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# Acute Respiratory distress syndrome (ARDS) after pulmonary resections

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CAZURI CLINICE COMENTATE

**Sindromul de detresă respiratorie acută (Adult  
Respiratory Distress Syndrome - ARDS -)  
pe plămân unic**

R.T. Stoica, Geneveva Cadar, N. Galie

Rezumat

Sindromul de Detresă Respiratorie Acută (Adult Respiratory Distress Syndrome) -ARDS- aparține după pneumonectomia sau edemul pulmonar postpneumonectomie (PPE) este recunoscut ca o complicație a cărei apariție este imprezvizibilă, statistic greu de apreciat și asociată cu o mortalitate mare. Sunt prezentate 2 cazuri (3,4%) de ARDS apărute după pneumonectomia stângii. Criteriile de diagnostic au fost clinice, paraclinice și radiologice. Confirmarea fiind anatomo-patologică, într-un caz care a decedat, și în cel de-al doilea prin evoluție clinică, radiologică și prin tomografia computerizată. Pe marginea acestor cazuri și a datelor din literatură sunt discutate elementele comune și cele specifice patologiei ARDS după pneumonectomie.

25/01/2006

Insuficiența respiratorie acută, cu expresia ei

Tomografia computerizată descrie o forma-  
țiune tumorală dezvoltată în segmentul anterior al

uscate și tuse. Secretul de respirație  
fost 1,8. Se reinstituie VM cu SIMV alternând în  
timpul zilei cu ASB- cu PEEP de 5-7cmH<sub>2</sub>O, și  
FiO<sub>2</sub> de 0,4-0,6. Bronhoscopic se evidențiază  
secreții minime, din aspiratul bronșic culturile  
fiind sterile.

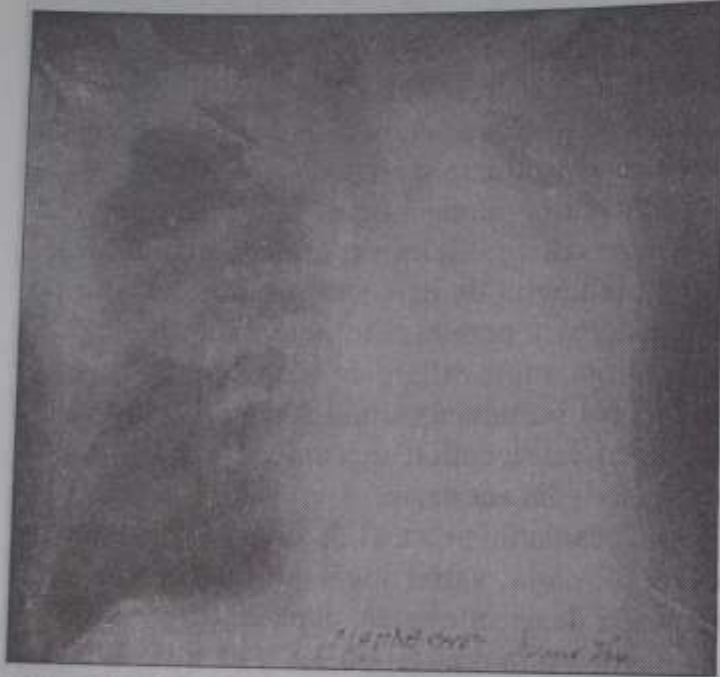


Fig. 2b. M.D., bărbat, 72 ani, a 3-a zi postoperator cu imagine de ARDS

trabeculare.

### Discuții

ARDS este o formă de insuficiență respiratorie acută în care modificările schimburilor gaze pulmonare duc la hipoxemie severă și sunt datorate edemului pulmonar necardiogen, rezulta

