1 úvod, respirační insuficience
2 spirometrické dělení, restrikční
3 a obstrukční poruchy
4 poměr ventilace/ k perfúsi, poruchy kardiopulmonální a další doplňky

Vybrané ventilační (spirometrické) parametry

-Dechová frekvence, [1/min] normální 12-16 dechů / min

-Minutová ventilace [volume/min] norma: 6-8 L/ min

-(F)VC - Forced vital capacity (usilovná/ forsírovaná VC)

ženy: [21.7 – (0.101 x věk)] × (cm) = [mL]

muži: [27.63 – (0.112 x věk)] × (cm) = [mL]

Hodnoty v mezích 80 - 120 % náležité hodnoty se považují za normální

-MVV (Vmax) = Maximal voluntary ventilation

Objem dosažený během (20-ti sekundové) maximální ventilace

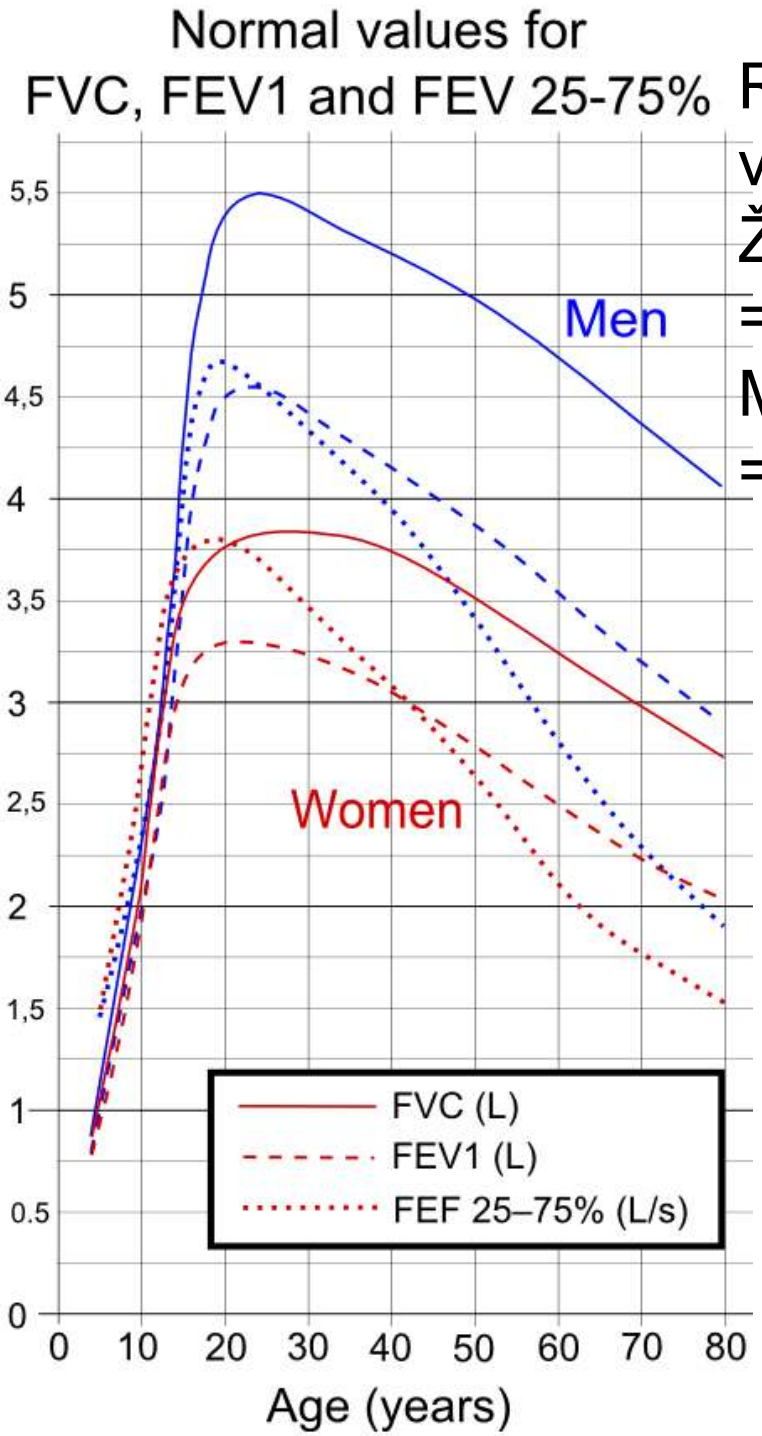
Maximální dechový objem (TV) X maximální ventilace

Po dobu 10 – 30 sec > 40 L/min

- **Ventilační rezerva**:

minutová ventilace / MVV > 1 : 7 (> 1:5)

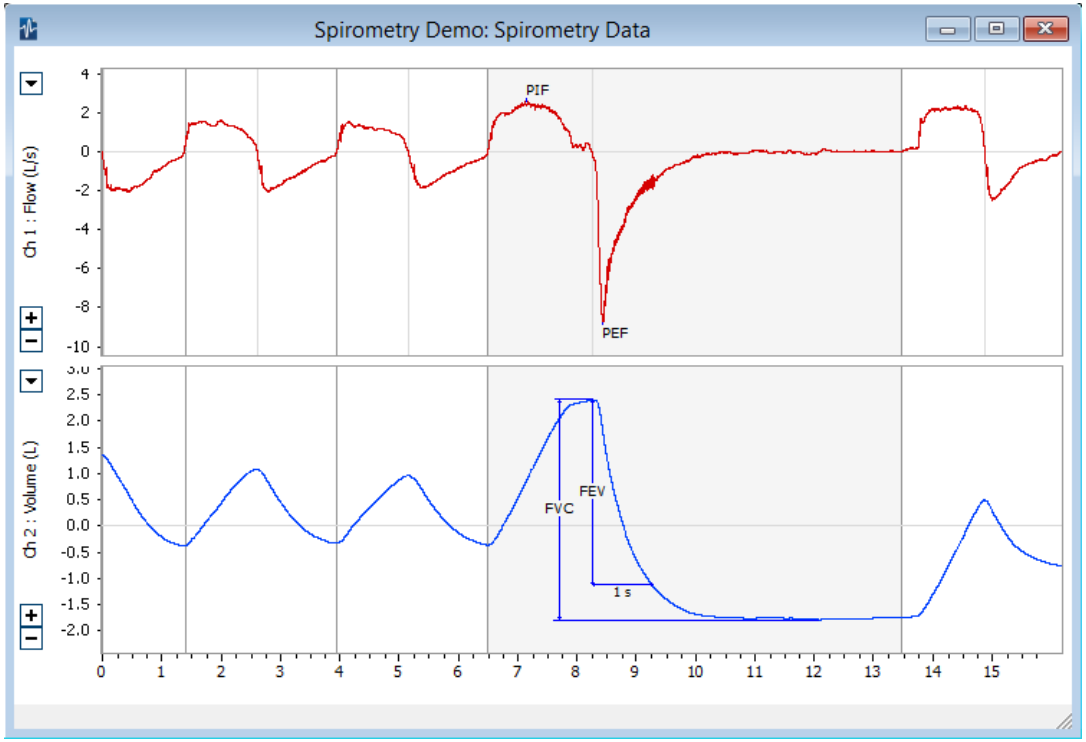
= 1 : 2



Regresní rovnice pro určení náležité vitální kapacity:

Ženy: [21.7 – (0.101 x age(y))] ×h (cm) = (mL)

Muži: [27.63 – (0.112 x age(y))] × h (cm) = (mL)



Restrictive diseases

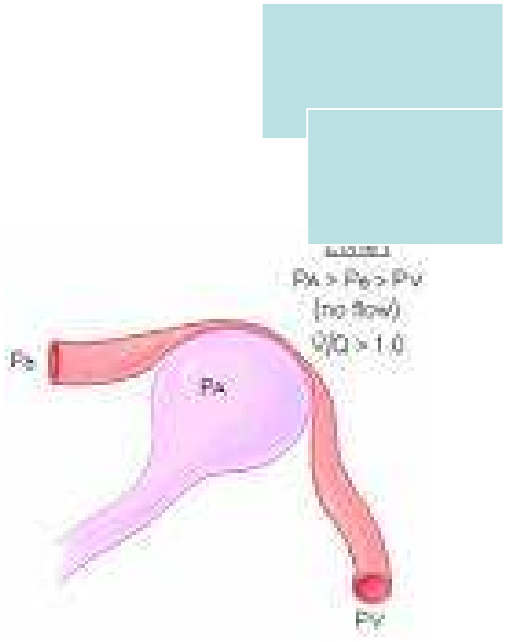
anatomical and/or functional loss of surface for gas exchange

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

Možné poruchy funkce dýchacího systému

- Porucha **ventilace**
- Porucha **perfúze**
- Porucha **distribuce**
  ventilace a perfúze

  = ventilačně perfúzní nerovnováha
- Porucha **difúze**



Osnova/ Shrnutí

- **Plicní poruchy podle cesty dýchacích plynů do krve –** poruchy 1) ventilace, 2) difúze

3) perfúze/ plus ventilačně perfusní nehomogenity,

4) ostatní a mimoplicní poruchy

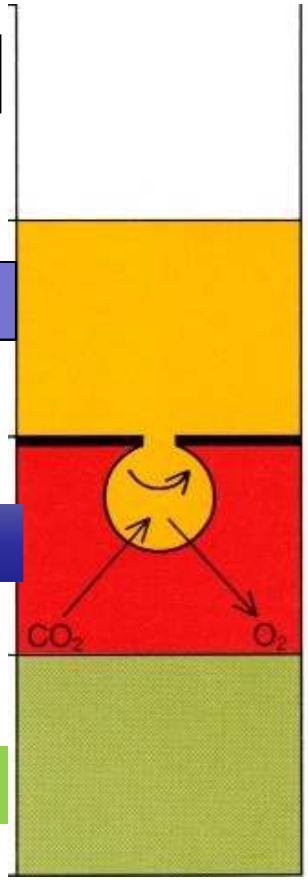
- **Statické parametry** – intrapleurální tlak, surfaktant, **restrikční poruchy**
- **Dynamické parametry** – **obstrukční poruchy,** viz další přednáška
- **Typické restrikční** poruchy – **edém plic, ARDS/ atelektáza, plicní fibróza, hrudní deformity, pneumothorax, atd**
- **Posouzení** ventilační funkce = **spirometrie, pletysmografie –** budou podrobněji na vyšetřovacím semináři další týden

