Examinations of Respiratory System

seminar

Department of Pathological Physiology
First Medical Faculty CUNI

(version 25)

Functional lung tests/ Spirometry

Ventilation

Diffusion

Perfusion

Blood gases

Endoscopic examination

Imaging methods

X-ray imaging

scintigraphy

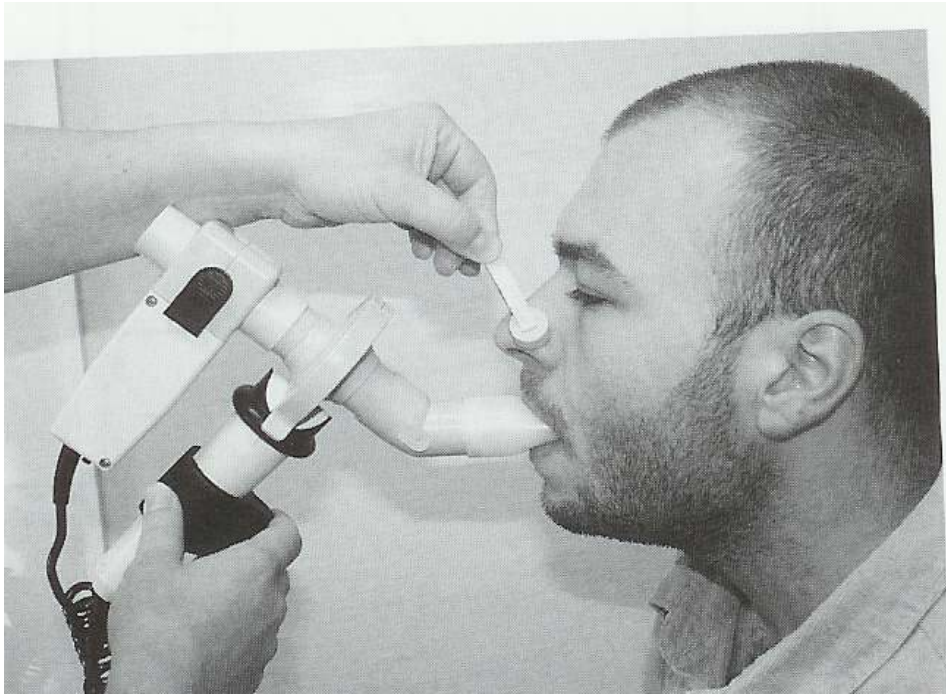
angiography

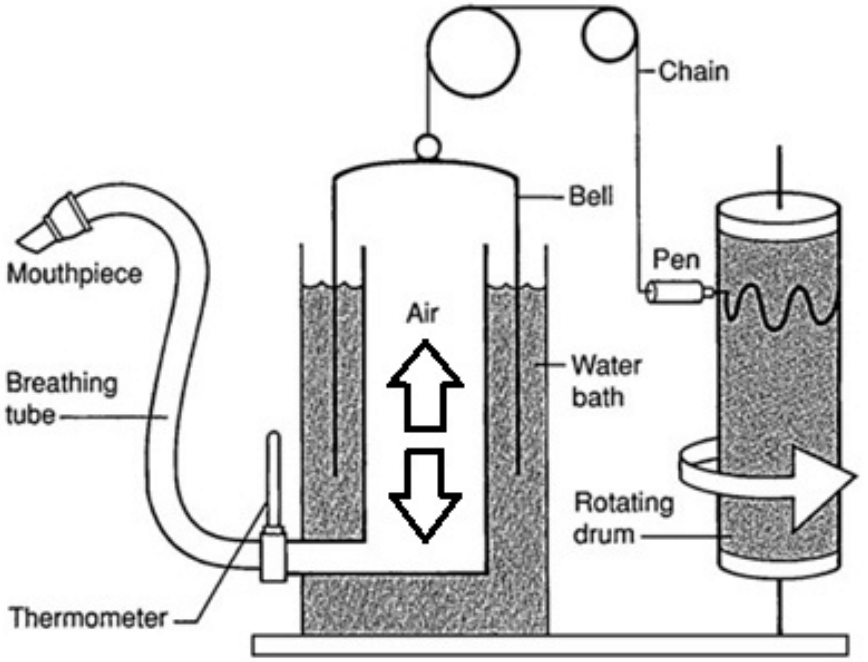
ultrasonography

MRI

Laboratory tests

Flow spirometer (versus Groh's s. with cylinder)



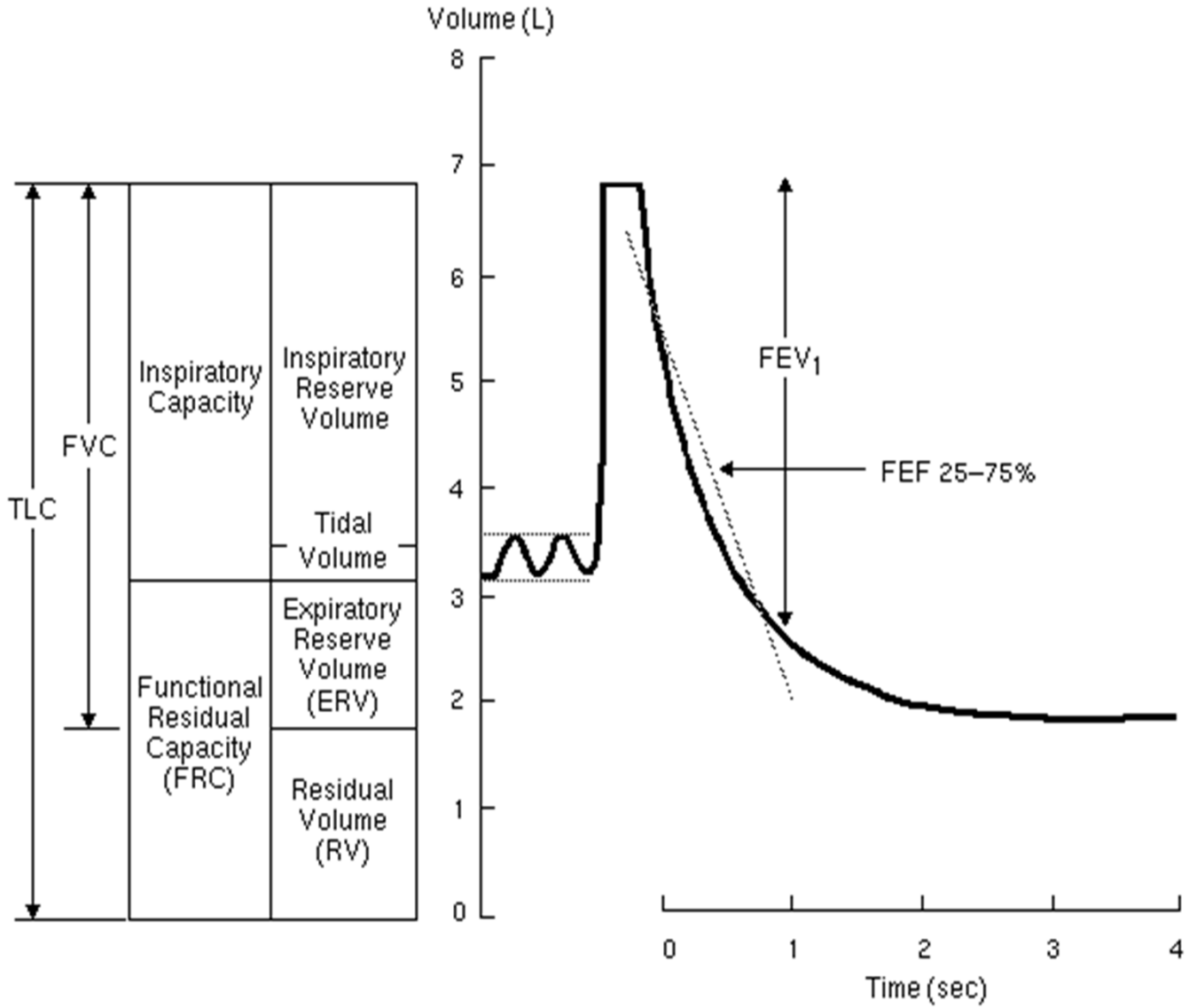


Ventilation

Spirometric volumes (and capacities)

- VT - tidal volume
- VC - vital capacity
- ERV, IRV - expiratory (inspiratory) reserve volume
- TLC = Total lung capacity
- FRC = Functional residual capacity
- RV = Residual volume

Normal spirogram



Dynamic ventilation parameters and tests

-Breathing in rest: ventilatory rate (f/ min) (~ 12 breaths/ min)

-Minute ventilaton (volume/ min) 6-8 L/ min

- **FVC - Forced vital capacity**

  Total volume exhaled during the forced expiration

Normal VC values based on Regression equation in healthy set

female: [21.7 – (0.101 x age)] × (cm) = (mL)

male: [27.63 – (0.112 x age)] × (cm) = (mL)

Values between 80 to 120 % of predicted are considered to be normal

MVV (Vmax) = Maximal voluntary ventilation

maximal tidal volume (TV) and maximal ventilation rate measured for 10 – 30 sec

> 40 L/min

- **Ventilatory reserve**:

  minute ventilation / MVV >1:7, > 1 : 5

  = 1 : 2 means dyspnea at rest

FEV_1 - Volume of gas exhaled during the first second of forced expiration

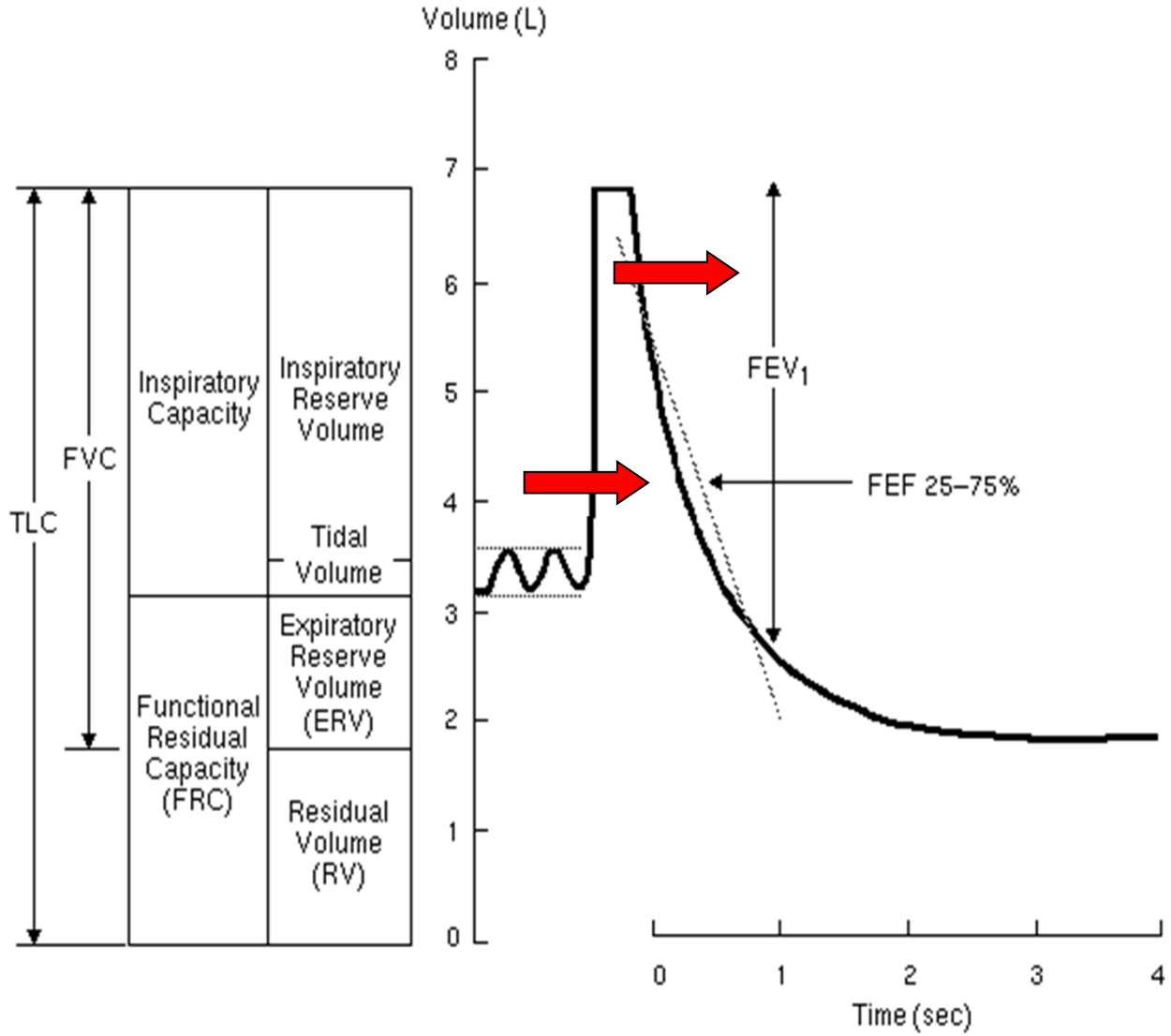
- Evaluation of disease severity in patients with obstructive diseases
- Evaluation of therapy response
- Prognostic parameter: if $FEV_1 < 1$ L (5-year survival less then 50% of patients)