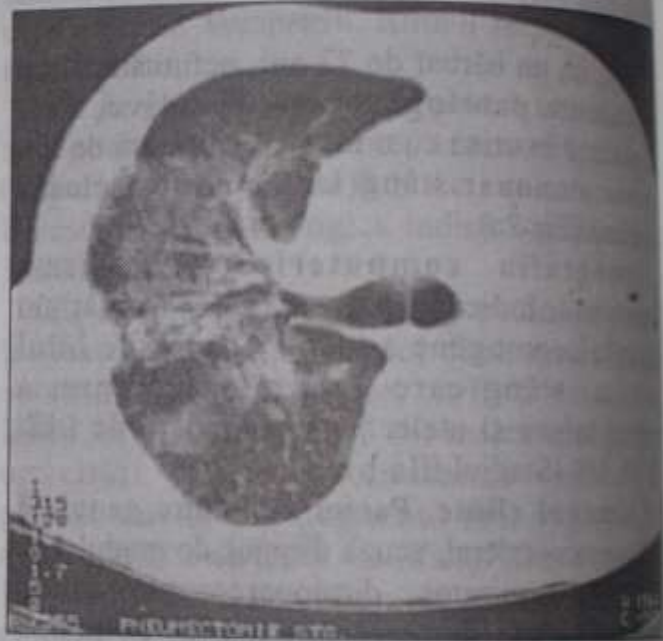


Fig. 3a

# ARDS after pulmonary resections

- **How often**
- Etiology
- Diagnosis
- Prevention and treatment
- Mortality

*Naveed Alam et al : Incidence and Risk Factors for Lung Injury After Lung Cancer Resection, Ann Thorac Surg 2007;84:1085–91*

- Incidence of ALI/ARDS postoperative 3,1% (44/1428 patients with curative lung resections for cancer (jan 2001- june 2004). (Sloan-Kettering Cancer Center, NY)

*CHEST 110:3161 JUNE, 1993: W Sherman: Postpneumonectomy Pulmonary Edema A Retrospective Analysis of Associated Variablies*

- Incidence of 2,6%. 21 patients from 806 pneumonectomies from 1977-1988. (Mayo Clinic)

*CHEST 2006; 130:73–78*

*Dulu A et al: Prevalence and Mortality of Acute Lung Injury and ARDS After Lung Resection*

- Prevalence ALI/ARDS: postpneumonectomy 2,45%, lobectomy 2,96%, sublobar resections 0,99%(2192 resections(2002-2004) (Sloan Kettering)

# ARDS after pulmonary resections

- How often
- Etiology
- Diagnosis
- Prevention and treatment
- Mortality



# Etiology?

- Excessive perioperative fluid administration

*Licker M, al. Risk factors for acute lung injury after thoracic surgery for lung cancer. Anesth Analg 2003; 97:1558-1565.*

- Previous treatment with radiotherapy

*Parquin F, Marchal M, Mehiri S, et al. Post-pneumonectomy pulmonary edema: analysis and risk factors. Eur J Cardiothorac Surg 1996;10:929 –32*

- Duration of operation

*Turnage WS, Lunn JJ. Postpneumonectomy pulmonary edema. A retrospective analysis of associated variables. Chest 1993; 103:1646-1650.*

- Right-sided pneumonectomy

*Kutlu CA et al. Acute lung injury and acute respiratory distress syndrome after pulmonary resection. Ann Thorac Surg 2000;69:376–80.*

- High intraoperative airway pressure (Paw)

*K. Leon et al.: Anesthesia and Intensive care, Jan 2009: Risk factors for post-pneumonectomy acute lung injury/ acute respiratory distress syndrome in primary lung cancer patients*

- Other risk factors for ALI after thoracotomy:

COPD, postop FEV<sub>1</sub> < 45%, ppo lung perfusion

< 55% vs preop, no previous physiotherapy, alcohol abuse, male sex, age > 60, intraoperative fluid administration > 2L, fresh frozen plasma administration

- *Using decreased ppo FEV<sub>1</sub> in the multivariate analysis, and increased perioperative fluid administration remained independent predictors of postoperative lung injury. With Dlco only decreased postoperatively, predicted Dlco remained a significant, independent risk factor.*

*Alam N et al Incidence and Risk Factors for Lung Injury After Lung Cancer Resection Ann Thorac Surg 2007;84:1085–91*

- **The pathogenesis of post-pneumonectomy ALI/ARDS is not fully understood, but intraoperative factors such as tidal volume V<sub>T</sub> and airway pressure P<sub>aw</sub> may contribute to the lung injury seen in this syndrome.**



- An increase in blood flow through the remaining lung in some patients may promote disruption of the capillary endothelial cell- alveolar cell barrier, allowing protein-rich fluid to flood the alveolus.

Mathru M et al Permeability pulmonary edema following lung resection. Chest 1990; 98:1216-18

- Mediators of inflammation, such as leukotrienes, platelet-activating factor, and various other cytokines, cause an increase in pulmonary capillary pressure without a change in capillary permeability. ...Even though inflammation and increased permeability may be prominent features of ARDS, the formation of edema fluid is increased by increases in pulmonary capillary hydrostatic pressure.

