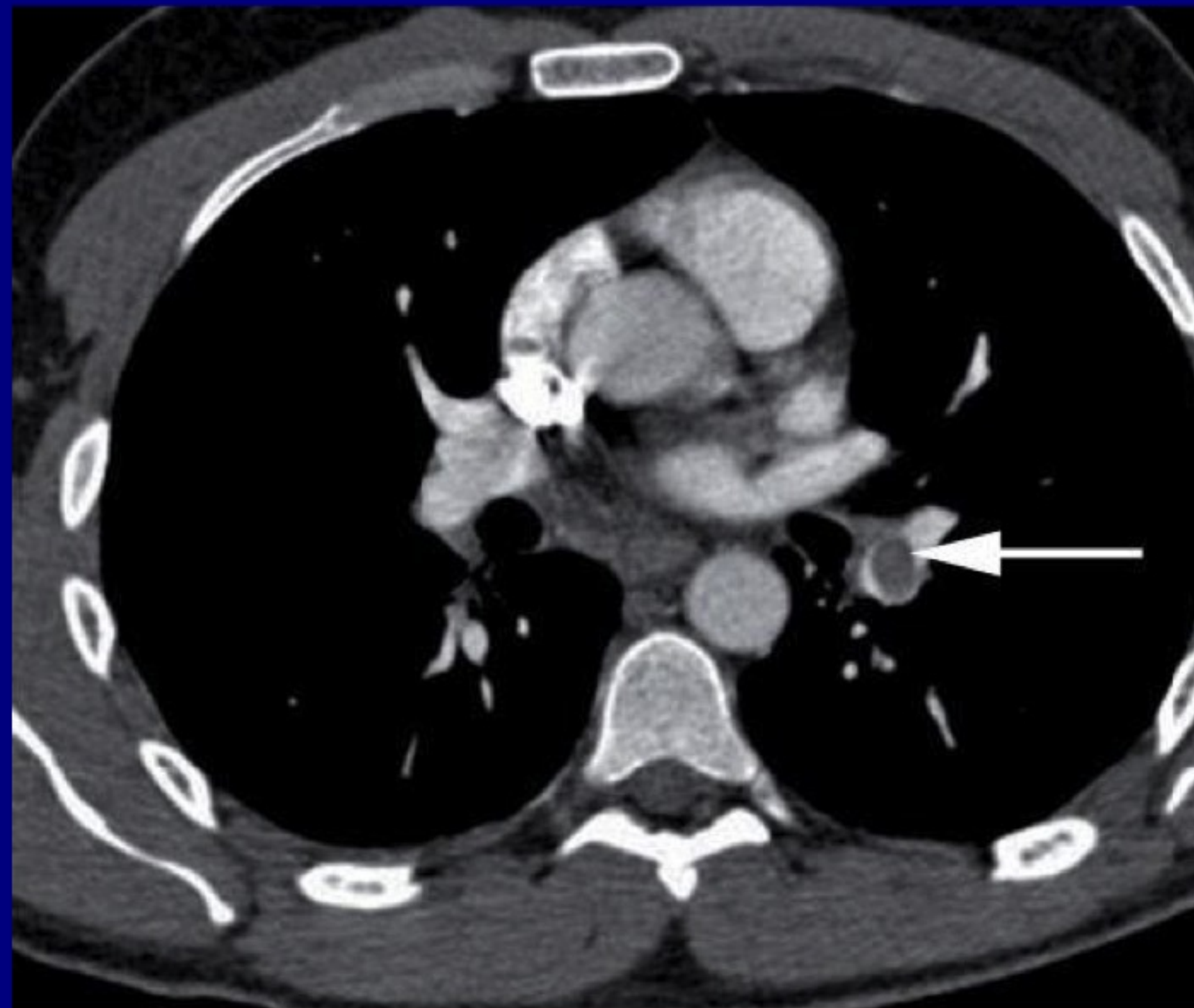
- Recognized post-injury complication: 1934*
- Mortality rates: **25-50%**
- Clinical presentation: acute hypoxia, collapse
- Diagnostic study: **autopsy**



**McCartney, Am J Pathology*

Current Perspective: PE

- “Potentially preventable” complication
- Clinical Presentation: **unexplained drop PaO₂**
- Often incidental finding: multidetector CT scan
- **Quality indicator:** CMS, JACHO, AHRQ

