

**Oxygenation Failure
Dyspneic Patient
Oxygen Therapy
ARDS**

Jan Maláška

- 63 yo female patient
- She collapsed aprox. 14 days ago
- Now she complains about chest pain on right side
- Due to worsening dyspnea an examination and differential diagnosis is ongoing at local hospital

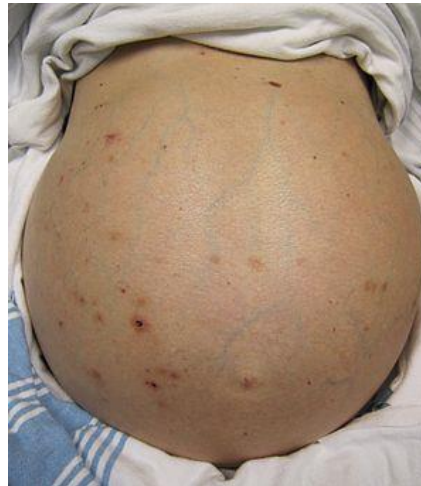
- 1. What do you think about the working diagnosis?**
- 2. Which examination, imaging methods and lab test you want to schedule?**

Dyspnea

1. **Pulmonary** - COPD, astma bronchiale, pneumonia.
2. **Heart-** AHF, valvular problems, TED
3. **Blood disease-** Anaemia, SCD
4. **Neuromuscular-** dystrophia, Myasthenia Gravis
5. **Others** – obesity, ascites, surgery, trauma, goiter
6. **Psychogenic**

Dyspnea -examination

- Physical Examination



Dyspnea - diagnostics

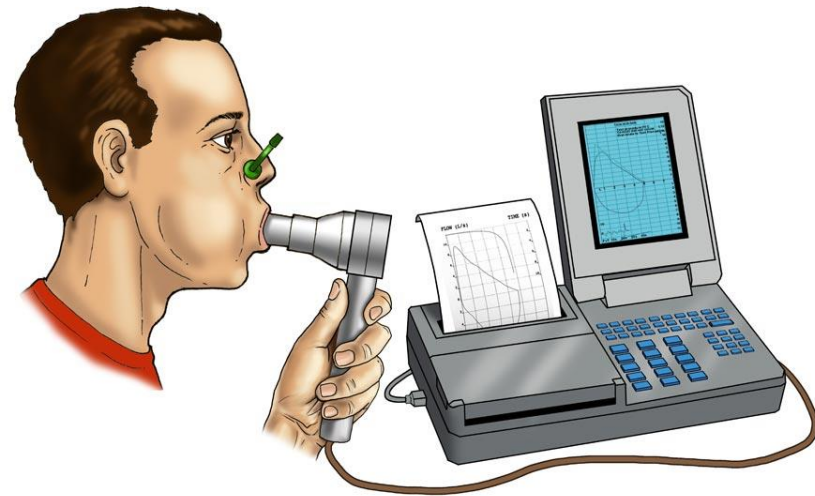
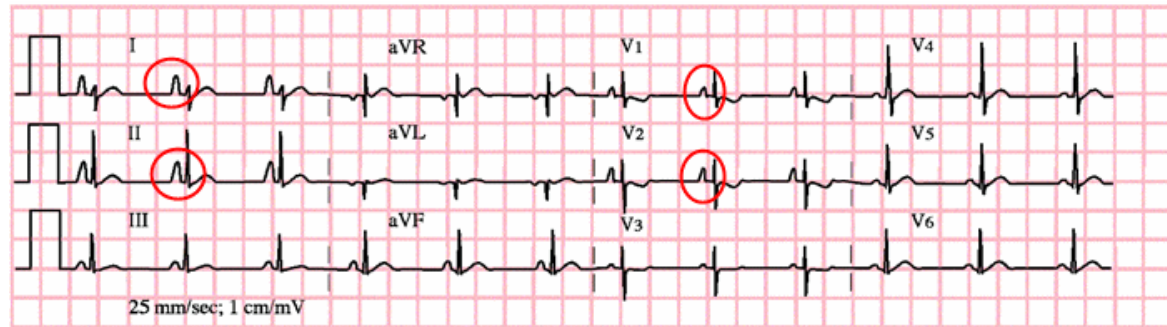
- **Lab-tests**

- ABG
- BC
- Liver Enzymes
- BUN, creat, Na, K, Cl, Mg, Ca, P
- CRP, PCT
- Cardiac enzymes, BNP, pro-BNP
- D-dimers

Parametr	Normální hodnoty
pH	7,36-7,43
paCO ₂	4,8-5,8 kPa
paO ₂	10-13 kPa
HCO ₃ ⁻	22-26 mmol/l
BE	od -3 do 3 mmol/l

Dyspnea – imaging methods

- Chest X-ray
- ECG
- ECHO
- Abdominal US
- spirometry
- Lung CT
- CT-angiography



- A. Airways patent**
- B. Respiratory Rate aprox. 27 breaths/min**
- C. BP 84/55 HR 131 (b.p.m.)**
- D. Alert, not fully orientated**

Lab results on admission

(*) (malaskja)		<1. (*)=
Vyšetření	Jedn.	2017 14.02 18:29
Urea	mmol/l	14.8
Kreat.	umol/l	282
Na	mmol/l	130
K	mmol/l	4.3
Cl	mmol/l	93
Ca	mmol/l	1.67
P	mmol/l	3.08
Mg	mmol/l	0.57
Osmol.	mmol/kg	
Bi-celk.	umol/l	11.1
Bil-přím	umol/l	8.9
ALT	ukat/l	1.32
AST	ukat/l	2.83
GGT	ukat/l	0.98
ALP	ukat/l	0.6
AMS	ukat/l	

F2 Podrobně F7 F8 PgUp PgDn Pohyb

How many organs are in dysfunction or failure?

SOFA score (Sequential Organ Failure Assessment)

SOFA score	0	1	2	3	4
Respiratory PaO ₂ /FIO ₂ (mm Hg) SaO ₂ /FIO ₂	>400	<400 221–301	<300 142–220	<200 67–141	<100 <67
Coagulation Platelets 10 ³ /mm ³	>150	<150	<100	<50	<20
Liver Bilirubin (mg/dL)	<1.2	1.2–1.9	2.0–5.9	6.0–11.9	>12.0
Cardiovascular^b Hypotension	No hypotension	MAP <70	Dopamine ≤5 or dobutamine (any)	Dopamine >5 or norepinephrine ≤0.1	Dopamine >15 or norepinephrine >0.1
CNS Glasgow Coma Score	15	13–14	10–12	6–9	<6
Renal Creatinine (mg/dL) or urine output (mL/d)	<1.2	1.2–1.9	2.0–3.4	3.5–4.9 or <500	>5.0 or <200

Laboratoř při příjmu

Wemu - [host - amish (SSH)]

Soubor Editace Nastavení Okna Nápověda

VÝSLEDKY BIOCHEMICKÝCH VYŠETŘENÍ		ŠEBKOVÁ MARCELA 545807/2125							
(*) (malaskja)		(č.dokl.:*)							
Wyšetření	Jedn.	2017 14.02 23:32	2017 14.02 23:28	2017 14.02 23:27	2017 14.02 21:30	2017 14.02 21:22	2017 14.02 19:39	2017 14.02 18:31	2017 14.02 18:29
Glukóza	mmol/l				3.5				1.9
cB-gluk.	mmol/l		4.6			3.7	3.1		
TG	mmol/l								
CRP	mg/l								412
Transf.	g/l								
Laktát	mmol/l			3	3.6				4.3
B(a)pH		7.19			7.21			7.26	
B(a)pCO2	kPa	5.6			5.1			4.6	
B(a)pO2	kPa	10			11.1			11.5	
B(a)HCO3	mmol/l	15.9			15.2			14.9	
B(a)BD-	mmol/l	-11.8			-11.9			-11.1	
B(a)BE+	mmol/l								
B(a)sO2c		0.896			0.926			0.941	
B(a)Ca2+	mmol/l				0.96			0.84	
B(a)CapH	mmol/l				0.88			0.78	
Uhustota									