Cope DK et al. Pulmonary capillary pressure: a review. Crit Care Med 1992; 20:1043-56

DR NAVEED ALAM (Memorial Sloan-Kettering  
Cancer Center, NY):

Certainly in the initial experiments by Dr Zeldin he thought that it was related to some form of increased permeability of the capillaries and increased hydrostatic effects. And some physiologic studies with animals have been done. But I do not think we really know. **I think the consensus now is that this is really just another form of ARDS with the inciting factor being surgical lung trauma.**

*Incidence and Risk Factors for Lung Injury After Lung Cancer Resection*  
*Ann Thorac Surg* 2007;84:1085-1091

# ARDS after pulmonary resections

- How often
- Etiology
- Diagnosis
- Prevention
- Mortality
- Update

# Diagnosis

- *Post-pneumonectomy ALI/ARDS begins a few days after surgery:*

The mean time from operation to presentation with ALI was  $5.2 \pm 1.7$  days and for ARDS  $4.2 \pm 1.1$  days (Kutlu et al)

- *Diagnosis criteria for ALI/ARDS: American-European Consensus Conference on ARDS (Berlin 2011)*
- *Sometimes difficult to appreciate the PAWP after pneumonectomy*
- *Pumonary Hypertension and Congestive heart disease may co-exist*

# ARDS after pulmonary resections

- How often
- Etiology
- Diagnosis
- Prevention and treatment
- Mortality



# Prevention and treatment

- Early admission in ICU
- Prevention : risk factors!
  - Excessive perioperative fluid administration (Zeldin) (*increasing fluid administration causes injury or is an effect of the injury itself !?*)
  - *Should the patients be kept “dry” ?*
- 1–2 ml/kg/h in the intra- and postoperative periods and that a positive fluid balance of 1.5 l should not be exceeded

*Evans RG, Naidu B, Does a conservative fluid management strategy in the perioperative management of lung resection patients reduce the risk of acute lung injury? 2012 Interact Cardio Vasc and Thoracic Surgery 15, 498*

High dose steroids? No!! (ARDS Clinical Trial Network)

*Cerfolio et al. reported on the administration of steroids before ligation of the pulmonary artery in patients undergoing pneumonectomy, suggesting that this strategy reduced the incidence of post-pneumonectomy ARDS!*

*Intraoperative Solumedrol helps prevent postpneumonectomy pulmonary edema. Ann Thorac Surg 2003;76:1029 –35.*

# Treatment: Not different than any other form of ARDS

- Best ventilatory strategy?
- ARDS Network Protocol

*N Engl J Med* 2000; 342 (18): 1301-1308.

- Alternative/Rescue therapies (selected cases)
  - Inhaled nitric oxide and inhaled prostacyclin
  - HFJV, HFOV
  - ECMO
- NIV

# NIV

## **Noninvasive ventilation for acute respiratory failure after lung resection: an observational study**

*Aurelie Lefebvre et al  
Intensive Care Medicine  
April 2009, Volume 35, 663-670*

690 patients at risk of severe complications following lung resection, 113 (16.3%) with ARF, initially supported by NIV in 89 (78.7%), 59 with hypoxemic ARF (66.3%) and 30 with hypercapnic ARF (33.7%). The overall success rate of NIV was 85.3% (76/89). In-ICU mortality was 6.7% (6/89). The mortality rate following NIV failure was 46.1%.



# NIV



# What about protective ventilation?

- Protective ventilatory strategy during OLV decreases the proinflammatory response, improves lung function and results in earlier extubation

*Michelet P et al. Protective ventilation influences systemic inflammation after esophagectomy: a randomized controlled study. Anesthesiology 2006; 105:911-919.*

- 32 patients who underwent lung resection: the levels of inflammatory markers in bronchoalveolar lavage fluid were higher after OLV with a  $V_T$  of 10 ml/kg vs. 5 ml/kg

*Schilling T et al. The pulmonary immune effects of mechanical ventilation in patients undergoing thoracic surgery. Anesth Analg 2005; 101:957-965*

- *Recruitment manoeuvres: at the beginning of the intervention or when starting OLV!*