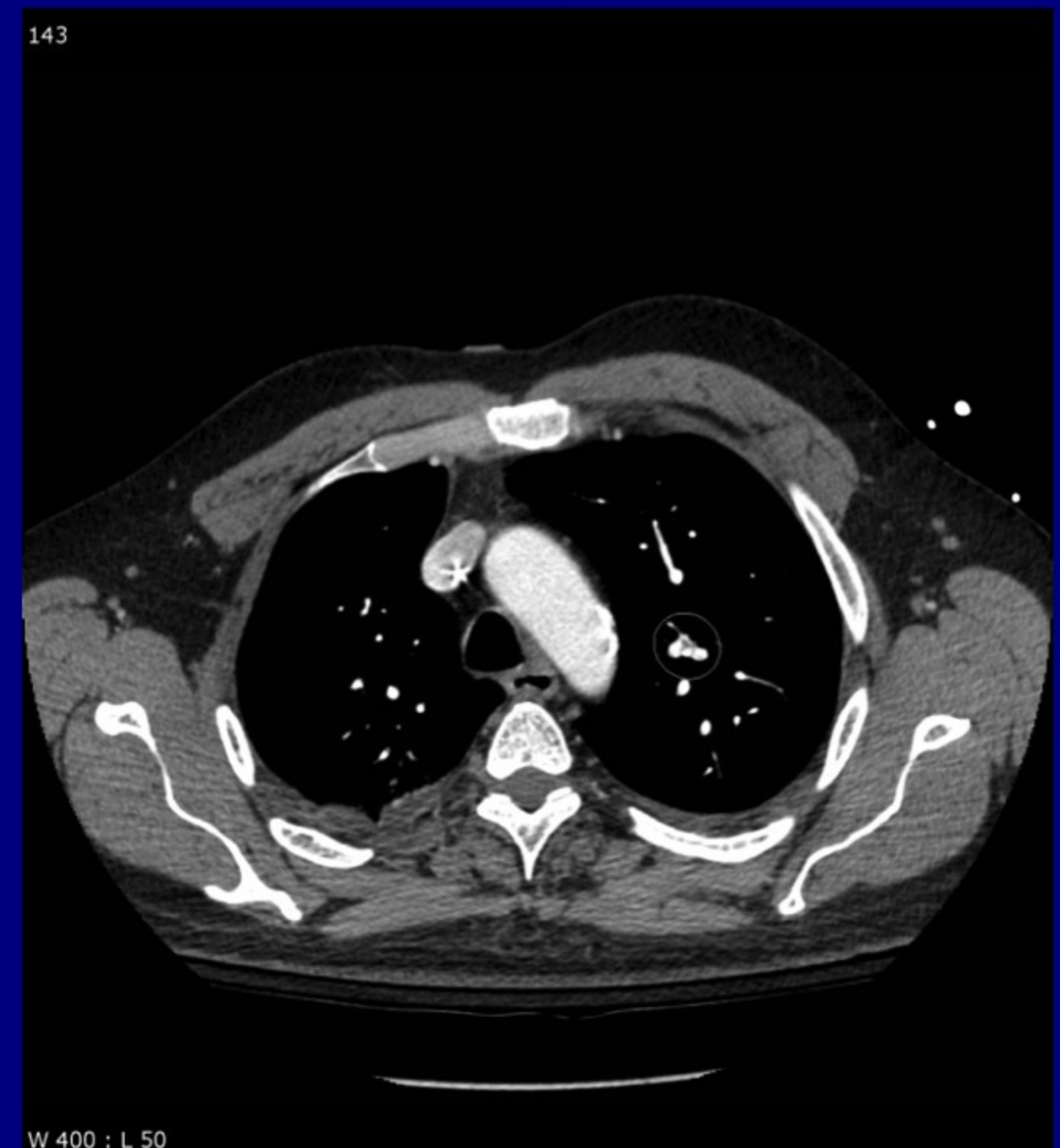
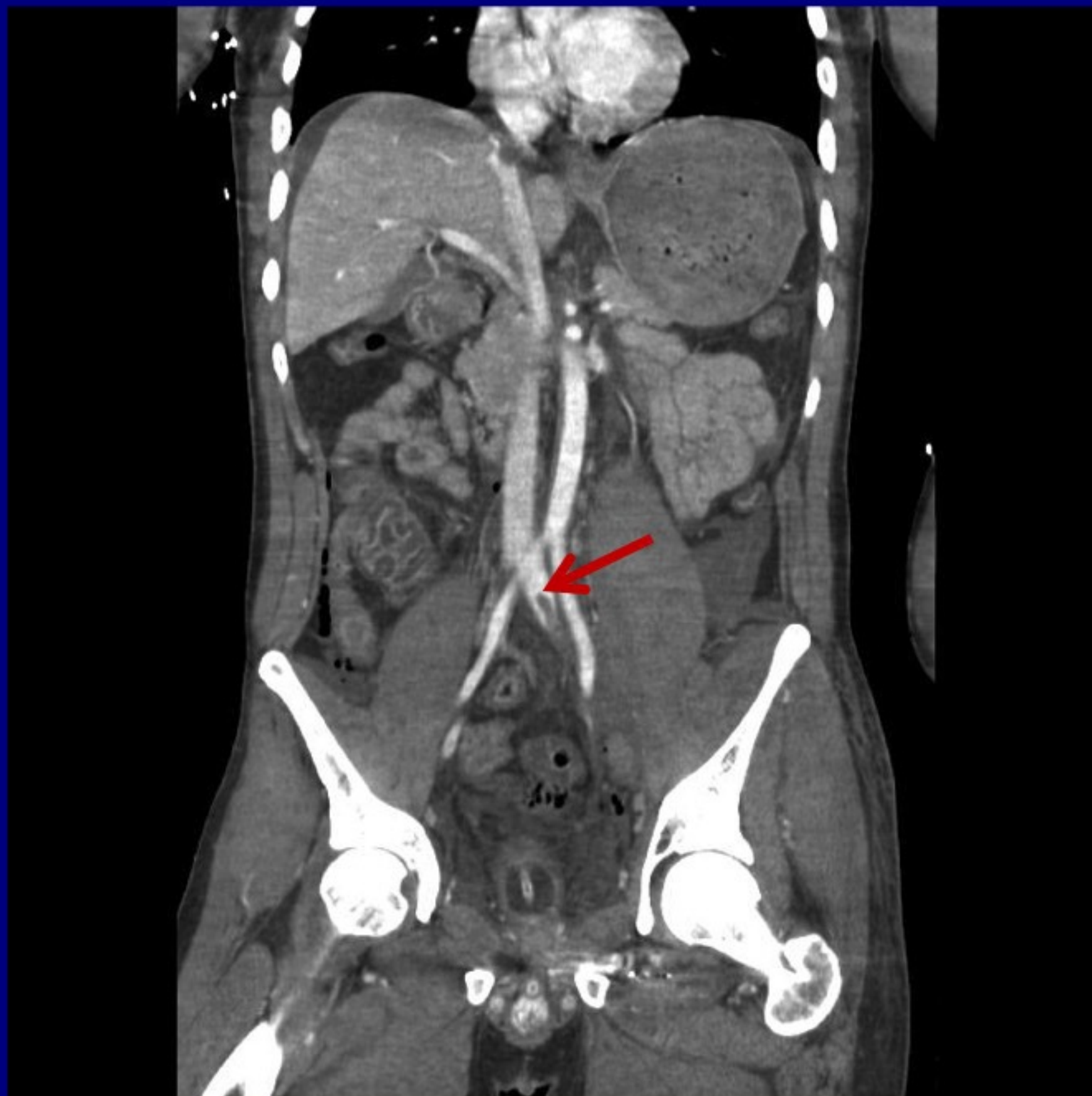


Purpose

- To describe the current **incidence** of pulmonary embolism following trauma in the United States
- To determine the **PE-attributable mortality**

Major Hypotheses

1. Risk factors for PE-different from DVT
2. PE-incidence rates are increasing
3. PE-attributable mortality is decreasing



Methods

- **ACS/NTDB**
- Adult patients: Level I/II centers*
- **Current** version: 2007-2009
- **Historical** comparison: 1994-2001 (version 1)
- **Comparison**: centers contributing to both
- Hierarchical logistic regression models: risk factors, mortality

**(centers reporting at least one complication)*



Results: Current NTDB Cohort

- 888,652 Patients; 326 Trauma Centers
- Overall mortality: 1.8%
- 9,398 episodes: **DVT (1.06%)**
- 3,738 episodes: **PE (0.42%)**
- Only 20% with PE had DVT reported