F2 Podrobně F7 F8 PgUp PgDn Pohyb Esc Přeruš I Tisk



ALTERED
MENTAL STATUS



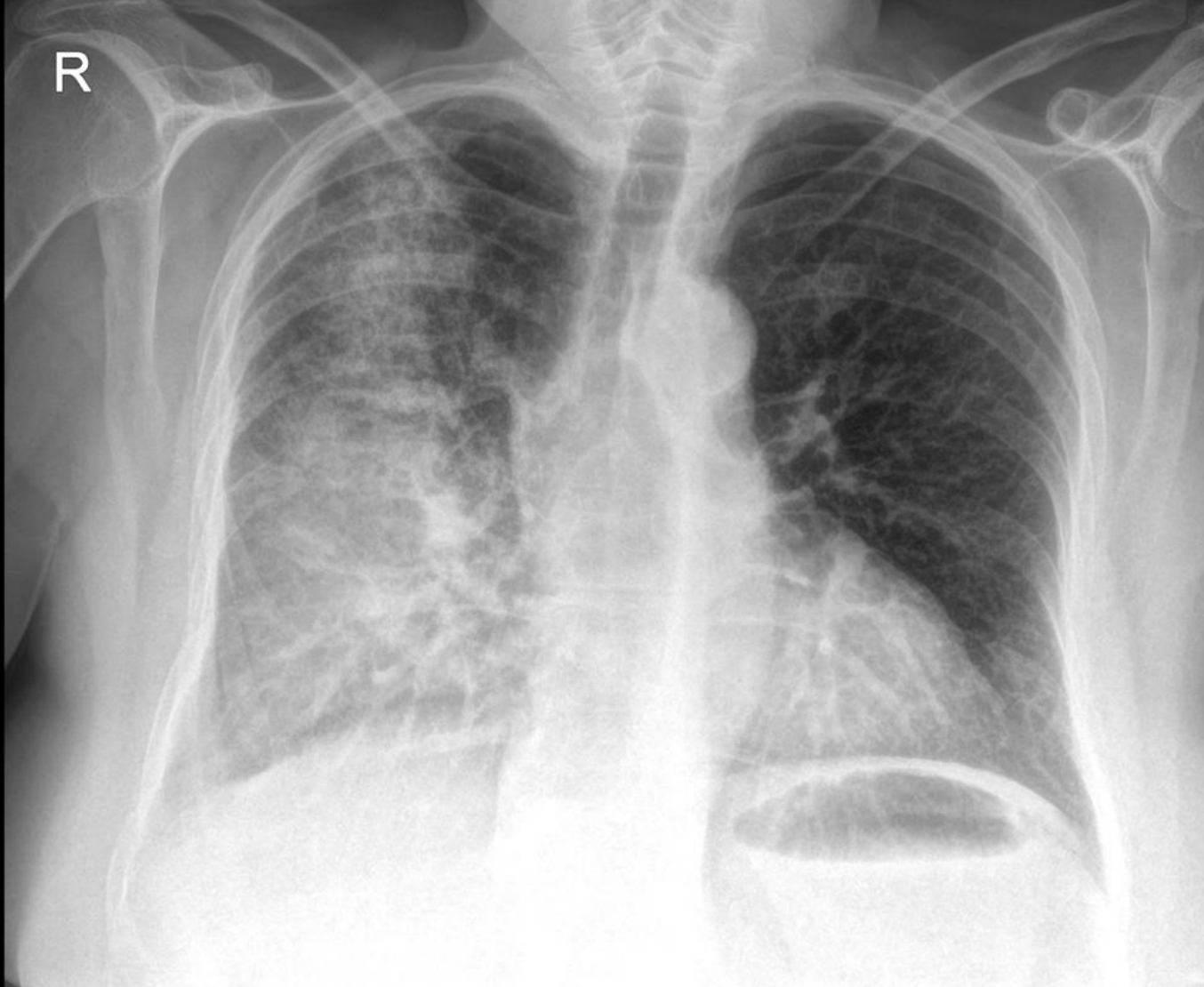
FAST RESPIRATORY
RATE



LOW BLOOD
PRESSURE

- alteration in mental status
- systolic blood pressure ≤ 100 mm Hg
- respiratory rate ≥ 22 /min

<http://www.qsofa.org/>



- Fracture of two ribs on the right side (from 5th to 7th)
- Lung contusion with large infiltration on the right side

Actual clinical findings

- SpO₂ 85%
- TK 90/45, p. 131/min
- AKI

Patient is admitted to ICU

- Diagnosis is sCAP
- Major problems?:
 1. Hyposaturation
 2. Hypotension
 3. AKI

Which equipment you choose?



Which flow? Which goal?



Kyslíkové brýle	
průtok O2 (l/min)	FiO2 (%)
0	21
1	25
2	29
3	33
4	37
5	41
6	45



Maska se zpětným vdechováním	
průtok O2 (l/min)	FiO2 (%)
7	65%
8.15	70-80%



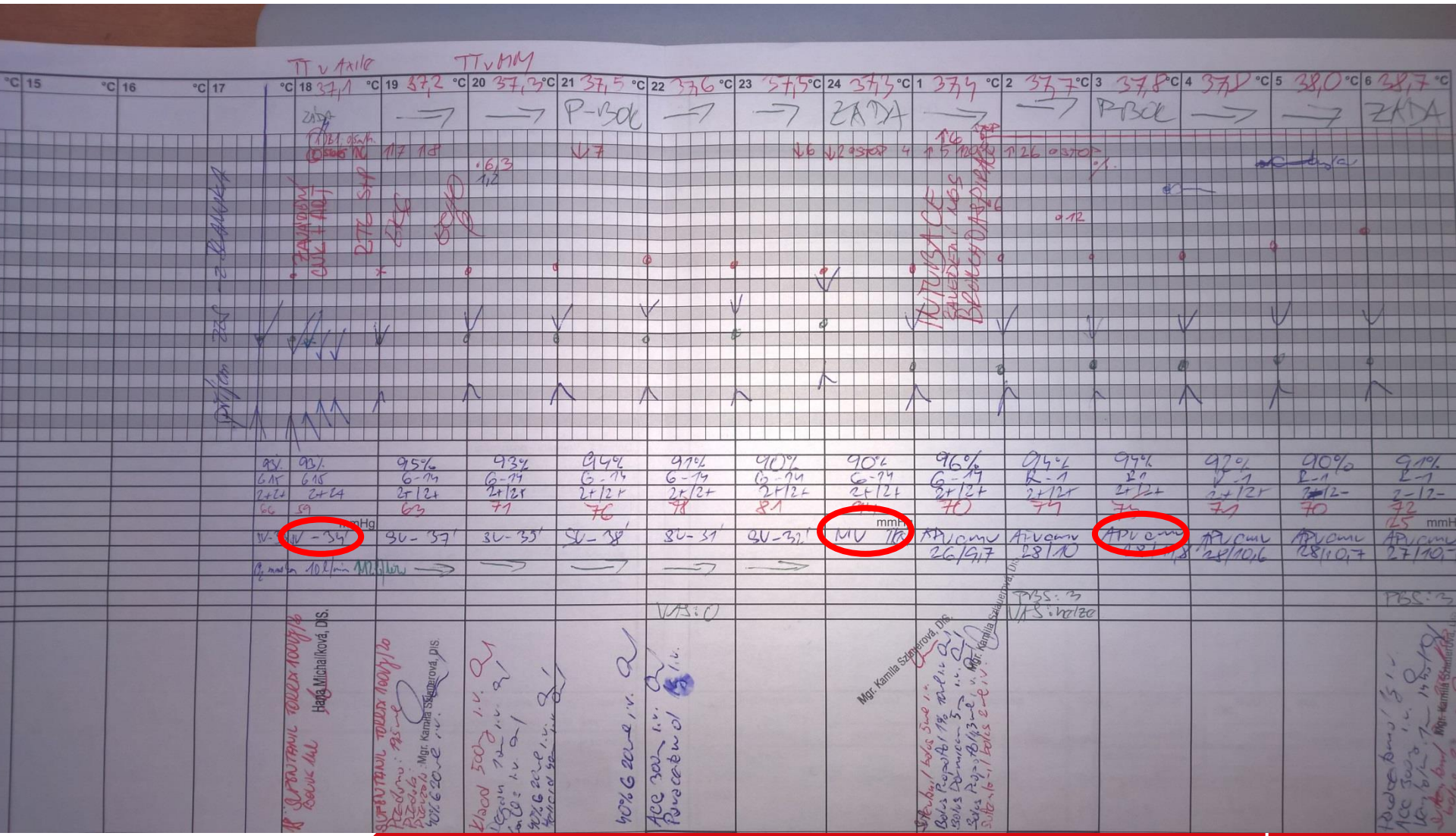
Maska bez zpětného vdechování	
průtok O2 (l/min)	FiO2 (%)
6	55-60
8	60-80
10	80-90
12	90
15	90-100

*za podmínky že nekolabuje rezervoár

What is the maximal flow?

What about the gases from central distribution?

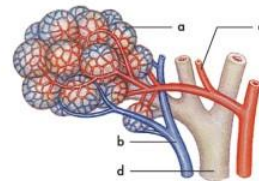
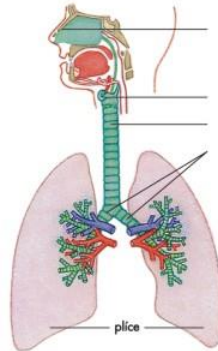
Several Hours after Admisson in ICU



Transport of O₂ and CO₂

Alveolar Ventilation

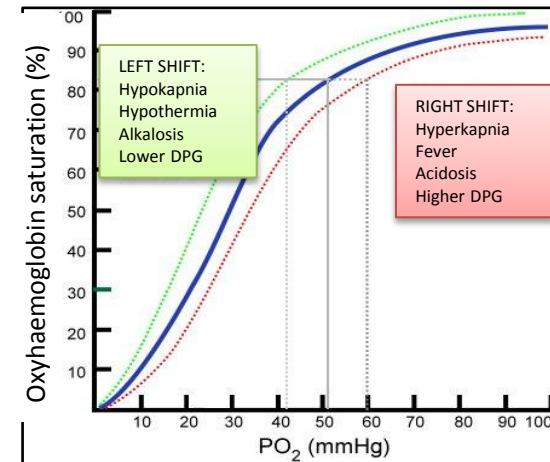
(exchange of CO₂ between alveoli and environment)

