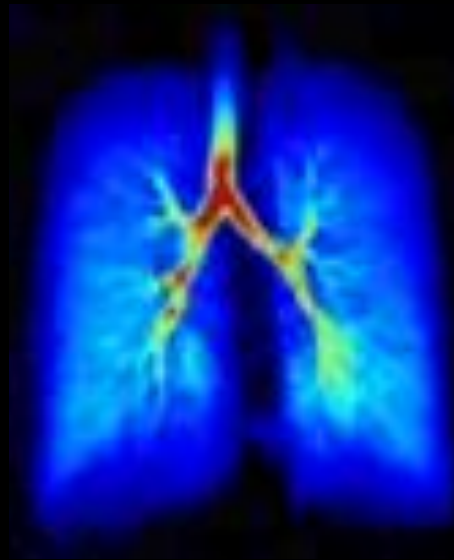


# The Anaesthesiologist's Role in Perioperative Lung Protection

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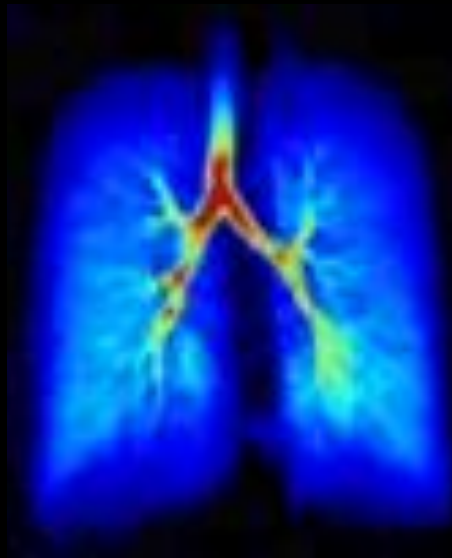
Peter Slinger MD, FRCPC    University of Toronto  
([peter.slinger@uhn.on.ca](mailto:peter.slinger@uhn.on.ca))

# Protecting the Lungs: From Who/What?

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## Healthy Lungs:

- ◆ The Perioperative Experience (Surgeon)

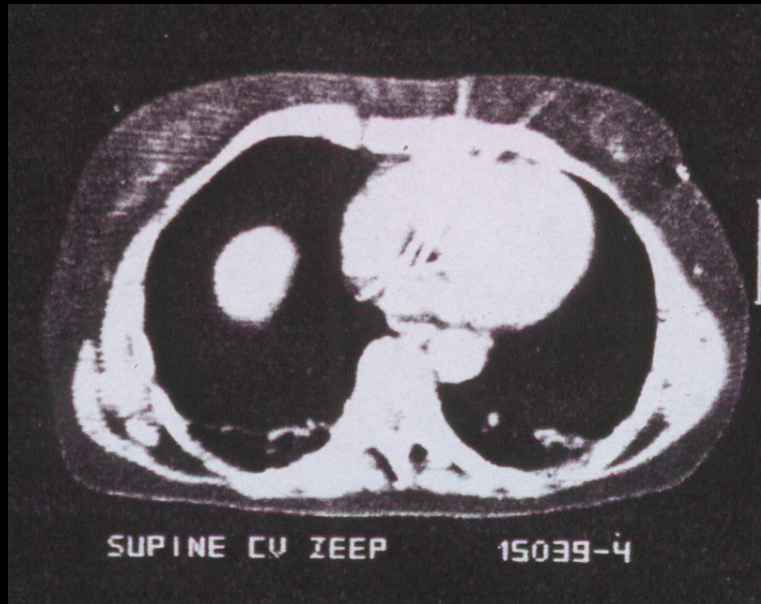


## Unhealthy Lungs:

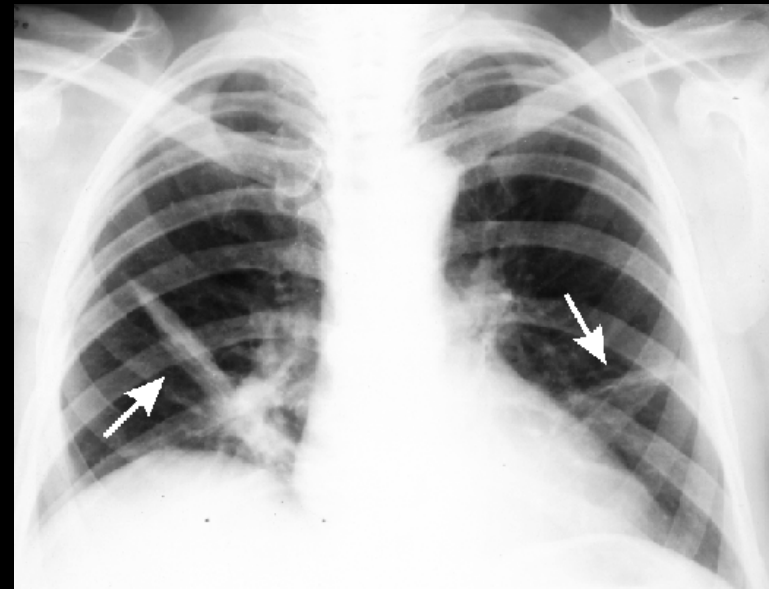
- ◆ The Anaesthesiologist: Bronchospasm Lung injury

# Atelectasis

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Intra-op.