FEF 25-75% - Forced expiratory flow from 25 to 75 % of the vital capacity

(Also: **MMFR = Maximal Midexpiratory Flow Rate**)

- often more sensitive measurement of early airflow obstruction then FEV1 (normal values: 2 – 4 L/sec)
- False results may be obtained in patients with abnormally small lungs

Normal spirogram



PEFR = Peak expiratory flow rate

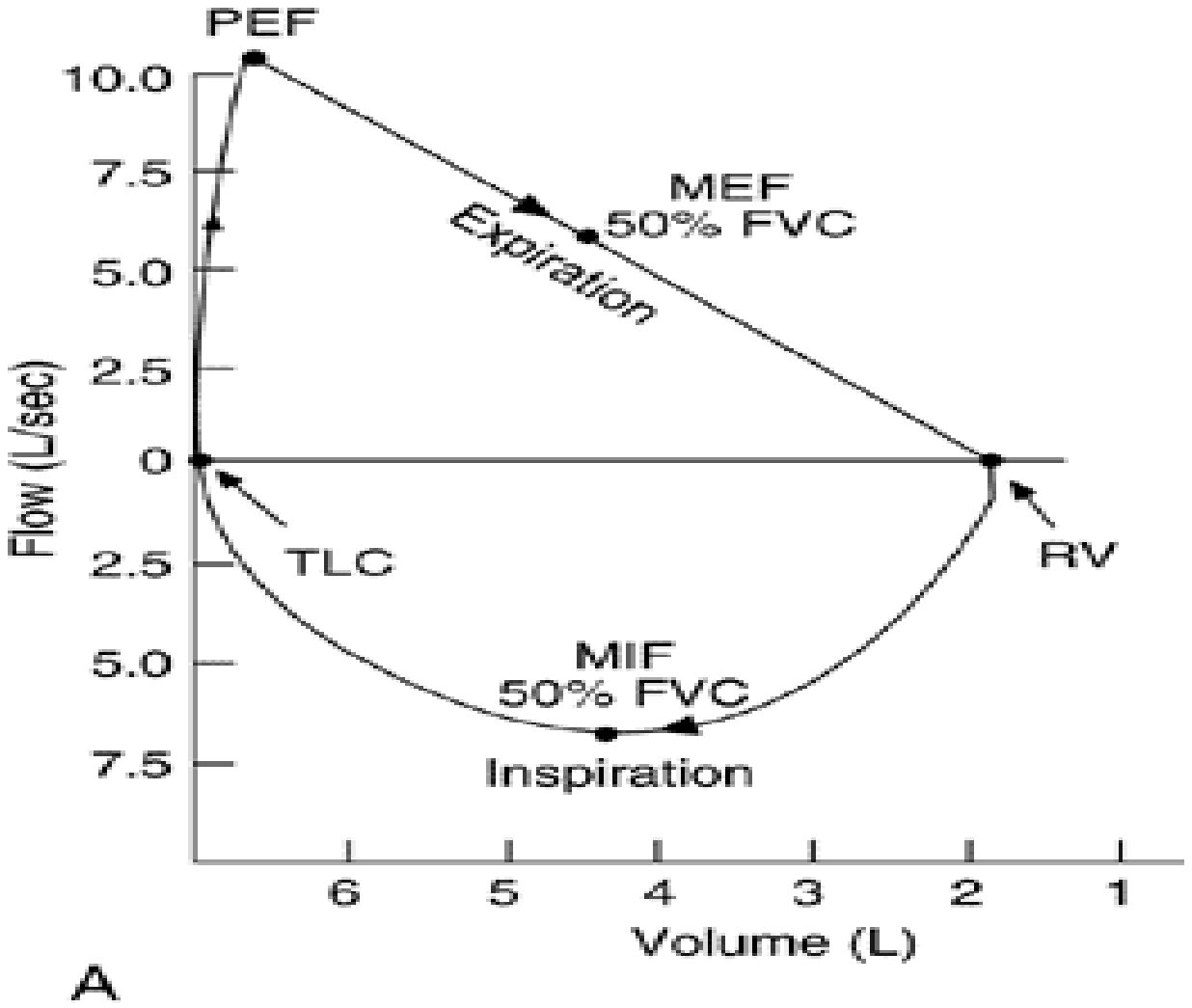
- Wright's peak flow meter:
- repeated measurements of PEFR by patient to evaluate changes in dynamic pressure of the airways

Flow volume loops

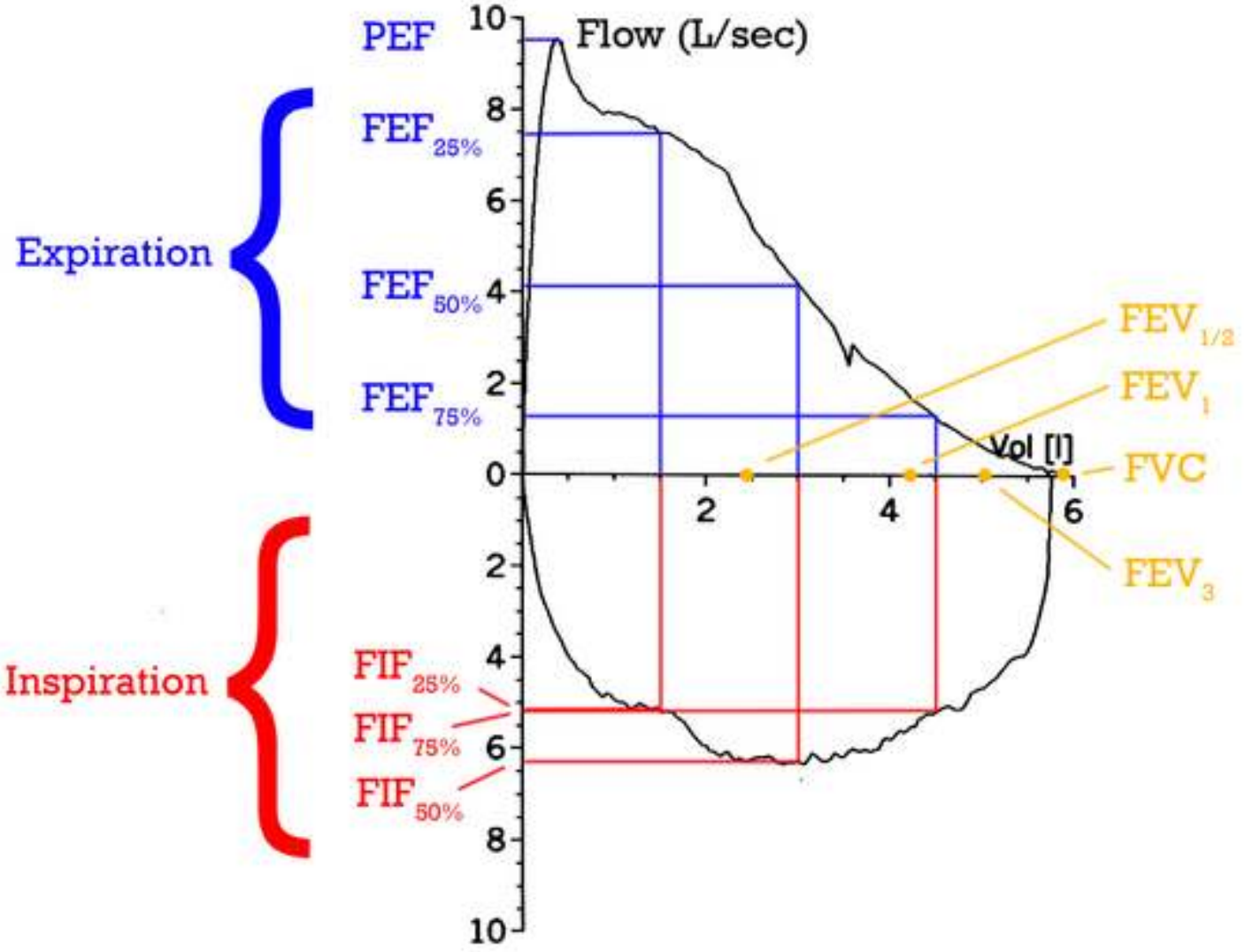
measurement of flow dependend on volume

Inspiration
Exspiration

Normal flow volume curve



Inspiratory and Expiratory flows



Restrictive diseases

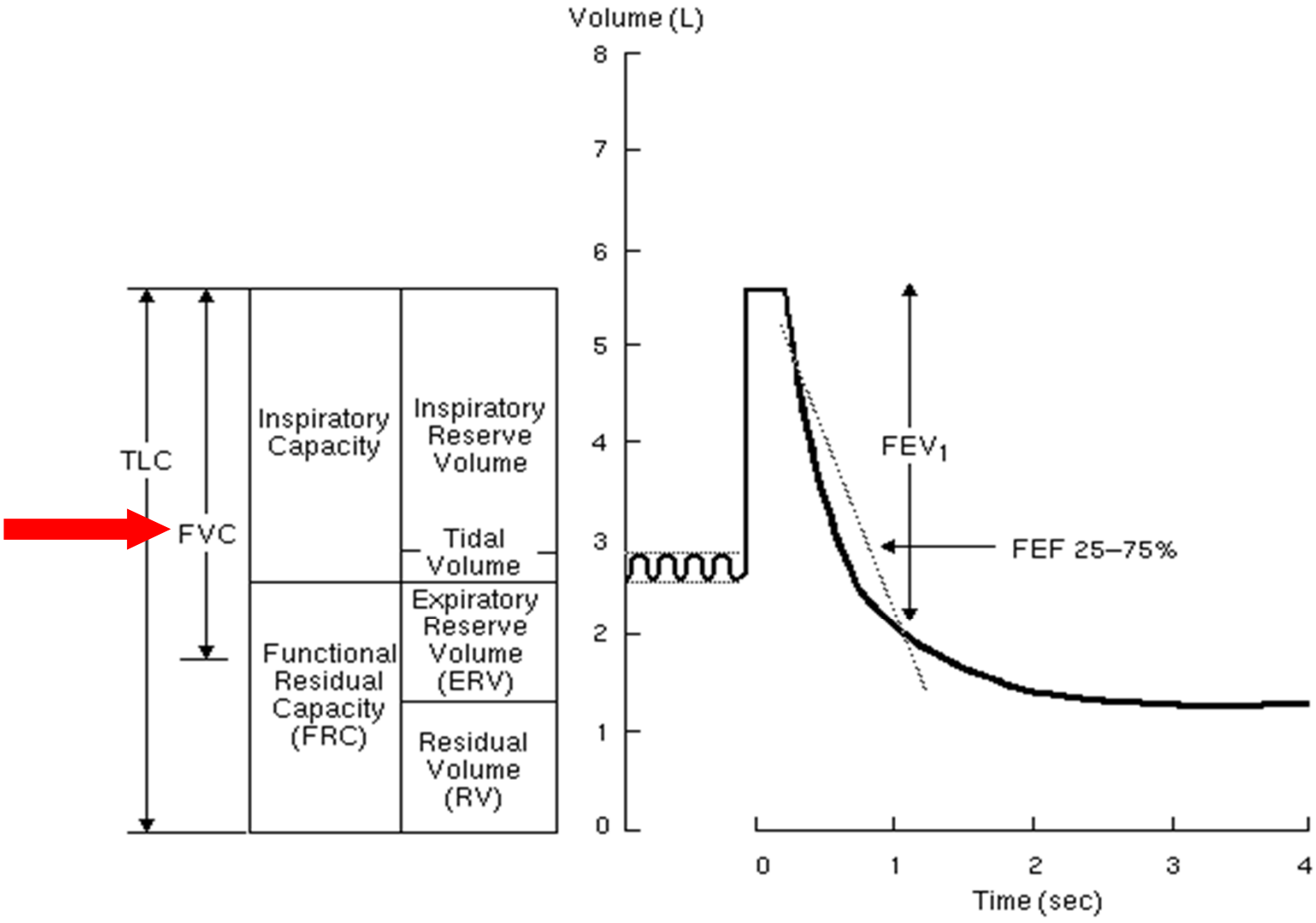
anatomical and/ or functional loss of surface for gas exchange