Vzduch

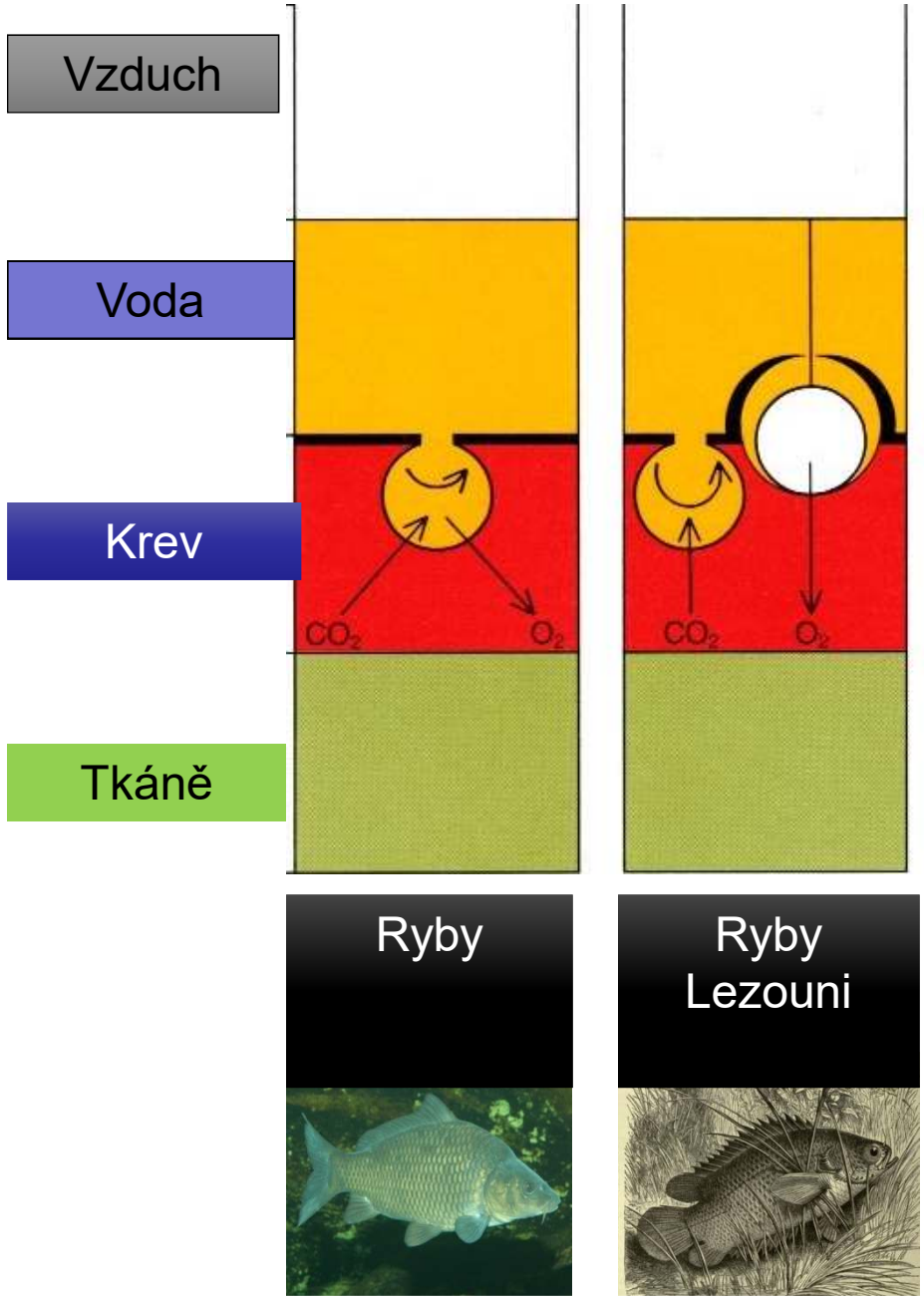
Voda

Krev

Tkáně



Ryby

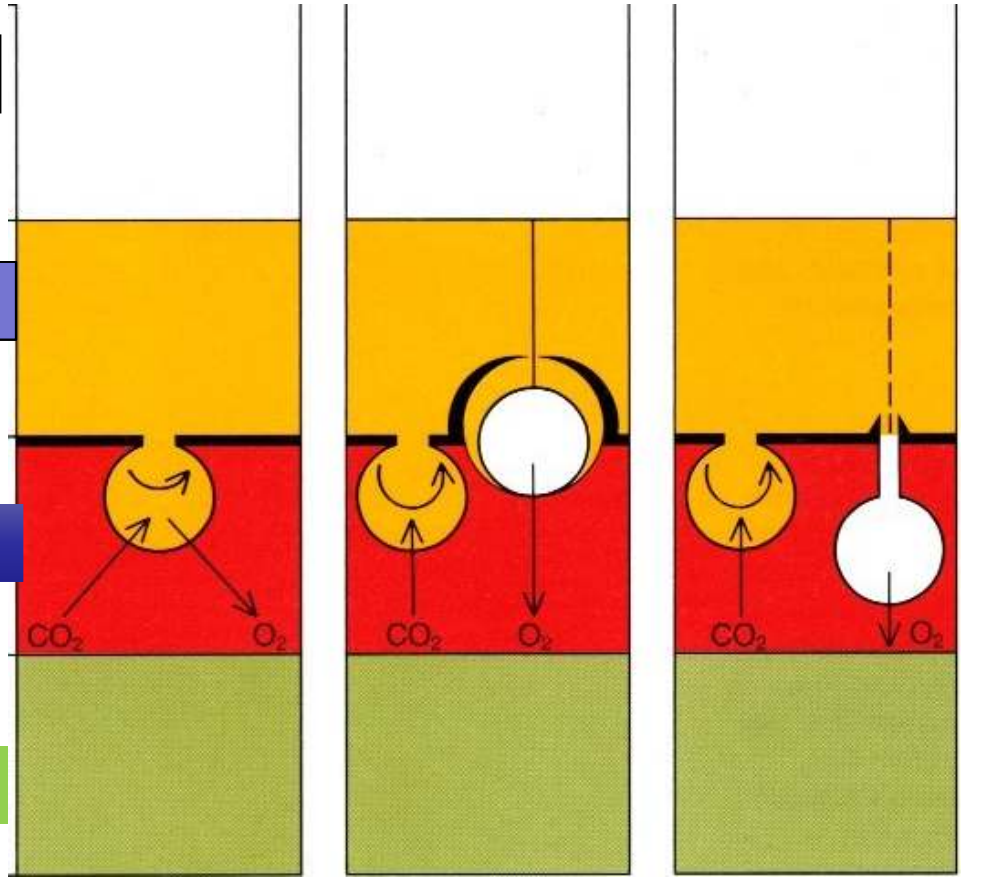

Vzduch
Voda
Krev
Tkáně
CO_2
O_2
CO_2
O_2
Ryby
Ryby
Lezouni

Vzduch

Voda

Krev

Tkáně



Ryby

Ryby Lezouni

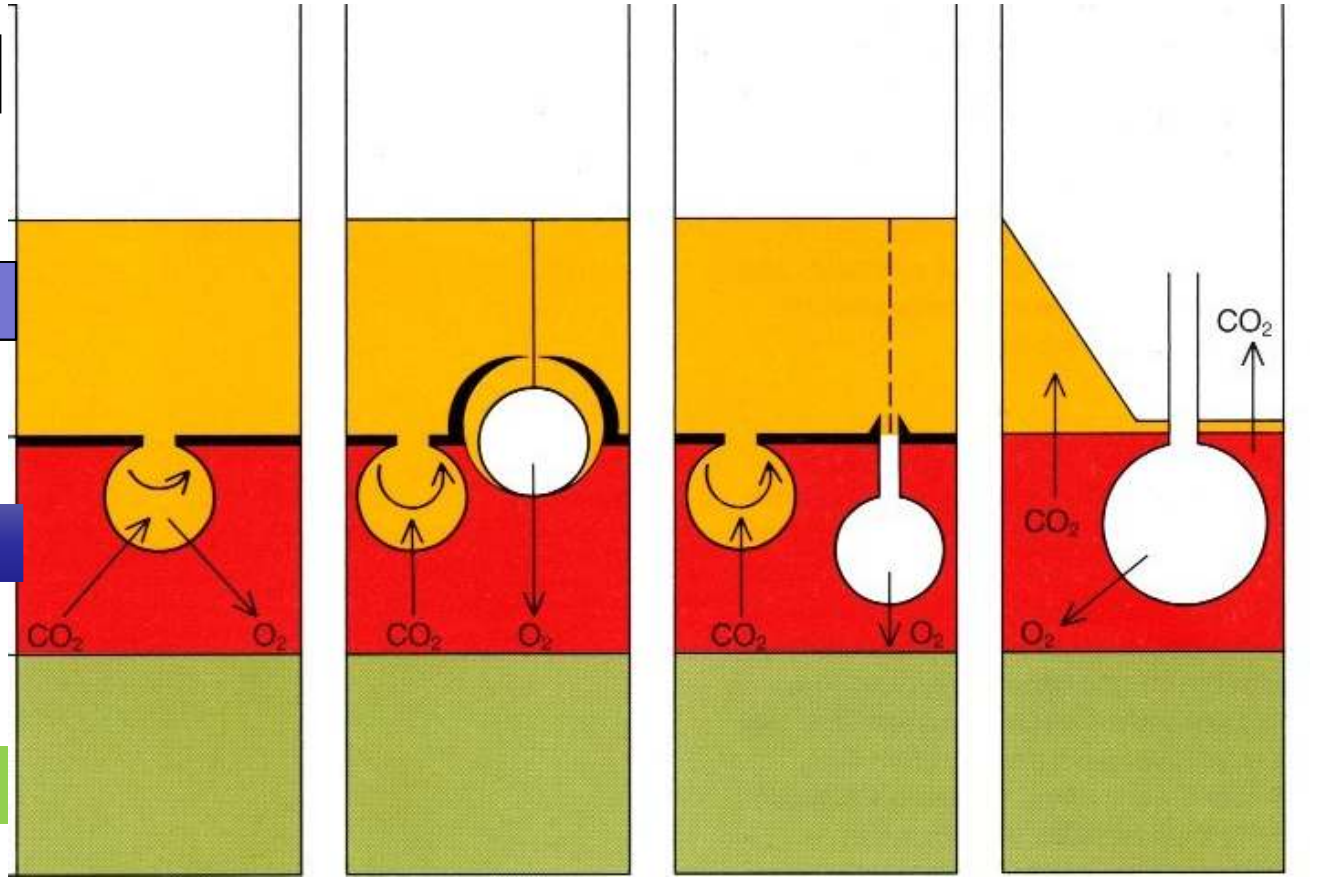
Ryby Dvojdyšní

Vzduch

Voda

Krev

Tkáně



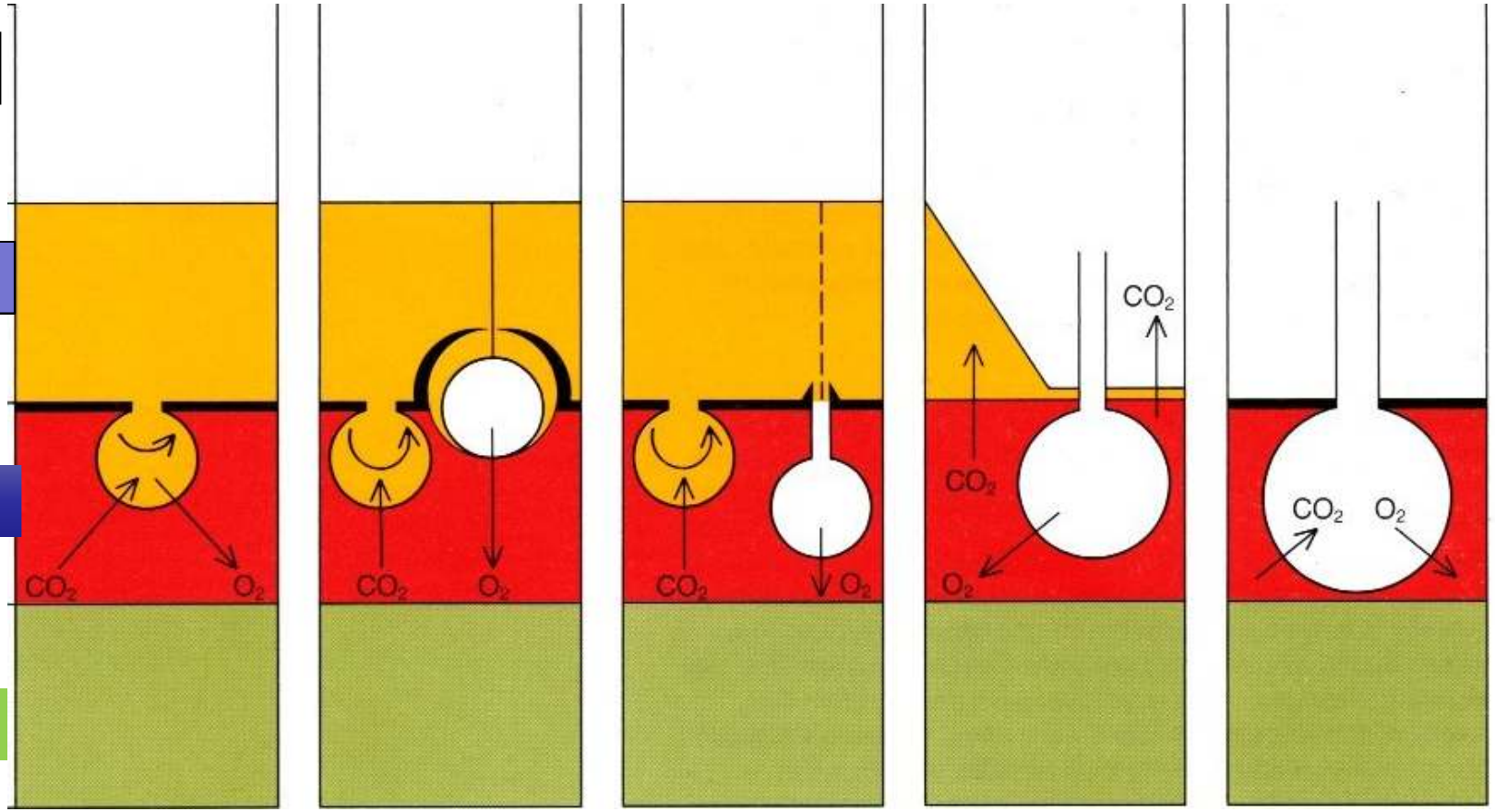
Ryby	Ryby Lezouni	Ryby Dvojdyšní	Obojživelníci