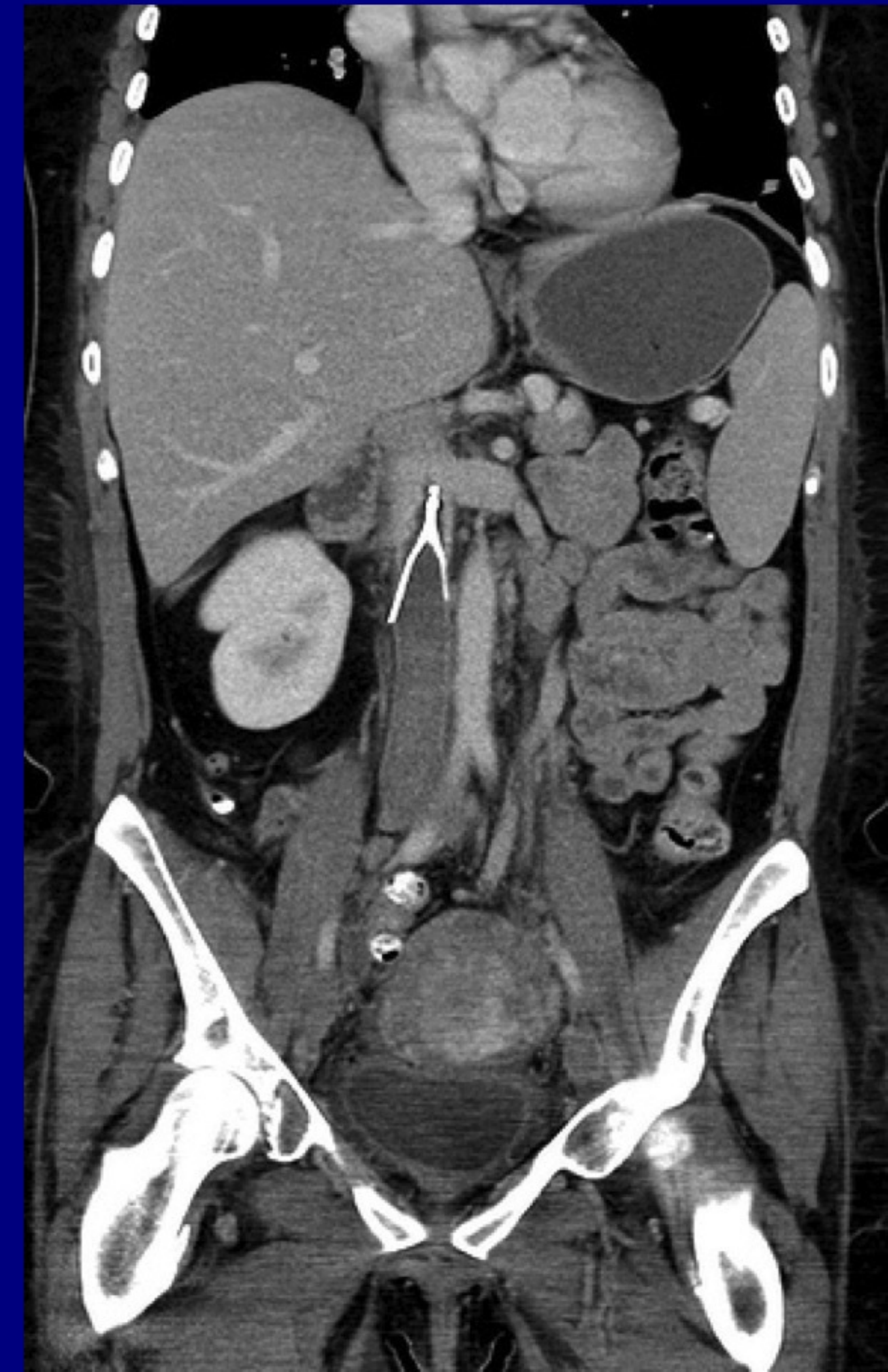


Risk Factor Analysis

Risk Factor	DVT (9,398); OR (95% CI)	PE (3,738); OR (95% CI)
Severe TBI	1.34 (1.20-1.48)*	0.87 (0.73-1.04)
Ventilator Days >3	5.31 (5.05-5.60)*	3.81 (3.48-4.18)
Severe Chest Injury (AIS \geq 3)	1.07 (1.01-1.12)	1.42 (1.30-1.55)*
Lower Ext. Fracture (AIS \geq 3)	1.53 (1.45-1.62)	1.81 (1.67-1.97)
Pelvic Fracture	1.32 (1.24-1.41)	1.19 (1.08-1.32)
Spine Injury (AIS \geq 4)	1.58 (1.42-1.75)	1.91 (1.61-2.27)
Shock (SBP \leq 90)	1.23 (1.14-1.34)	1.19 (1.04-1.36)

Results: IVC Filters

- 16,809 patients: 1.9% of total population
- 13,201: Prophylactic
- Center clustering: **0%-10.6%**