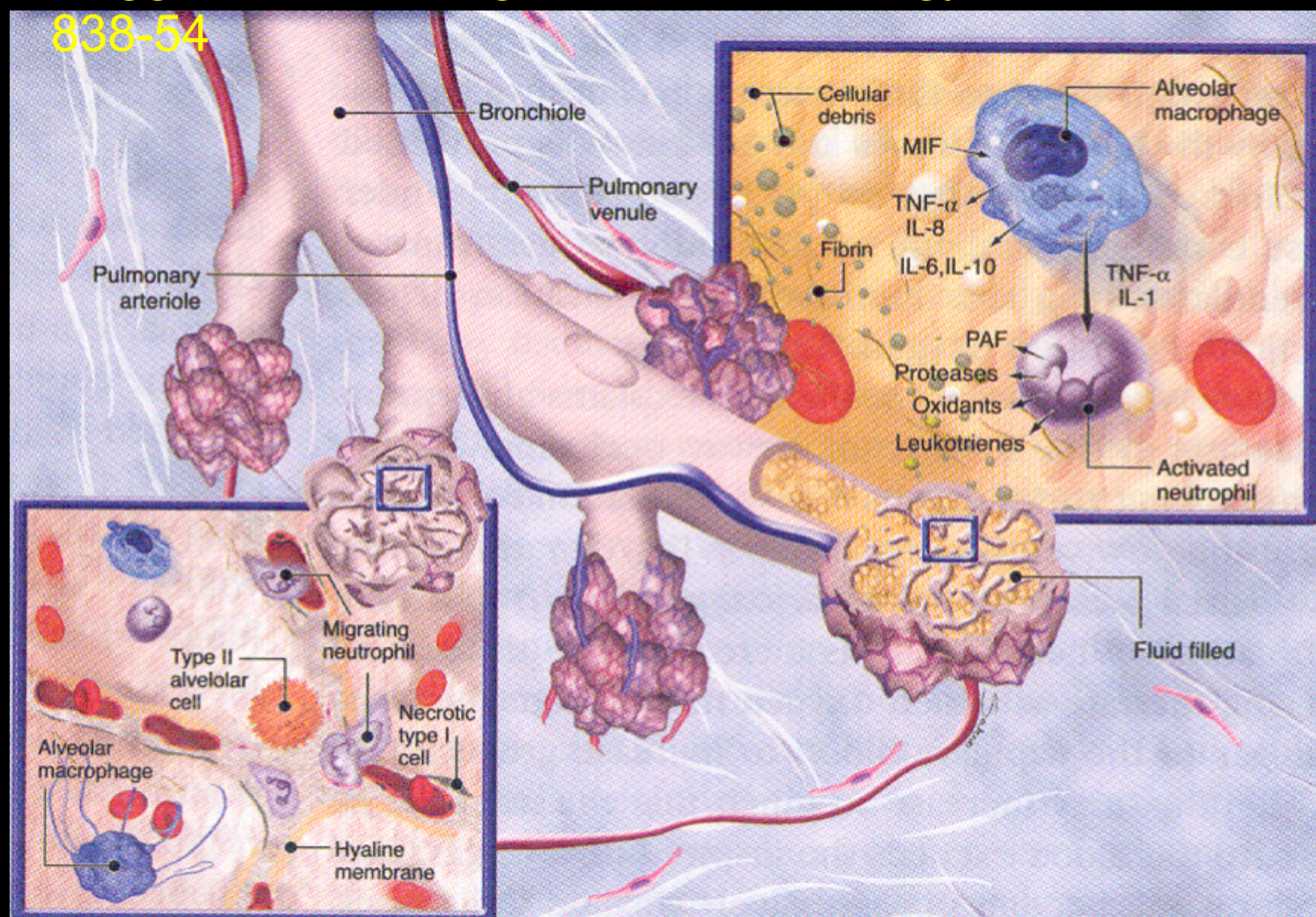


Recovery Room

# Pulmonary Atelectasis

Duggan M, Kavanagh B. Anesthesiology 2005, 102:

838-54



# CPAP Treatment of Post-op. Hypoxemia

Squadrone V, et al. JAMA 2005, 293: 589-95

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## Patients:

- ◆ n= 209
- ◆ Major Abd. Surg.
- ◆  $\text{PaO}_2/\text{FiO}_2 < 300$  post-op. in Rec.Room
- ◆  $\text{FiO}_2$  0.5 by mask or CPAP until  $\text{PaO}_2/\text{FiO}_2$  stable  $> 300$  (19-28h)

## Results:

- ◆ CPAP decreased sepsis ( $p = .03$ )
- ◆ Decreased pneumonia ( $p = .02$ )
- ◆ Decreased re-intubation ( $p < .01$ )

# CPAP devices

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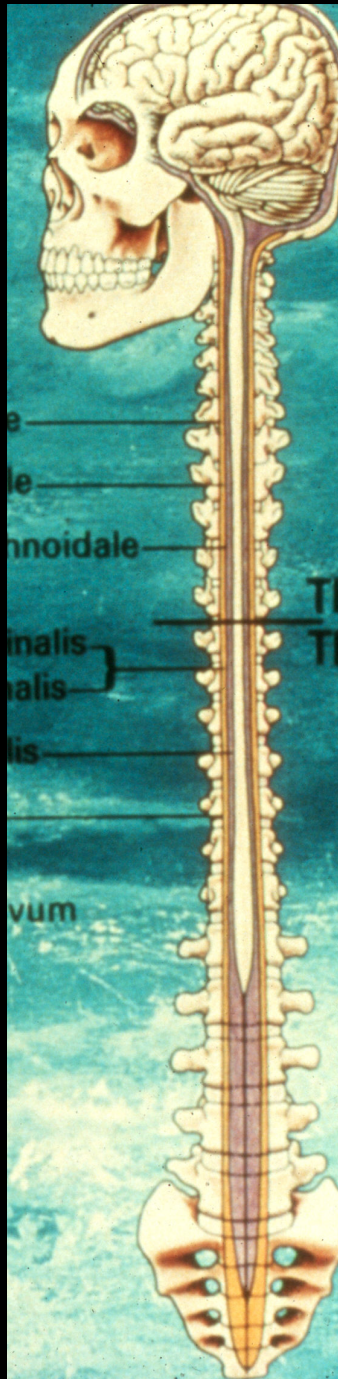


Squadrone V, JAMA 2005



Maitre B , AJRCCM 2000

“Boussignac Mask”