Vzduch

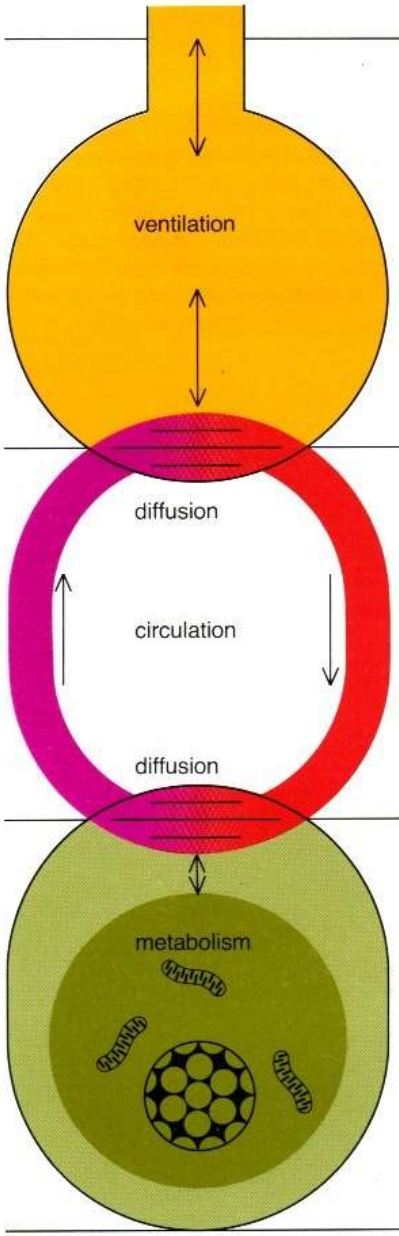
Voda

Krev

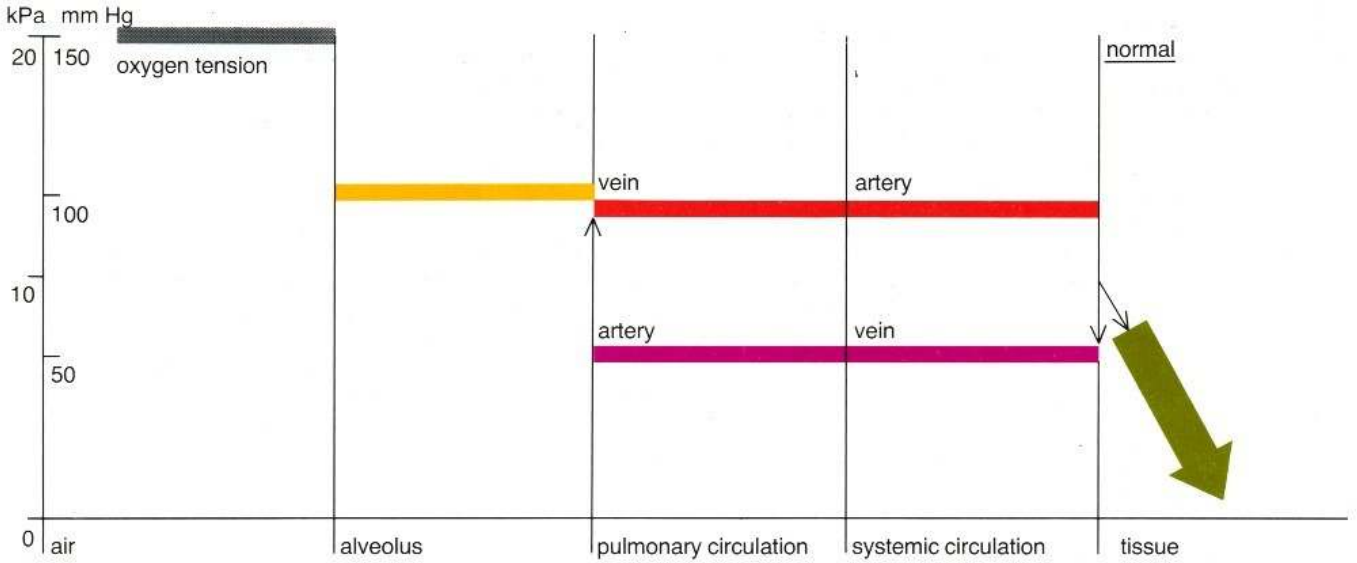
Tkáně

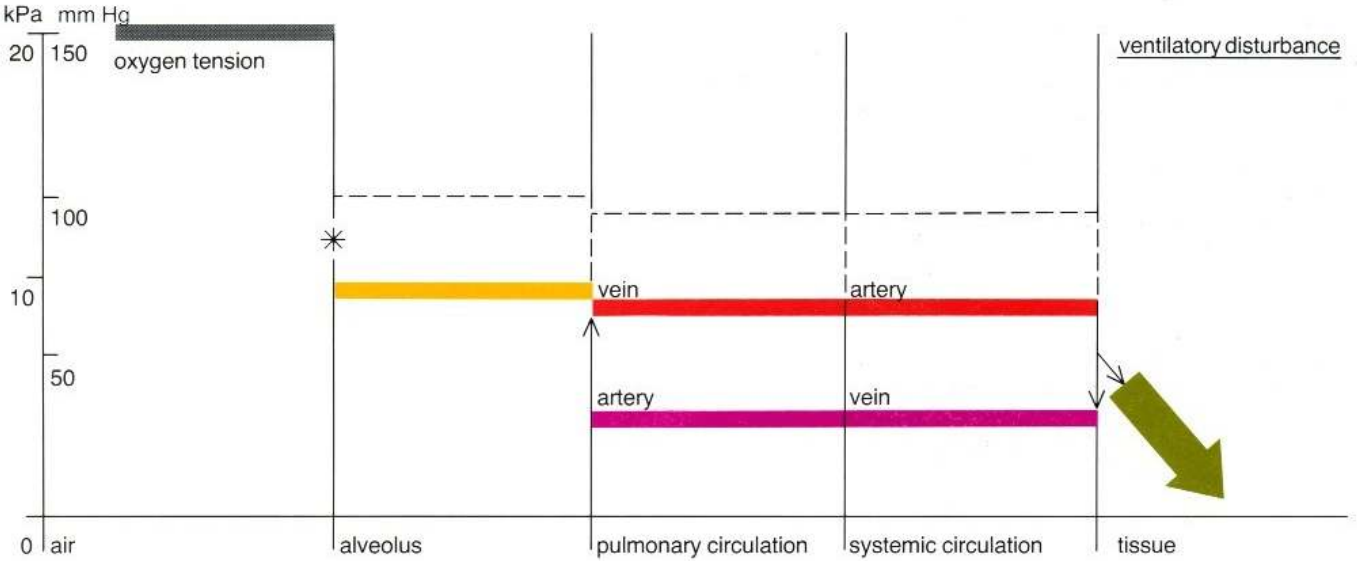


Ryby	Ryby Lezouni	Ryby Dvojdyšní	Obojživelníci	Savci
				



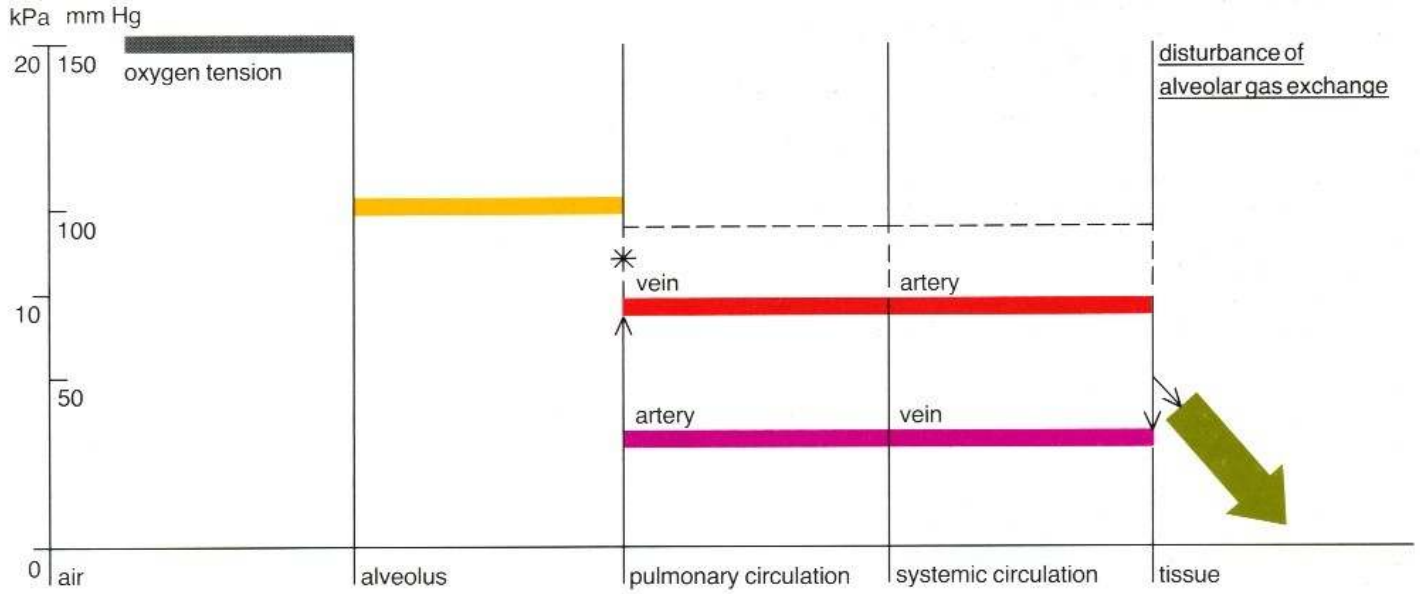
process	compartment	$\dot{V}o_2$ l/min	Vo_2 l	Po_2 mm Hg	$\dot{V}co_2$ l/min	Vco_2 l	Pco_2 mm Hg
	air	0.25	∞	150	0.20	≃ 0	≃ 0
ventilation	airway (lung)		0.03	–		0.02	–
	alveolus (lung)		0.40	100		0.17	40
diffusion	arterial (blood)			90–100			40
circulation	capillary (blood)		0.80			2.70	
diffusion	venous (blood)			35–45			45
metabolism	extracellular (tissue)			40			45
	intracellular (tissue)		0.30			3.30	
	mitochondria (tissue)			<5			>45
		0.25	1.53		0.20	6.19	

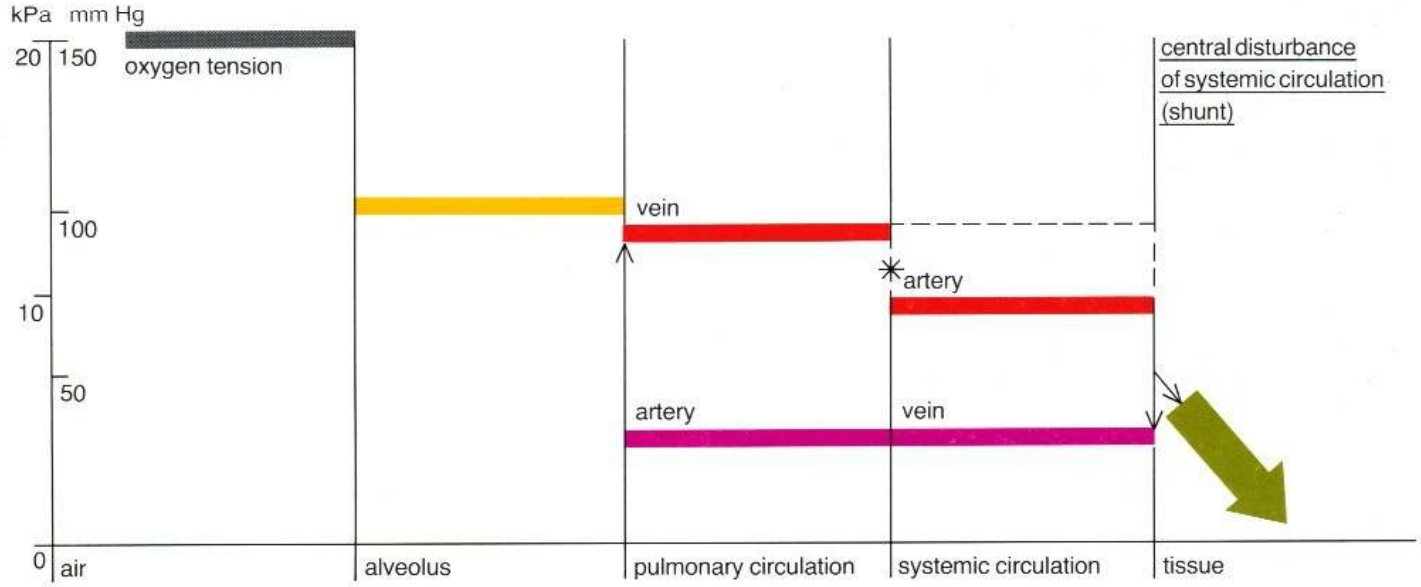




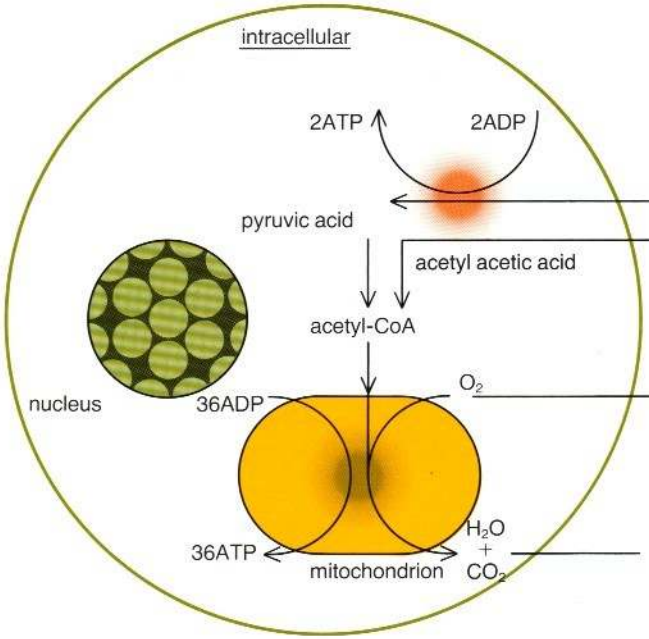
* disturbance

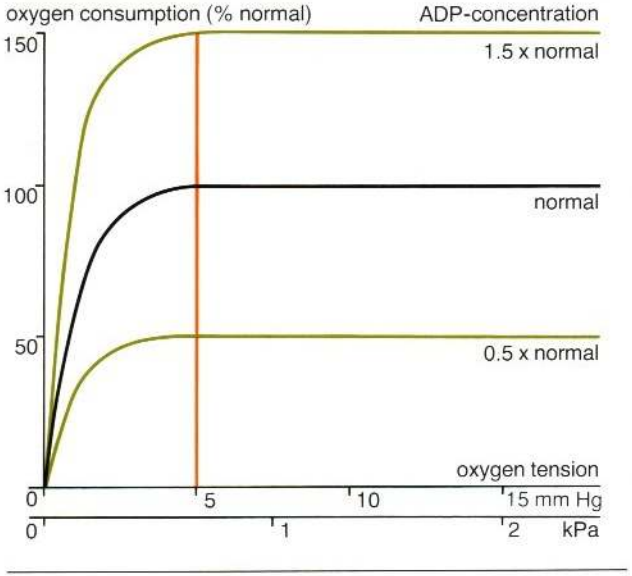
1 mm Hg = 0.133 kPa (see A3)



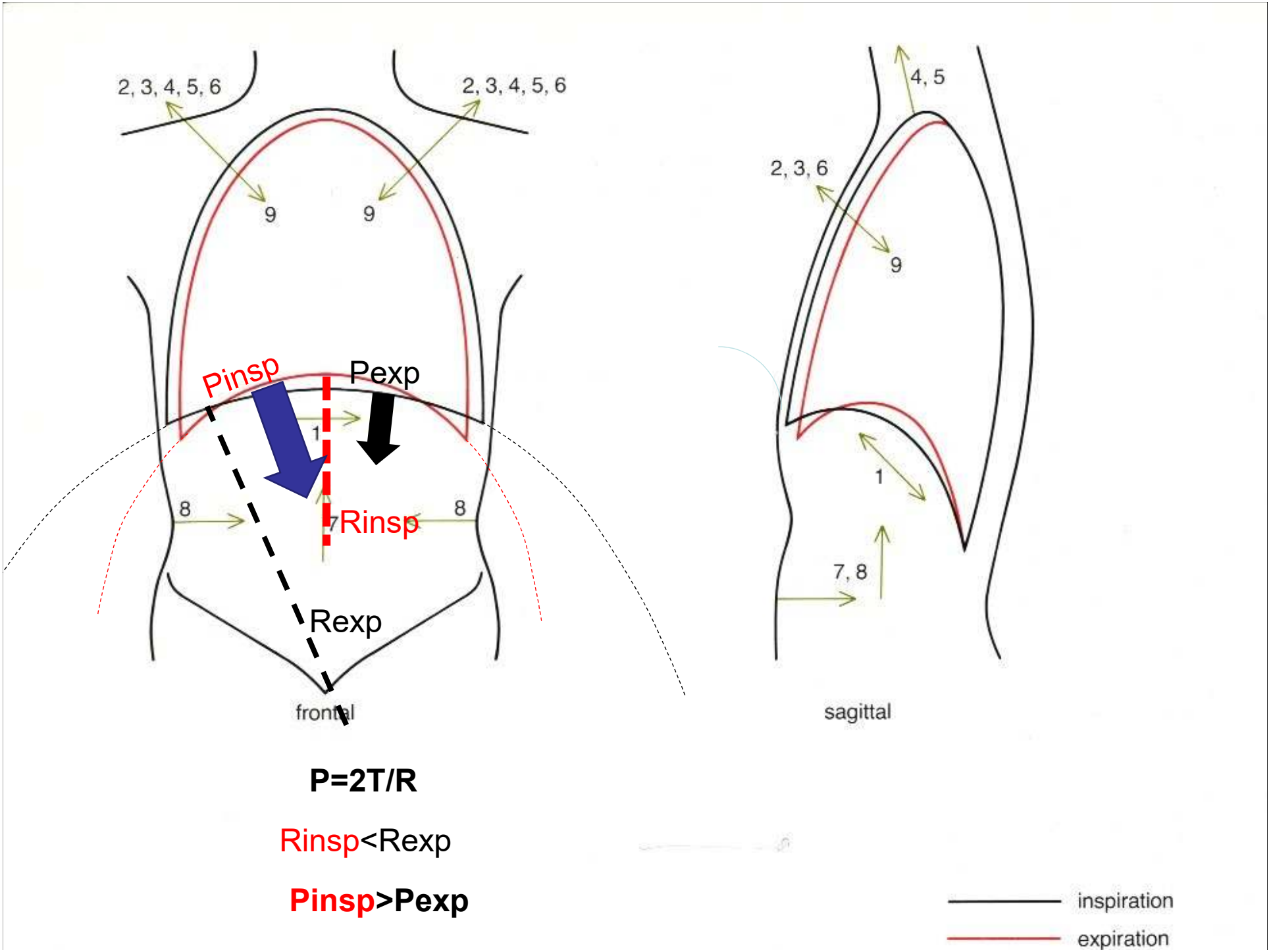


* disturbance
1 mm Hg = 0.133 kPa (see A3)