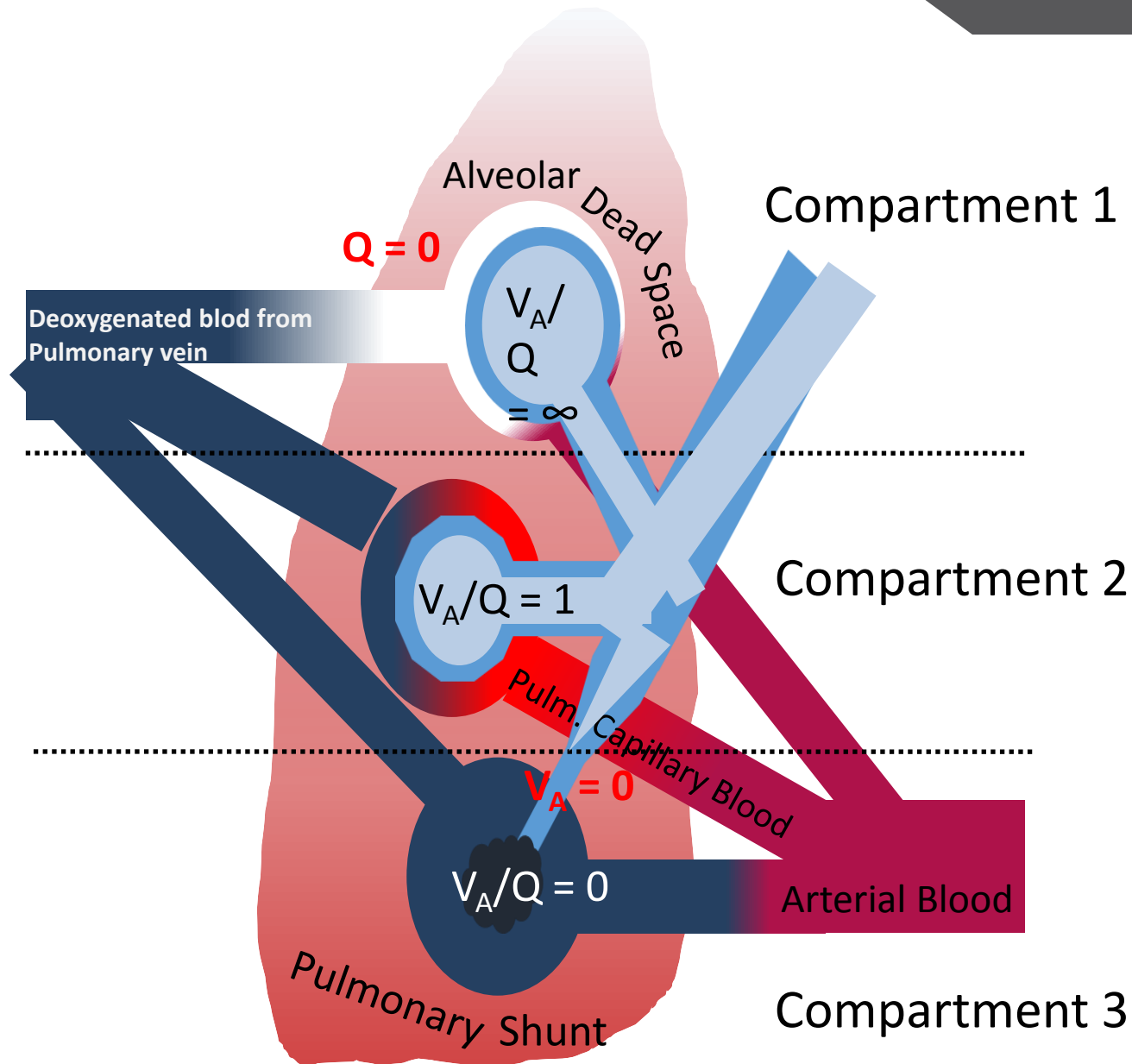


Diffusion

(diffusion of O₂ from alveolus into blood)

Transport of O₂ a CO₂ in the blood





Types of Respiratory Failure?

Oxygenation Failure

Basily due to failure of alveolo-capillary transport.

1. V/Q mismatch
2. Increase in pulmonary shunt
3. Diffusion abnormalities

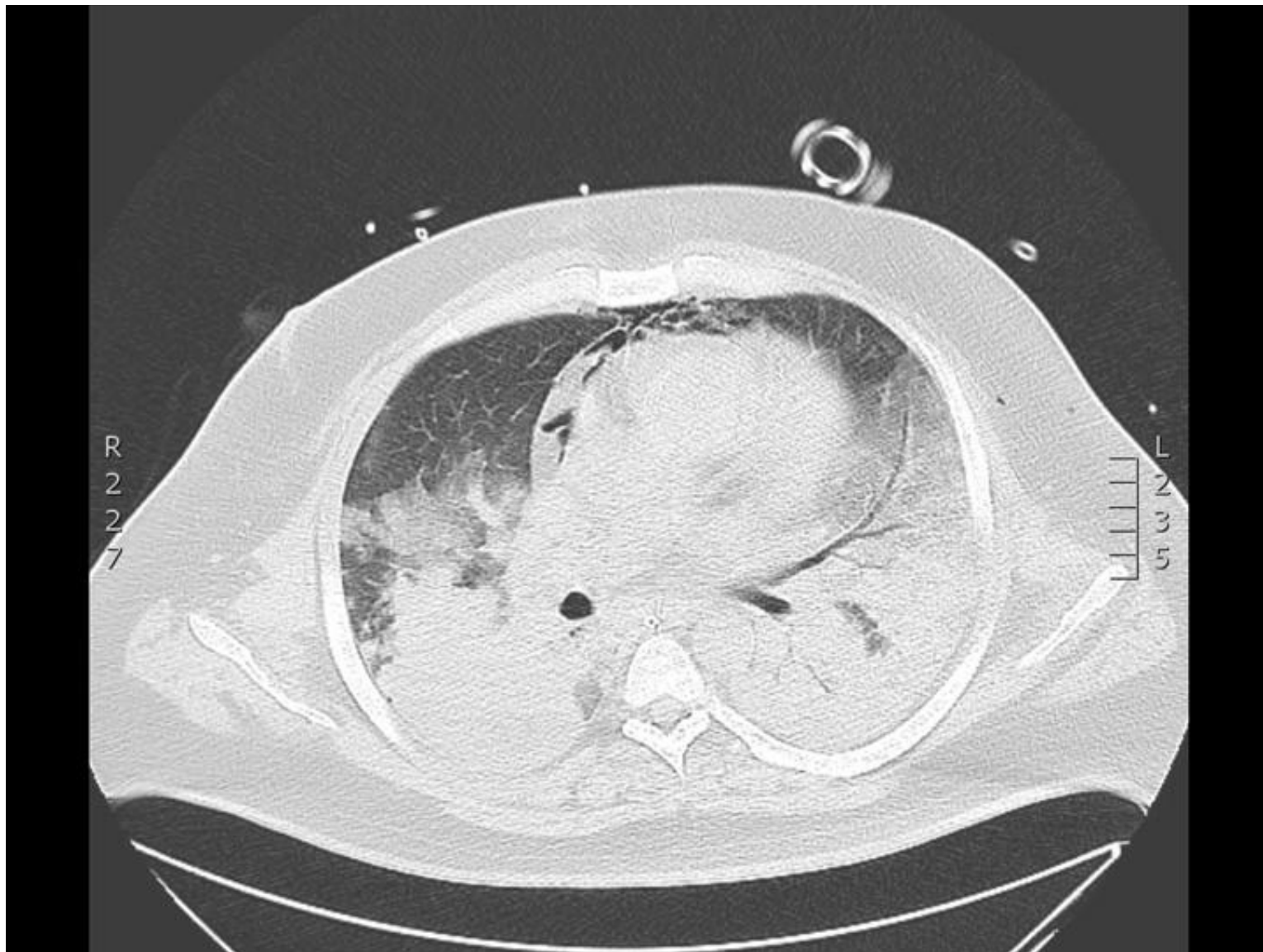
paO₂ (spO₂, saO₂)

Ventilatory failure

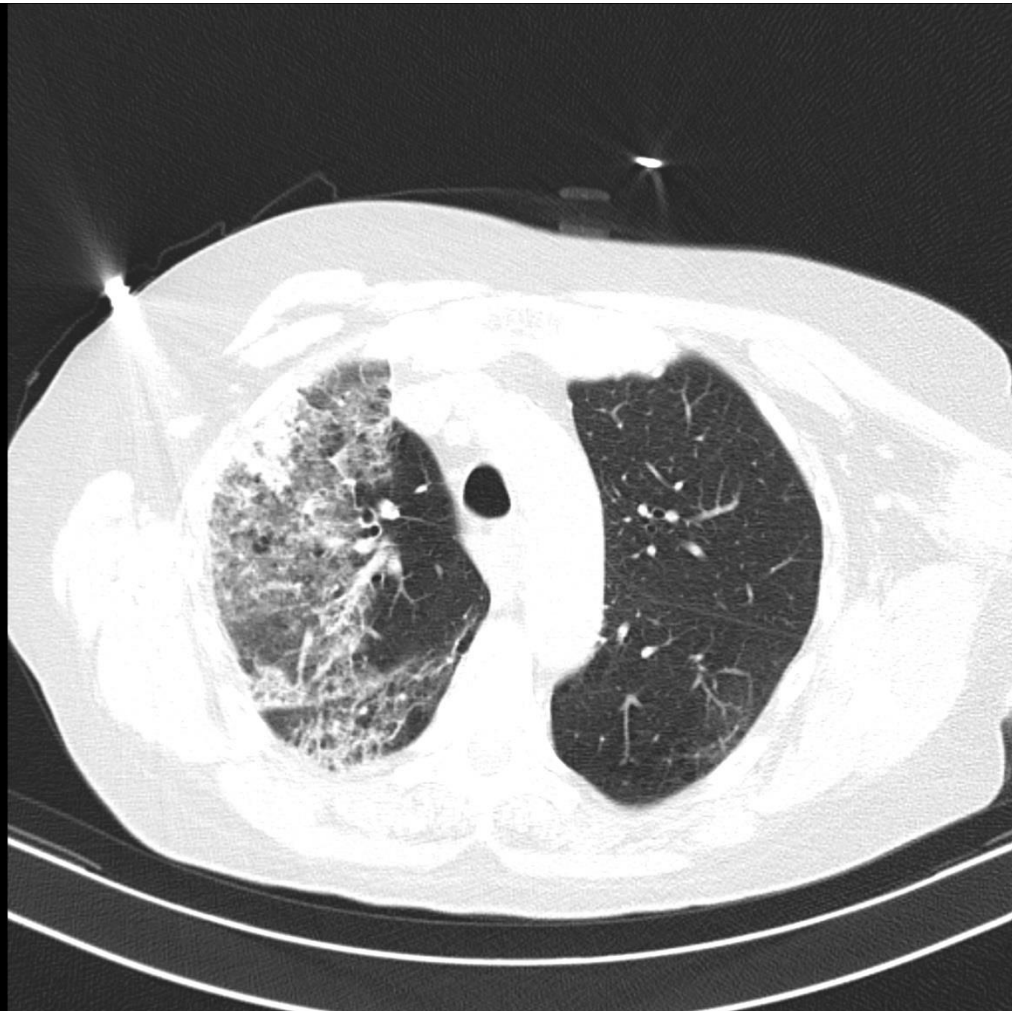
Due to failure of „muscle pump“ of the chest (disorders of CNS, chest, respiratory muscles, neuro-muscular junction)

Increase in V_D/V_T mismatch

pCO₂ (ETCO₂)



CT scan after admission



Day 2.

- Patient is still tubed
- diagnostic fibroscopy with BAL is performed
- BAL - bronchoalveolar lavage – aprox. 150 ml of normal saline is instilled and alveoli are washed
- Ongoing haemodynamic stabilisation
- Improving in oxygenation
- Sedation is withdraw
- A IHD is performed on day 3
- Etiological is prooved? Any Idea?