resection
atelectasis
lung edema
lung fibrosis
thoracic deformities / breathing movements
pneumonia
pneumothorax

Characteristics

- decreased vital capacity (VC)
- decreased function residual capacity (FRC)
- decreased compliance
- normal shape of flow volume loops
- more negative intrapleural pressure during inspiration
- increased in pulmonary vascular resistance
- hypoxemia

Spirogram - **restrictive** disease



Obstructive diseases

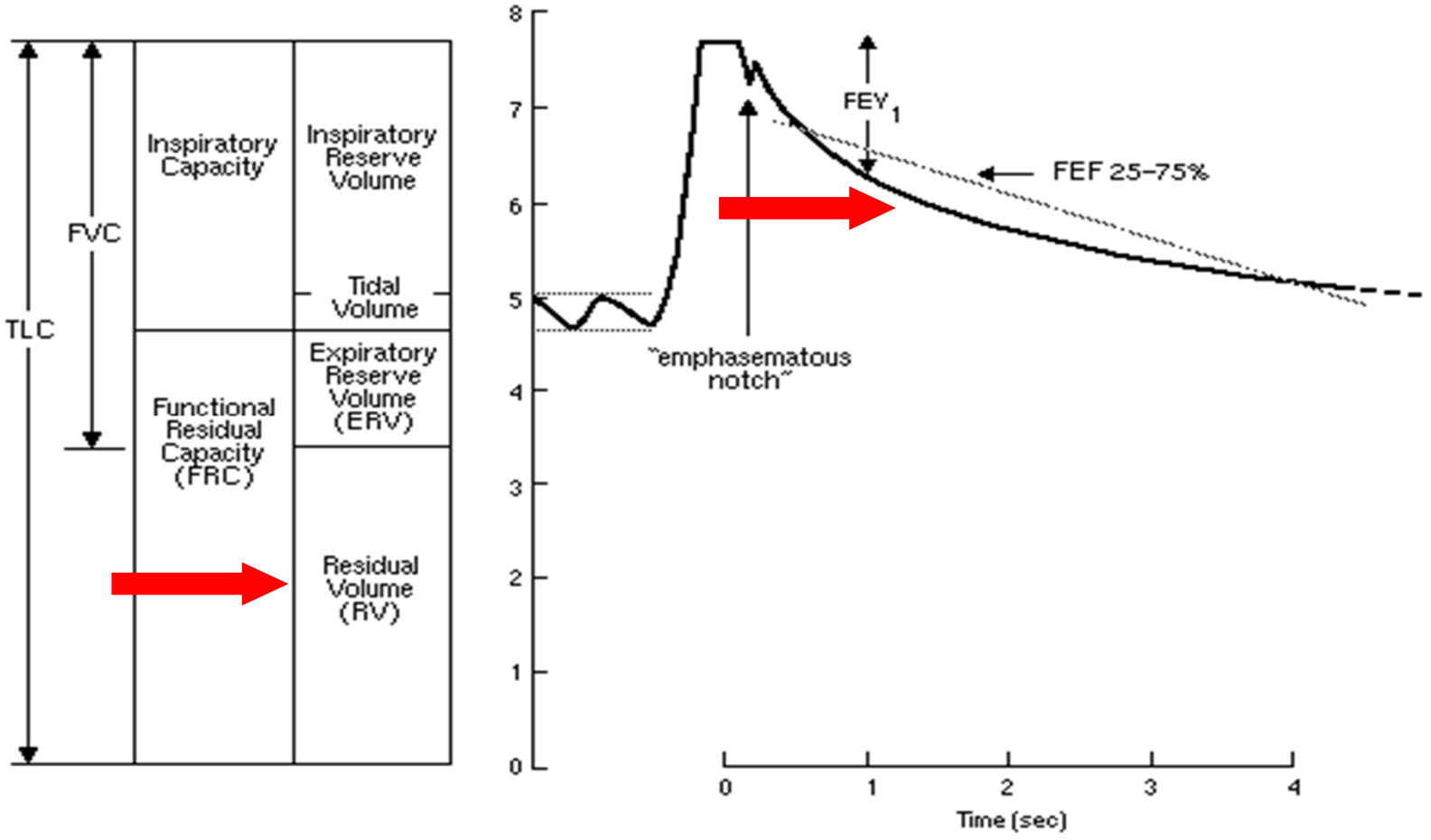
increased resistance of airways
intrathoracic
extrathoracic

Asthma bronchiale /COPD

- intrathoracic
- expiratory obstruction
- decreased FVC
- decreased FEV1
- decreased $FEF_{25-75\%}$
-decreased PEFR

flow volume curve

Spirogram - **obstructive** disease **Asthma, COPD**



Evaluation of Flow Volume Curve

1. ***peak-flow-metry*** (PEF)
2. measurement of ***expired volume*** in different time intervals, mainly in 1 sec (FEV1)
3. ***relation of expired flow to volume***

a) mean expiratory flow 25-75 % FVC (FEF_{25-75}, FMF)
b) mean expiratory flow in any point of FVC ($MEF_{25,50,75}$)

Values from ***initial*** phases of expiration depend on
maximal effort of pacient
changes of extrathoracic airways

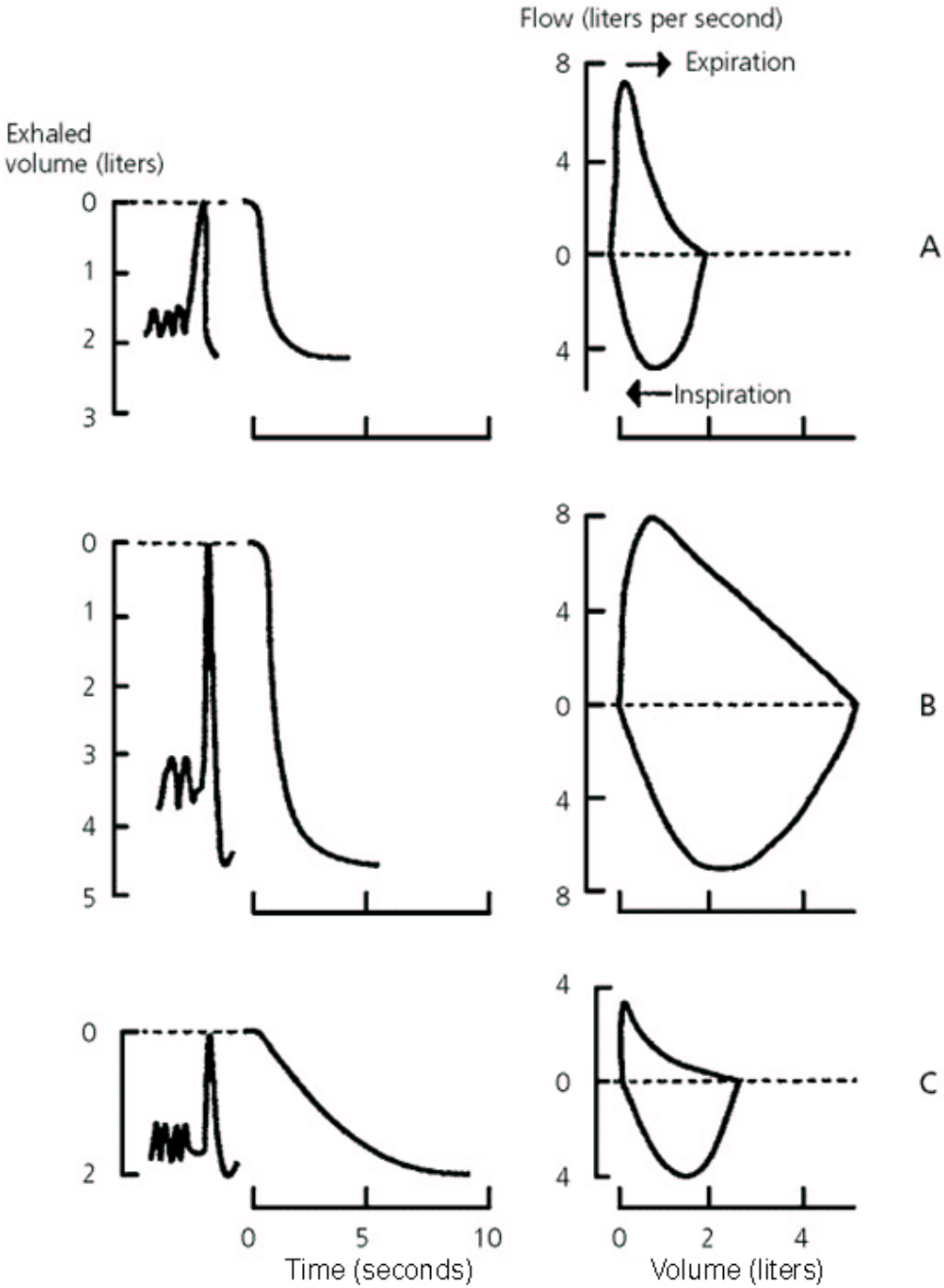
Values from ***later*** phases of expiration depend on
mechanical lung properties

Evaluation of ***shape*** of expiration curve
maximal flow is in approx. 80 % of FVC

100–75 %: part ***dependent*** on expiratory effort
(velocity and muscular effort)

75–15 %: part ***independent*** on expiratory effort
(relation between lung volume and maximal flow)
– indicator of airway resistance and lung elasticity