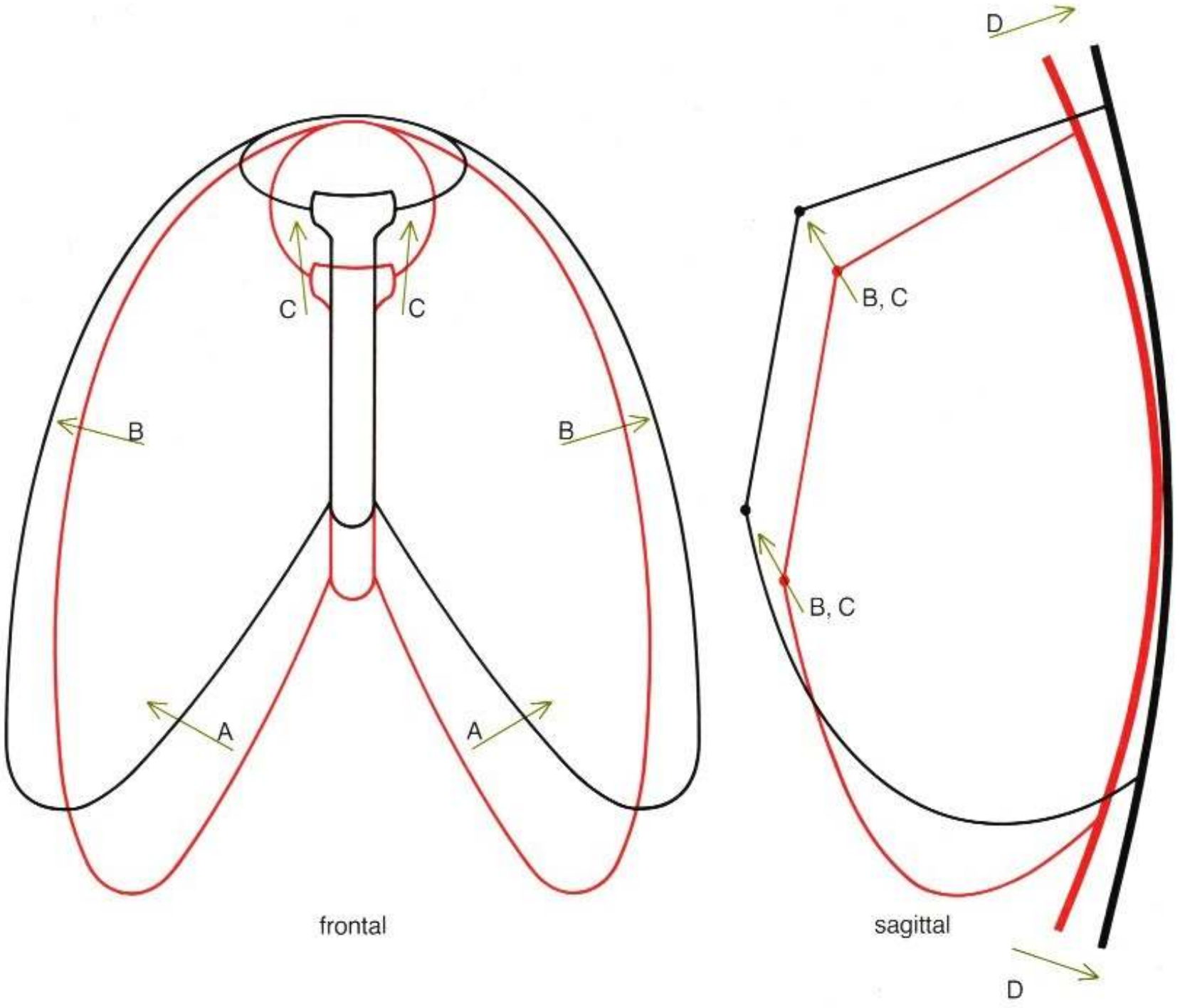
ADP = adenosine diphosphate
ATP = adenosine triphosphate

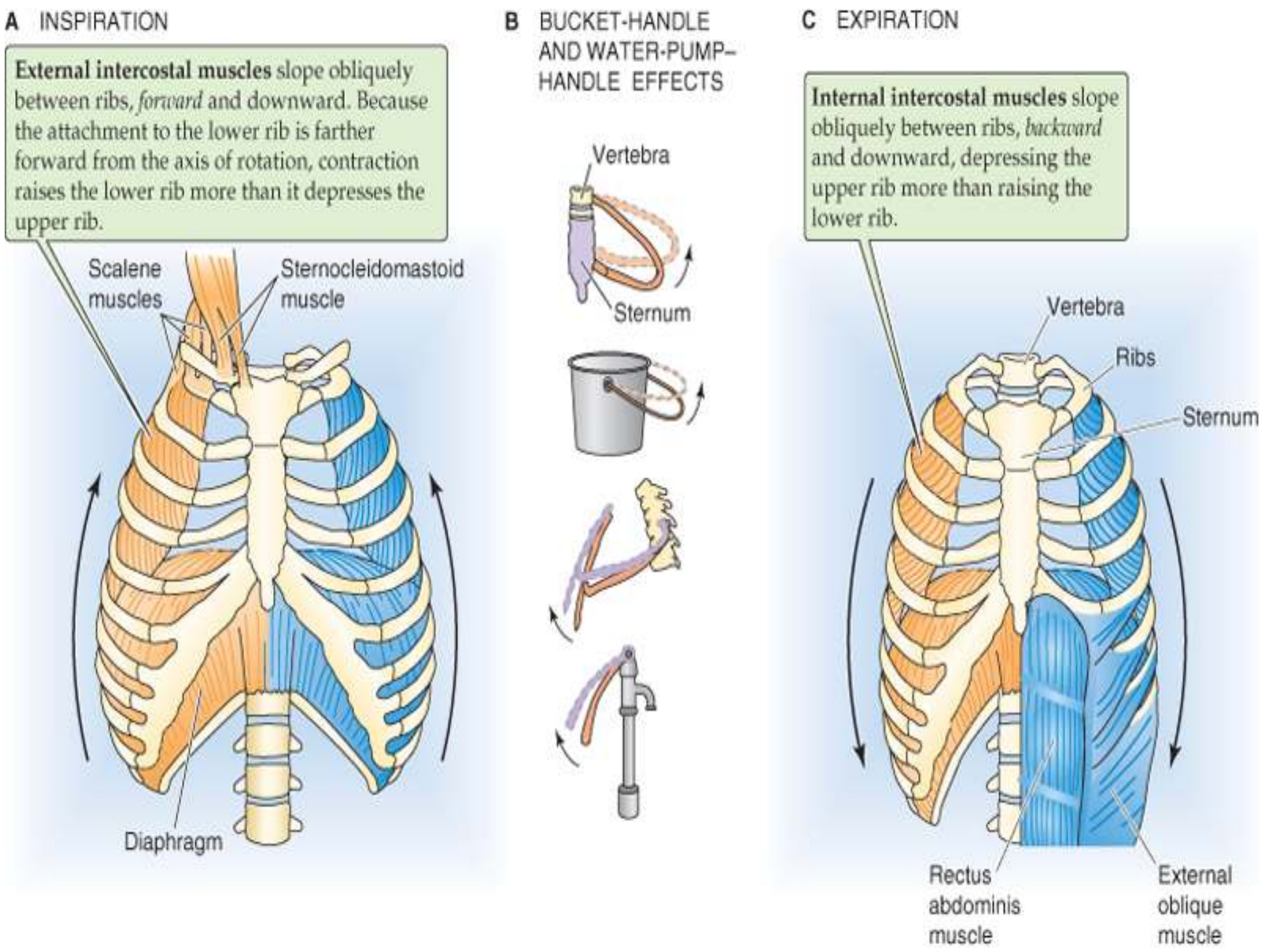


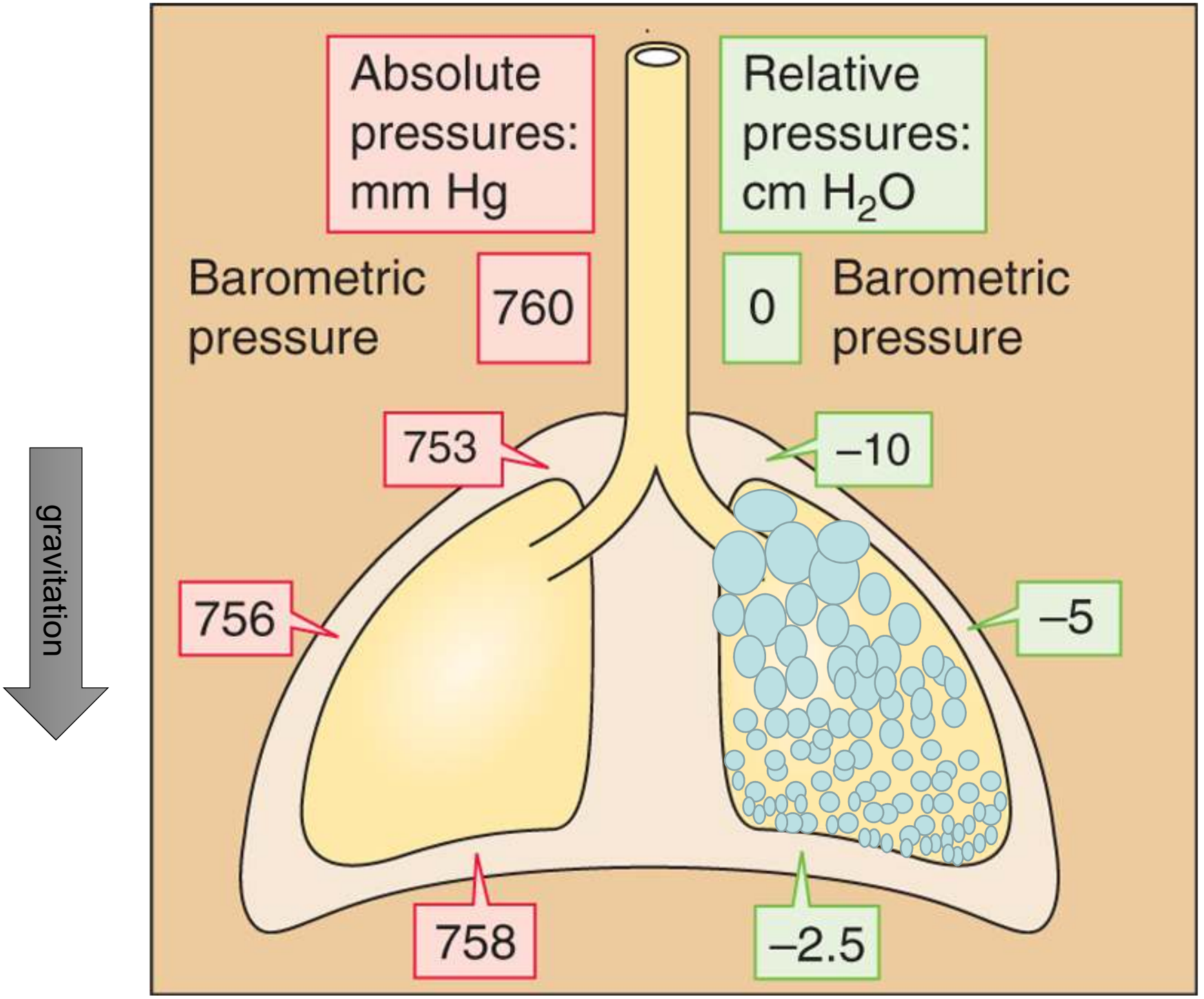
P=2T/R

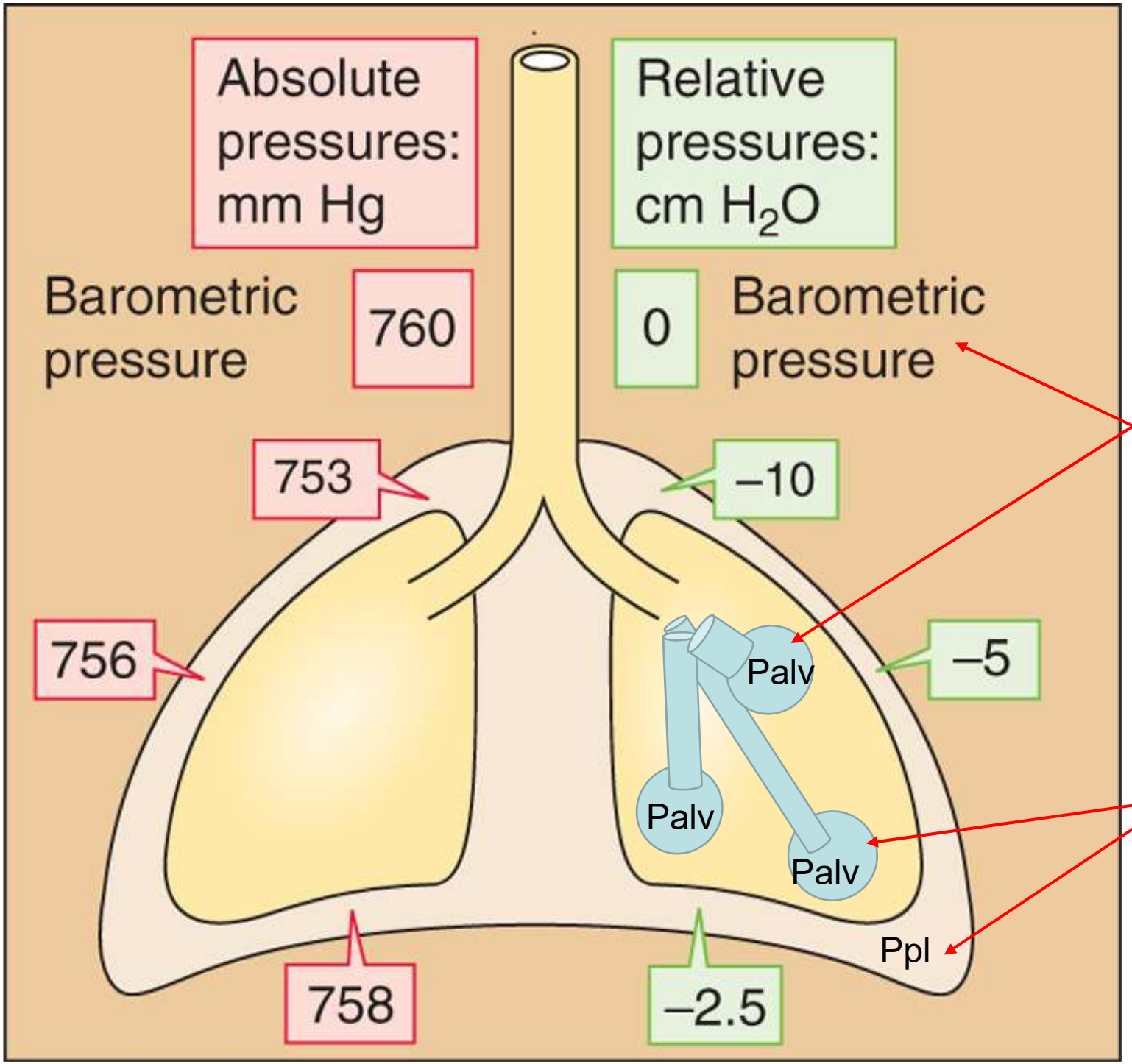
Rinsp<Rexp

Pinsp>Pexp


C
C
B
B
A
A
frontal
D
B, C
B, C
sagittal
D


A INSPIRATION
External intercostal muscles slope obliquely between ribs, forward and downward. Because the attachment to the lower rib is farther forward from the axis of rotation, contraction raises the lower rib more than it depresses the upper rib.
Scalene muscles
Sternocleidomastoid muscle
Diaphragm
B BUCKET-HANDLE AND WATER-PUMP–HANDLE EFFECTS
Vertebra
Sternum
C EXPIRATION
Internal intercostal muscles slope obliquely between ribs, backward and downward, depressing the upper rib more than raising the lower rib.
Vertebra
Ribs
Sternum
Rectus abdominis muscle
External oblique muscle