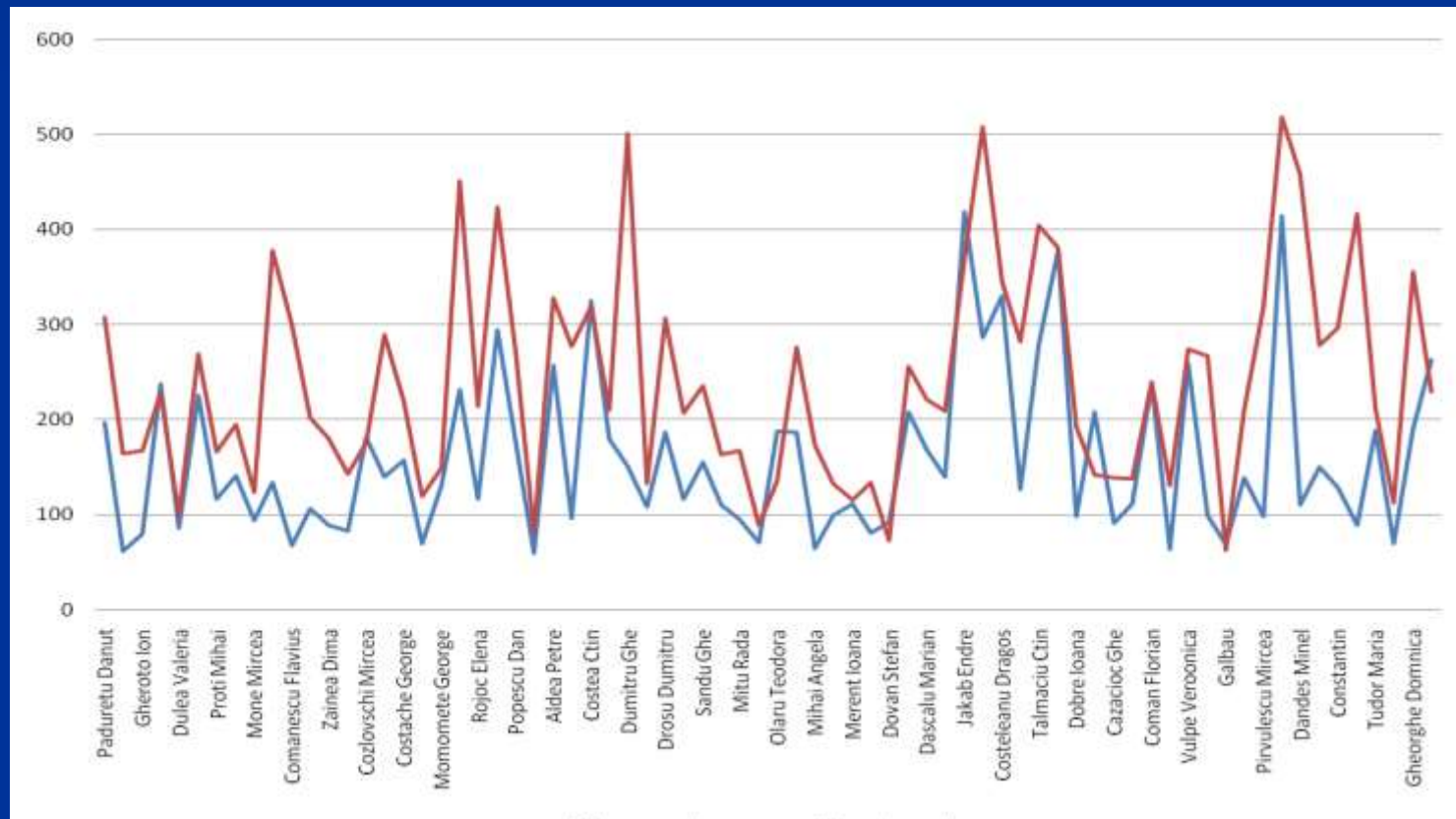


# Recruitment manoeuvres during OLA

## Studiu preliminar: PaO<sub>2</sub> post recrutare

before recruitment

-- post-recrutement



# Protective ventilation during OLA

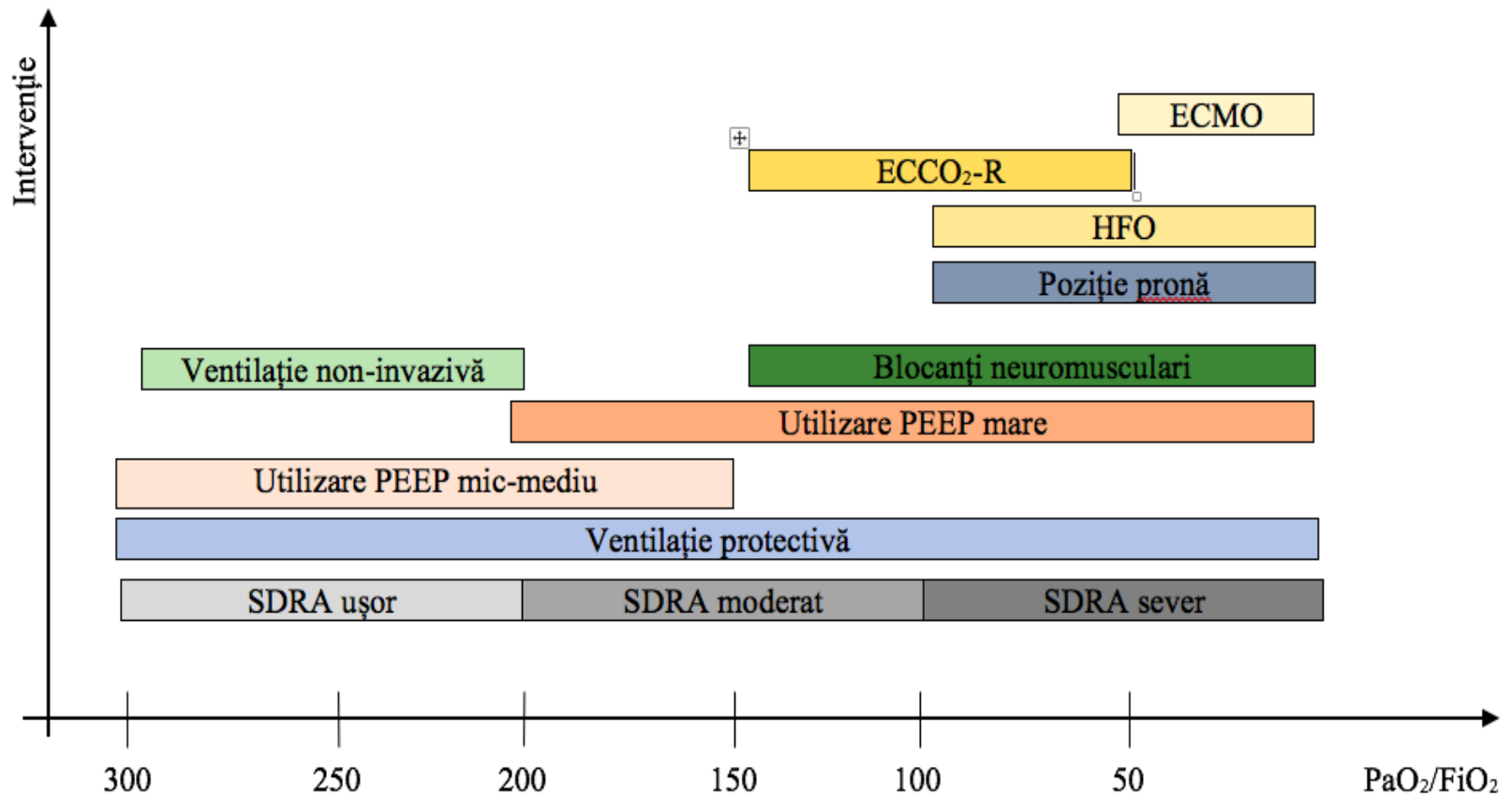
Before Recruitment Man

After RM + 7cm H2O PEEP

Patient ID	Birthdate	Age	Sex	Physician	Location
COMANEER					
SYRINGE SAMPLE ACID/BASE 37°C			Units	Ref	
pH	7.3401				( 7
pCO2	41.5		mmHg		(
pO2	67.21		mmHg		(
HC03-act	21.9		mmol/L		
HC03-std	21.4		mmol/L		
ctCO2	23.2		mmol/L		
BE(B)	-3.6		mmol/L		
BE(ecf)	-3.9		mmol/L		
OXYGEN STATUS 37°C					
ctHb	6.81		g/dL		(
Hct	20		%		(
ctO2(a)	8.91		mL/dL		(
B02	9.11		mL/dL		(
pO2	67.21		mmHg		(
sO2	95.4		%		(
F02Hb	92.11		%		(
FC0Hb	3.31		%		(
FMethb	0.2		%		(
FHHb	4.4		%		(
COMANEER					
SYRINGE SAMPLE ACID/BASE 37°C			Units	Ref	
pH	7.3491				( 7
pCO2	39.1		mmHg		(
pO2	209.51		mmHg		(
HC03-act	21.1		mmol/L		
HC03-std	21.0		mmol/L		
ctCO2	22.3		mmol/L		
BE(B)	-4.2		mmol/L		
BE(ecf)	-4.6		mmol/L		
OXYGEN STATUS 37°C					
ctHb	6.31		g/dL		(
Hct	19		%		(
ctO2(a)	9.41		mL/dL		(
B02	8.51		mL/dL		(
pO2	209.51		mmHg		(
sO2	99.71		%		(
F02Hb	98.6		%		(
FC0Hb	2.0		%		(
FMethb	0.3		%		(
FHHb	0.3		%		(

28/10/2009

# Rescue therapies



Tobin MJ. Mechanical Ventilation (3rd edn).  
New York : McGraw-Hill, 2012.