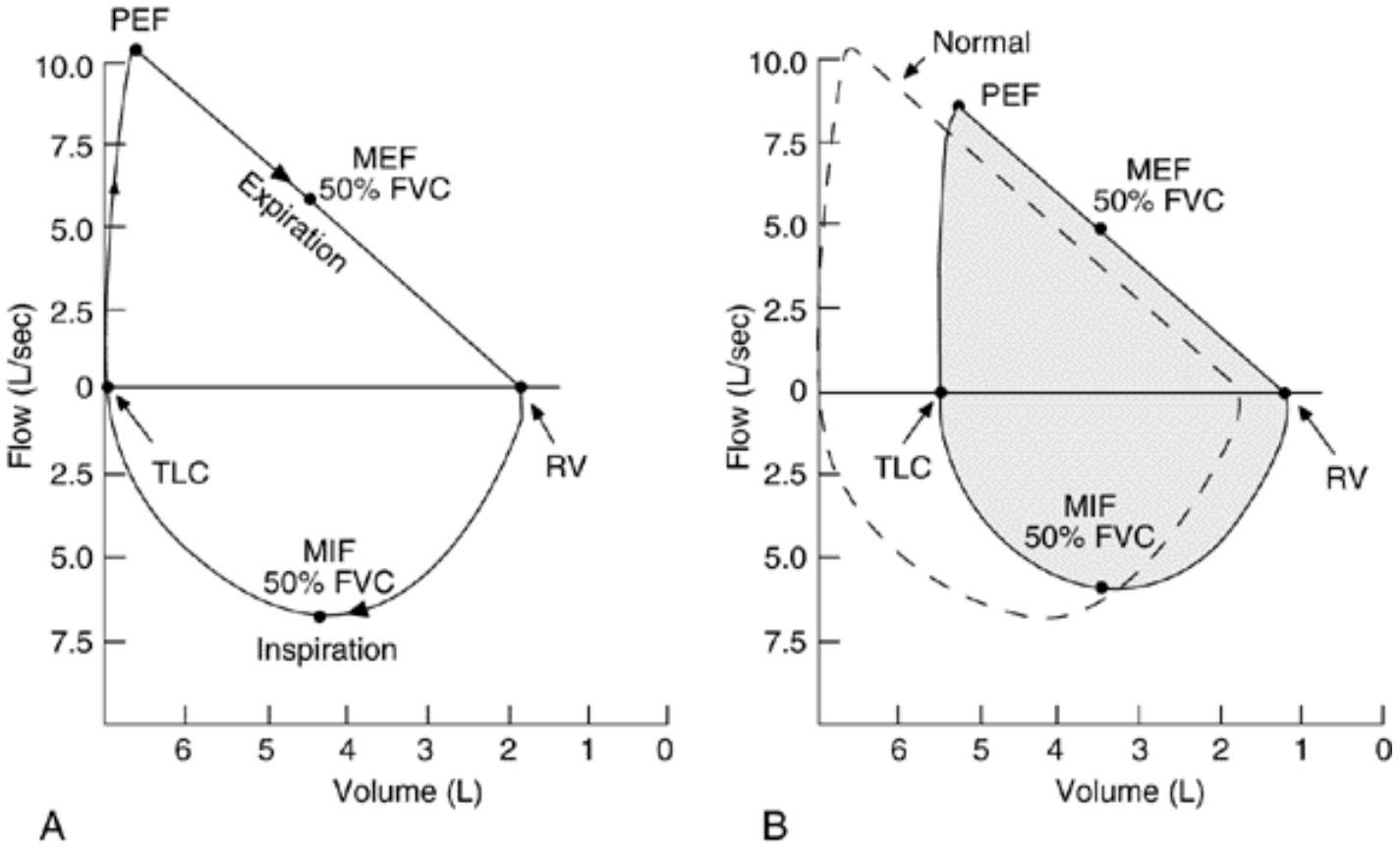
15–0 %: part ***dependent*** on expiratory effort


Flow (liters per second)
Exhaled volume (liters)
Expiration
Inspiration
A
B
C
Time (seconds)
Volume (liters)

Flow volume curves in different conditions

Normal

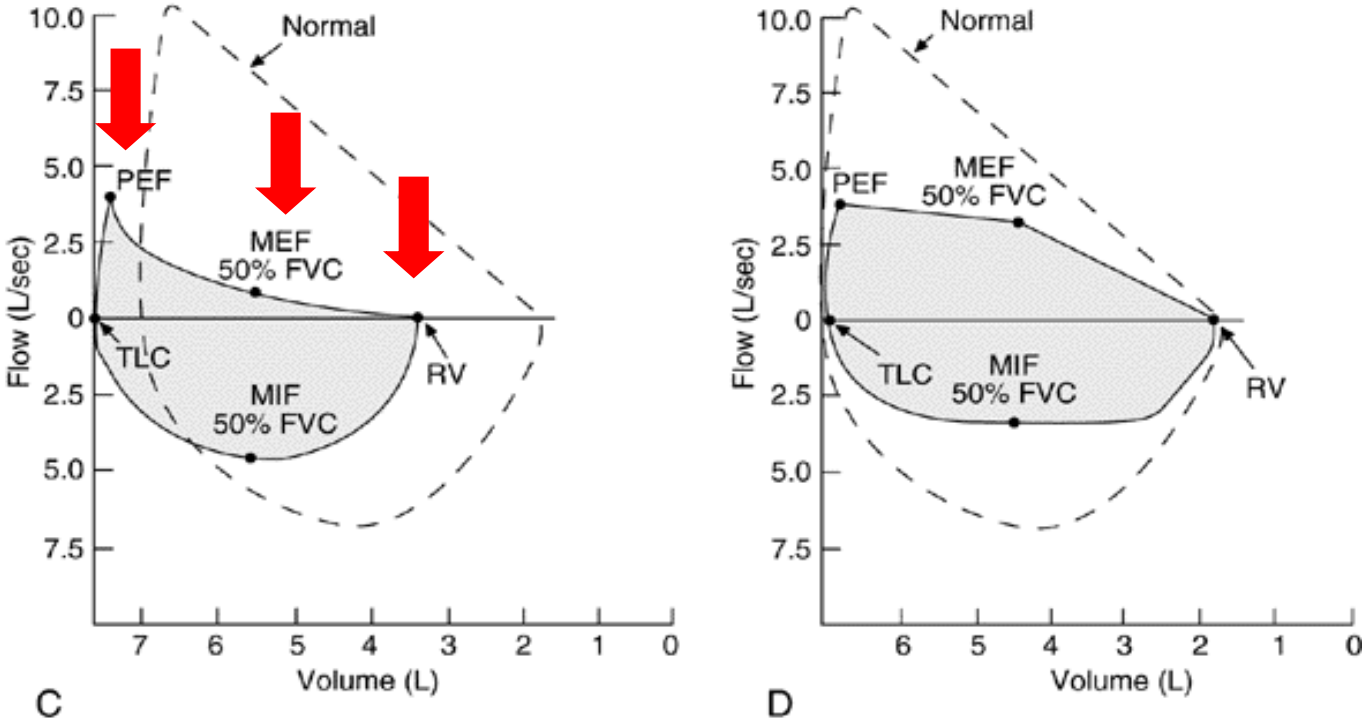
Restrictive disease (parenchymal)



Obstructive diseases

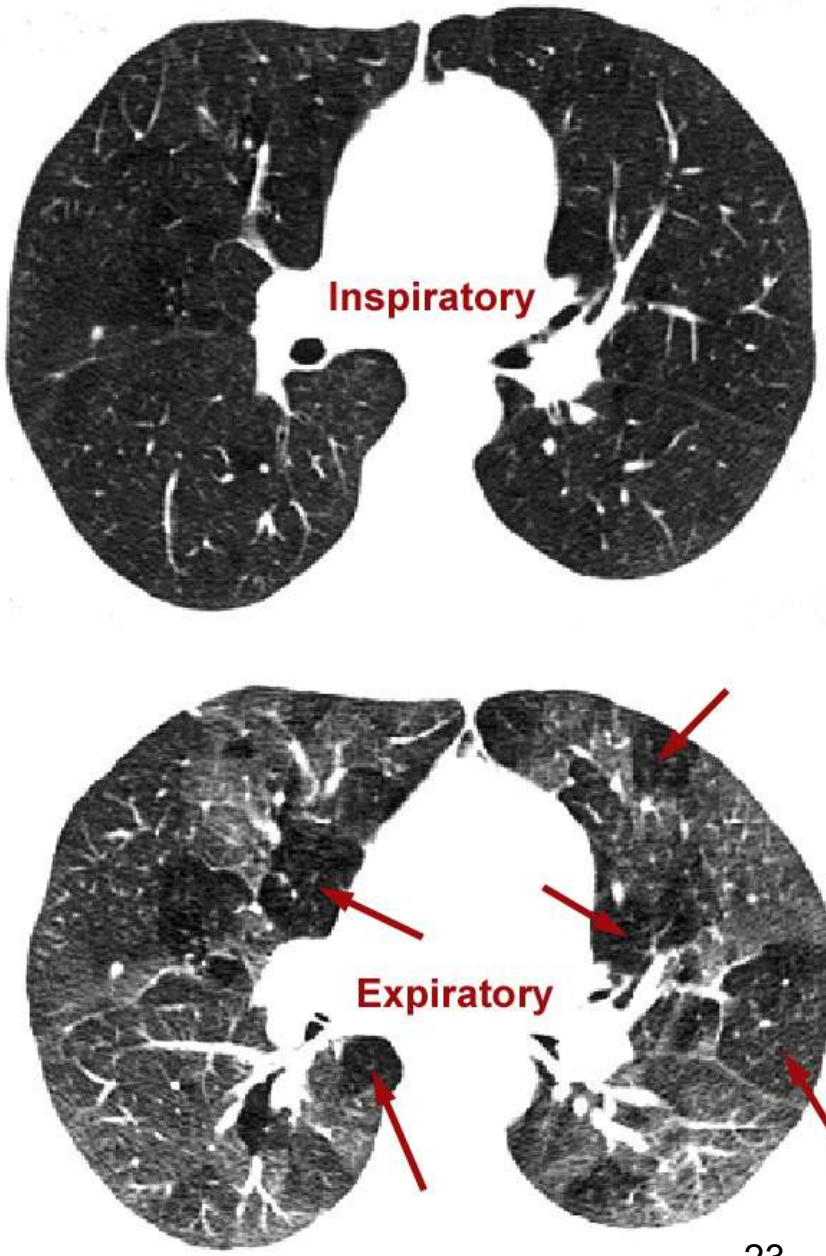
Asthma, COPD

Fixed obstruction of upper airway



AIR TRAPPING
(Schematic picture)

Warning: this slice image/ pathologic-anatomic section (? CT scan/ ? CT angiography) captures emphysematous distension.
But it does not reflect functional relations.
Functional properties are set by resistance, pressure gradients, and by measurable spirometric parameters, not visible macroscopically…



Alveolar-capilary diffusion and perfusion

a/ ***Blood gases*** (paO_2, $paCO_2$, pH)

b/ ***Partial gas pressure in alveoli*** (pAO2, $pACO_2$; P(**A**-a)O_2)

c/ ***mean pressure in a. pulmonalis***: PAP < 20 mmHg [2.67kPa]; PAP =15-30/5-13 mmHg)