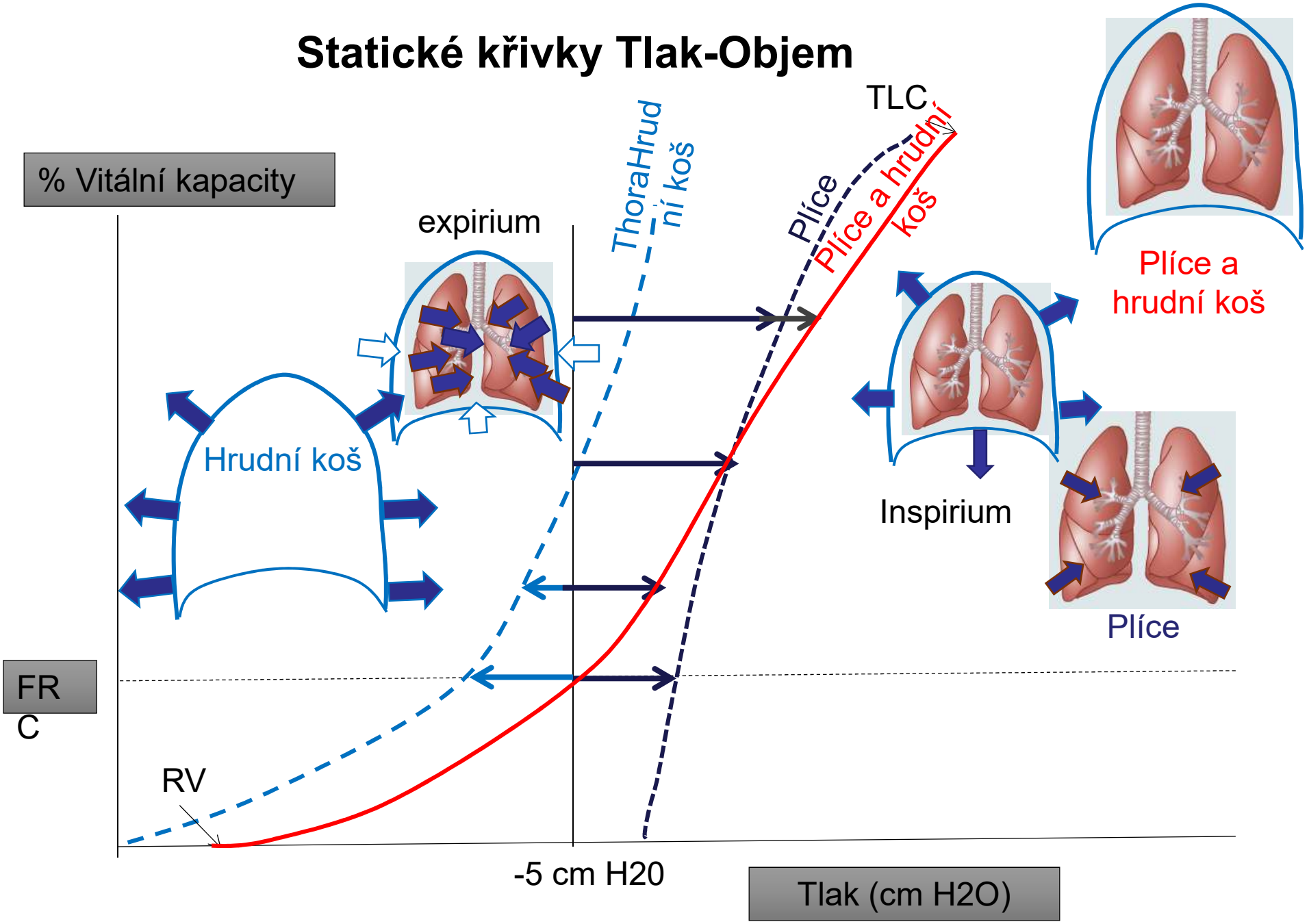

Absolute pressures: mm Hg
Relative pressures: cm H_2O
Barometric pressure
760
0
Barometric pressure
753
−10
756
−5
758
−2.5
gravitation