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Wemu - [host - amish (SSH)]
Soubor Editace Nastavení Okna Nápověda
VÝS_MIK1:  Další Předch Ukaž Tisk Hledej Návrat
( ) (malaskja) (17 / 18)
VÝSLEDKY Z MIKROBIOLOGIE ŠEBKOVÁ MARCELA 545807/2125
Datum, čas odběru: 14.02.17 10:36 Mat.: Ter.: R Žád.: 2016847039
TEXT:
Odběr : 14.2.2017
Komentář :
Vyšetření: Průkaz Ag pneumokoka - Moč
Průkaz antigenu Streptococcus pneumoniae:
S.pneumoniae..... pozitivní
St: Viděl: 15.02.17 11:49 - root Podp.: 15.02.17 - DaSta
Zobrazení předchozího výsledku
F1Pomoc ShiftF5Do schránky ShiftF7Do schránky+ EscPřeruš
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Wemu - [host - amish (SSH)]
Soubor Editace Nastavení Okna Nápověda
VYS_MIK1: [ ] Další Předch Ukaž Tisk Hledej Návrat
-()-----(malaskja)----- (9 / 18)-----
VÝSLEDKY Z MIKROBIOLOGIE ŠEBKOVÁ MARCELA 545807/2125
Datum,čas odběru: 15.02.17 11:33 Mat.: Ter.: R Žád.: 2016856429
TEXT:
Odběr : 15.2.2017
Komentář : odsátý mat. při bronchoskopii
Vyšetření: Kultivační vyšetření - sekret z ETK
Aerobní kultivace:
Nález: ředění sputa 10 na -3 Streptococcus pneumoniae v M fázi
Stanovení kvalitativní citlivosti na antibiotika:
penicilin.....C tetracyklin.....C
erytromycin.....C cotrimoxazol.....C
Anaerobní kultivace:
Nález: Nevyrostly žádné mikroby.
Mikroskopické vyšetření materiálu:
epitelie DCD..... ojediněle
Leukocyty..... + - ++
G+ koky ve dvojicích..... +
St: Viděl: 17.02.17 12:46 - root - Podp.: 17.02.17 - DaSta
Zobrazení předchozího výsledku
F1Pomoc ShiftF5Do schránky ShiftF7Do schránky+ EscPřerus
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What is Artificial ventilation?

- Artificial ventilation is an organ support.
- Ventilatory machine partially or completely secures the flow throughout respiratory system.

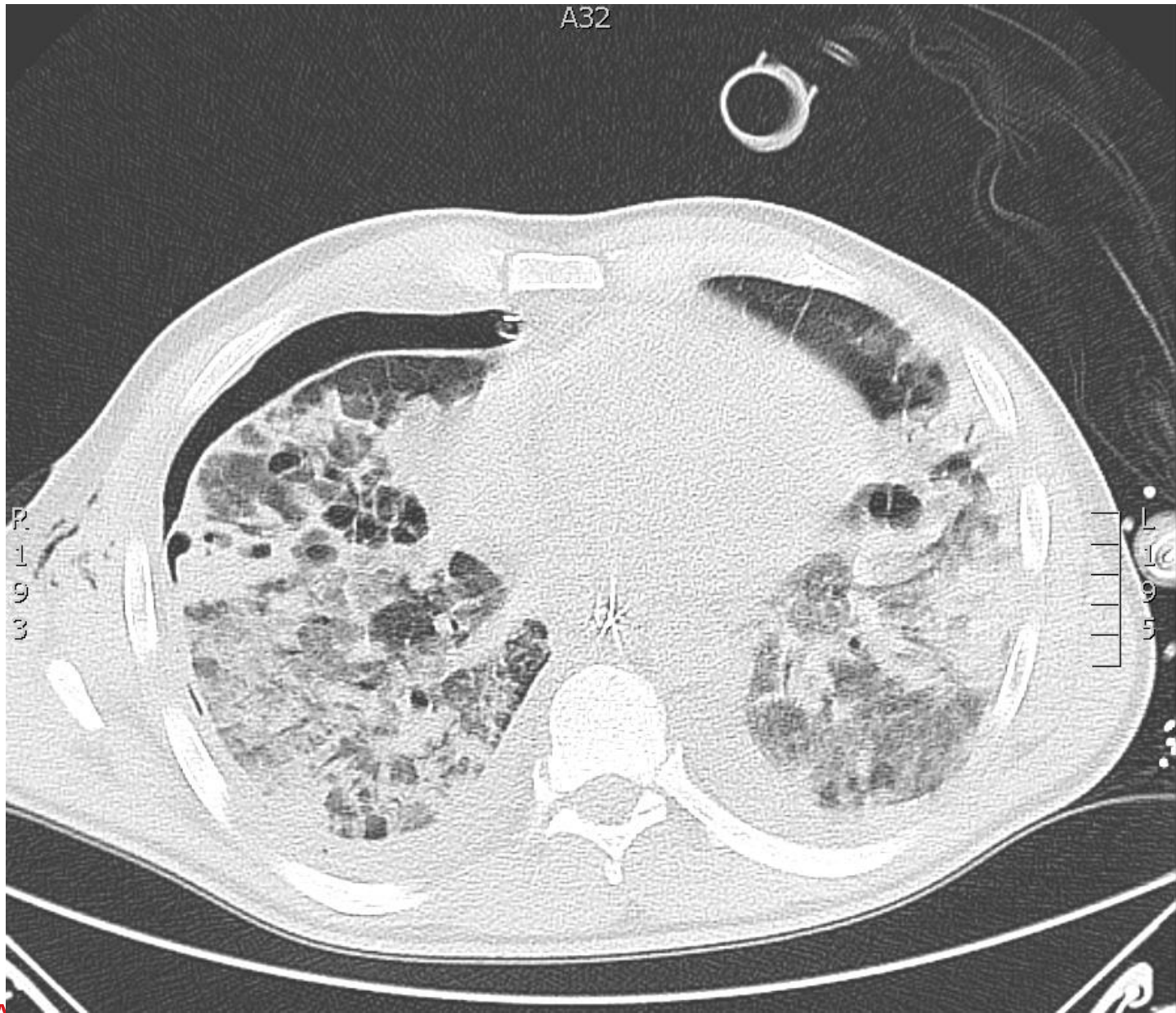
Physiological Goals

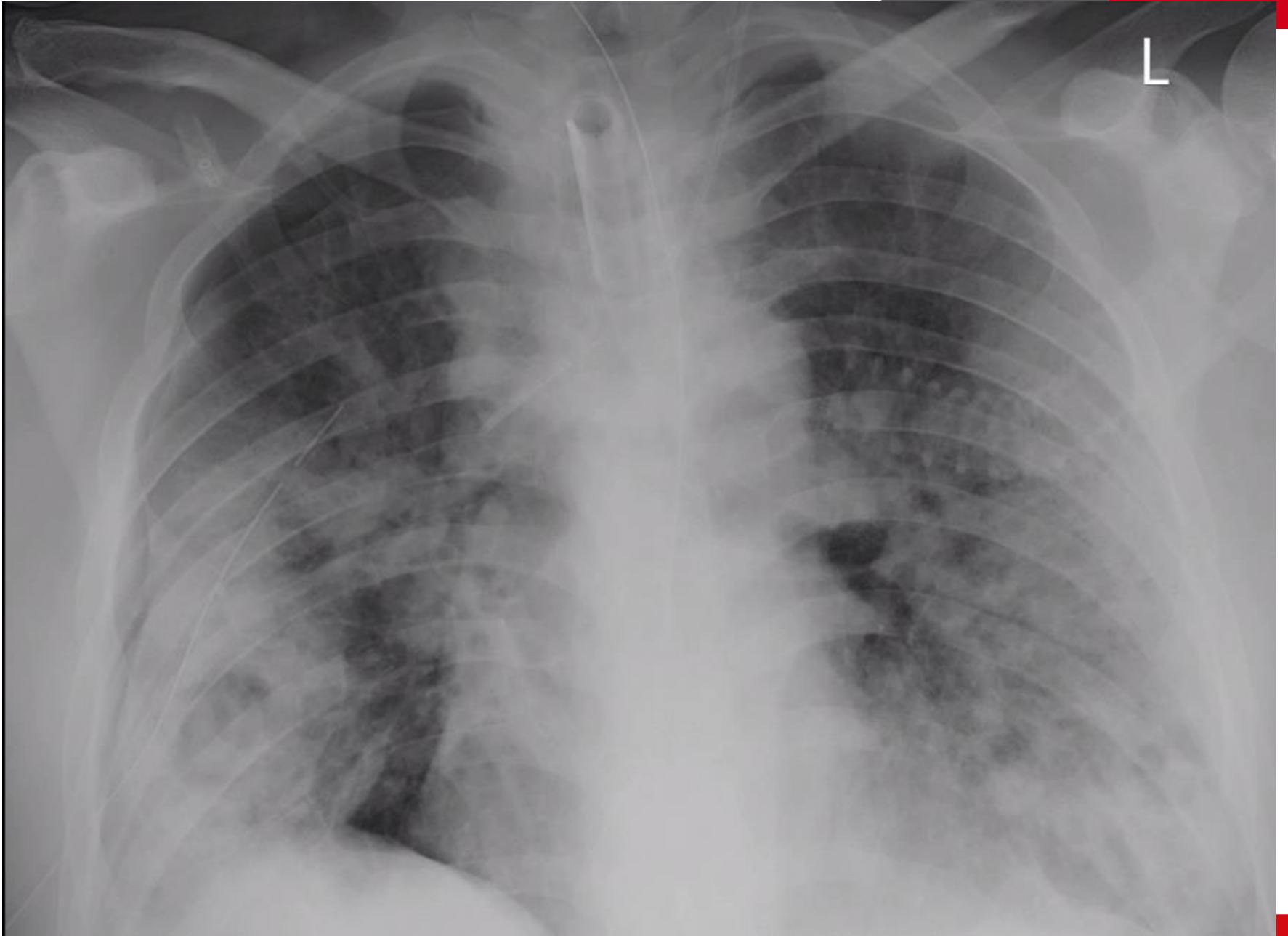
To reach the preset goals of oxygenation and ventilation

1. Normalise oxygenation (PaO₂ > 60 mmHg = 8 Kpa, SaO₂>90%)
2. Maintain adequate ventilation, typically a PaCO₂ of 35-45 mmHg= 4,5-6,0 Kpa
3. Normalise acid-base balance
4. Reduce patient WOB
5. Lowering VO₂

Clinical Goals

Reduction of adverse affects of arteficial ventilation





Indication for Arteficial Ventilation

Oxygenation

- $\text{PaO}_2 < 70 \text{ mmHg}$ (9 Kpa) despite oxygen therapy
- P/F index $\text{PaO}_2/\text{FiO}_2 < 200 \text{ mmHg}$