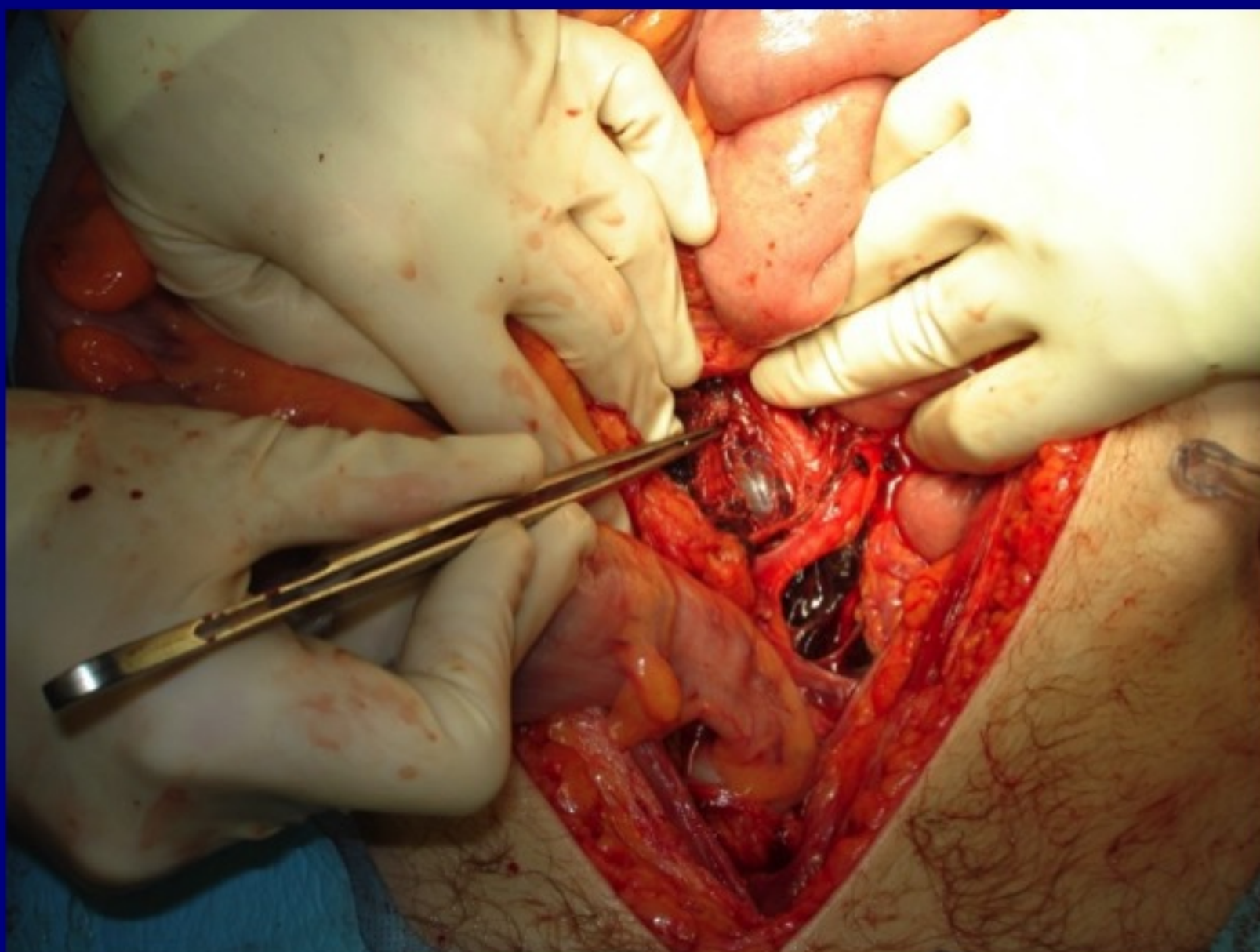


Changes over Time: PE

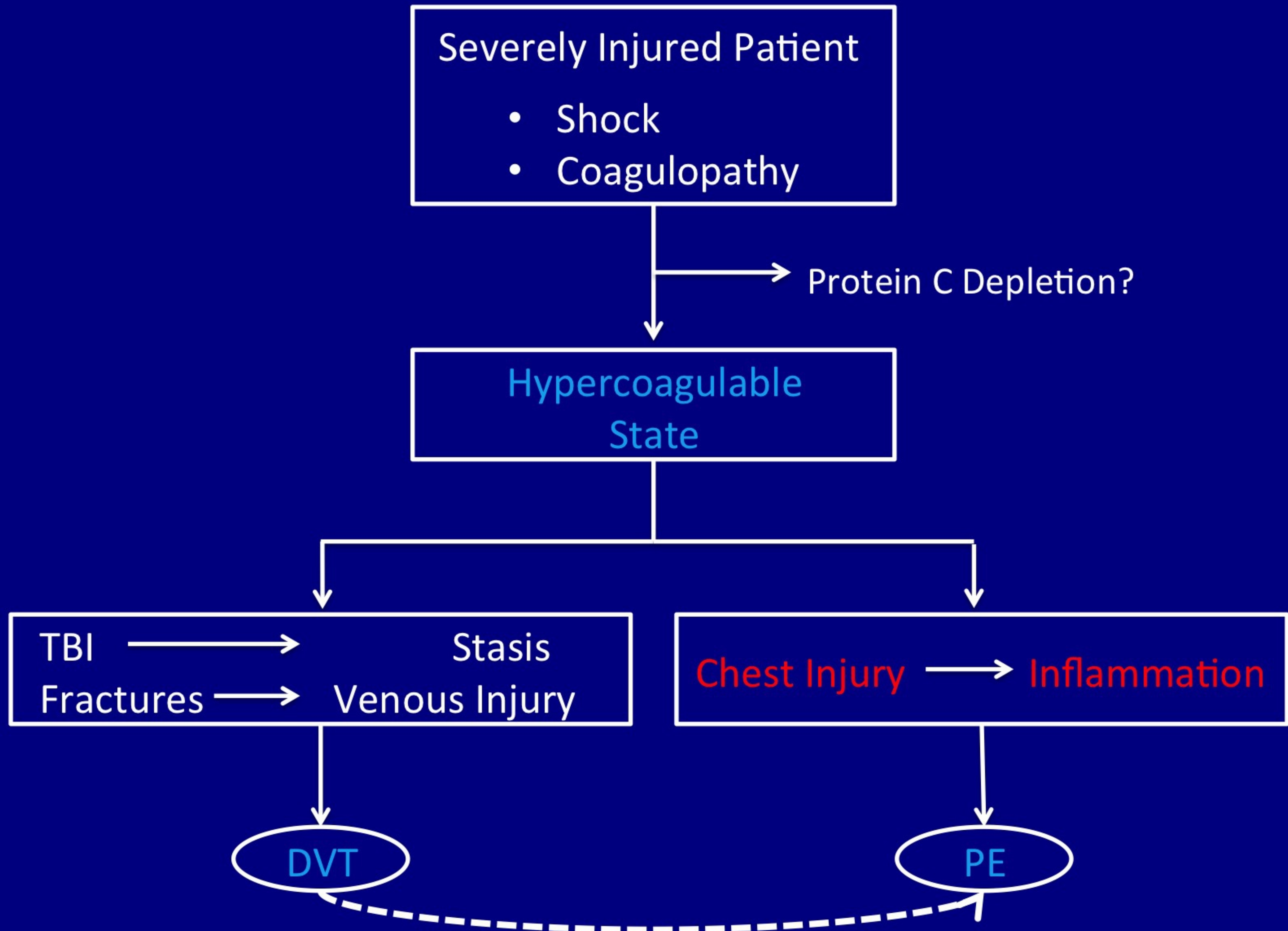
	Historical Number (%)	Adjusted OR (95% CI)	Current Number (%)	Adjusted OR (95% CI)
PE Rate	499 (0.21%)		890 (0.49%) p<0.01)	
Mortality-PE	73 (15%)	4.05 (3.02-5.46)	111 (11%)	2.42 (1.91-3.06) p<0.01)

Discussion: Potential Explanation

- 1. True increased incidence of PE
- 2. Better reporting in NTDB/ NTDS
- 3. “Sicker” patients in current cohort
- 4. Failure of VTE prophylactic measures*
- 5. Improved methods of detection*