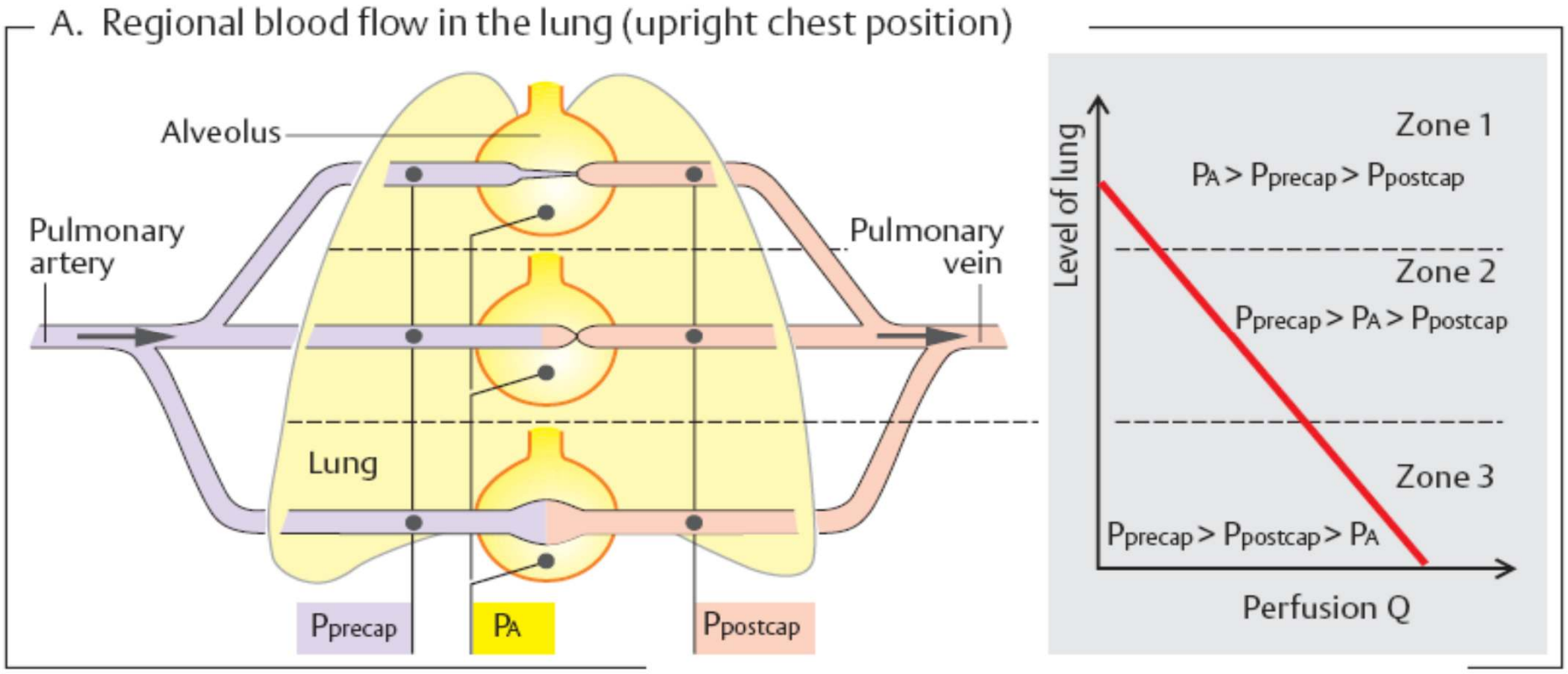
- Flow directed pulmonary arterial (Swan-Ganz) catheter
- Diseases causing hypoxemia are potentially capable of **increasing pulmonary vascular resistance** (COPD, interstitial lung disease, chest wall disease, recurrent pulmonary emboli...)

d/ ***Ventilation / perfusion scan***

e/ ***Diffusion capacity of lungs*** for CO (0.3 %) or O2 (DLCO; DLO2 = 1.23 × DLCO)
(single breath, 10 secm hold, then exhale) decrease is caused by:
a) Thickening of alveolocapilary membrane (fibrosis...)
b) Destruction of alveolocapilary membrane (emphysema..)
c) Anaemia

Limiting factors	Gases			
	O_2	CO_2	CO	N_2O
Alveolo-capillary membrane	+	-	+	-
Blood volume and HB	+	+	+	-
Circulation	+	+	-	+

Ventilation to perfusion ratio



The box on the right is not Wine cupboard But pletysmograph

Plethysmo-graphy = body test

measuring:

- spirometry
- flow curves
- other volumes:
  - RV – residual volume
  - ITV – introthoracic volume
  - FRC – functional residual capacity
- resistance

OXYGEN - hypoxia

Oxygen consumption

= Hemoglobin × blood flow (CO) × (AV difference)

AV difference

activity of the tissue (oxygen extraction), paO_2, pvO_2

Hypoxia

* Transport (anemic) hypoxia
* Ischemic hypoxia
* Histototoxic hypoxia (decrease in AV difference)
* Hypoxic hypoxia

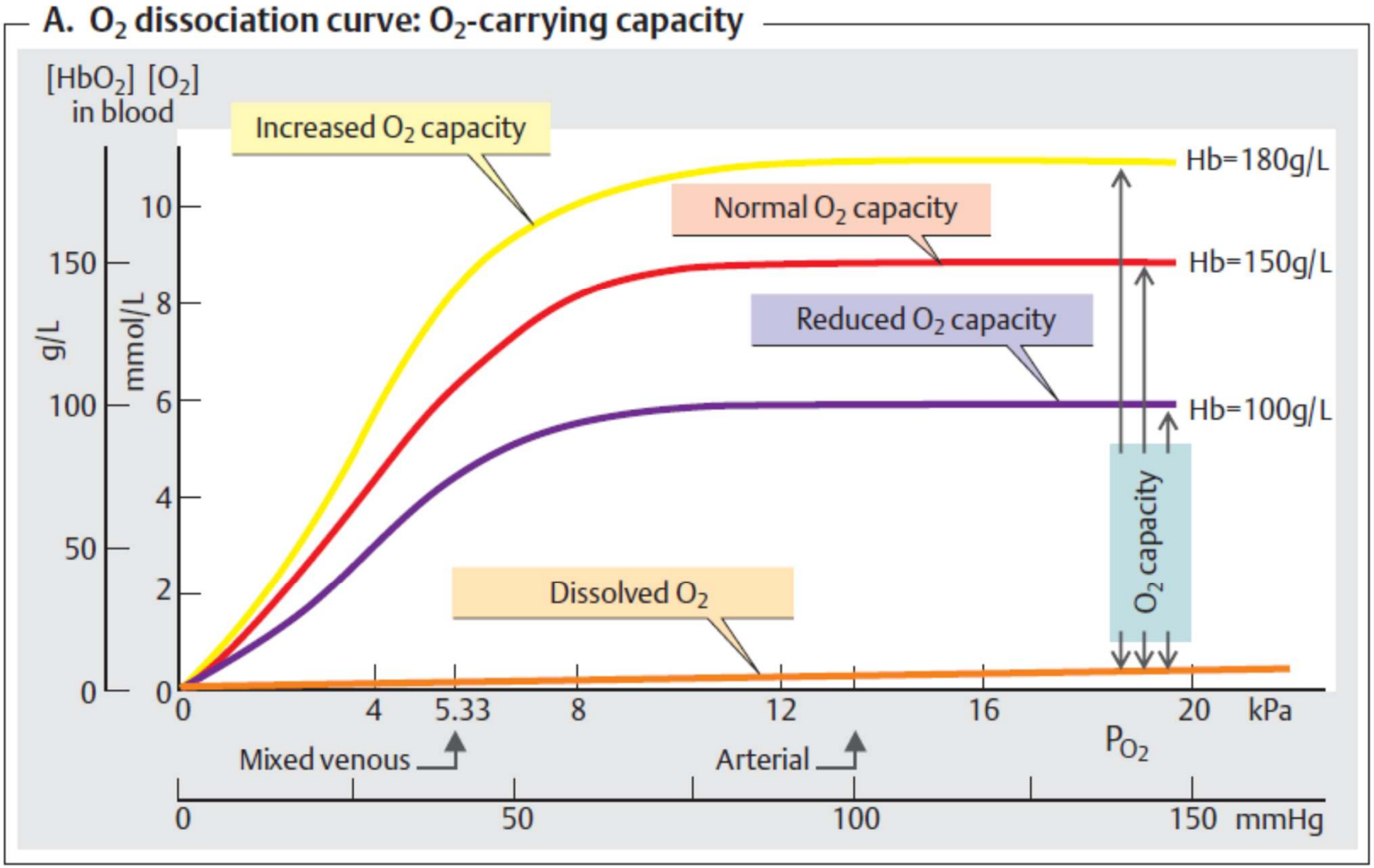
Factors influencing paO_2

- p_AO_2
- $p_{ATM}O_2$
- ventilation
- ventilation/perfusion
- difusion
- right-left shunt

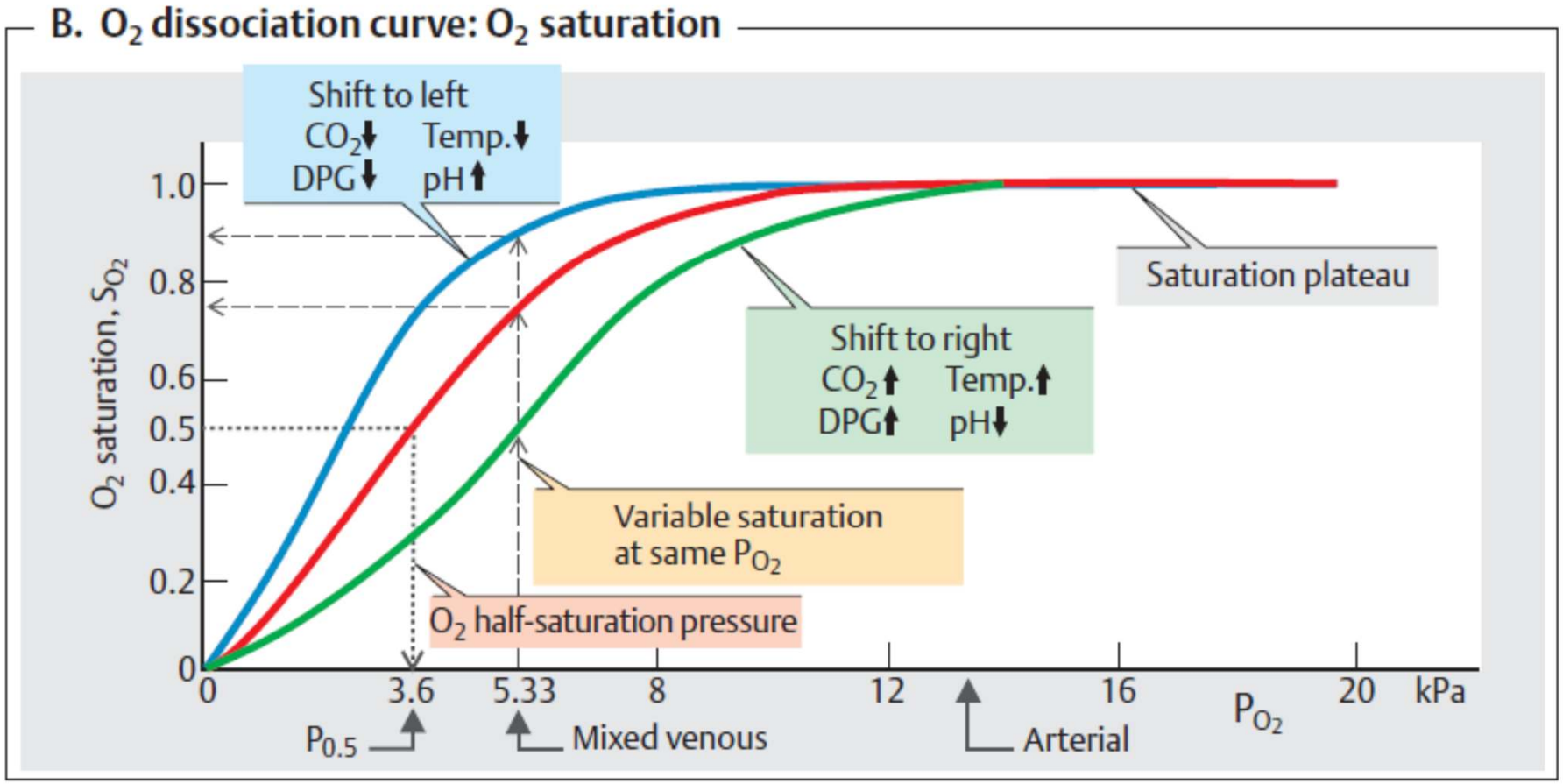
CARBON DIOXIDE (CO_2)

- Hypocapnia = lower **CO_2**
- Hypercapnia = higher **CO_2**

depends mainly on alveolar ventilation
acid base balance !!