Ventilation

- Apnea
- $\text{PaCO}_2 > 55 \text{ mmHg}$ (7,5 Kpa)

Lung Mechanics

- $\text{DF} > 35/\text{min}$

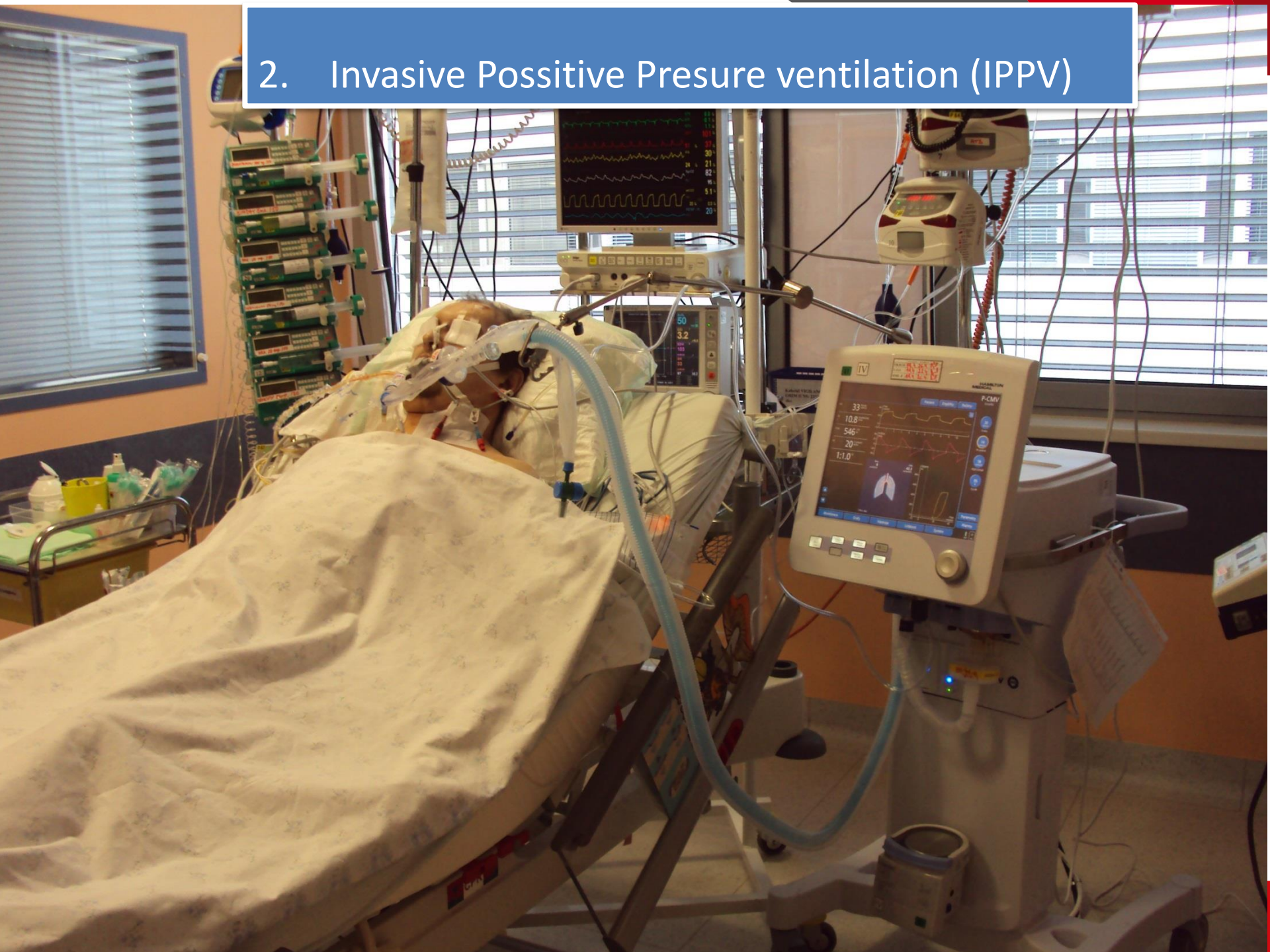
Two basic modes of Artificial Ventilation

1. Non-invasive Ventilation (NIPPV)
2. Invasive Positive Pressure ventilation (IPPV)

1. Non-invasive Ventilation (NIPPV)



2. Invasive Positive Pressure ventilation (IPPV)



Generations of Artificial Ventilators

- **I. Generation:**
mechanical regulatory unit – OXYLOG 1000
- **II. Generation:**
partially electronic regulatory unit - OXYLOG 2000



III. Generation



- Electronic feed-back
- Out-of-date



IV. Generation



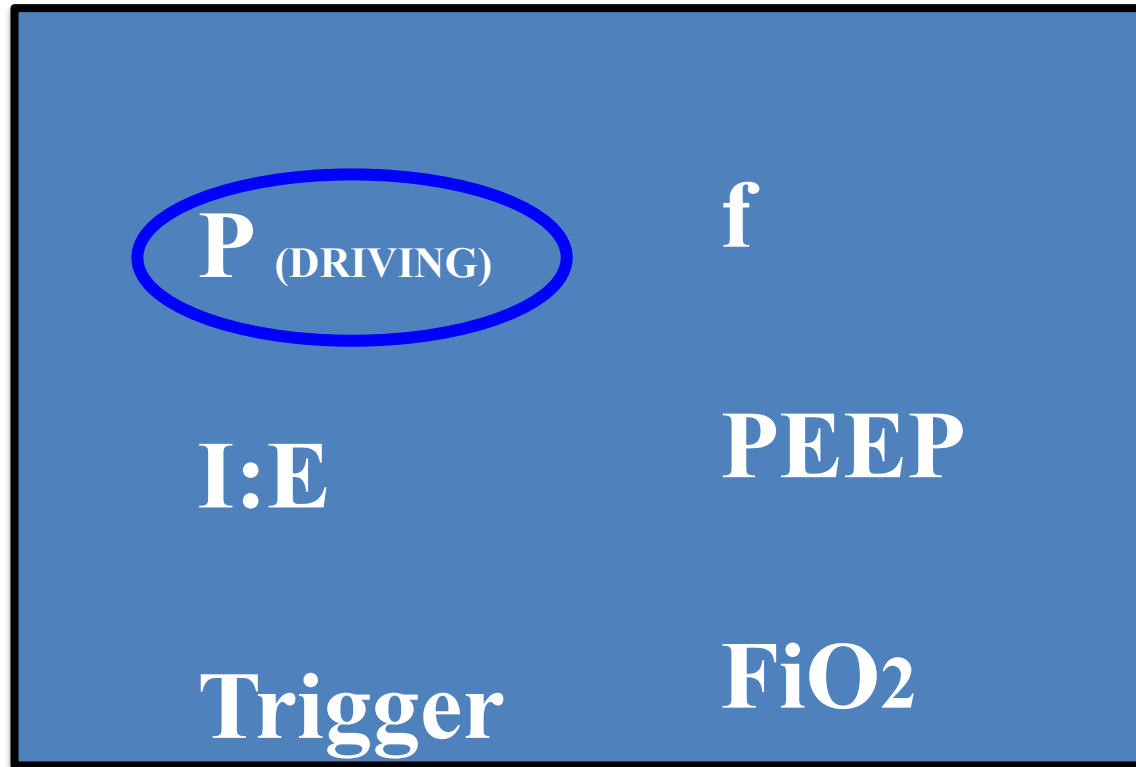
1. REGIMENS w/FULLY VENTILATORY SUPP.

1. CMV or VCV – Volume Control Ventilation
2. PCV – Pressure Control Ventilation
3. *PRVC – PRESSURE regulated VOLUME control*

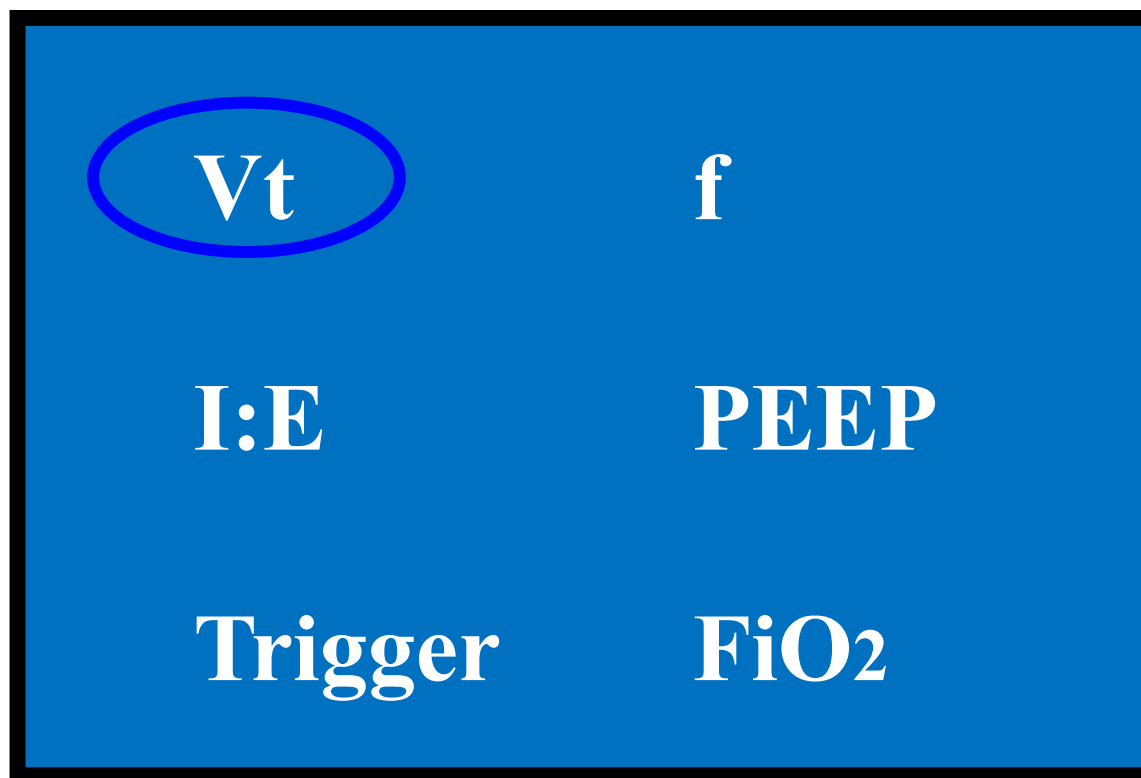
2. REGIMENS w/PARTIALLY VENTILATORY SUPP.