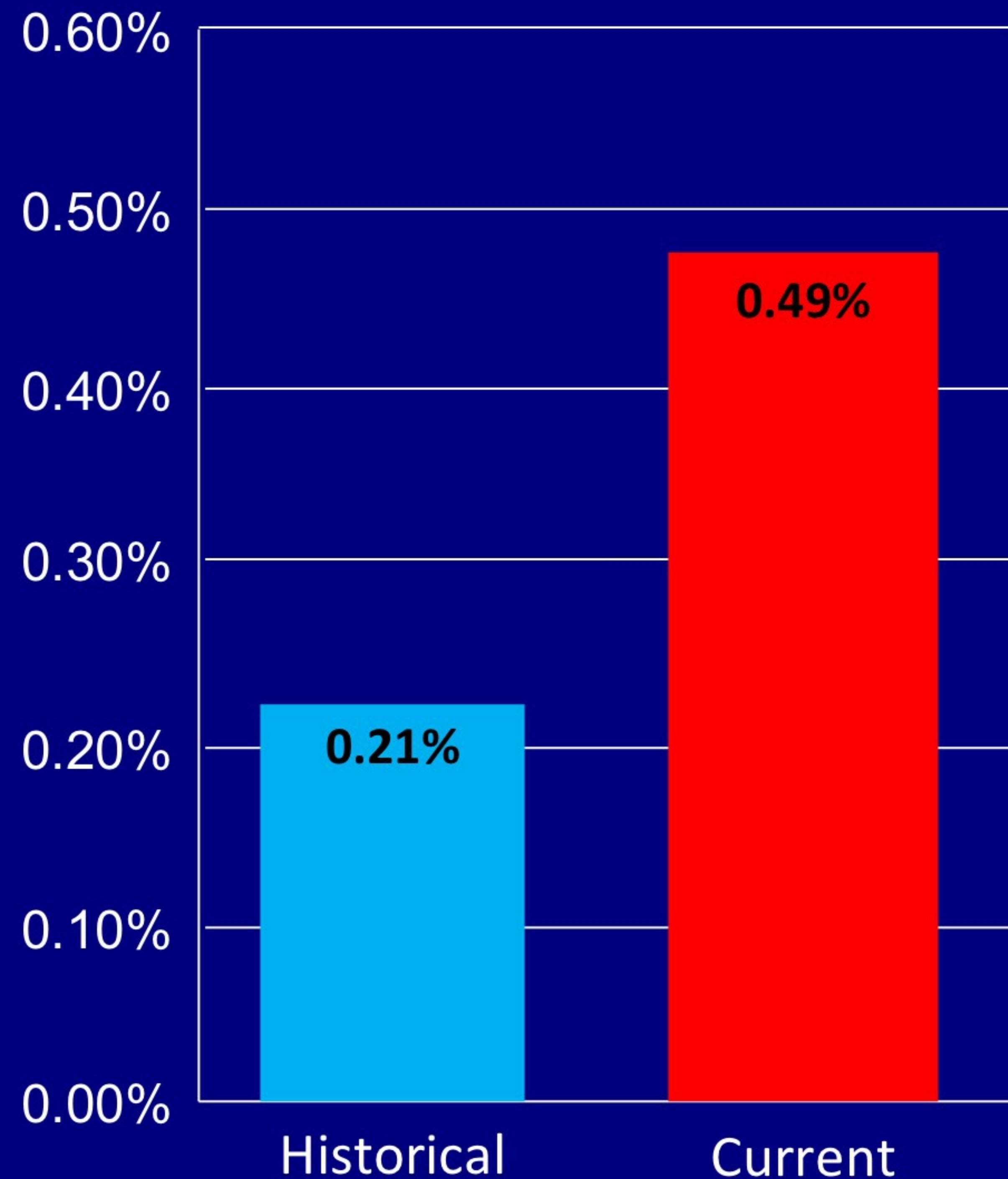


Uncoupling DVT and PE

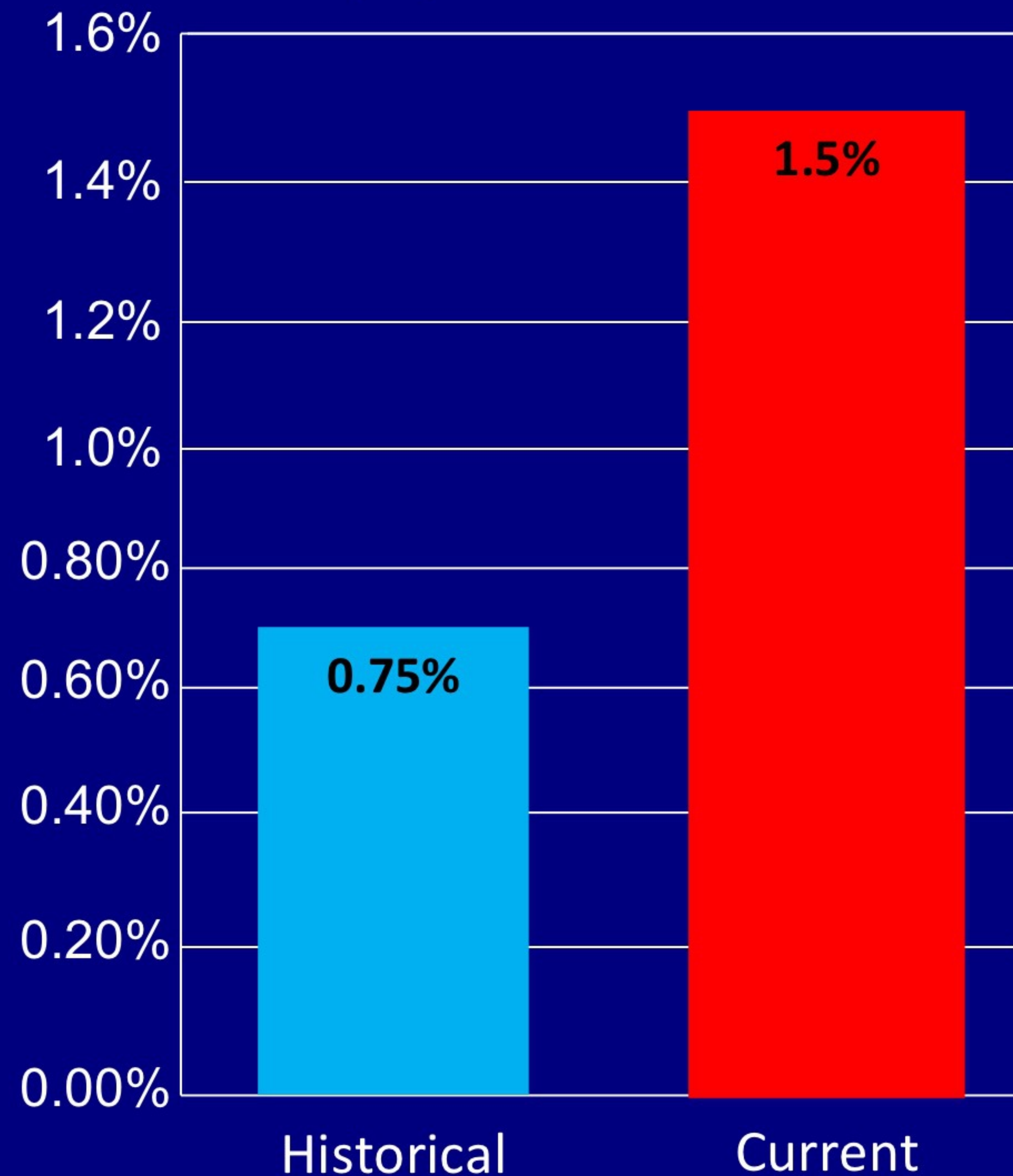


PE rates versus Prophylactic IVC filters

PE rates

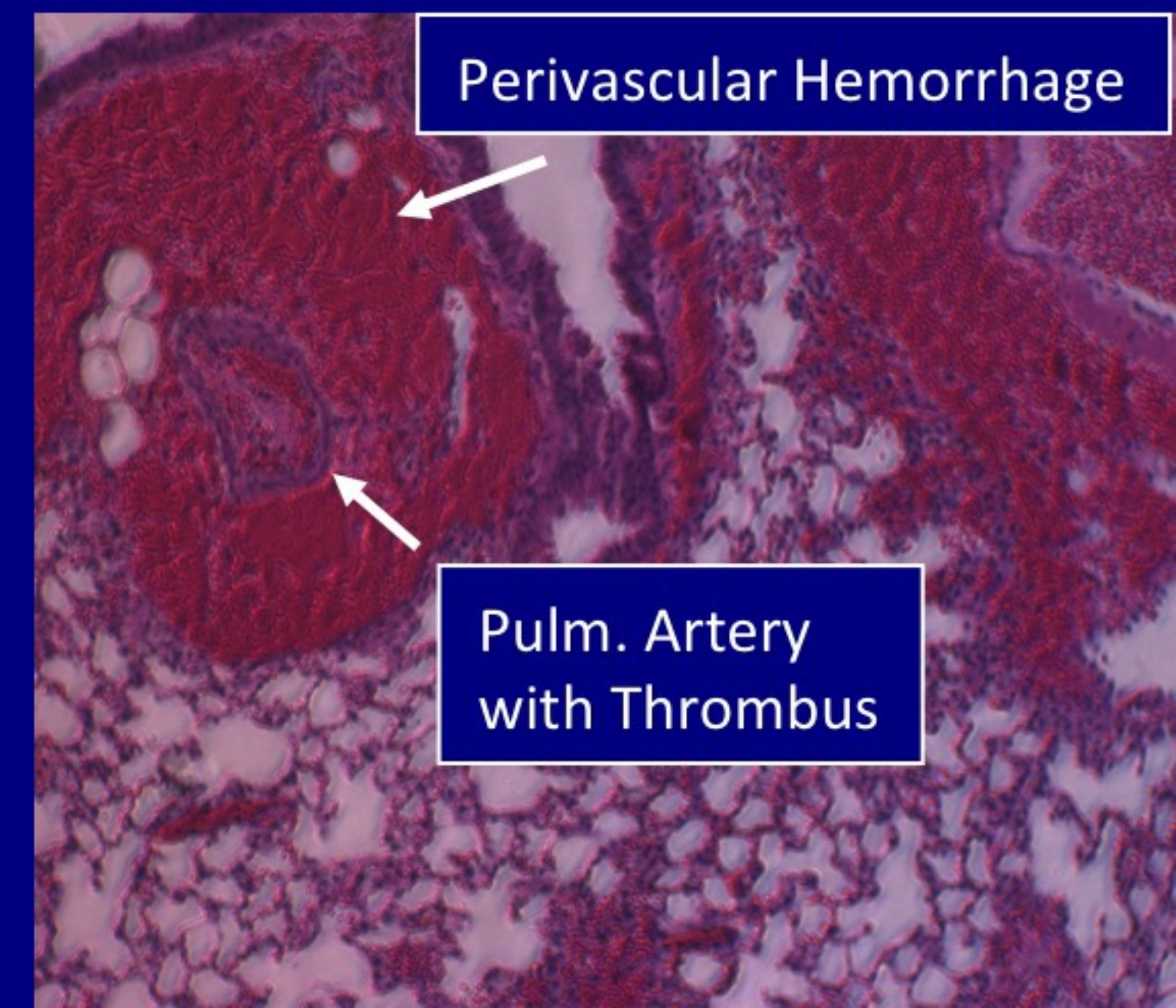


Prophylactic IVC Filters