# The Comparative Effects of Analgesia on Pulmonary Outcomes : Meta-Analysis

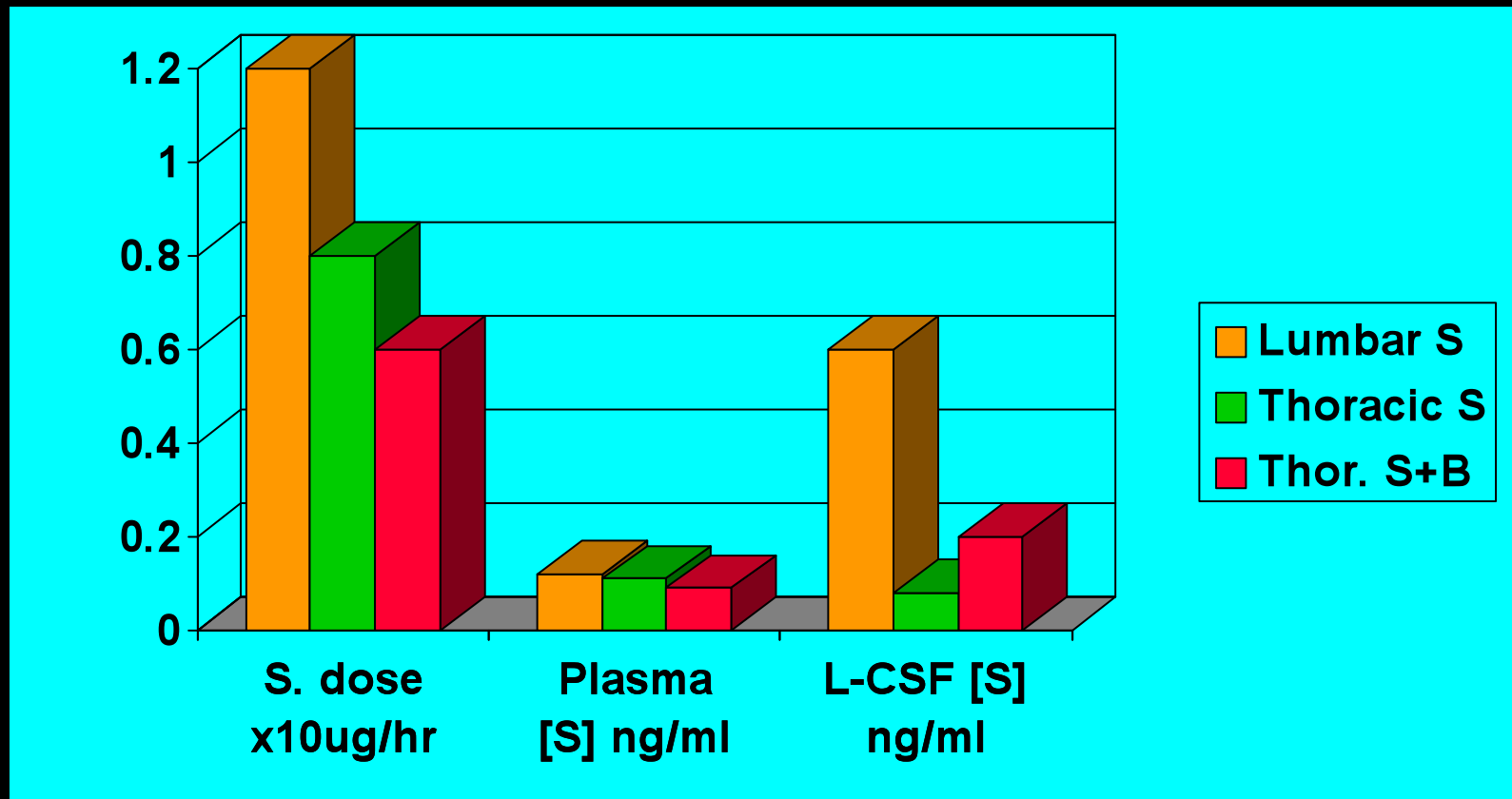
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Ballantyne JC, et al. Anesth Analg 1998, 86: 598

- ◆ Atelectasis decreased Epidural opioid/LA vs. Systemic opioid
- ◆ Pulmonary Infections decreased Epidural opioid/LA vs. Systemic opioid
- ◆ Pain VAS movement (not PFTs) correlate with outcome

# The Pharmacokinetics of Continuous Epidural Sufentanil and Bupivacaine Infusion after Thoracotomy

Hansdottir V, et al. Anesth Analg 1996; 83:401  
(n=37, double blind, lumbar CSF samples)

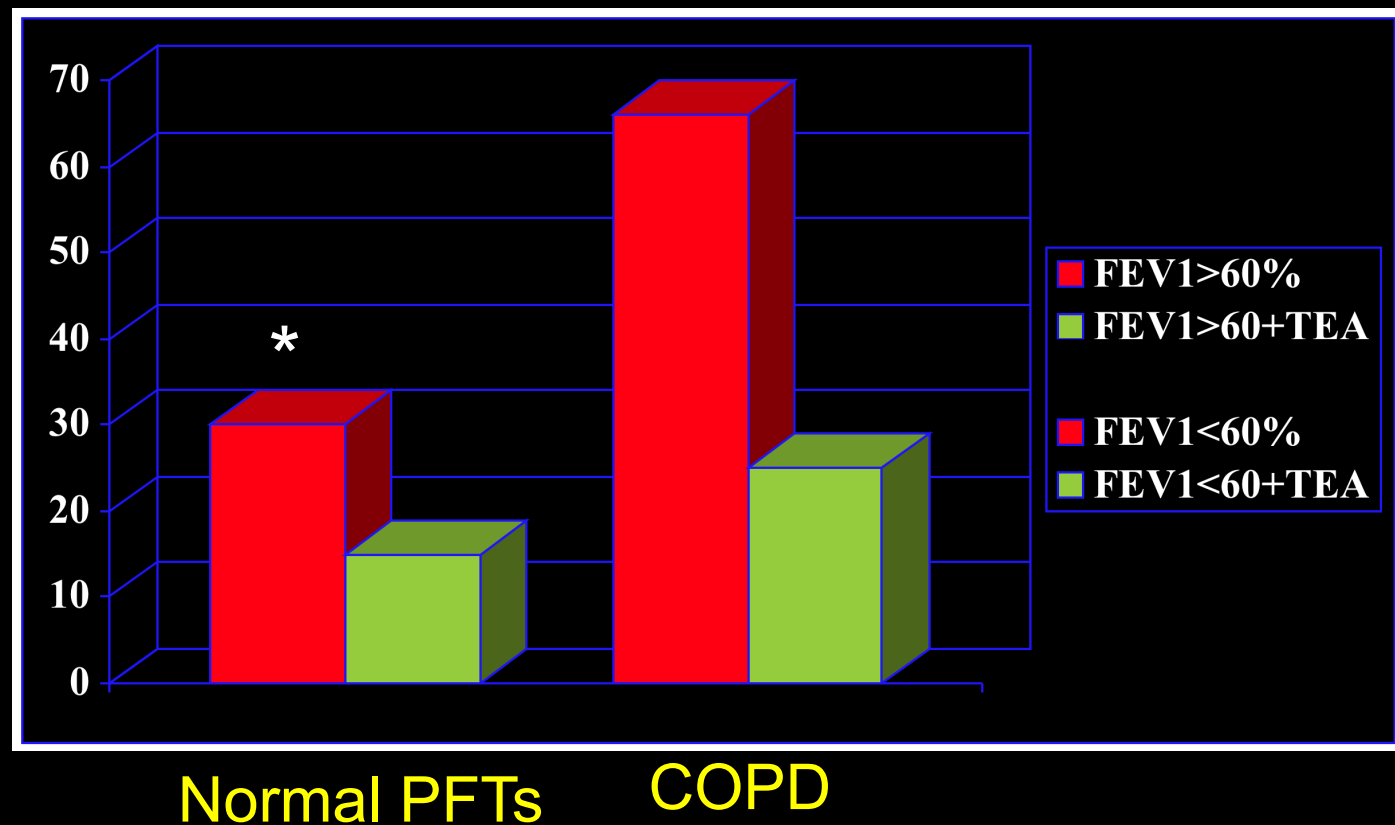


(signif.  $p < .05$  between all 3 techniques  
for dose and concentrations)