1. PS or SPONT (PSV, ASB)– Pressure Support
2. *SIMV*
3. *BIPAP nebo DuoPAP* – Bilevel Positive Airway Pressure
4. *CPAP* – Continuous Positive Airway Pressure

PCV – PRESSURE CONTROL VENTILATION



CMV – CONTROL MANDATORY VENTILATION



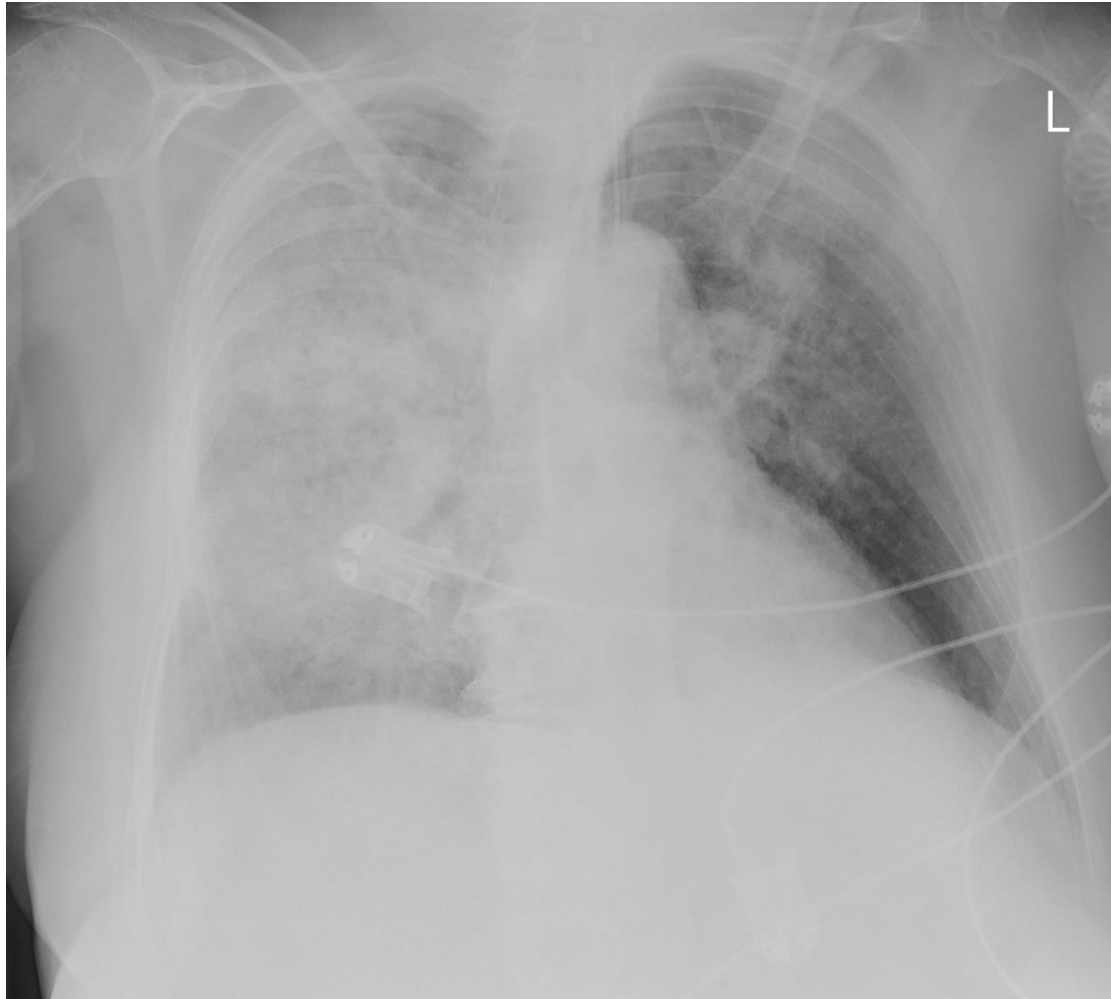
P support

PEEP

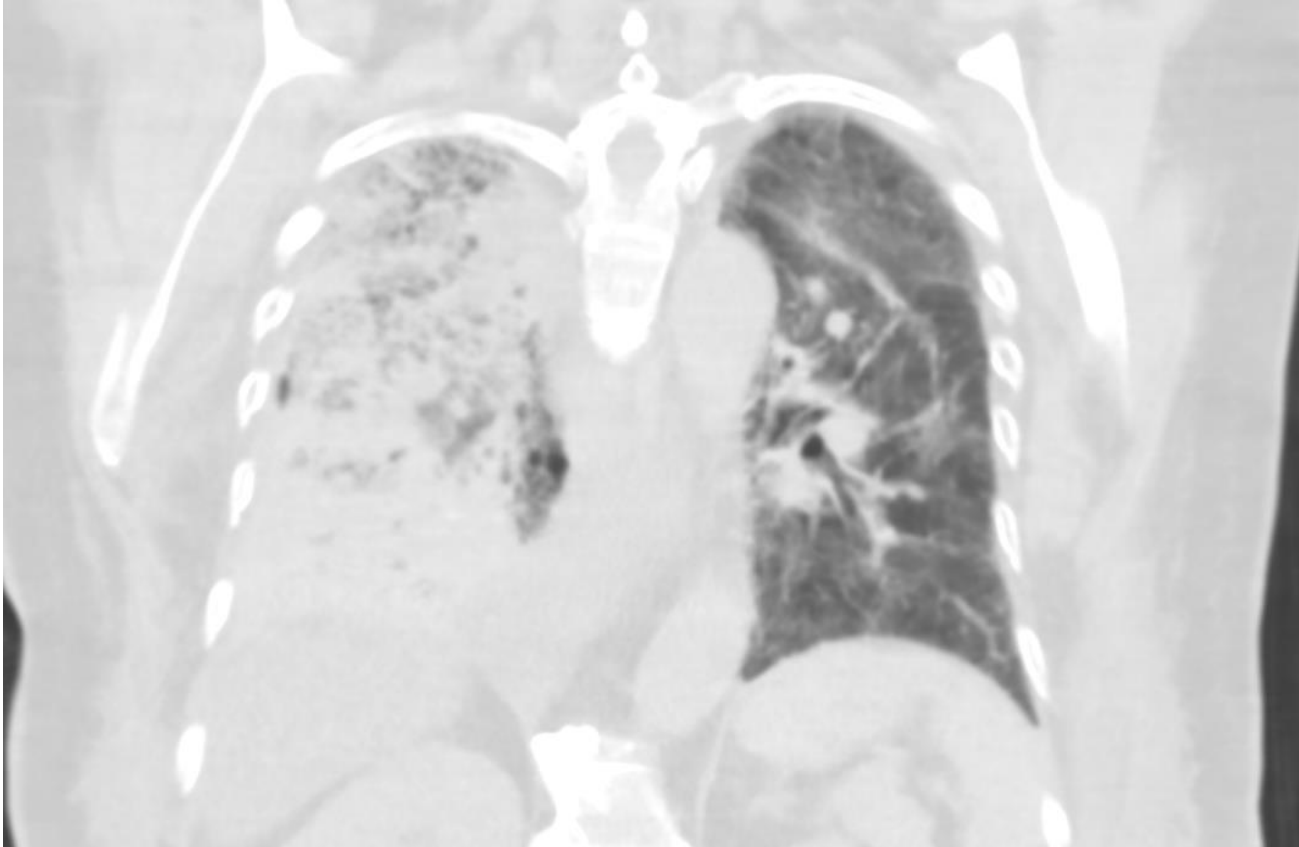
Trigger

FiO₂

CHEST X-ray after 2 days

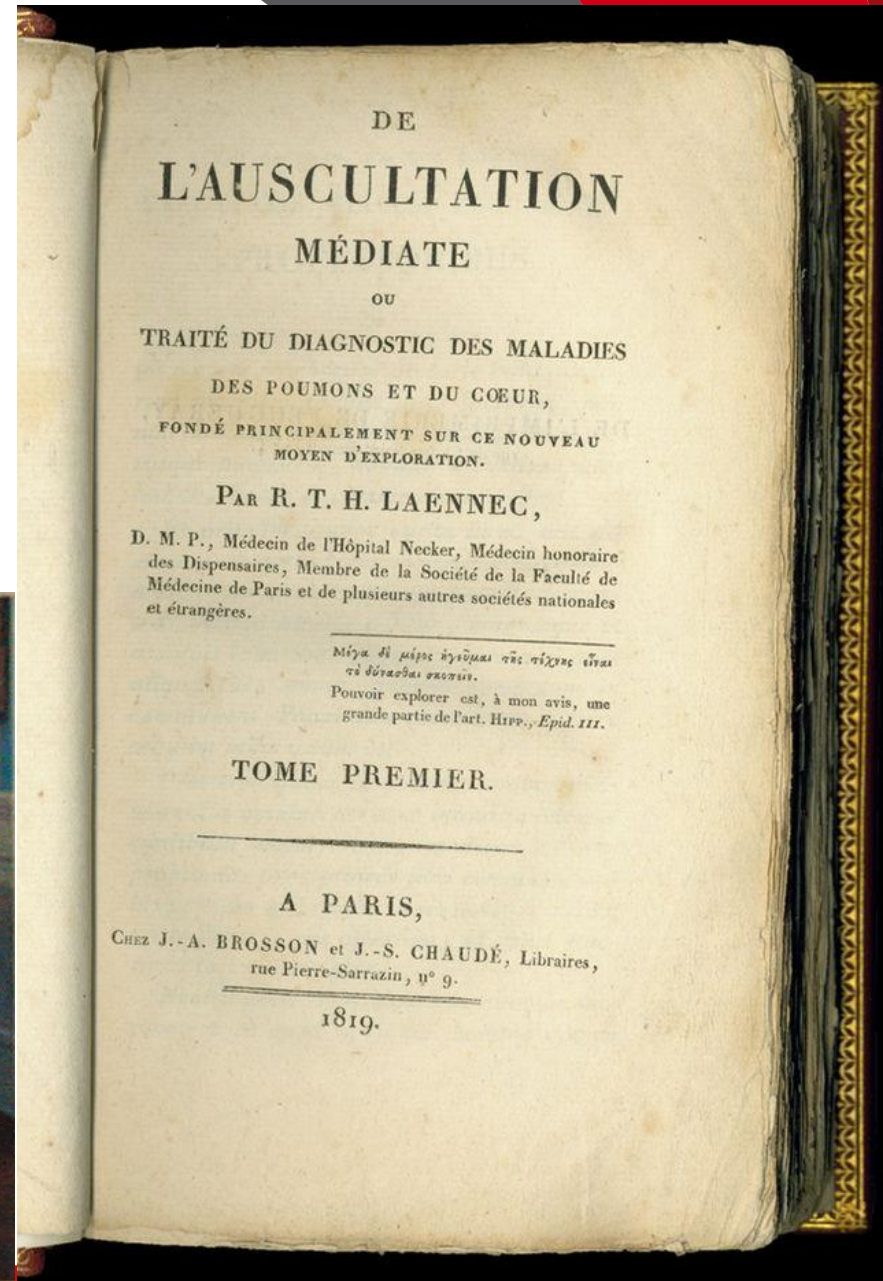


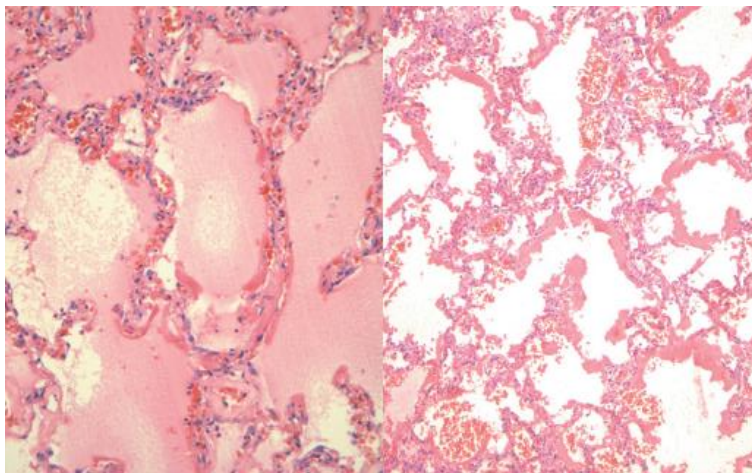
AFTER SEVERAL DAYS



ARE WE TALKING ABOUT ARDS?

- R.T.H. Laennec
- First published report about ARDS
- „Idiopathic lung oedema“
- ...*œdème pulmonaire sans insuffisance cardiaque...*





Autopsy:

- Atelectasis
- Vascular congestions
- Haemorrhagy
- Lung Oedema
- Hyaline membranes

ACUTE RESPIRATORY DISTRESS IN ADULTS

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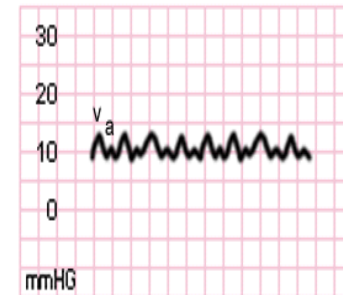
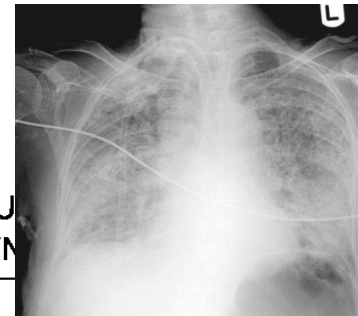
Summary The respiratory-distress syndrome in 12 patients was manifested by acute onset of tachypnoea, hypoxaemia, and loss of compliance after a variety of stimuli; the syndrome did not respond to usual and ordinary methods of respiratory therapy. The clinical and pathological features closely resembled those seen in infants with respiratory distress and to conditions in congestive atelectasis and postperfusion lung. The theoretical relationship of this syndrome to alveolar surface active agent is postulated. Positive end-expiratory pressure was most helpful in combating atelectasis and hypoxaemia. Corticosteroids appeared to have value in the treatment of patients with fat-embolism and possibly viral pneumonia.

Lancet. 1967 Aug 2;2(7511):319-23.

Report of the American-European consensus conference on ARDS: definitions, mechanisms, relevant outcomes and clinical trial coordination

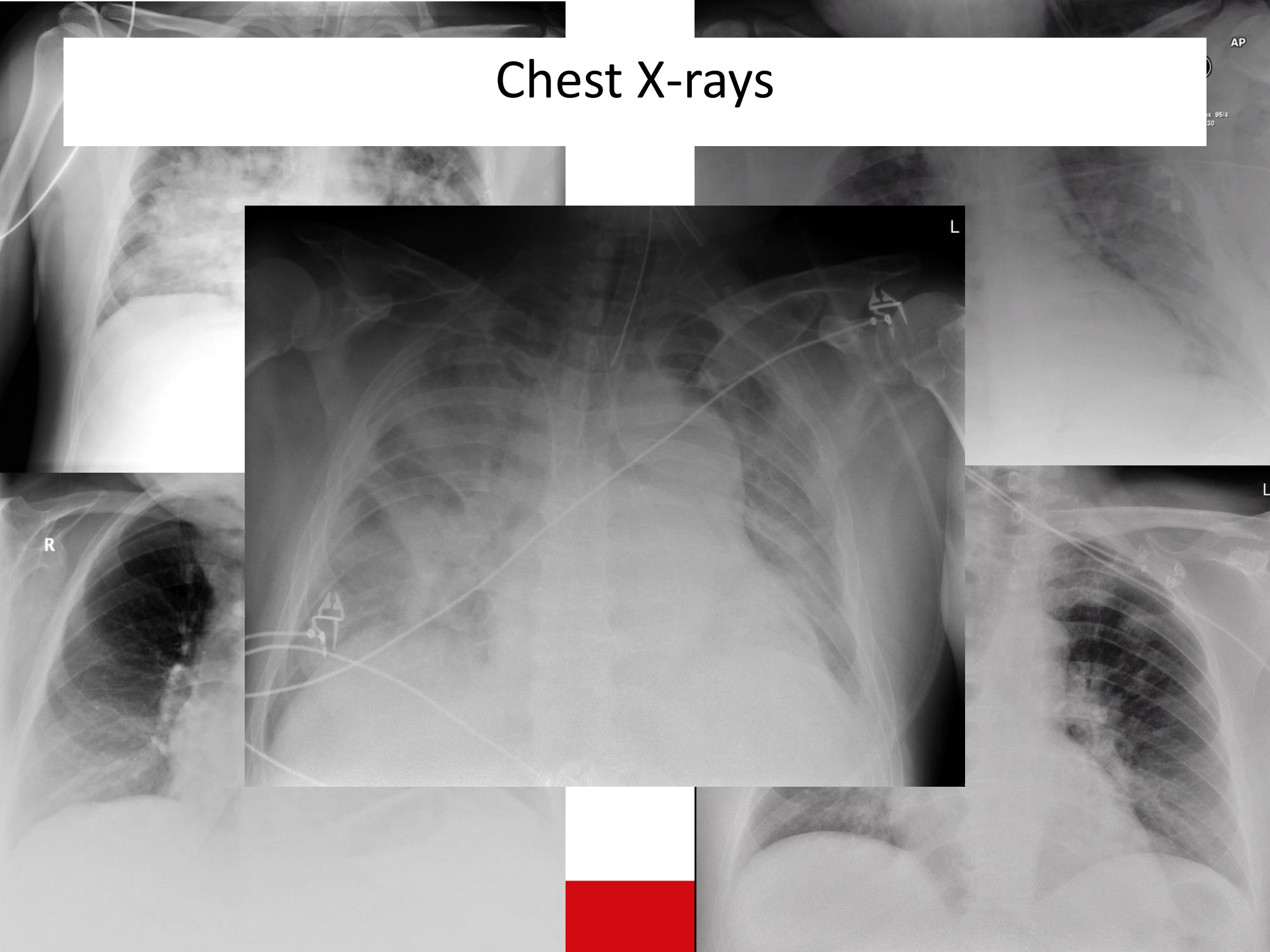