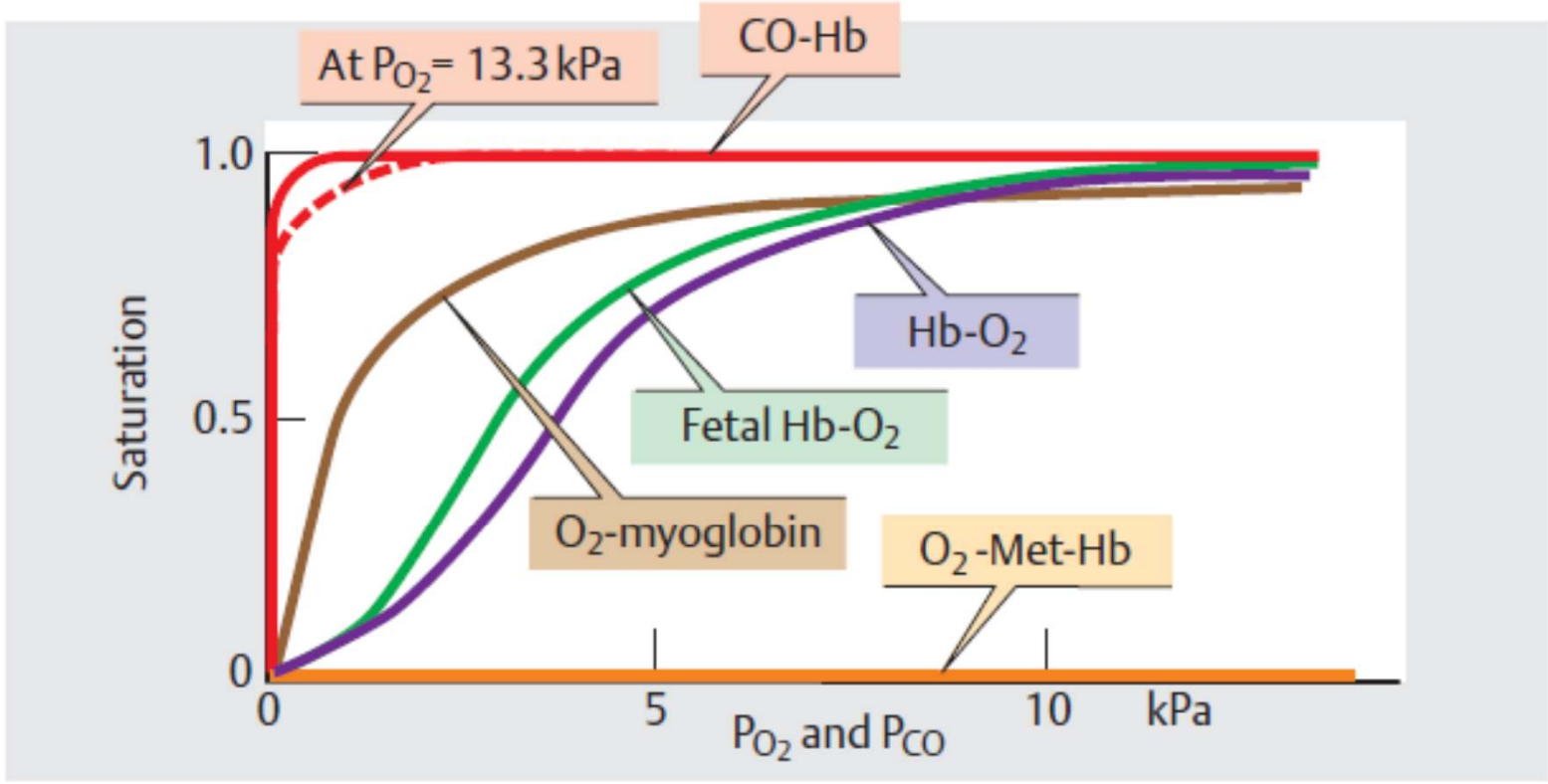


Blood gasses – HB saturation by O2



HB - O2 dissociation curve

C. O_2 and carbon monoxide (CO) dissociation curves



other HBs dissociation curves

Endoscopic examination of the lungs

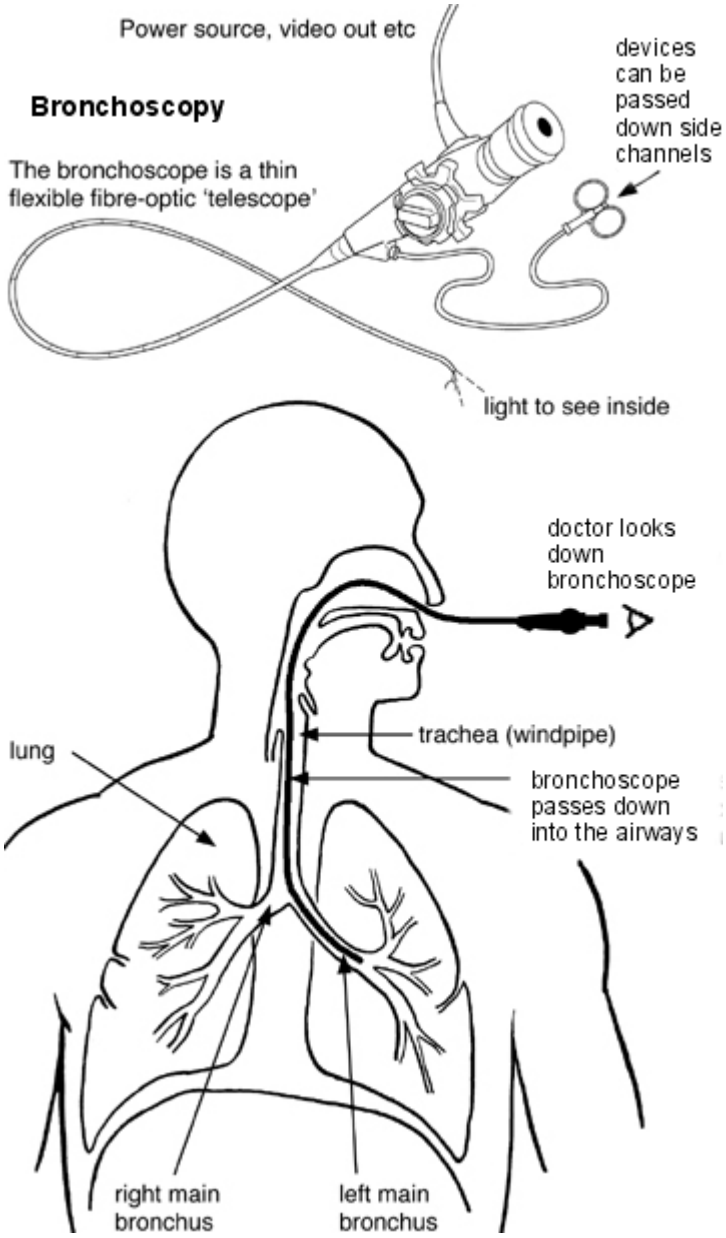
1. **Bronchoscopic examination**

Fibroscopy (Flexible fiberoptic bronchoscope)

- Visualization of tracheobroncial tree
- Biopsy of suggestive or obvious lesions
- Lavage, brushing or biopsy of lung regions for culture, cytological and microbiologic examination
  * bronchiolo-alveolar **lavage** (BAL): saline 150-500mL
  * transbronchial lung **biopsy**

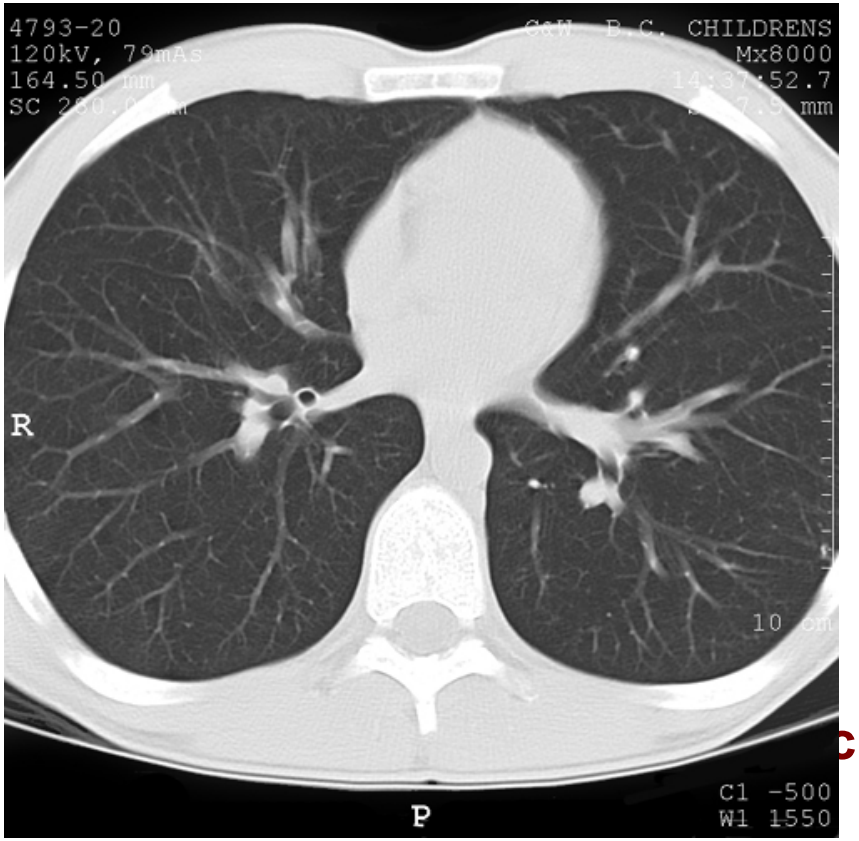
2. **Mediastinoscopy** – insertion of lighted mirror lens system through a insertion on the base of the neck anteriorly