## ■ Prone position

*Tatineni S, Sasikumar S, Shanbhag V. Prone position for management of refractory hypoxemia in a patient with single lung. Ind J Respir Care 2012; 1: 69–72*

- Split ARDS patients into only two categories: PaO<sub>2</sub>/FIO<sub>2</sub> <150 mmHg and >150 mmHg assessed at PEEP ≥5 cmH<sub>2</sub>O.
- ARDS patients with an PaO<sub>2</sub>/FIO<sub>2</sub> ratio <150 mmHg, the mechanical ventilation should start with the following settings: lower VT, neuromuscular blockade for the first 48 h and prone positioning for long sessions until PaO<sub>2</sub>/FIO<sub>2</sub> is >150 mmHg.

*Guérin C, Reignier J, Richard JC, et al. Prone positioning in severe acute respiratory distress syndrome. N Engl J Med 2013; 368: 2159–2168.*

# PROSEVA STUDY

# ECMO

- 8 patients (2009-2015) Median PaO<sub>2</sub>/FiO<sub>2</sub>: 68mmHg

Median Sequential Organ Failure Assessment before ECMO was 15 (range, 12 to 17), predicting a mortality rate greater than 80%.

Hospital survival was 50%.

In severe and refractory ppARDS, VV-ECMO allows lung recovery and therefore increased survival.

*Reeb J et al Extracorporeal Membrane Oxygenation for Acute Respiratory Distress Syndrome After Pneumonectomy.*



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Extracorporeal Membrane Oxygenation for Severe Acute  
Respiratory Distress Syndrome

A. Combes, D. Hajage, G. Capellier, A. Demoule, S. Lavoué, C. Guervilly, D. Da Silva, L. Zafrani, P. Tirot, B. Veber, E. Maury, B. Levy, Y. Cohen, C. Richard, P. Kalfon, L. Bouadma, H. Mehdaoui, G. Beduneau, G. Lebreton, L. Brochard, N.D. Ferguson, E. Fan, A.S. Slutsky, D. Brodie, and A. Mercat, for the EOLIA Trial Group, REVA, and ECMONet\*

- Among patients with very severe ARDS, 60-day mortality was not significantly lower with ECMO (35%) than with a strategy of conventional mechanical ventilation (46%) that included ECMO as rescue therapy

*Combes A et al., Extracorporeal Membrane Oxygenation for Severe Acute Respiratory Distress Syndrome N Engl J Med 2018; 378:1965-1975*

*Statistics are an operational tool and not a religion; the knowledge, skill, and common sense of physicians are the values in the balance with “0.05”.*

*L. Gattinoni, Critical Care 2018 22:17*

# ARDS after pulmonary resections

- How often
- Etiology
- Diagnosis
- Prevention and treatment
- Prognosis and Mortality

# Mortality

- Mortality rate 40% (20 patients/50), 50% after pneumonectomy, 42% after lobectomy and 22% after sublobar resections (*A.Dulu, Chest,2006*)
- *Increased age associated with higher mortality*
- *Marginally significant association between mortality and time of presentation to the ICU after surgery (p 0.06).*
- 100% mortality in ARDS postpneumonectomy (confirmed at authopsy)!!! (19 patients)
- To prevent stump fistula (high pressure) it may be necessary HFJV or DLT intubation (*S. Turnage, Chest 1993*)
- Mortality 64,4% ALI/ARDS post pulmonary resections. (*Kutlu 2000*)



European Journal of Cardio-thoracic Surgery 34 (2008) 898–902

EUROPEAN JOURNAL OF  
CARDIO-THORACIC  
SURGERY

[www.elsevier.com/locate/ejcts](http://www.elsevier.com/locate/ejcts)

## The mortality from acute respiratory distress syndrome after pulmonary resection is reducing: a 10-year single institutional experience<sup>☆</sup>

Sarah S.K. Tang<sup>a</sup>, Karen Redmond<sup>a</sup>, Mark Griffiths<sup>b</sup>, George Ladas<sup>a</sup>,  
Peter Goldstraw<sup>a</sup>, Michael Dusmet<sup>a,\*</sup>

<sup>a</sup>Department of Thoracic Surgery, Royal Brompton Hospital, Sydney Street, London, SW3 6NP, UK