# Reduction of Respiratory Complications in Lung Resection by Thoracic Epidural

\*  $p < .05$

%  
Resp.  
Complic's



Licker M, et al. Ann Thorac Surg 2006; 81: 1830-8

# Epidural Anaesthesia and Analgesia and Outcome of Major Surgery (MASTER)

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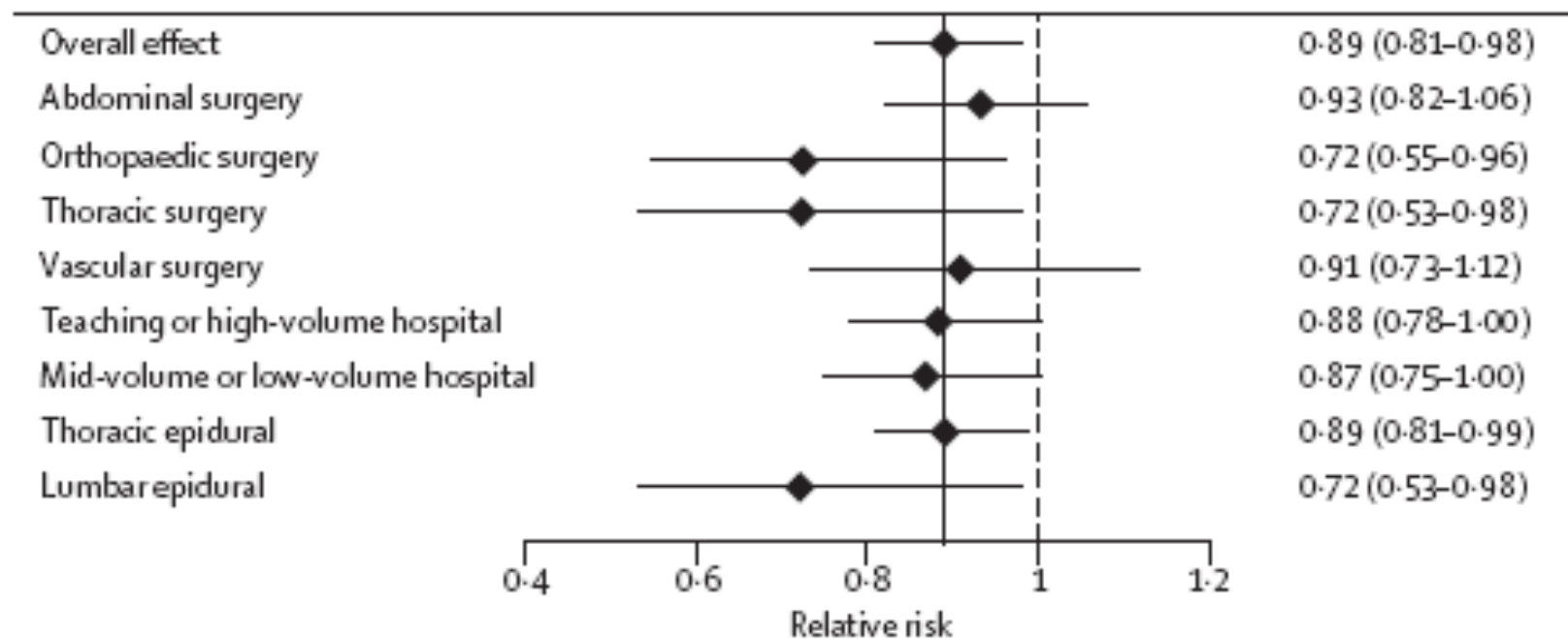
n = 888, random., ASA  $\geq 3$ , Abd./Esoph. Surg.,  
225/ 447 Epidural > 72h.

- ◆ Analgesia: Epid. vs. IV @ rest n.s.,  
with cough  $<.001$
- ◆ Resp. Fail. Epid. vs. IV: 23% vs. 30% (.02)

Rigg JRA, et al. Lancet 359: 1276-82, 2002

# Epidural Analgesia and Survival after Intermediate-to-high Risk Non-Cardiac Surgery

Wijeysundera D, et al. Lancet 2008, 372: 562-9



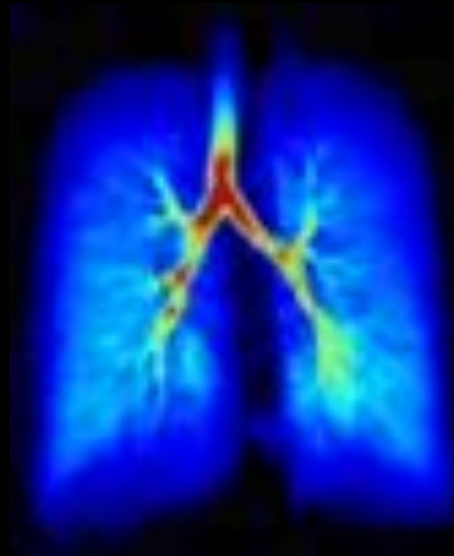
n = 88,000, 1994-2004

# Protecting the Lungs: From Who/What?

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## Healthy Lungs:

- ◆ The Perioperative Experience (Surgeon)

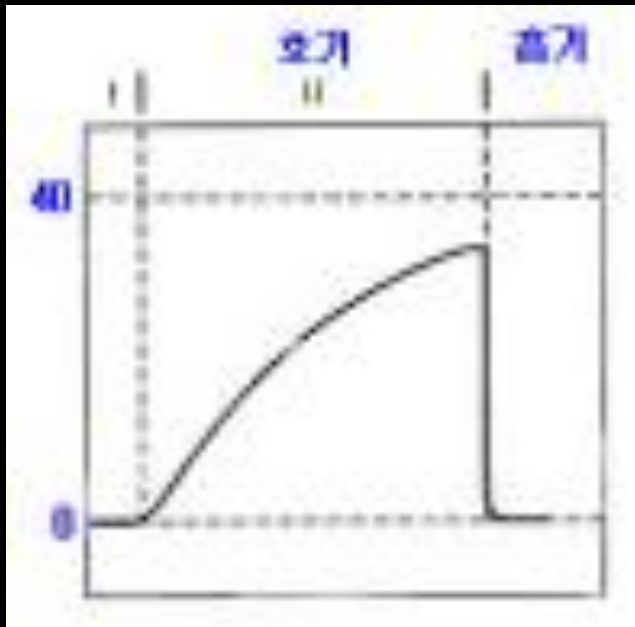


## Unhealthy Lungs:

- ◆ The Anesthesiologist:  
**Bronchospam**  
Lung injury

# Preventing Bronchospasm

PetCO<sub>2</sub>



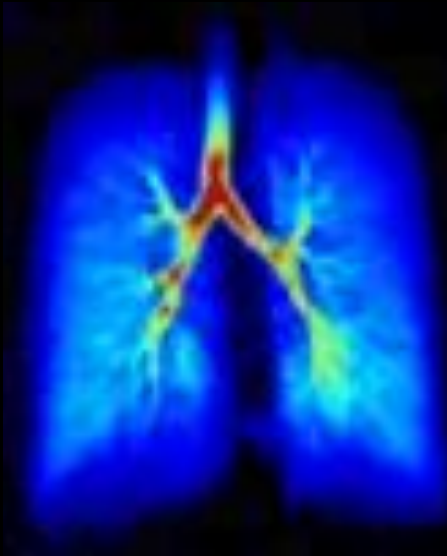
- ◆ Decrease preop a/w hyper-reactivity
- ◆ Avoid instrumenting the airway
- ◆ Instrument the airway during deep anesthesia
- ◆ Use broncho-dilating anesthetics