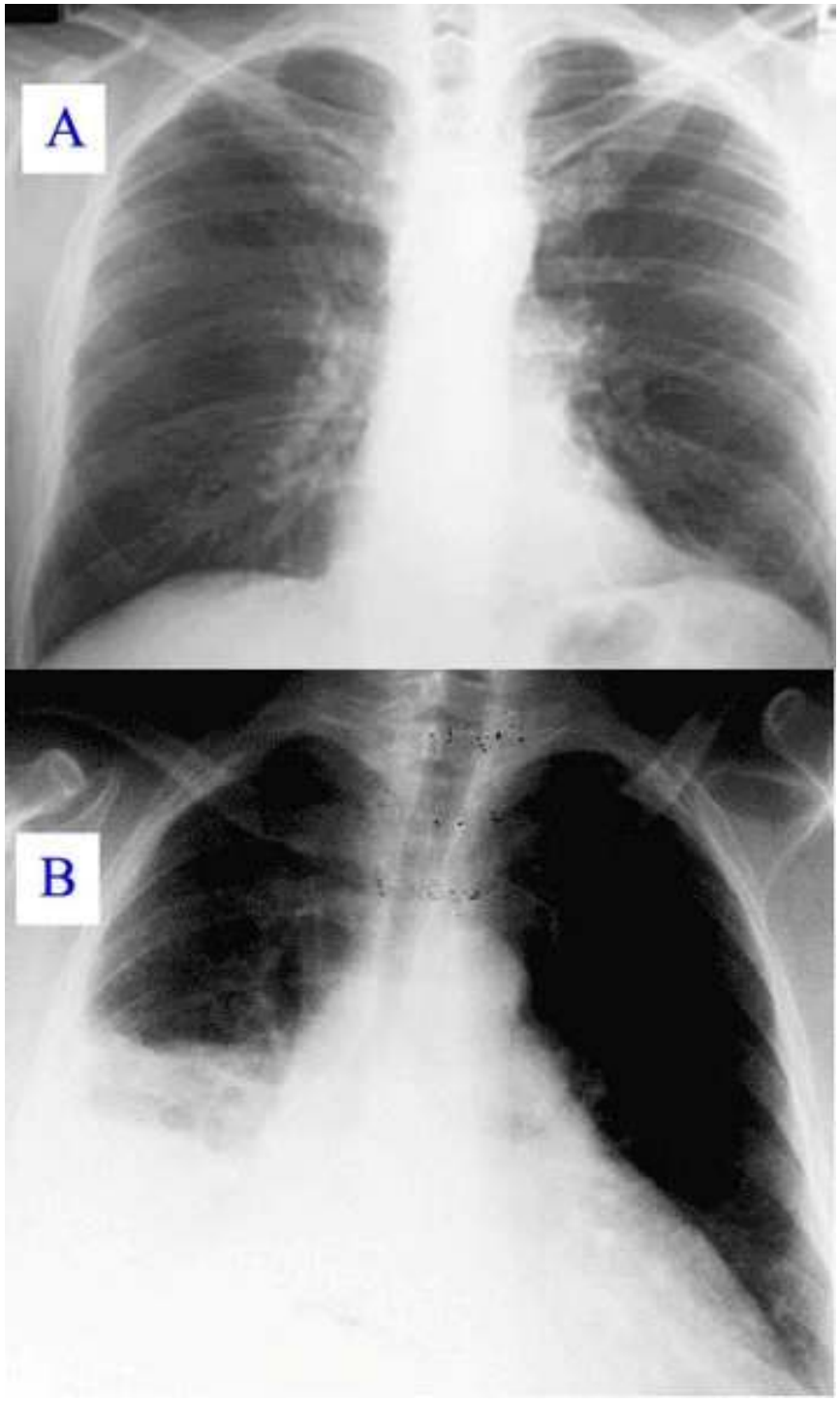
3. **Thoracoscopy**


Power source, video out etc
devices can be passed down side channels
Bronchoscopy
The bronchoscope is a thin flexible fibre-optic 'telescope'
light to see inside
doctor looks down bronchoscope
trachea (windpipe)
lung
bronchoscope passes down into the airways
right main bronchus
left main bronchus

Imaging methods

1. **Radiographic procedures** (Skiagram, Abreogram, Tomogram, ComputerTomogram)
- pneumonia, atelectasia, pneumothorax, pneumo-mediastinum, emphysema, cystic fibrosis, tumors