G.R. Bernard, A. Artigas, K.L. Brigham, J. Carlet, K. Falke, L. Hudson, M. Lamy, J.R. LeGall, A. Morris,
R. Spragg, The Consensus Committee

RECOMMENDED CRITERIA FOR ACUTE LUNG INJURY AND ACUTE RESPIRATORY DISTRESS SYNDROME



	Timing	Oxygenation	Chest Radiograph	Pulmonary Artery Wedge Pressure
ALI criteria	Acute onset	$PaO_2/FiO_2 \leq 300$ mm Hg (regardless of PEEP level)	Bilateral infiltrates seen on frontal chest radiograph	≤ 18 mm Hg when measured or no clinical evidence of left atrial hypertension
ARDS criteria	Acute onset	$PaO_2/FiO_2 \leq 200$ mm Hg (regardless of PEEP level)	Bilateral infiltrates seen on frontal chest radiograph	≤ 18 mm Hg when measured or no clinical evidence of left atrial hypertension

Chest X-rays



ARDS - BACKGROUND

I. PULMONARY – PRIMARY- ARDS:

- a) Aspiration of gastric content
- b) Pneumonia
- c) Inhalation trauma
- d) Lung Contusions
- e) Near-Drowning
- f) I/R injury after lung transplant

ARDS - BACKGROUND

II. EXTRA-PULMONARY – SECONDARY - ARDS :

- a. Sepsis/Septic Shock
- b. MODS in Shock
- c. Pancreatitis (SIRS)
- d. Massive Blood Products Therapy (TRALI)
- e. Drug Poisoning

Acute Respiratory Distress Syndrome

The Berlin Definition

JAMA. 2012;307(23):2526-2533

The ARDS Definition Task Force*



Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

Acute Respiratory Distress Syndrome	
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging ^a	Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation ^b	
Mild	$200 \text{ mm Hg} < \text{PaO}_2/\text{FiO}_2 \leq 300 \text{ mm Hg}$ with PEEP or CPAP $\geq 5 \text{ cm H}_2\text{O}$ ^c
Moderate	$100 \text{ mm Hg} < \text{PaO}_2/\text{FiO}_2 \leq 200 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$
Severe	$\text{PaO}_2/\text{FiO}_2 \leq 100 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$