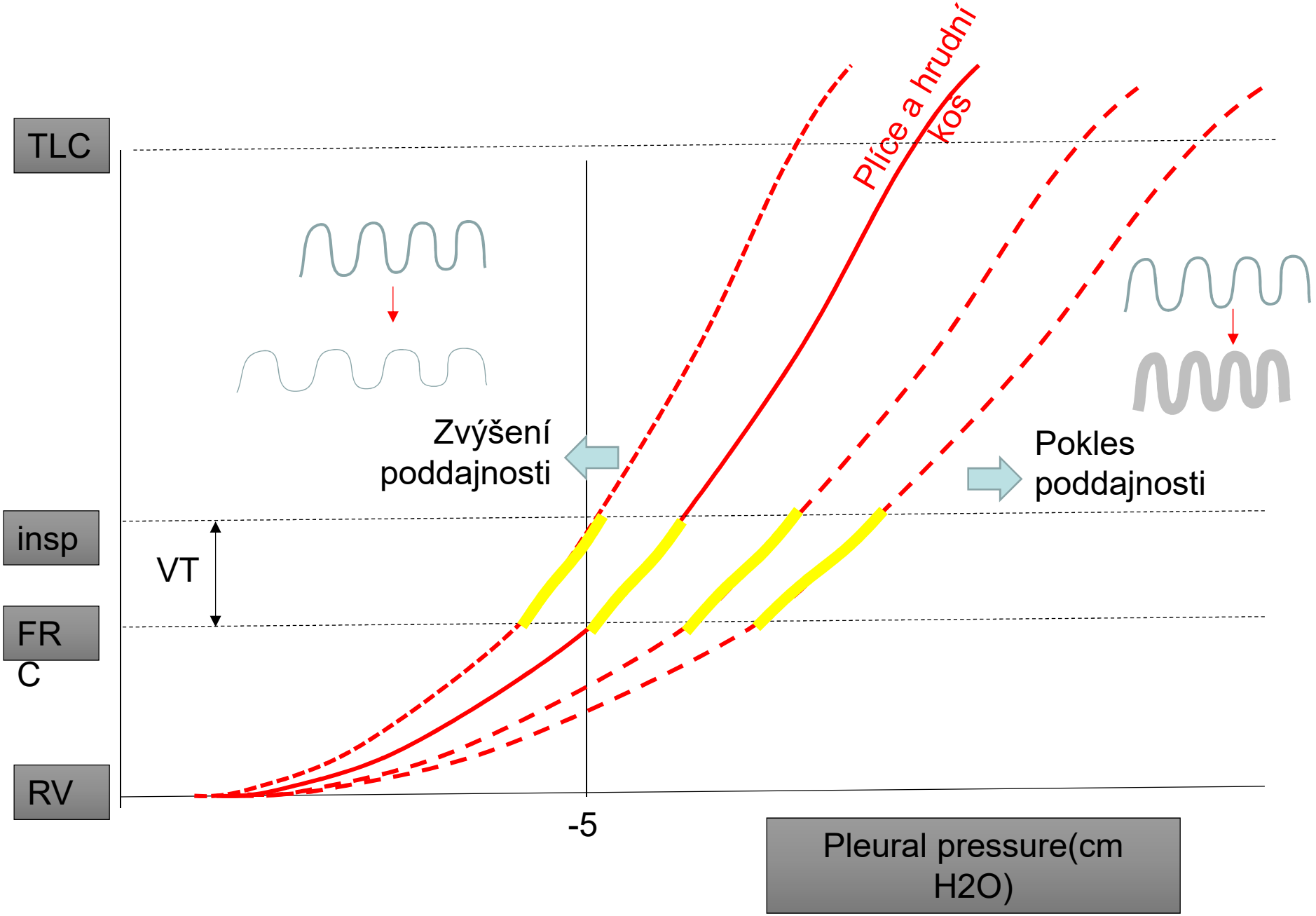
Transthorakální tlak

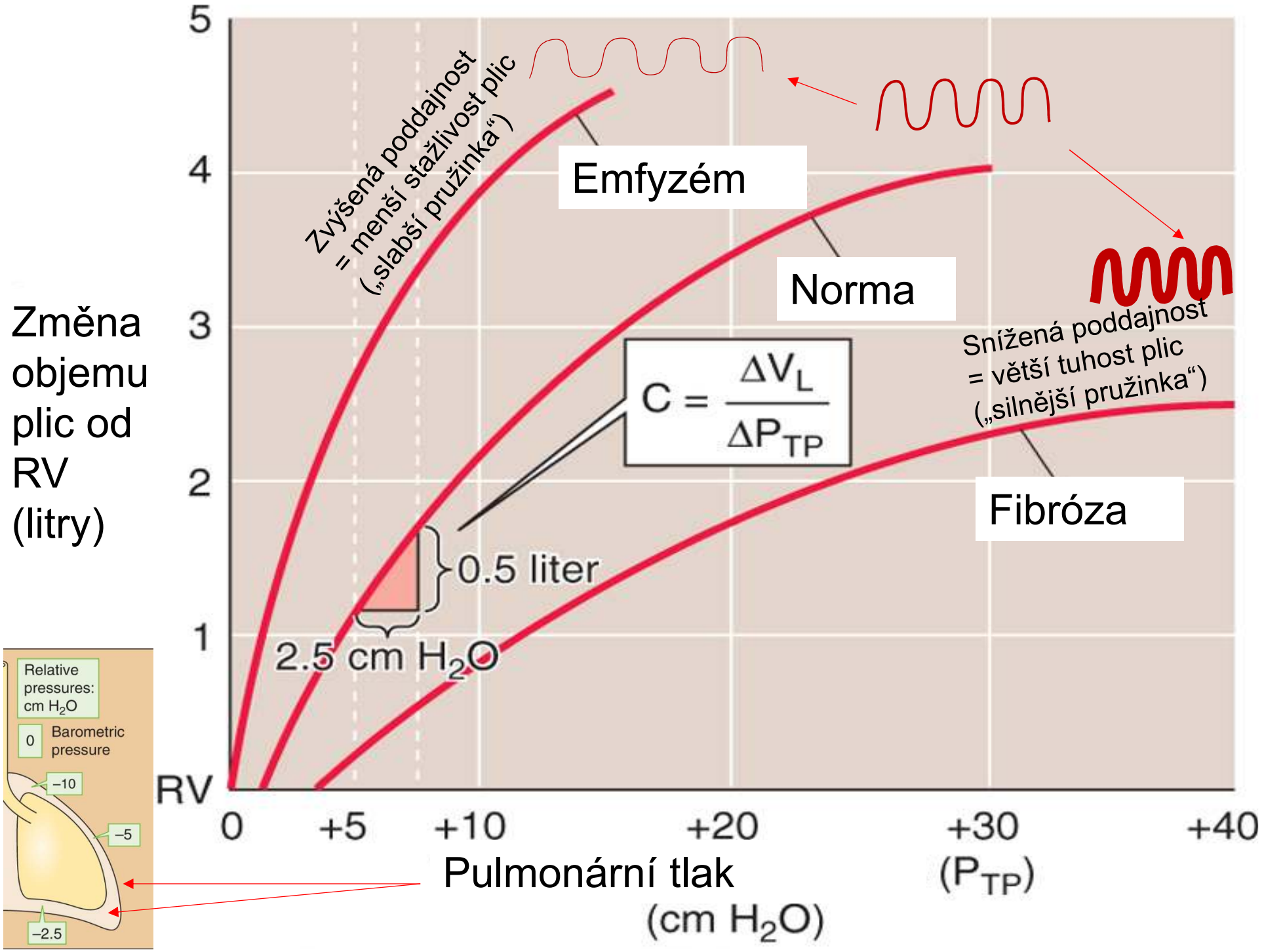
Transpulmonární tlak

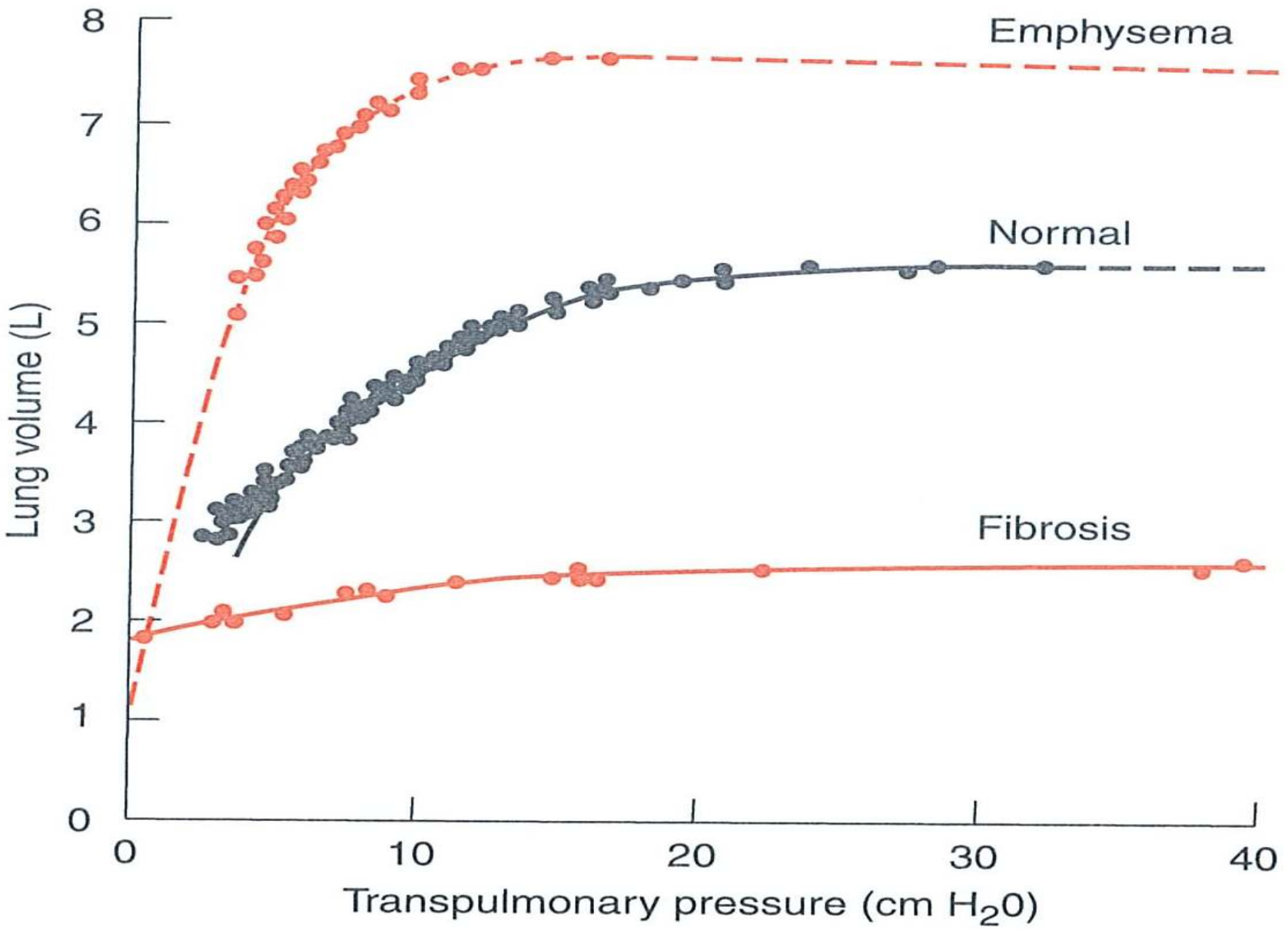
Statické křivky Tlak-Objem

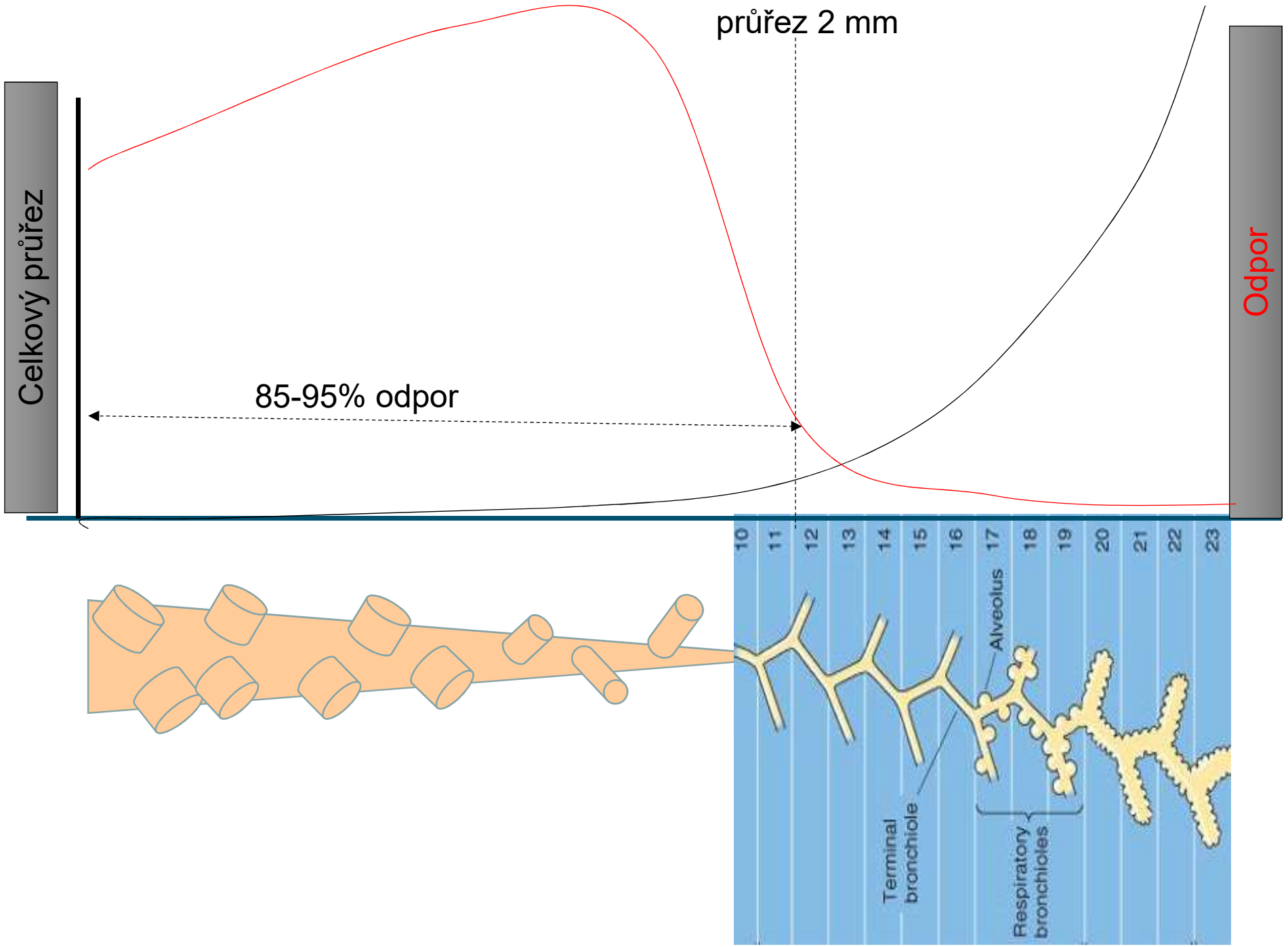


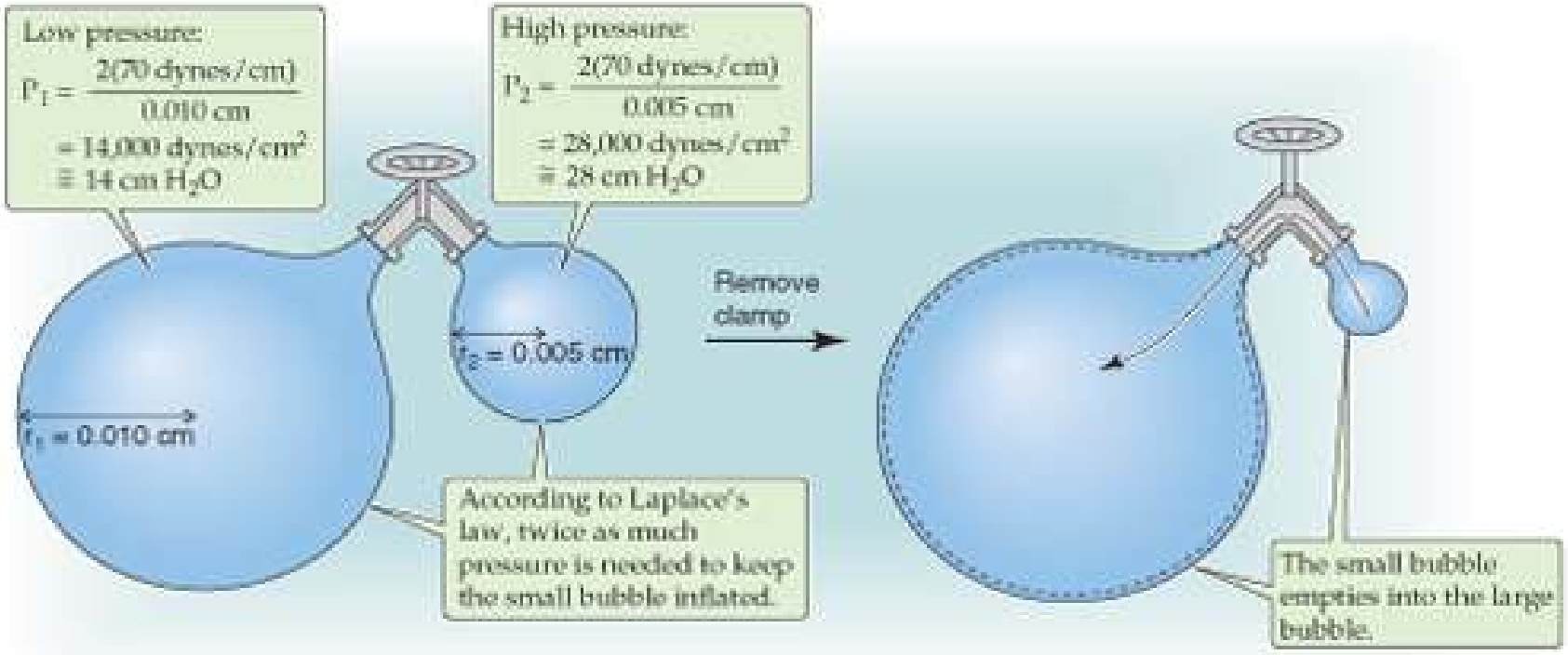
Pressure – Volume Static Curves



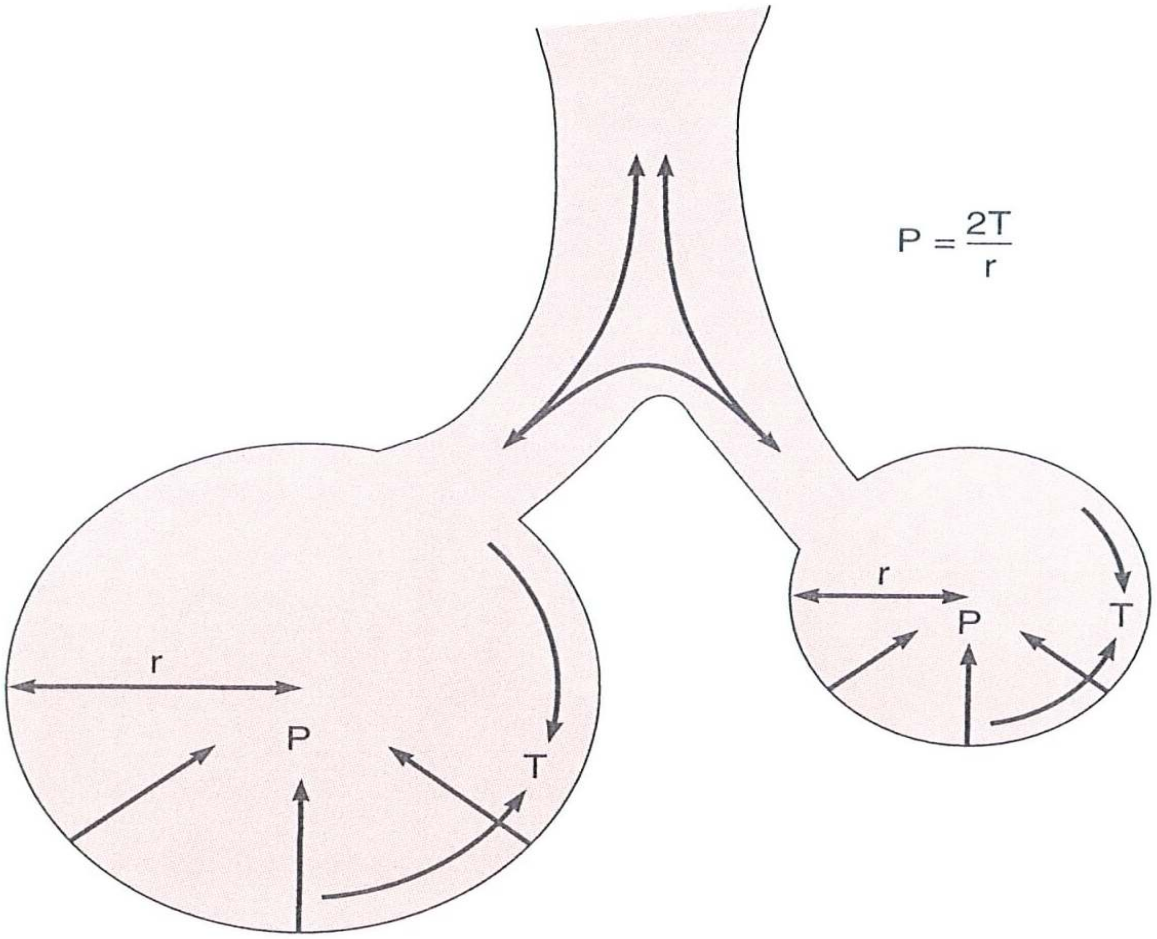

Změna objemu plic od RV (litry)
5
4
3
2
1
RV
Zvýšená poddajnost
= menší stažlivost plic
(„slabší pružinka“)
Emfyzém
Norma
Snížená poddajnost
= větší tuhost plic
(„silnější pružinka“)
Fibróza
$C = \frac{\Delta V_L}{\Delta P_{TP}}$
0.5 liter
2.5 cm H_2O
Relative pressures: cm H_2O
0
Barometric pressure
–10
–5
–2.5
0
+5
+10
+20
+30
+40
Pulmonární tlak
(P_{TP})
(cm H_2O)


Emphysema
Normal
Fibrosis
Lung volume (L)
0
1
2
3
4
5
6
7
8
0
10
20
30
40
Transpulmonary pressure (cm H_20)

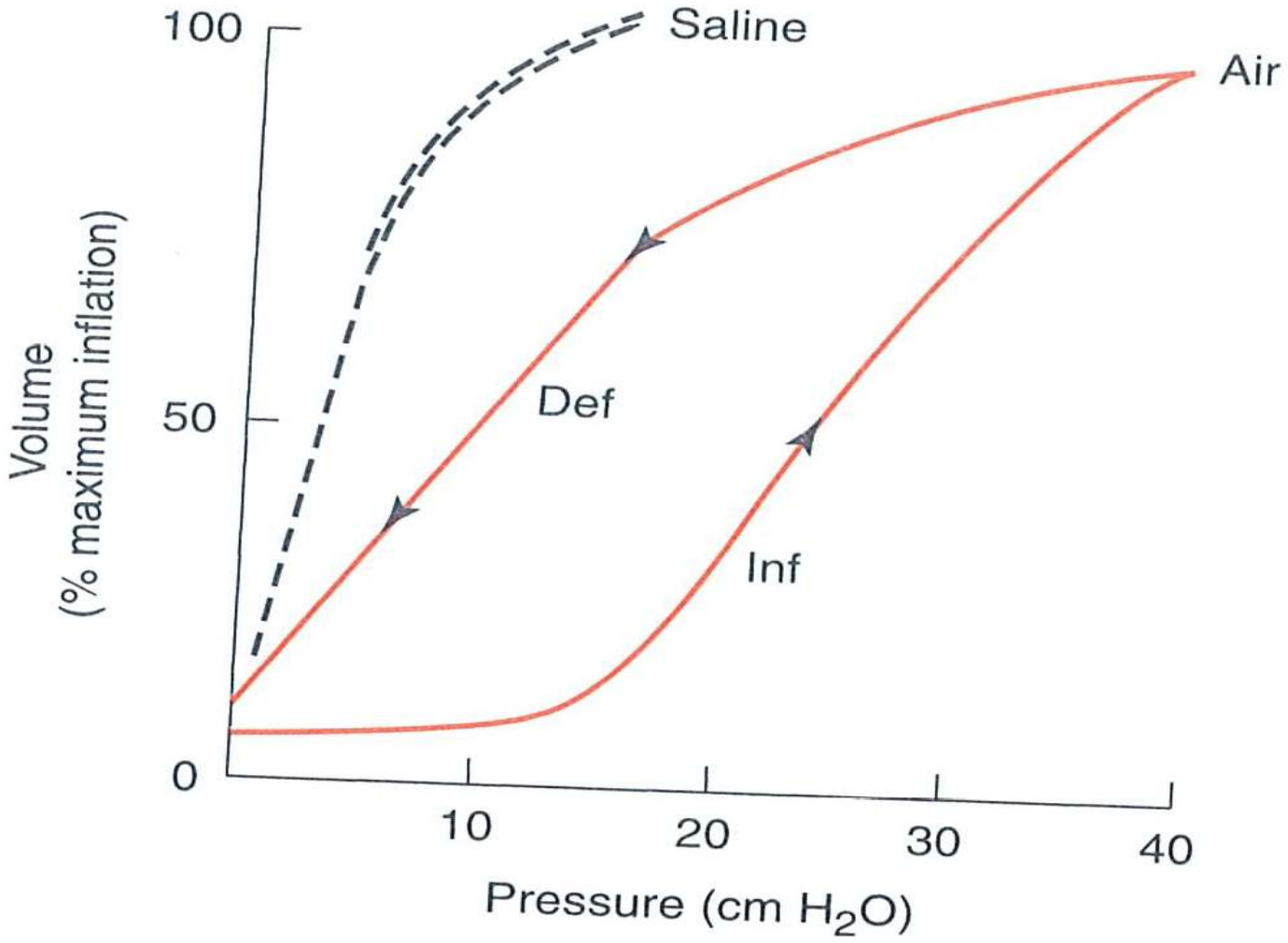

průřez 2 mm
Celkový průřez
Odpor
85-95% odpor
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Alveolus
Terminal bronchiole
Respiratory bronchioles