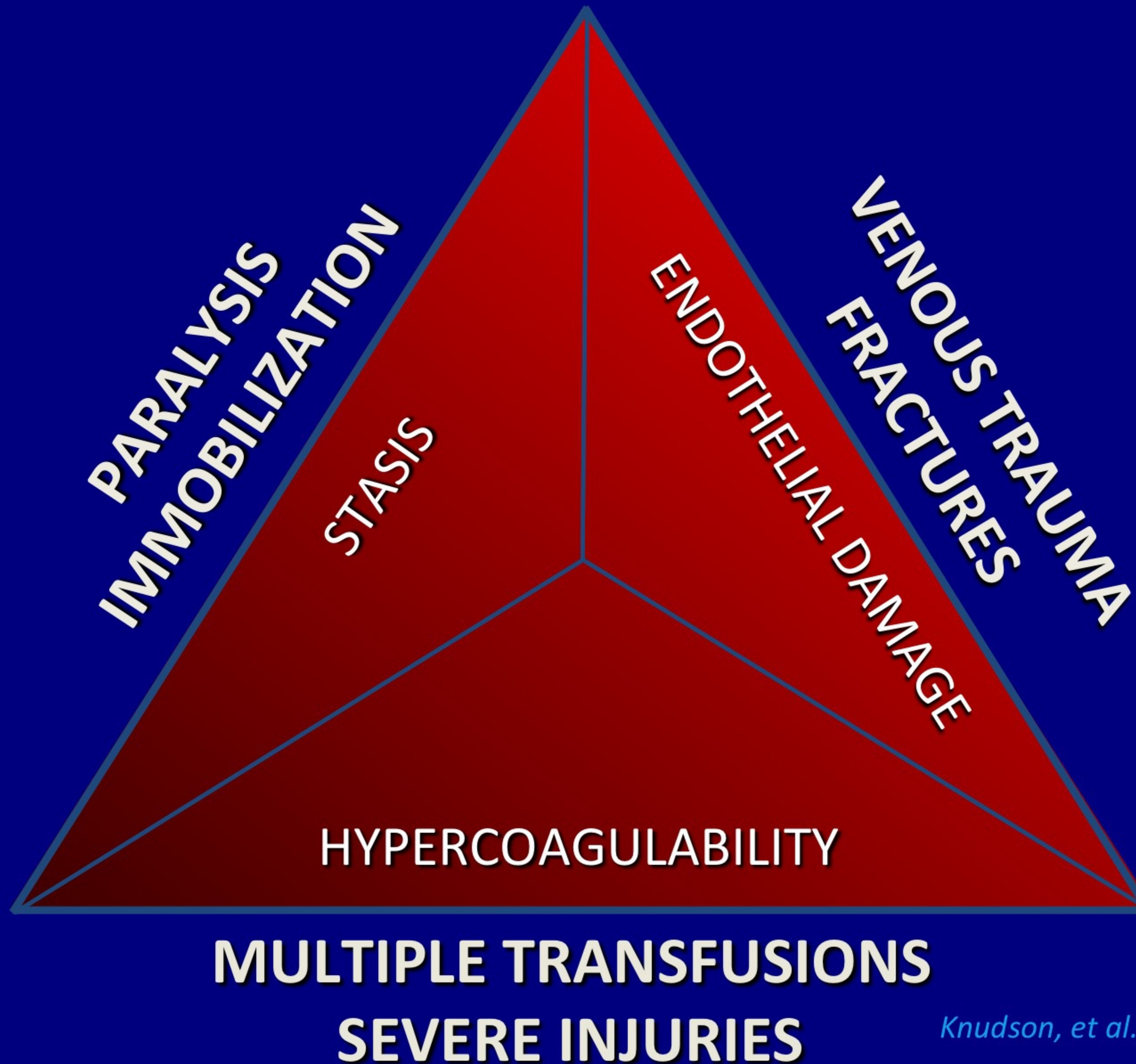


Conclusions

- **PE:** increasingly recognized post injury
- **PE:** decreased attributable mortality
- **PE:** may develop de novo
- **PE:** chest trauma/inflammation
- **PE:** may not be prevented by filters