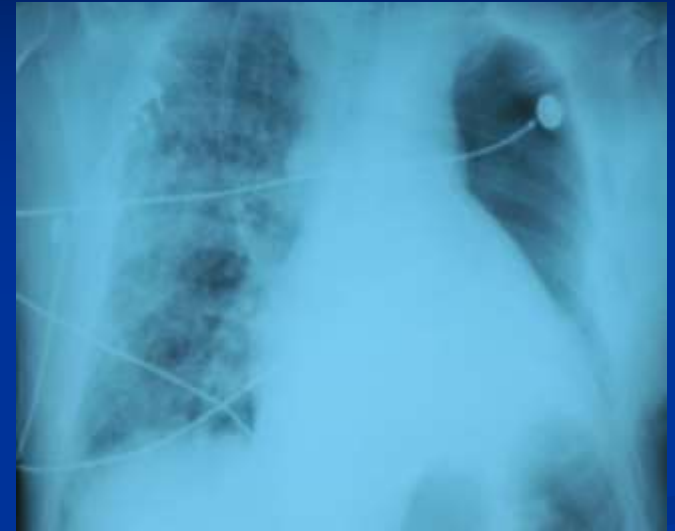
<sup>b</sup>Adult Intensive Care Unit, Royal Brompton Hospital, Sydney Street, London, SW3 6NP, UK

Received 29 February 2008; received in revised form 26 May 2008; accepted 9 June 2008

(pneumonectomy rate of 6.4% vs 17.4%). **Conclusions:** The incidence and mortality of ARDS have decreased in our institution. We postulate that this is due to more aggressive strategies to avoid pneumonectomy, greater attention to protective ventilation strategies during surgery and to the improved ICU management of ARDS.

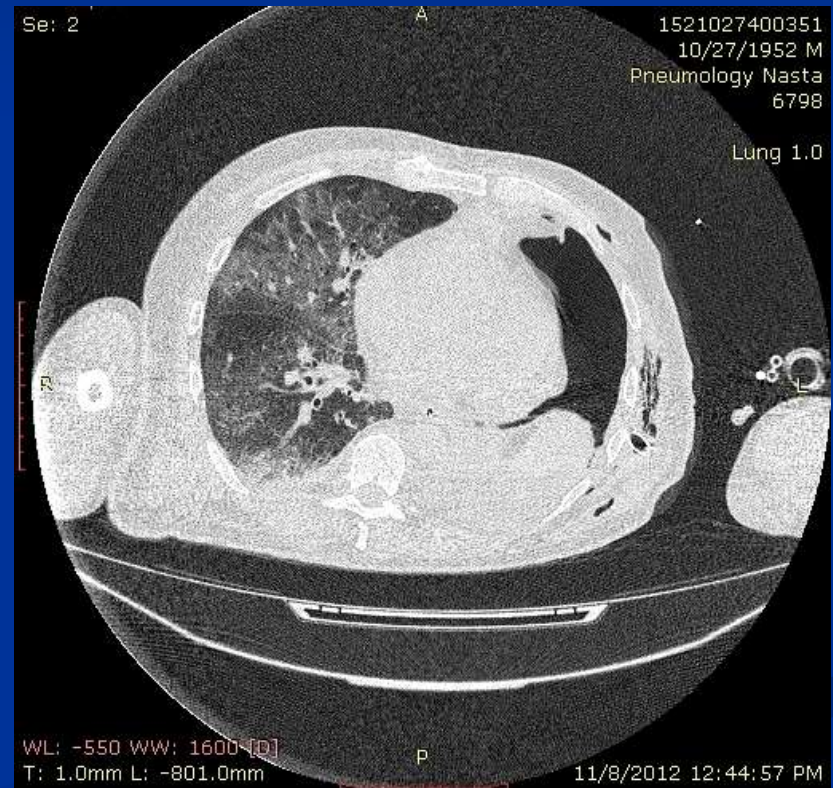
# Post-pneumonectomy ARDS: case illustration

- C.V. ♂, 60 y, *Left lung tumor*
- Left Pneumonectomy
- ARDS 3<sup>rd</sup> postop day
- MV( BiPap)
- Tracheostomy: 7<sup>th</sup> postop day
- Intestinal occlusion (volvulus) under MV: 8<sup>th</sup> postop day
- Laparotomy and cecostomy
- Weaning from ventilation 11<sup>th</sup> postop day
- Favourable evolution