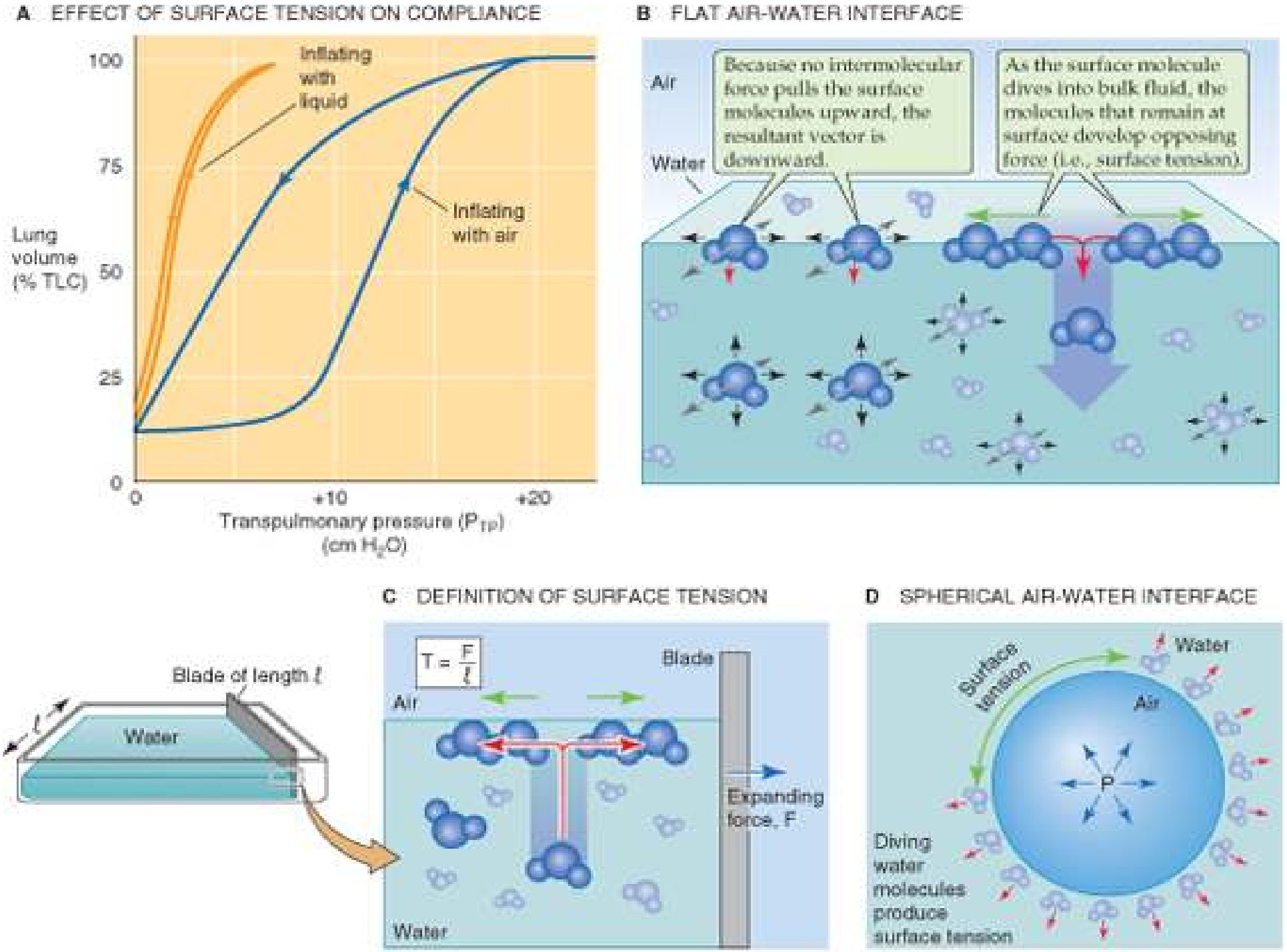

Low pressure:
$P_1 = \frac{2(70 \text{ dynes/cm})}{0.010 \text{ cm}}$
$= 14{,}000 \text{ dynes/cm}^2$
$\cong 14 \text{ cm } H_2O$
High pressure:
$P_2 = \frac{2(70 \text{ dynes/cm})}{0.005 \text{ cm}}$
$= 28{,}000 \text{ dynes/cm}^2$
$\cong 28 \text{ cm } H_2O$
$r_2 = 0.005$ cm
$r_1 = 0.010$ cm
According to Laplace's law, twice as much pressure is needed to keep the small bubble inflated.
Remove clamp
The small bubble empties into the large bubble.

Stabilita rozvinutí alveolů, síly proti kolapsu



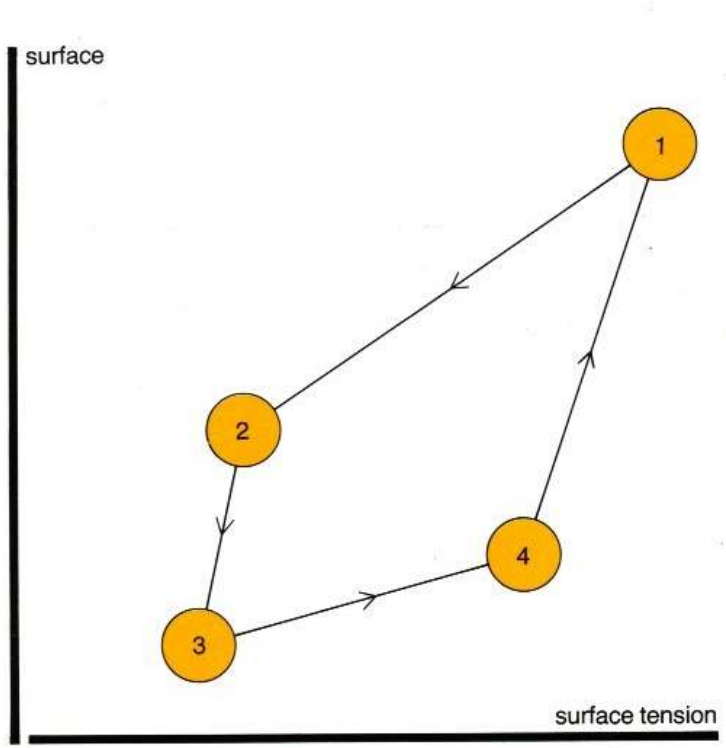
Compliance – effect of surfactant

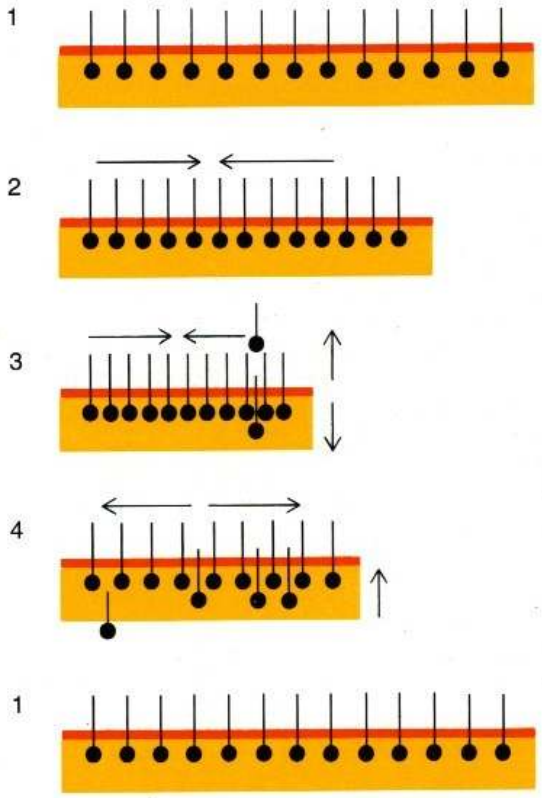


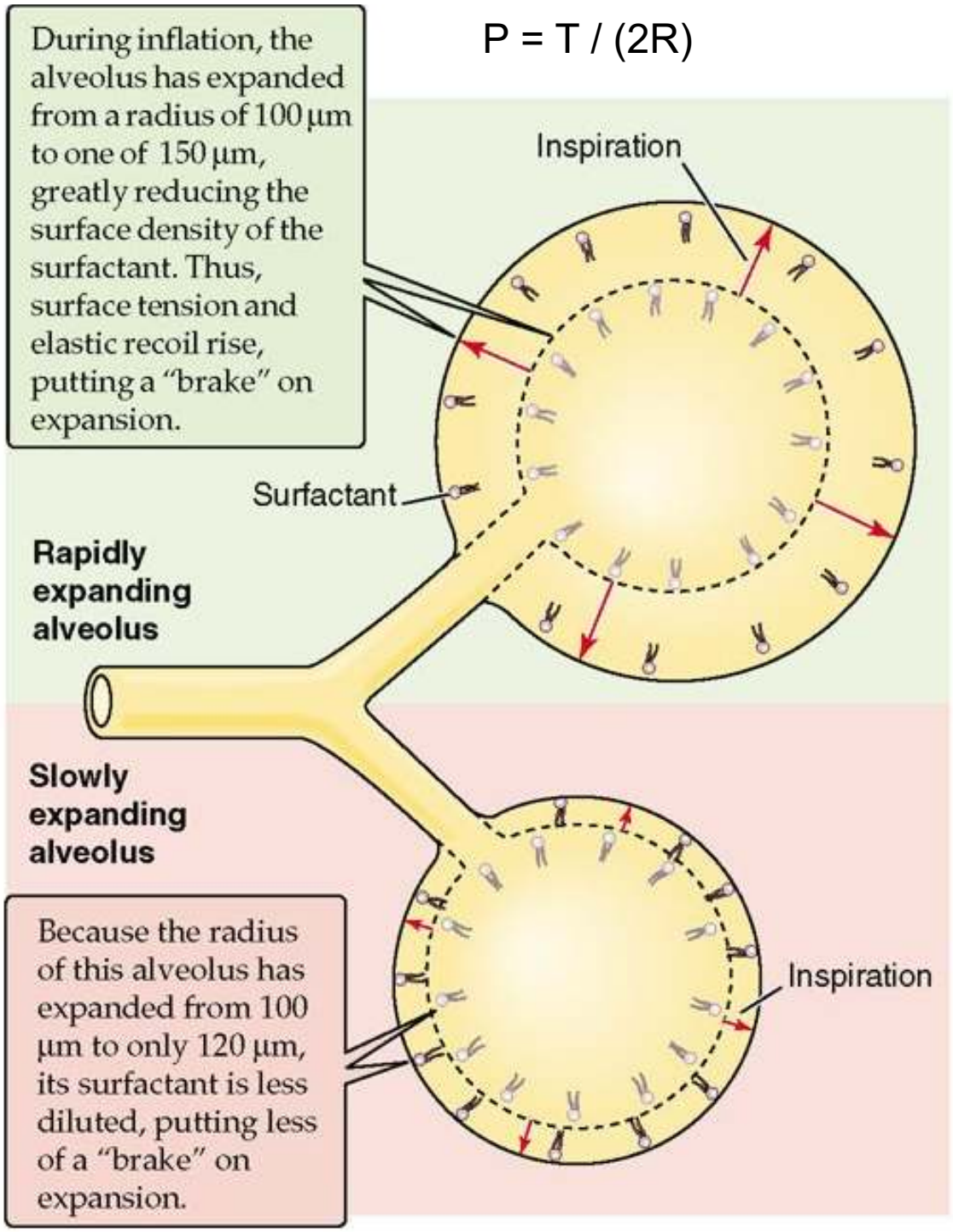

A EFFECT OF SURFACE TENSION ON COMPLIANCE
100
75
50
25
0
Lung volume (% TLC)
Inflating with liquid
Inflating with air
0
+10
+20
Transpulmonary pressure (P_{TP}) (cm H_2O)
B FLAT AIR-WATER INTERFACE
Air
Water
Because no intermolecular force pulls the surface molecules upward, the resultant vector is downward.
As the surface molecule dives into bulk fluid, the molecules that remain at surface develop opposing force (i.e., surface tension).
C DEFINITION OF SURFACE TENSION
Blade of length ℓ
ℓ
Water
$T = \frac{F}{\ell}$
Blade
Air
Expanding force, F
Water
D SPHERICAL AIR-WATER INTERFACE
Surface tension
Water
Air
P
Diving water molecules produce surface tension

Surfactant


alveolar space
alveolar surface
hypophase
granular pneumocyte
alveolar interstitium
endothelial cell
blood capillary
surfactant
counter-ion


surface
surface tension
1
2
3
4


1
2
3
4
1



$P = T / (2R)$

bez surfaktantu:

↑R

$P = T / (2R)$

se surfaktantem:

↑T ↑R

$P = T / (2R)$

bez surfaktantu:

↓R

$P = T / (2R)$

se surfaktantem:

↓T ↓R

$P = T / (2R)$

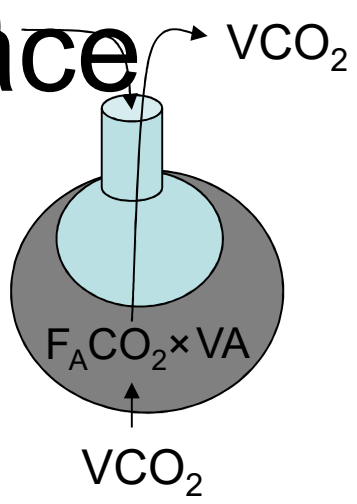
The „most important“ measure of respiratory system function