# Protecting the Lungs: From Who/What?

---

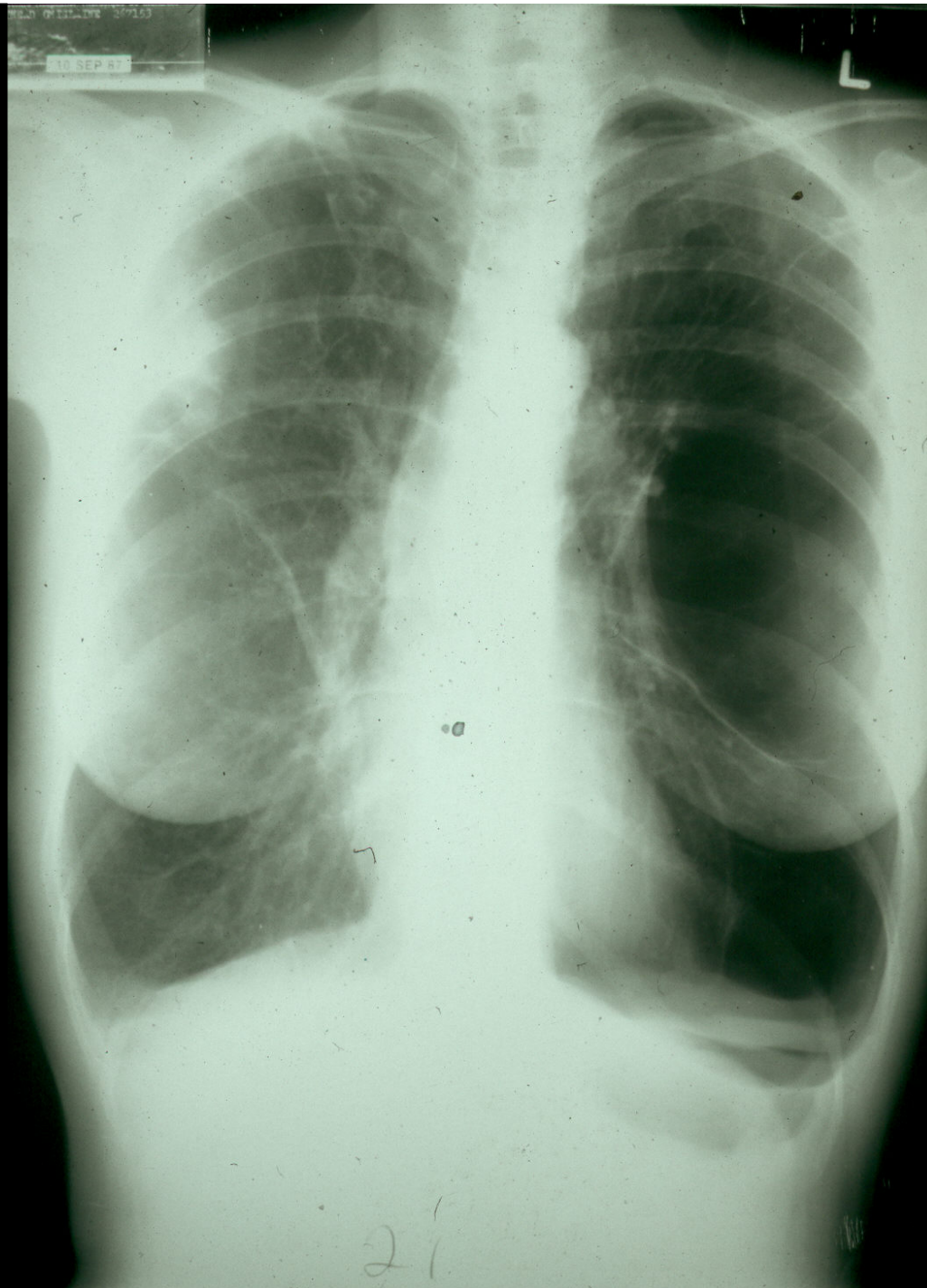
◆ Healthy Lungs:

◆ The  
Perioperative  
Experience  
(Surgeon)



◆ Unhealthy Lungs:

◆ The  
Anesthesiologist:  
Bronchospasm  
**Lung injury**





# Principles of Lung-Protective Ventilation:

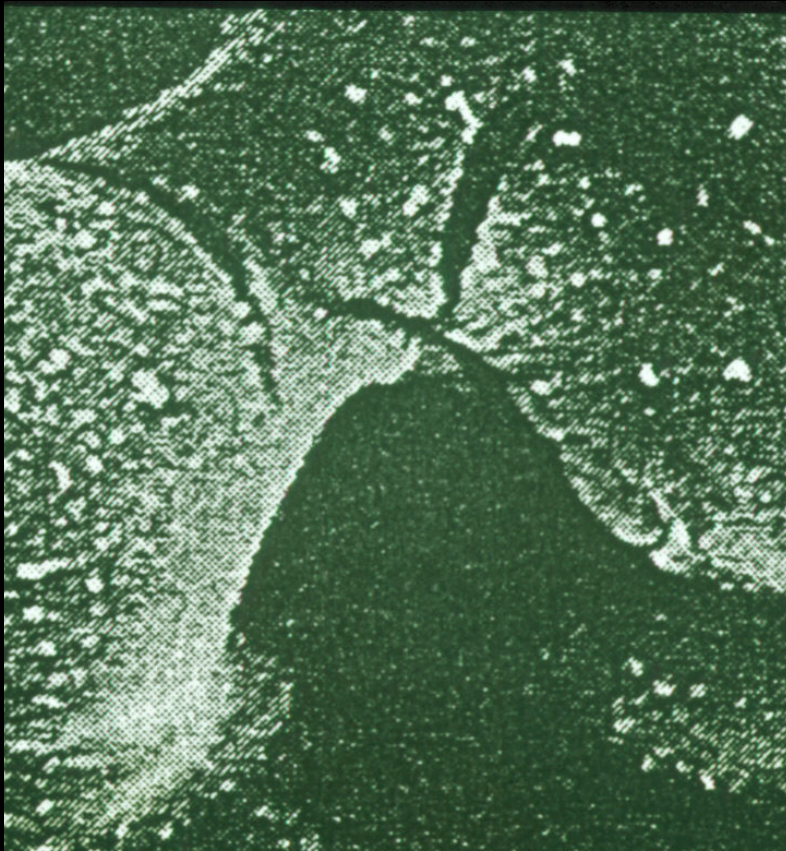
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- ◆ Mimic normal spontaneous ventilation
- ◆ FiO<sub>2</sub> as low as safe
- ◆ PEEP to maintain FRC
- ◆ Tidal volumes 4-6 ml/kg
- ◆ Frequent recruitment maneuvers
- ◆ Vary position / vary tidal volume
- ◆ Pressure-control ventilation (?)