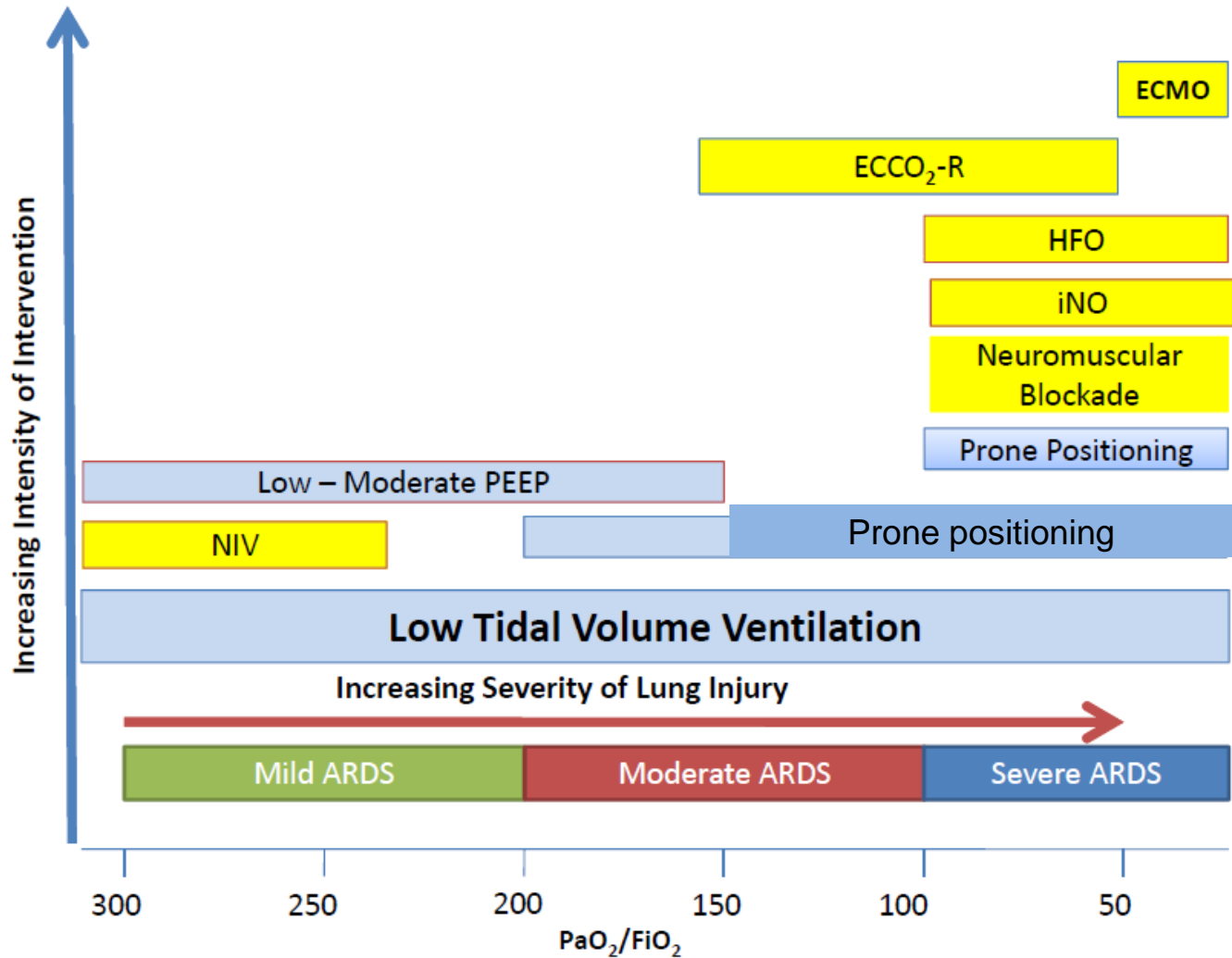




ARDS

	Mild	Moderate	Severe
Timing	Acute onset within 1 week of a known clinical risk factor or new/worsening respiratory symptoms		
Hypoxemia	PaO ₂ /FiO ₂ 201-300 with PEEP/CPAP ≥ 5	PaO ₂ /FiO ₂ ≤ 200 with PEEP ≥ 5	PaO ₂ /FiO ₂ ≤ 100
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload**		
Radiological Abnormalities	Bilateral opacities*	Bilateral opacities*	Opacities involving 3 + quadrants*
Additional Physiological Derangement	N/A	N/A	V _E Corr > 10 L/min or C _{RS} < 40 ml/cmH ₂ O

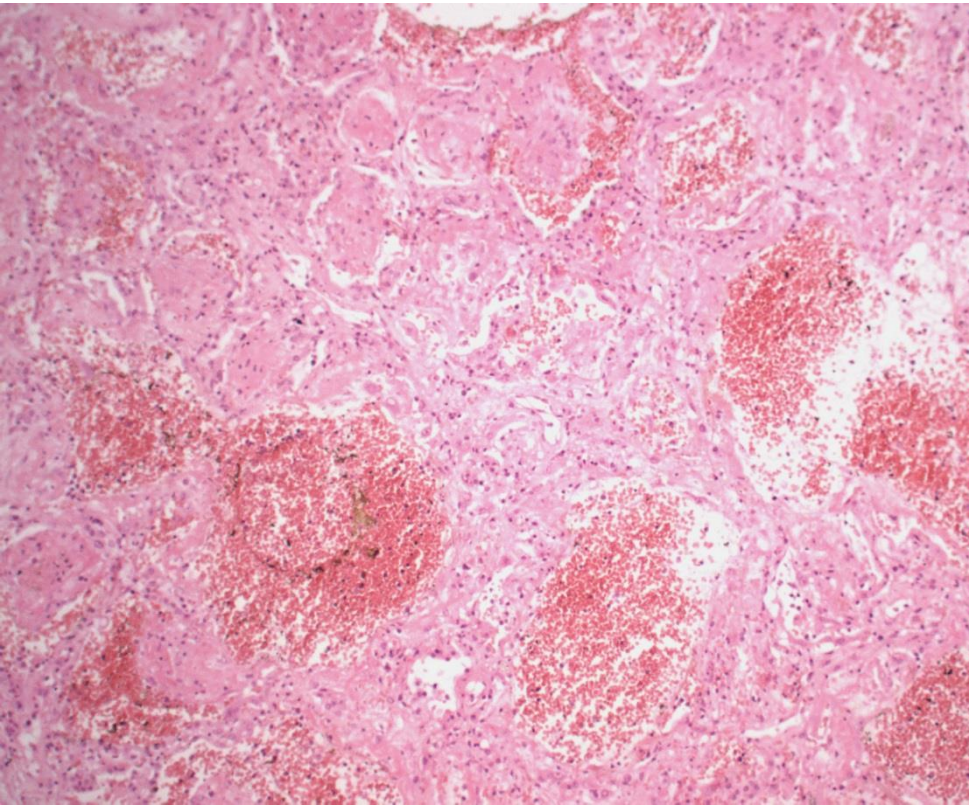
Timing of ARDS therapy



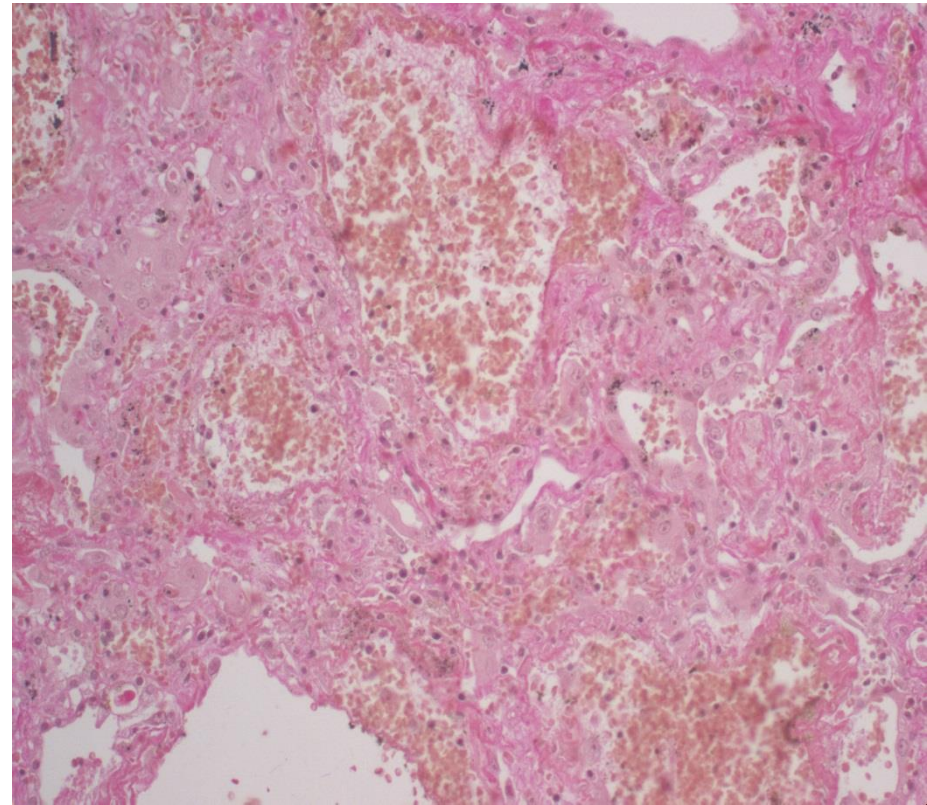
T.Thompson

Fibrosis in late-ARDS

HE



VG



HE – Lung Fibrosis
© MUDr.Moulis PAU FNB

I. NON-PHARMACOLOGICAL

1. Artificial Ventilation– $V_t=6$ ml/iBW, PEEP, FiO_2
2. PRONE POSITIONING
3. FLUID REGIMEN – „dry lungs“

II. PHARMACOLOGICAL



I. NON-PHARMACOLOGICAL (IPPV)

II. PHARMACOLOGICAL

1. Corticosteroids
2. Surfactant
3. NO
4. Prostaglandine E1

III. SUPPORTIVE