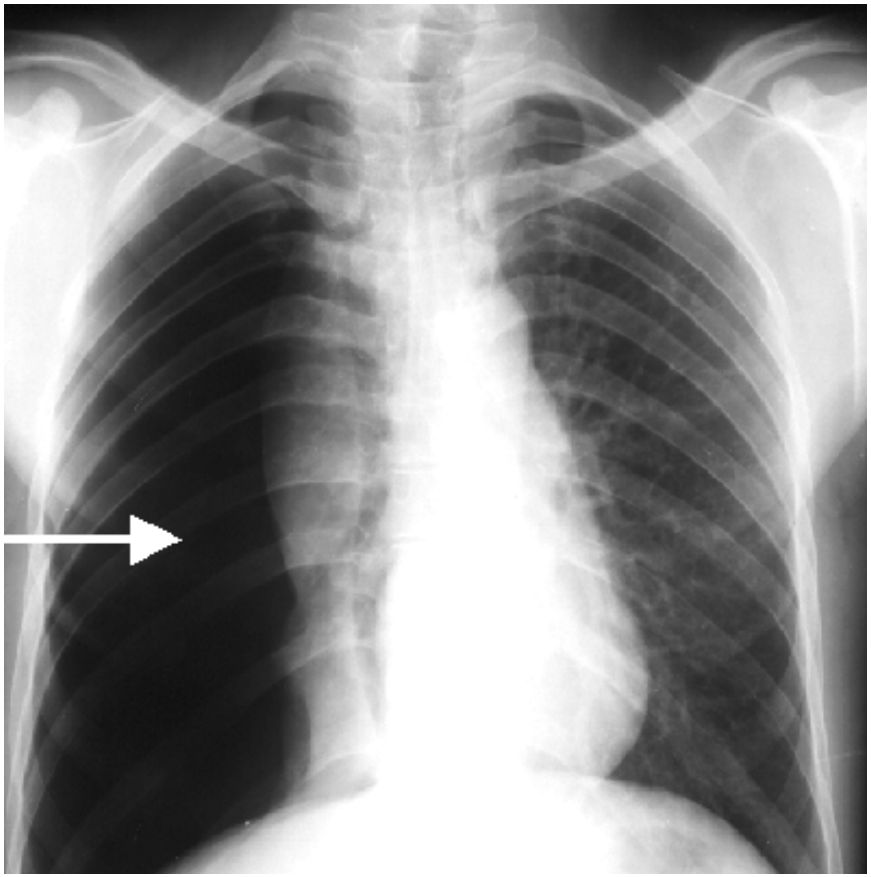




X-ray normal lung

X-ray pneumonia

Pneumothorax

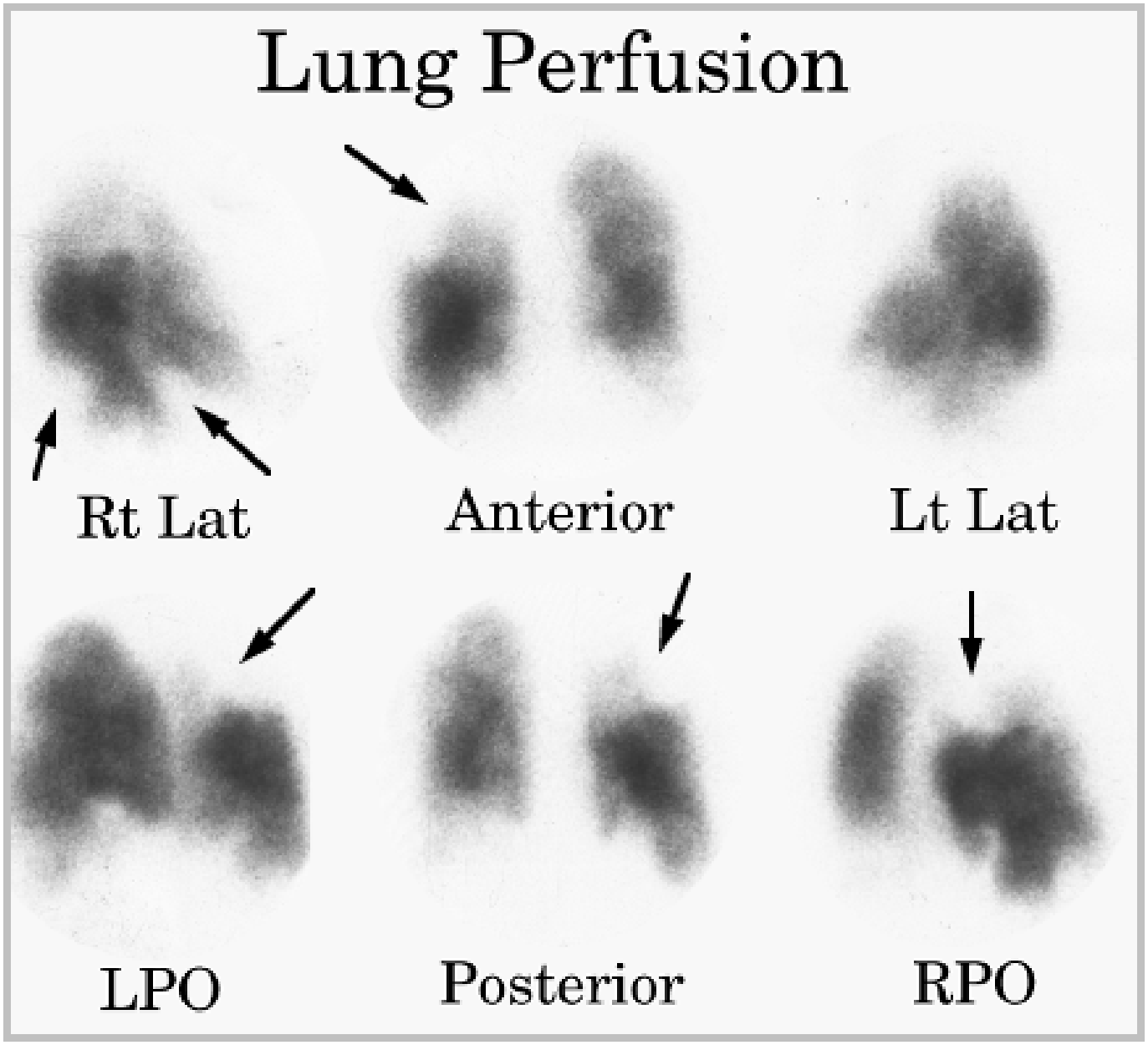


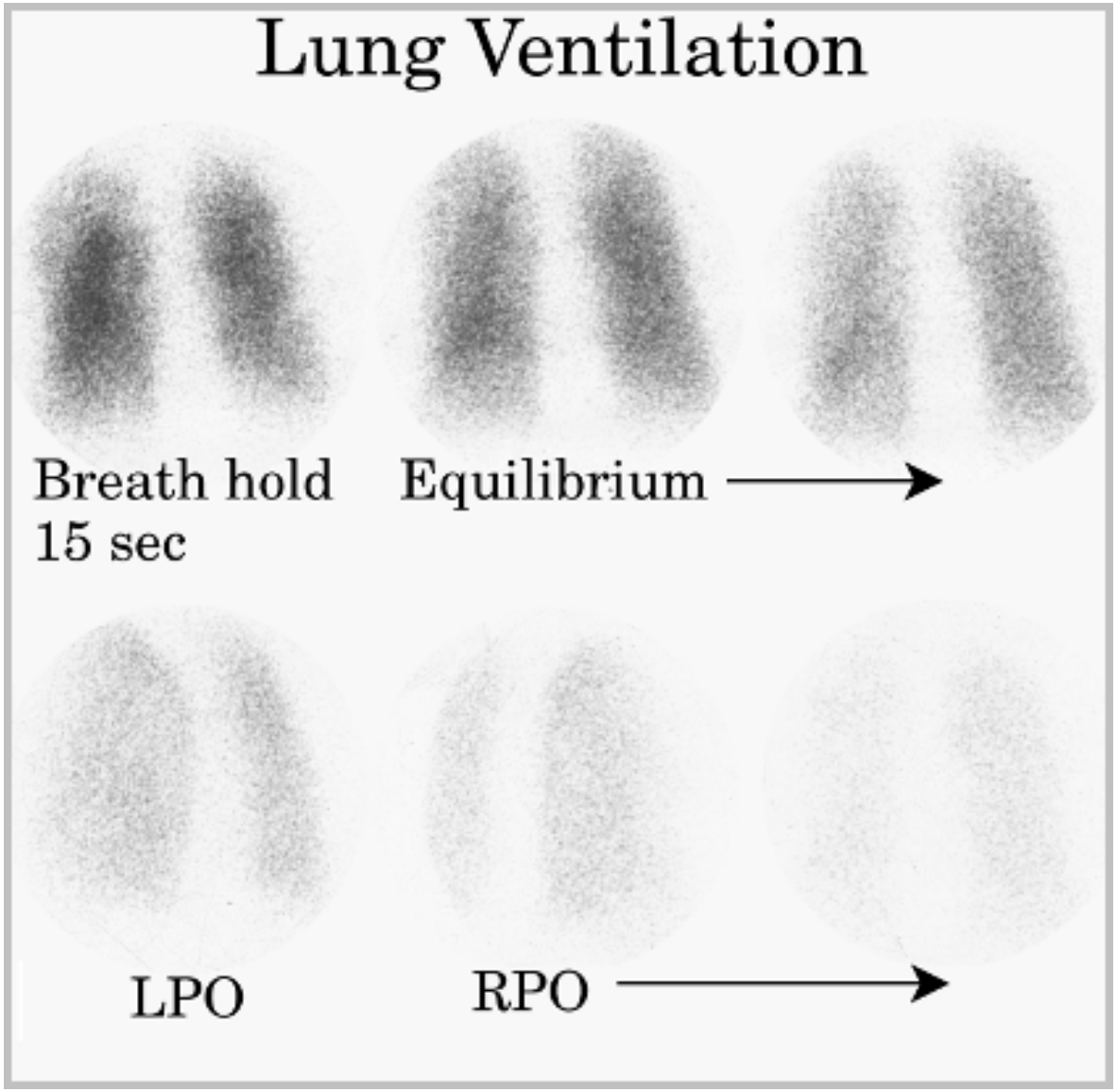
2. Pulmonary scintigraphy

a) ***Ventilation - perfusion scan***

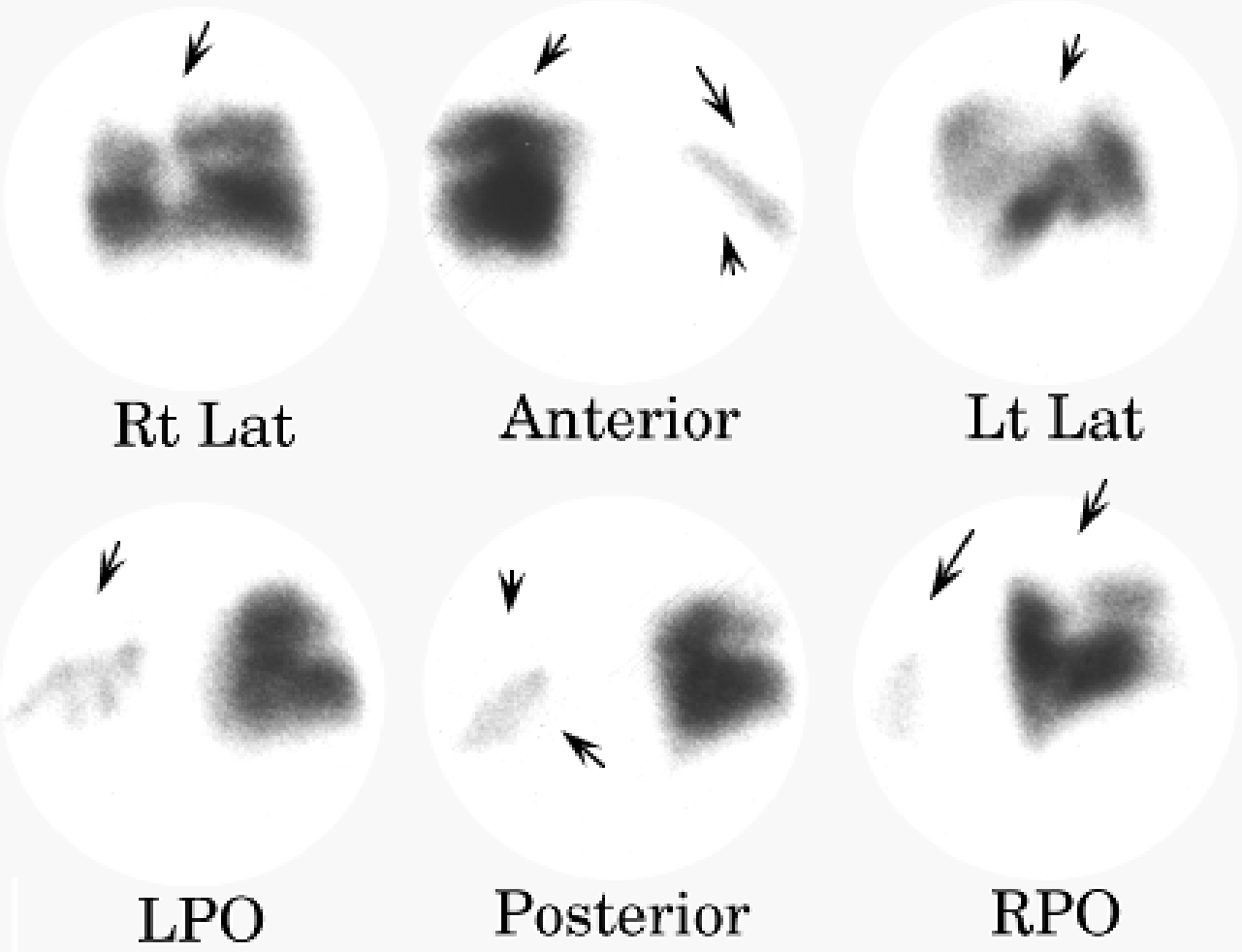
- diagnosis of pulmonary **embolism** and **parenchymal lung disease** should be performed in all clinically stable patients with the suspicion of pulmonary embolism
  - **Ventilation** scan - 133Xe gas
  - **Perfusion** scan – microspheres of albumin (50-100 mm labeled with gamma emitting isotope 99mTc

- "Mismatch" in ventilation and perfusion is characteristic for **pylmonary thrombo-embolism**


Lung Perfusion
Rt Lat
Anterior
Lt Lat
LPO
Posterior
RPO


Lung Ventilation
Breath hold
15 sec
Equilibrium
LPO
RPO

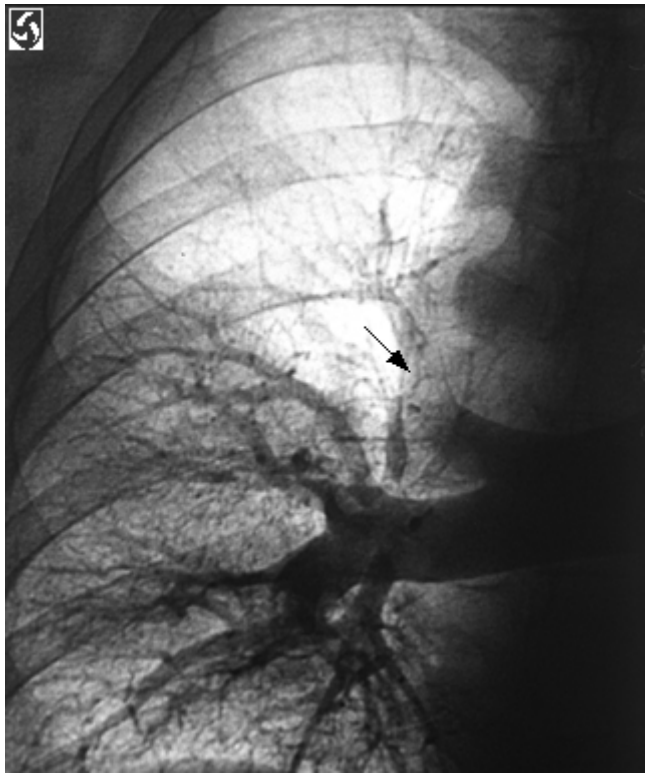
Lung Perfusion



b) ***Gallium scan*** – 67Gallium – accumulation in intrathoracic **inflammatory** and **neoplastic** tissues lungs and mediastinal **lymph** nodes

3. **Pulmonary angiography**

- Pulmonary thromboembolism, massive hemoptysis
- Injection of radio-opaque material into pulmonary artery or its branches



4. **Ultrasonography**

- evaluation of pleural processes percutaneous lung biopsy

5. **Nuclear Magnetic Resonance (MRI)**

- more sensitive then CT for distinguishing nonvascular tissues in the complex hilar region and central portions of lungs.
- same effectiveness as CT in lung cancer staging

Laboratory tests

- alpha-1-antitrypsin (deficiency: young non-smokers with emphysema)

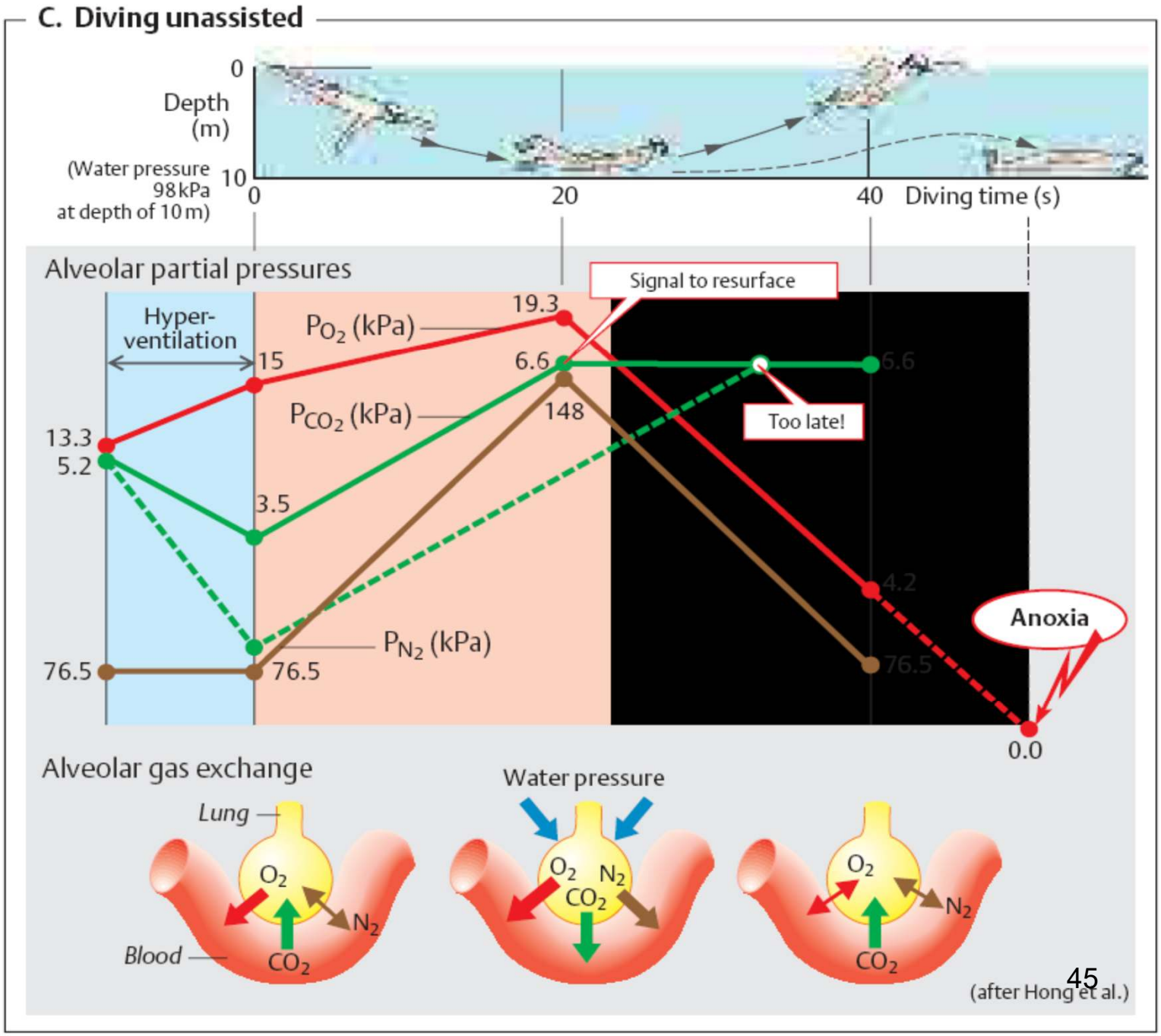
- Test of sweat for chlorides (Cystic fibrosis Cl^- > 60 mmol/L)

- Microbiology: cultivation of sputum or BAL (broncho-alveolar lavage), molecular test (PCR…): *Pseudomonas aeruginosa* (CF), *Staphylococcus aureus, Hemophilus influenzae, Burkholderia cepacia*

-Cytological examination of sputum or BAL

-Biopsy

suicide with the help of apnoe?



Pulse oxymetry

- Pulse oxymetry – measures saturation of O2 in Hb using photo-electric methods

- Lower sensitivity for pO_2 > 8 kPa, in worse skin perfusion and in presence of carboxy-hemoglobin and methemoglobin

Pulse oxymeter

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„seminar“

Petr Marsalek, and others

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