Fan E, et al. JAMA. 2005; 294:2889-96

# Patients with Micro-Vascular Lung Injury:

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- ◆ ARDS/ALI
- ◆ Lung Transplantation
- ◆ Major Pulmonary Resection

# Modern Anesthetic Techniques for Thoracic Operations

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**“Tidal volume (10-12 ml/kg) should remain the same when changing from two-lung to one-lung ventilation, as relatively large tidal volumes are needed to recruit alveoli in the dependent ventilated lung.”**

Brotsky JB, Fitzmaurice B. World J Surg 25: 162-6, 2001

# 55 y.o. Male, R Pneumonectomy

---



- ◆ Postop.  
Day 3
- ◆ Increasing  
Dyspnea x  
24h
- ◆ SpO2 90%,  
FiO2 0.5
- ◆ Other Vitals  
Stable

# Post-Pneumonectomy Pulmonary Edema: Analysis and Risk Factors

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Parquin F, et al. Eur J Cardiothorac Surg 10: 929, 1996

“ ...we see so often our anesthetic colleagues believe that you can actually oxygenate the patient with ringer's lactate...

...I think it is up to us to control what our anesthesia colleagues do, both in the operating theater and post-operatively.”

B Ross

# Post-Pneumonectomy Pulmonary Edema

Turnage WS, Lunn JL. Chest 103: 1646-50, 1993

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- ◆ 806 Pneumonectomies, 21 cases
- ◆ Right Pneumonectomy 16 vs. Left 5
- ◆ Mortality 21/21 (ARDS)
- ◆ Cases vs. Controls:
  - Fluid Balance (n.s.)
  - Fluid Administration (n.s.)
  - Mean PAOP: initial 10, final 13 (n.s.)

# Causes of Post-Pneumonectomy Pulmonary Edema

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## Probable:

- ◆ Endothelial injury
- ◆ Capillary pressure
- ◆ Lung Lymphatic damage
- ◆ Fluid overload
- ◆ Lung Hyperinflation

## Possible:

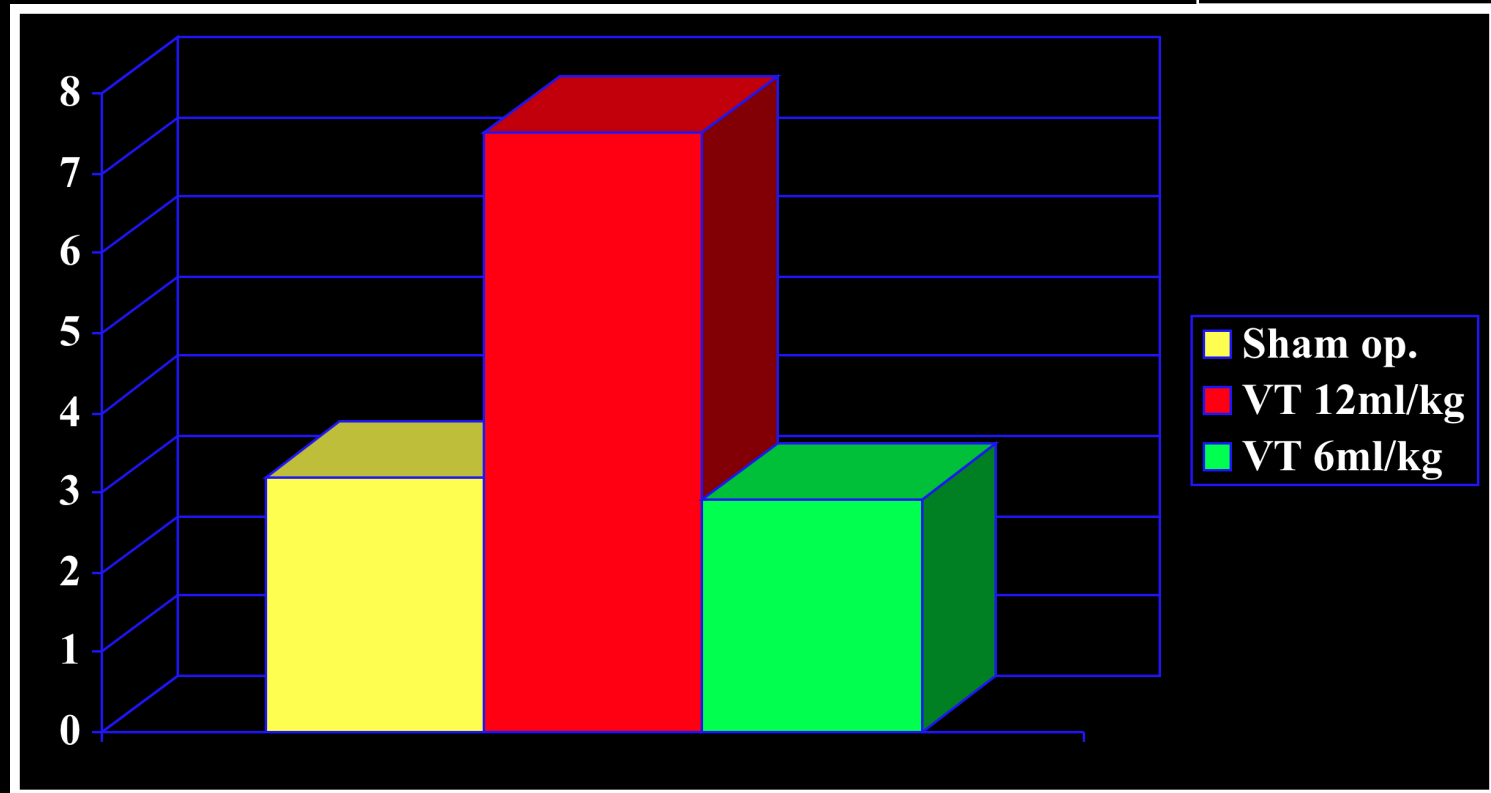
- ◆ RV dysfunction
- ◆ Cytokines
- ◆ Oxygen toxicity