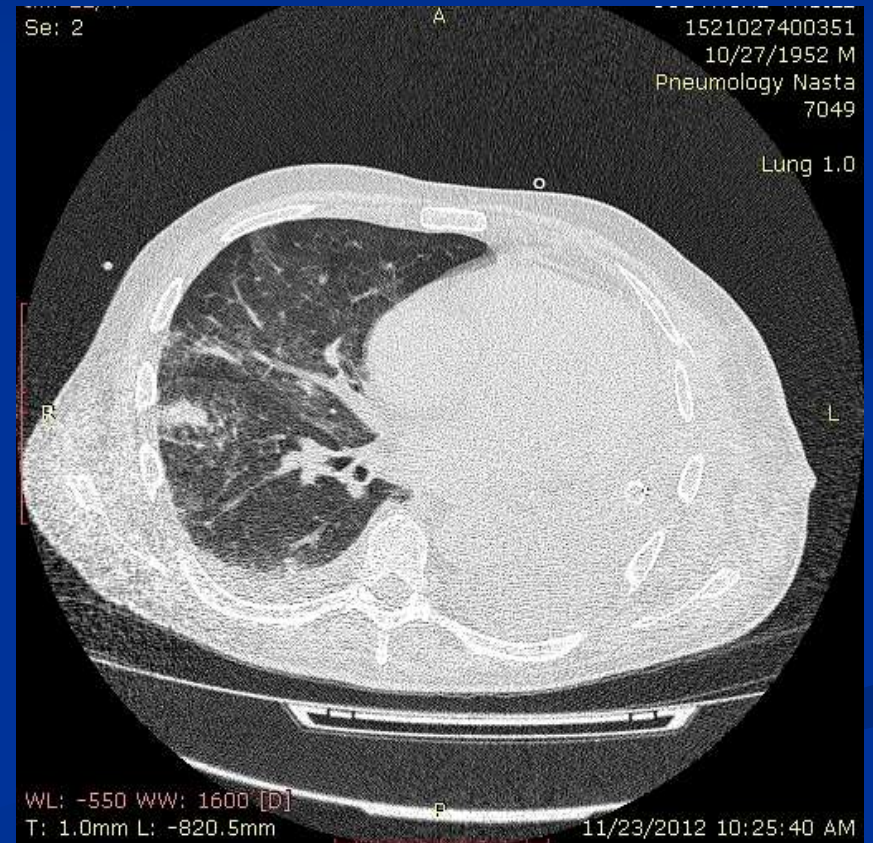
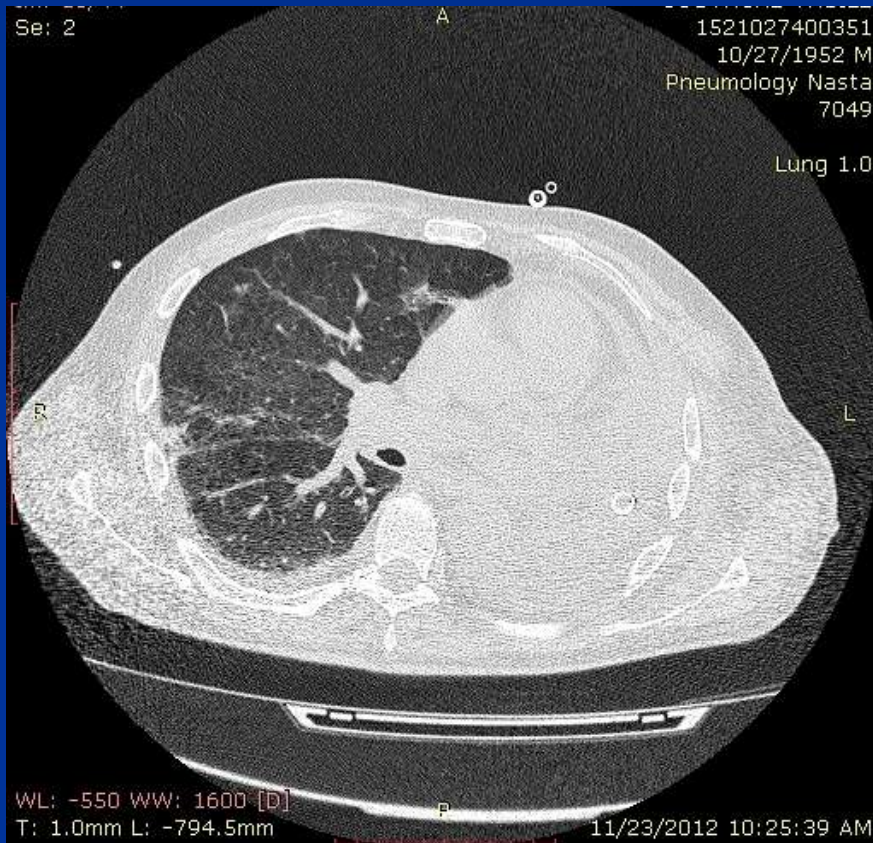
# Lung CT: Post-pneumonectomy ARDS





# CT: Post-pneumonectomy ARDS

## After weaning



# CONCLUSIONS

- ALI/ARDS post pulmonary resection:  
severe condition with high mortality
- Rapid ICU admission and treatment on  
mechanical ventilation
- Prevention strategies?

# Identifying patients with risk factors

- Right pneumonectomy
- Excessive perioperative fluid administration
- **High** intraoperative (Paw)
- **Other...**





Don't forget, there are not only surgical complications!