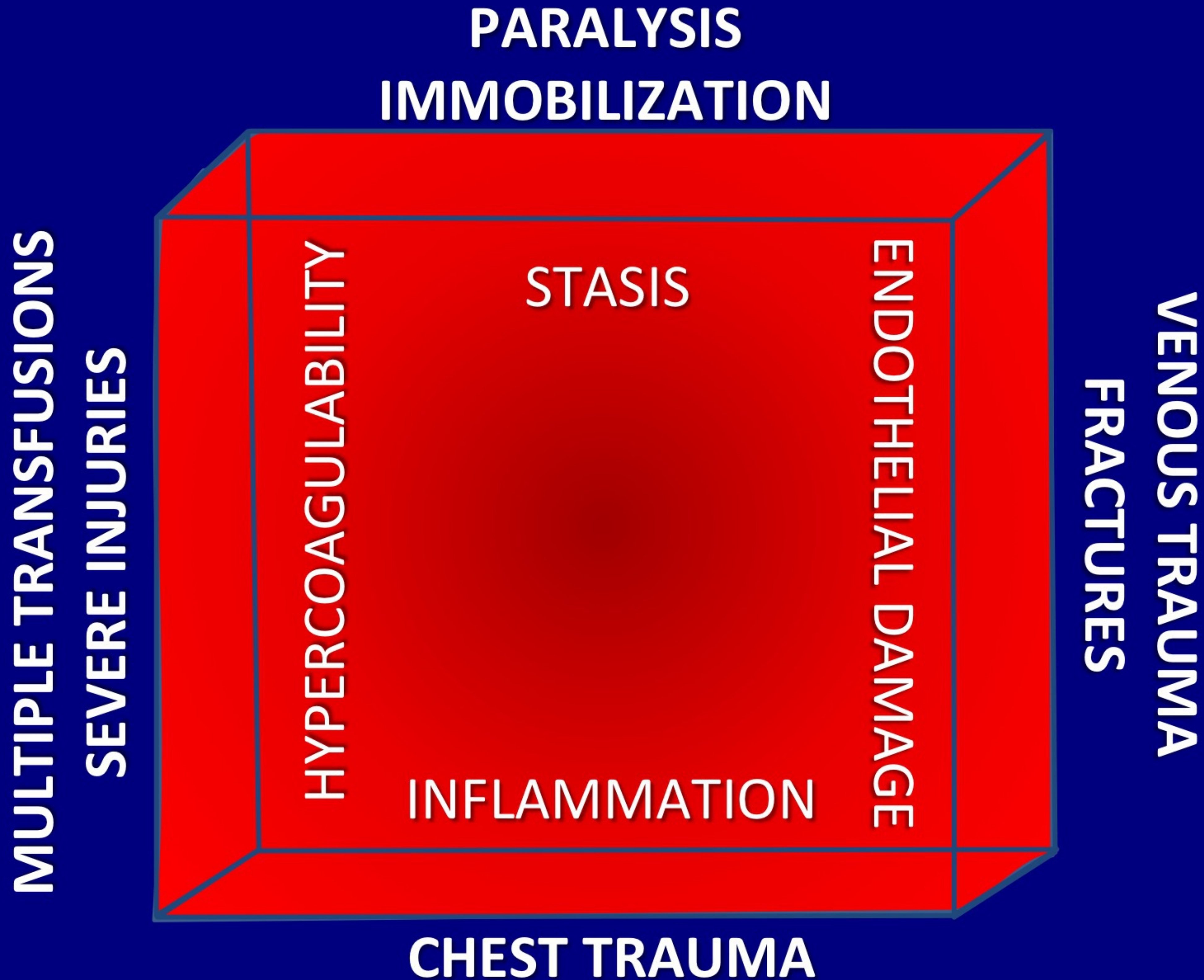


Knudson's Trauma Triad



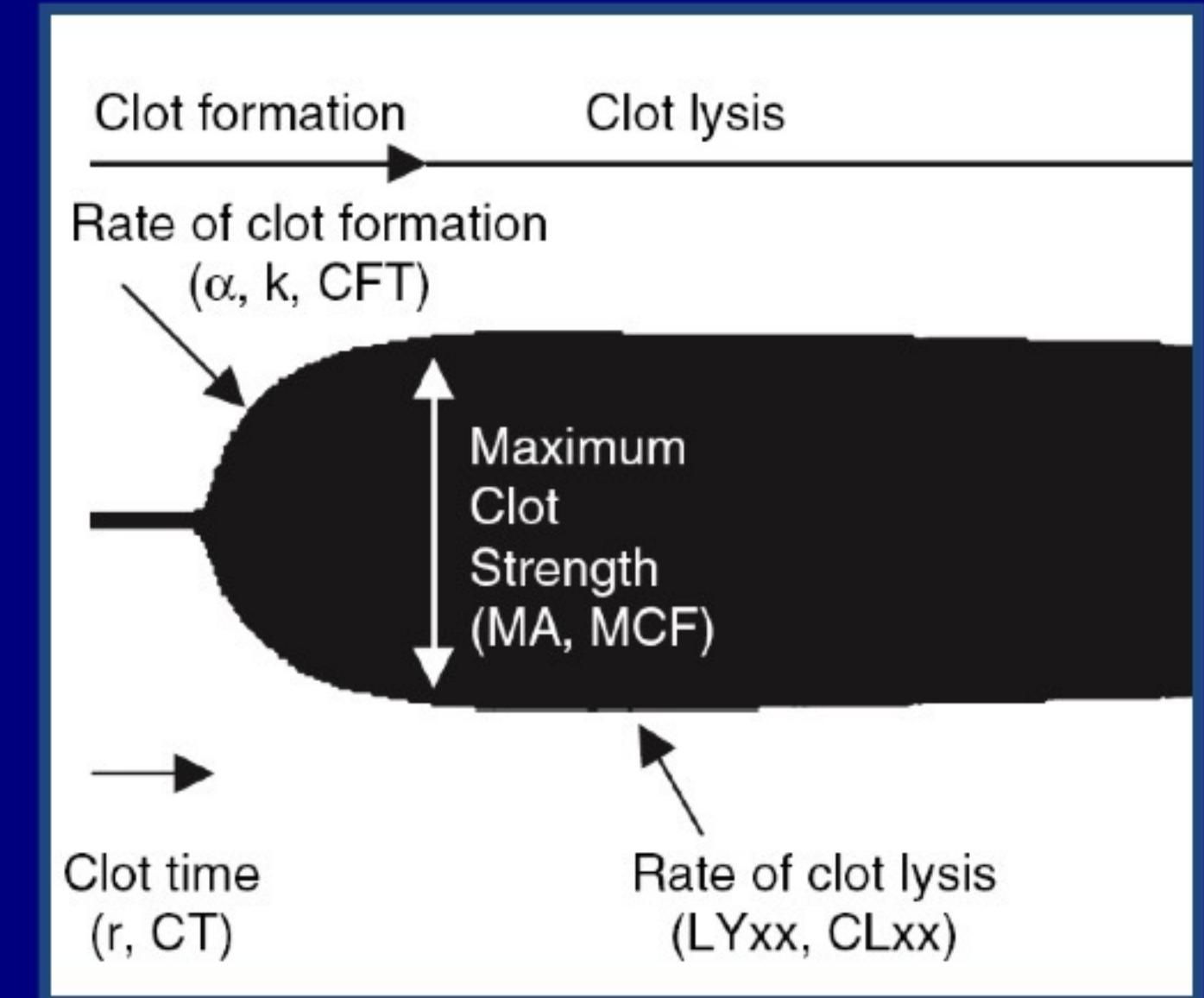
Knudson, et al., J Trauma, 1994

Knudson's Trauma Square