# Extravascular Lung Water after Pneumonectomy in Sheep

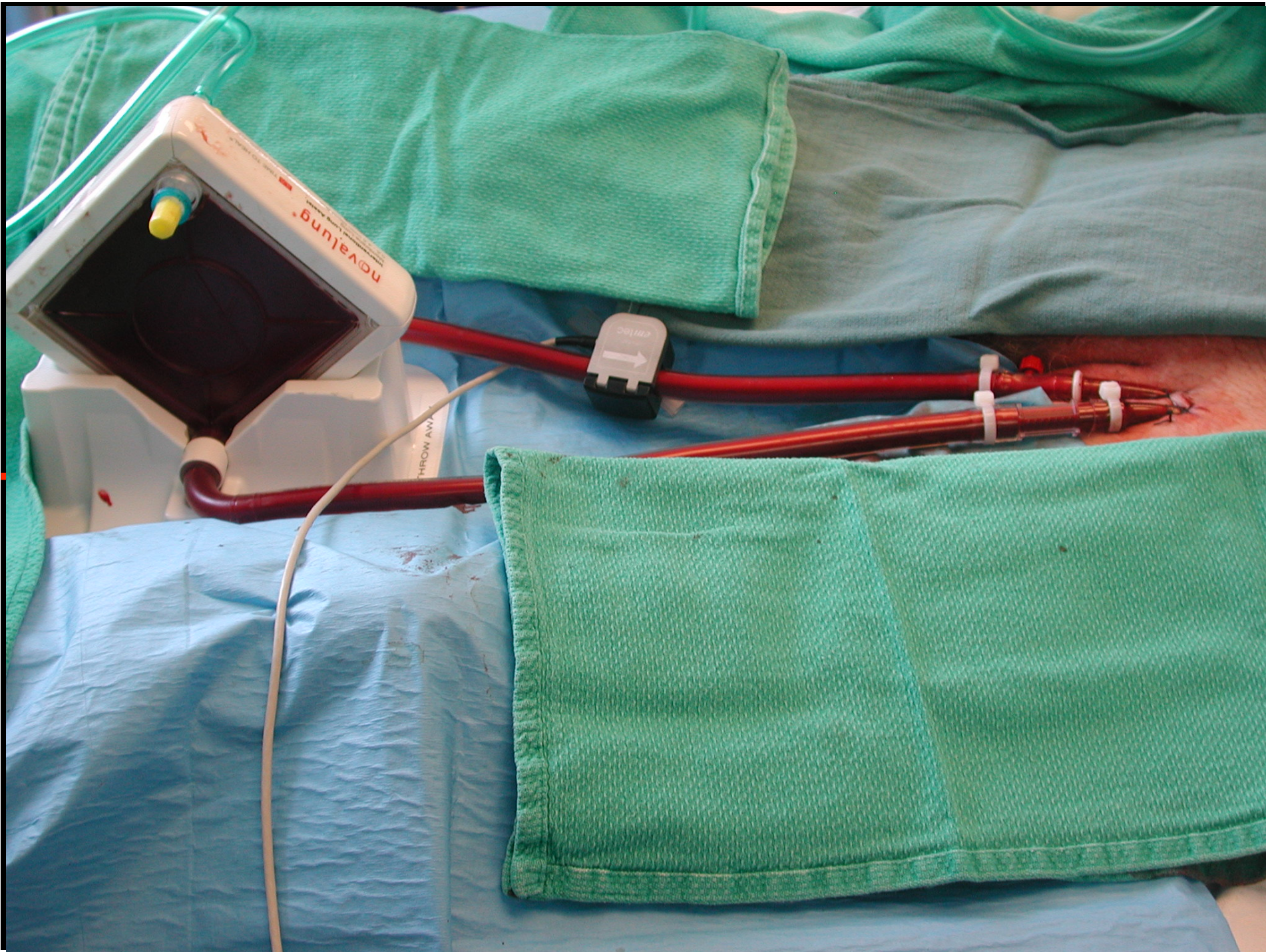
\*

\*p < .05

Extra-Vasc.  
Lung Water  
Index ml/kg

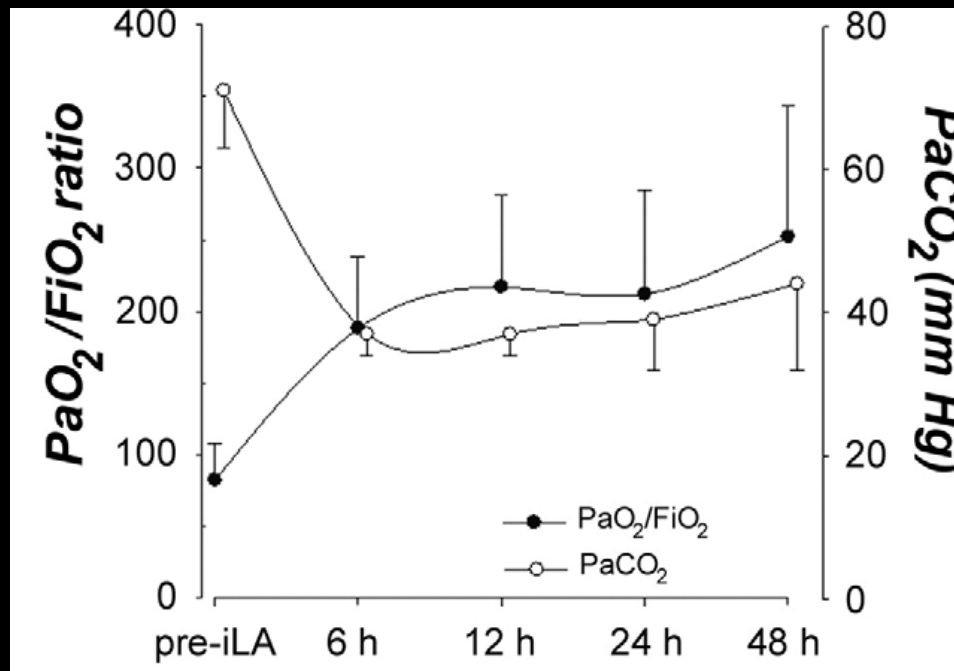


Kuzkov V, et al. Crit Care Med 35: 1550-9, 2007



# Extrapulmonary Ventilation for ARDS after Pulmonary Resection

Iglesias M, et al. Ann Thorac Surg 85: 237-44, 2008

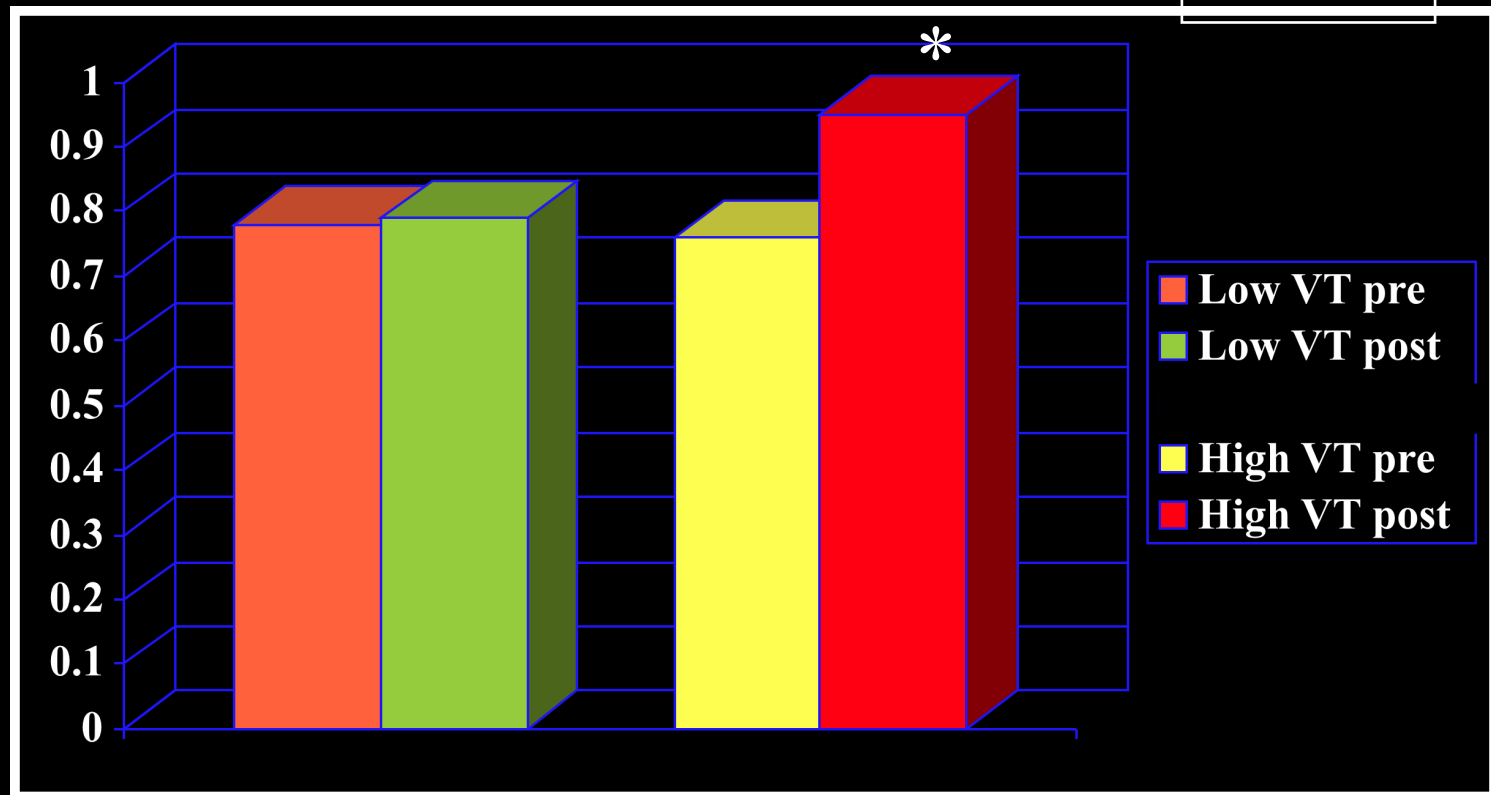


- ◆ N=9/239 (3%) resections  
7 Pneumonx, 2 lobex
- ◆ Novalung 4.3 (+/- 2 days)
- ◆ Flow 1.4 (+/- 0.4 l/min)
- ◆ Mean Vent settings: Vt 3ml/kg, RR 6, Pa/w peak 19, PEEP 12, FiO2 0.5
- ◆ 6/7 (86%) survive to discharge

# Low Tidal Vol. + PEEP Prevents Alveolar Coagulation in Patients Without Lung Injury

\*  $p < .05$