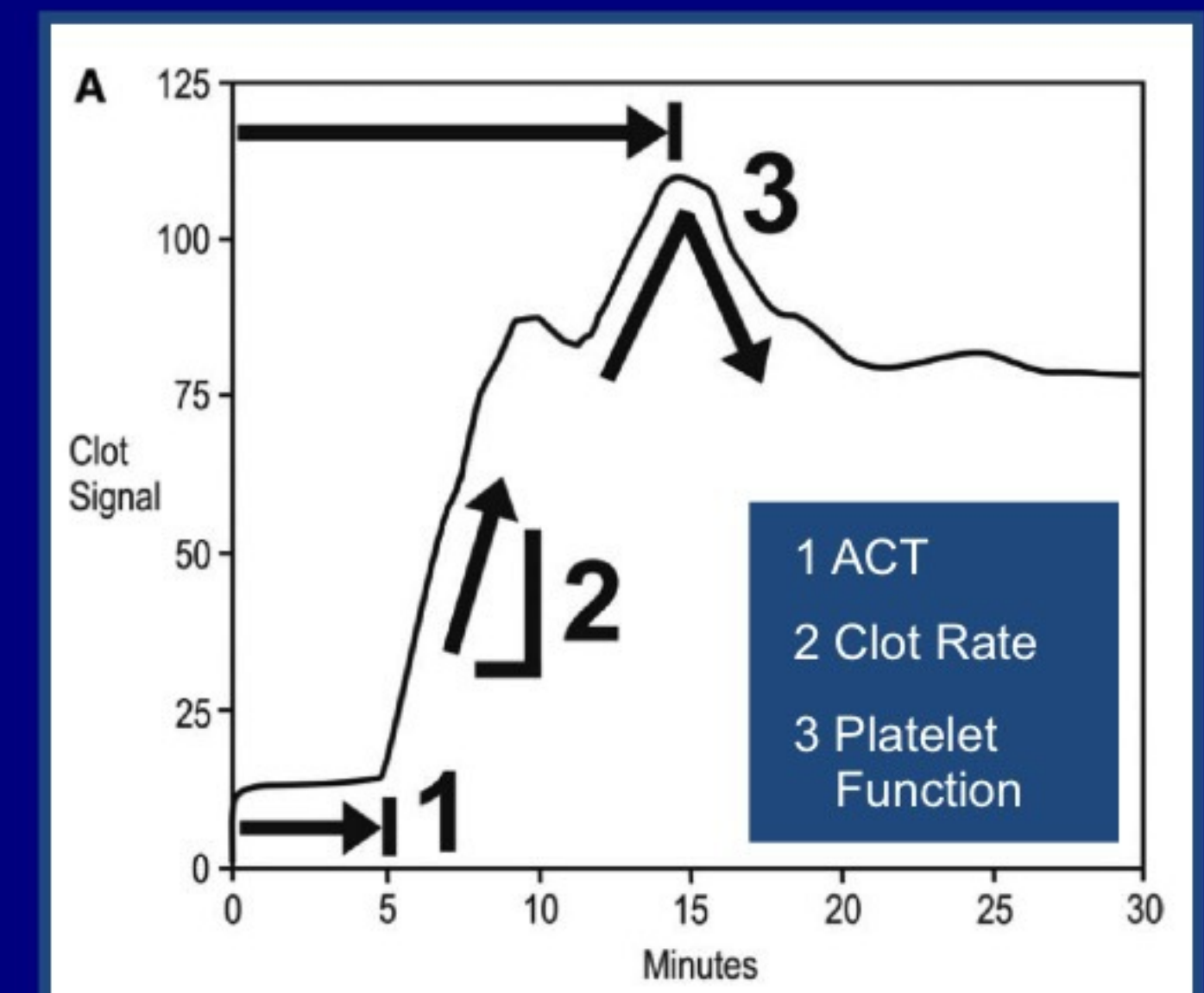


POC Coagulation Monitoring

Thromb-
elastograph
(Haemoscope Corp.)



Sonoclot
(Sienco Inc.)



Fibrinolysis Shutdown: New VTE Target?