BAL  
Thromb-  
Antithromb  
ng/ml



N=40, Abd. Surg. 5h PPV,  
VT= 12ml/kg vs. 6 ml/kg +/- 10cmH<sub>2</sub>O PEEP  
Choi G, et al. *Anesthesiology* 2006; 105: 689-95

# Transfusion-Related Acute Lung Injury

Bux J, Sachs U. Br J Haem 136: 788-99, 2007



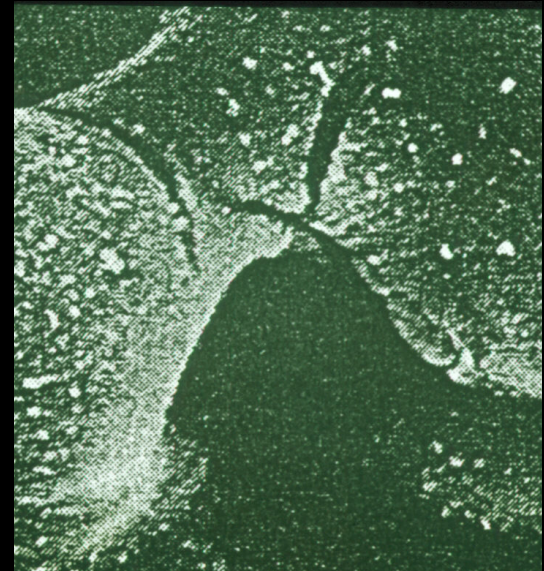
Normal  
Circulating  
Neutrophil

Damaged Pulmonary Capillary

ICAM



“One Hit”



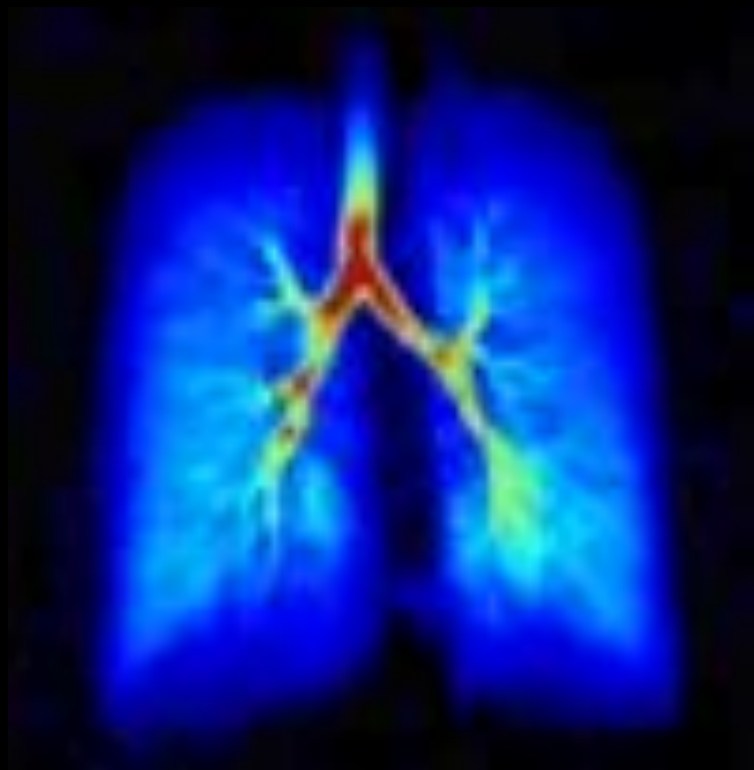
Cytokine Release

“Two Hit”

# Protecting the Lungs:

From Who/What?

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- ♦ **The Patient:**
  - Smoking Cessation
  - Physiotherapy
- ♦ **The Perioperative Experience:**
  - Atelectais
  - Analgesia
- ♦ **Anesthesiologist:**
  - Ventilation Injury
  - TRALI