- pO2 & pCO2 in arterial blood - („Astrup“)
- O2 solubility in water is low => need of Hemoglobin
- **pO2** = 13,3 kPa = **100 Torr**
- Conversion: 1 Atm = 10 m H2O = 100 kPa = 760 Torr = 760 mmHg

…….. 1 kPa = 10 cm H2O = 7,6 Torr

- **pCO2** = **40 Torr** = 5,3 kPa

Alveolární ventilace



$$VCO2 = F_ACO2 * VA$$

$$VA = VCO2/F_ACO2$$

$$P_ACO2 = F_ACO2 \times \text{Barometrický tlak}$$

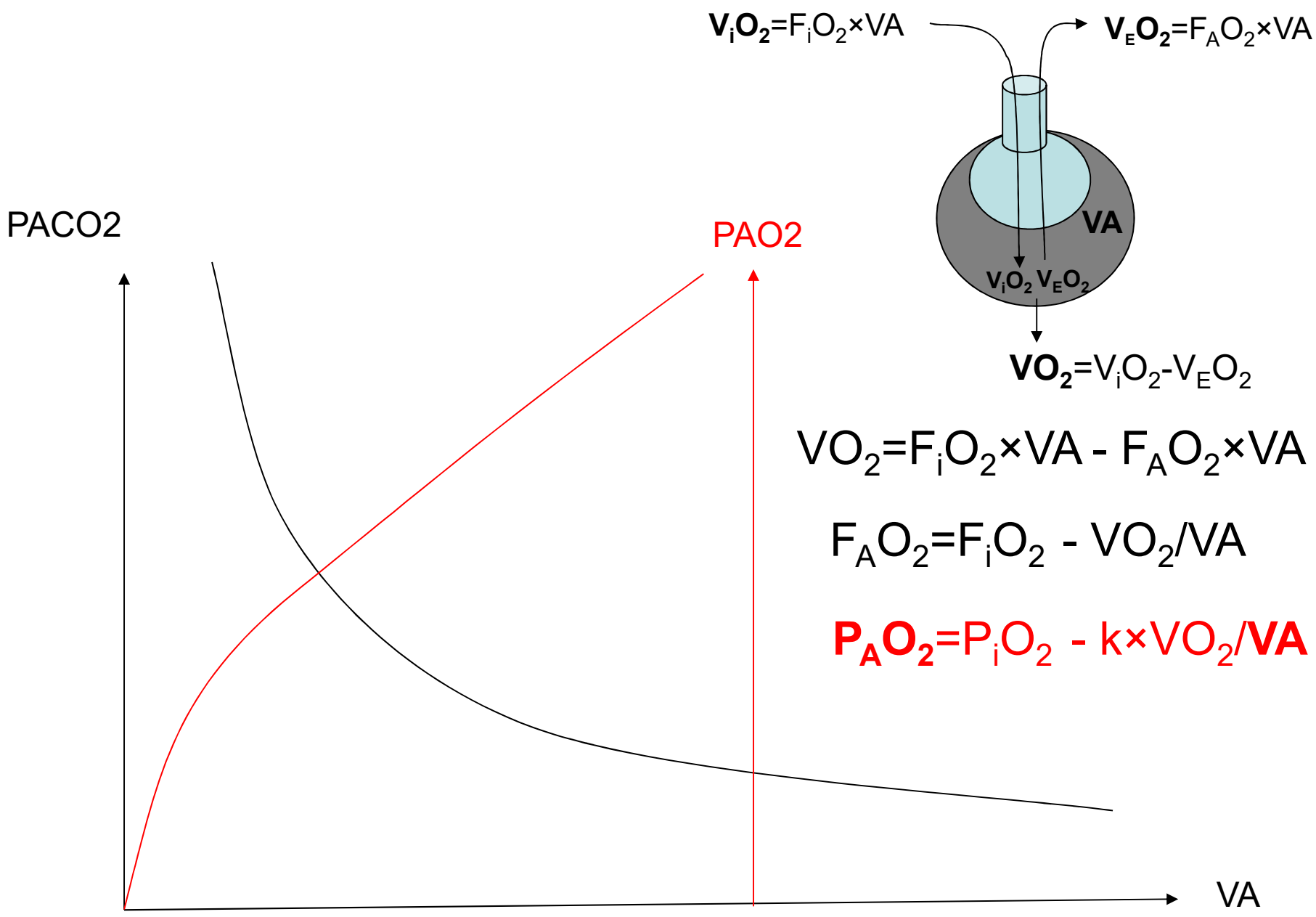
$$VA = k_1 \times VCO2/P_ACO2$$

$$P_ACO2 = k_2 \times VCO2/VA$$

STPD BTPS

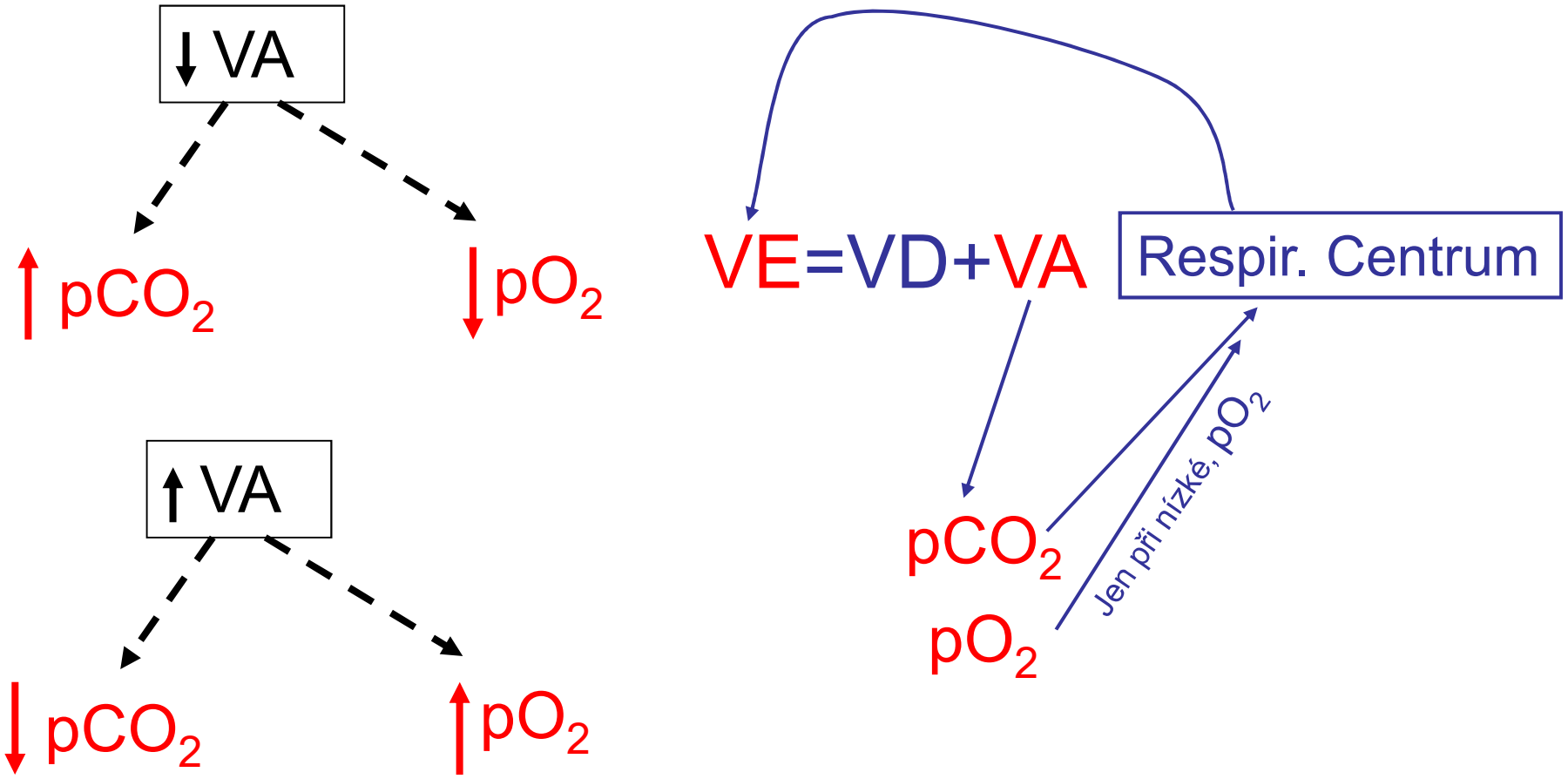
$$\frac{P \times V}{T} = R \qquad \frac{(P - P_{H_2O}) \times V_{BTPS}}{273 + t°_{patient}} = \frac{760 \times V_{BTPS}}{273}$$

$$P_ACO2_{[torr]} = 0{,}863 * VCO2_{[ml/min\ STPD]}/VA_{[l/min\ BTPS]}$$



$P_ACO2_{[torr]} = 0{,}863*VCO2_{[ml/min\ STPD]}/VA_{[l/min\ BTPS]}$

Chemorecepční řízení ventilace



Ventilation disorders

- **Lung impairment (mechanical properties change)**
  - **Obstructive disease -** ↑ increased resistance R of airways (R = "dynamic lung resistance")
  - **Restrictive disease** – ↓decreased lung compliance C ('↑ static resistance" `; C = 1/ static lung resistance)
- **Chest wall impairment**
  - ↓ decreased C of chest wall – severe scoliosis, extensive fibrosis, serial fractures
- **Insufficient activity of respiratory muscles** (// innervation or // muscle strength , // of CNS) – E.g.. Respiratory centre suppression in barbiturate poisoning, myasthenia gravis

Lung fibrosis = Interstitial lung disease (ILD)

- = diffuse parenchymal lung disease
- Inflamation in alveolar wall leads to scarring and collagen deposition
- Chest X-ray, pulmonary function testing, (lung biopsy)
- Affect the alveolar wall or the interstice of the lung (alveolar epithelium, capillary endothelium, basal membrane, interstice and perilymphatic tissue)
- Fibrosis may be a late sign

Causes of lung fibrosis/ ILD

- Inhalation of particles
  - 1. Azbestosis, silicosis, pneumoconiosis, = Pneumokonioser
  - 2. hypersensitivity (farmer's lung) = Alveolitis allergica
- Drug induced (Abio, chemo, Antiarrhythmic) =
- Connective tissue disease: Systemic sclerosis, Dermatomyositis, SLE, RA
- Infection: Atypical pneumonia, pneumocystis, TBC
- Lymphangitic carcinoma = maligne sygdromme

  Idiopatic: Sarcoidosis
- Idiopathic pulmonary fibrosis = Alveolitis fibrosa

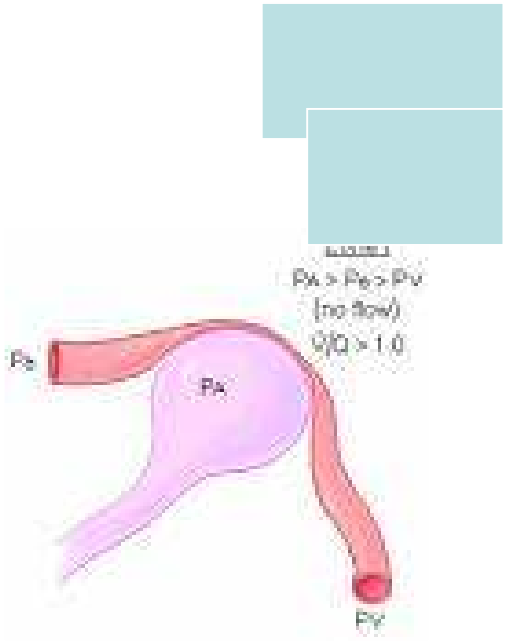
Fibrosing alveolitis= Idiopathic pulmonary fibrosis

- Unknown cause – Autoimmunity?
- People after 50 / 3 years life expectancy
- Symptoms:
  - Tachypnoe, cyanosis, finger clubbing
- Dg:
  - Chest X-ray
  - HRCT
  - Spirometry/whole body pletysmography
  - Blood gas analysis
  - Inflamatory and autoimmunity testing
- Biopsy and histology: Histology: Usual interstitial pneumonia

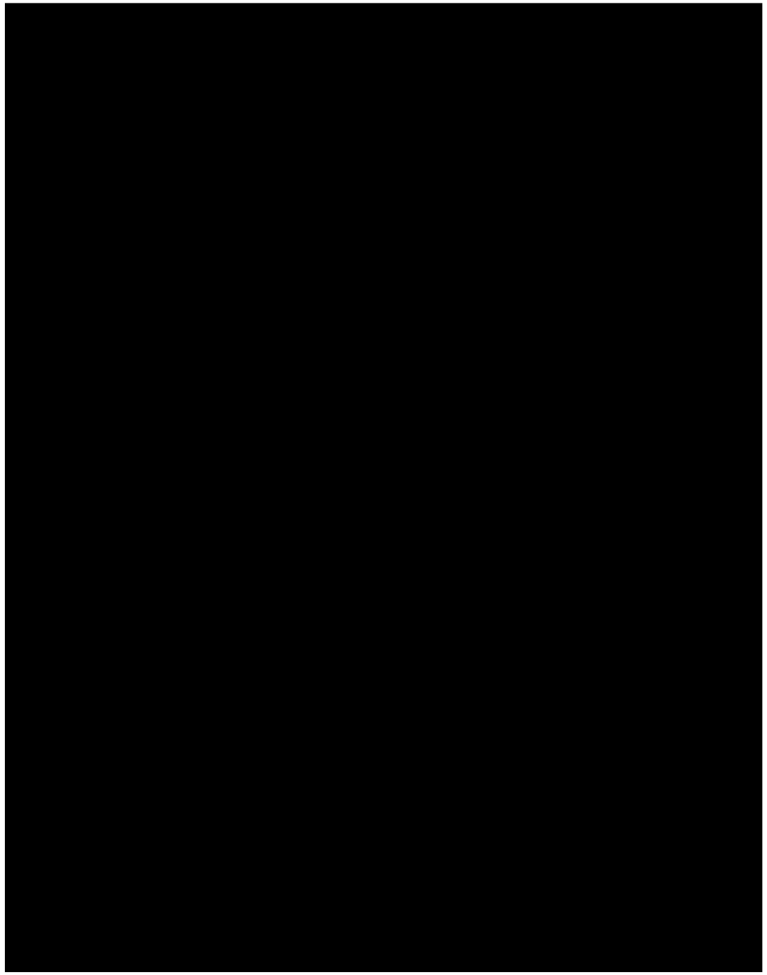
Možné poruchy funkce dýchacího systému

- Porucha **ventilace**
- Porucha **perfúze**
- Porucha **distribuce**
  ventilace a perfúze

  = ventilačně perfúzní nerovnováha
- Porucha **difúze**



Ventilace

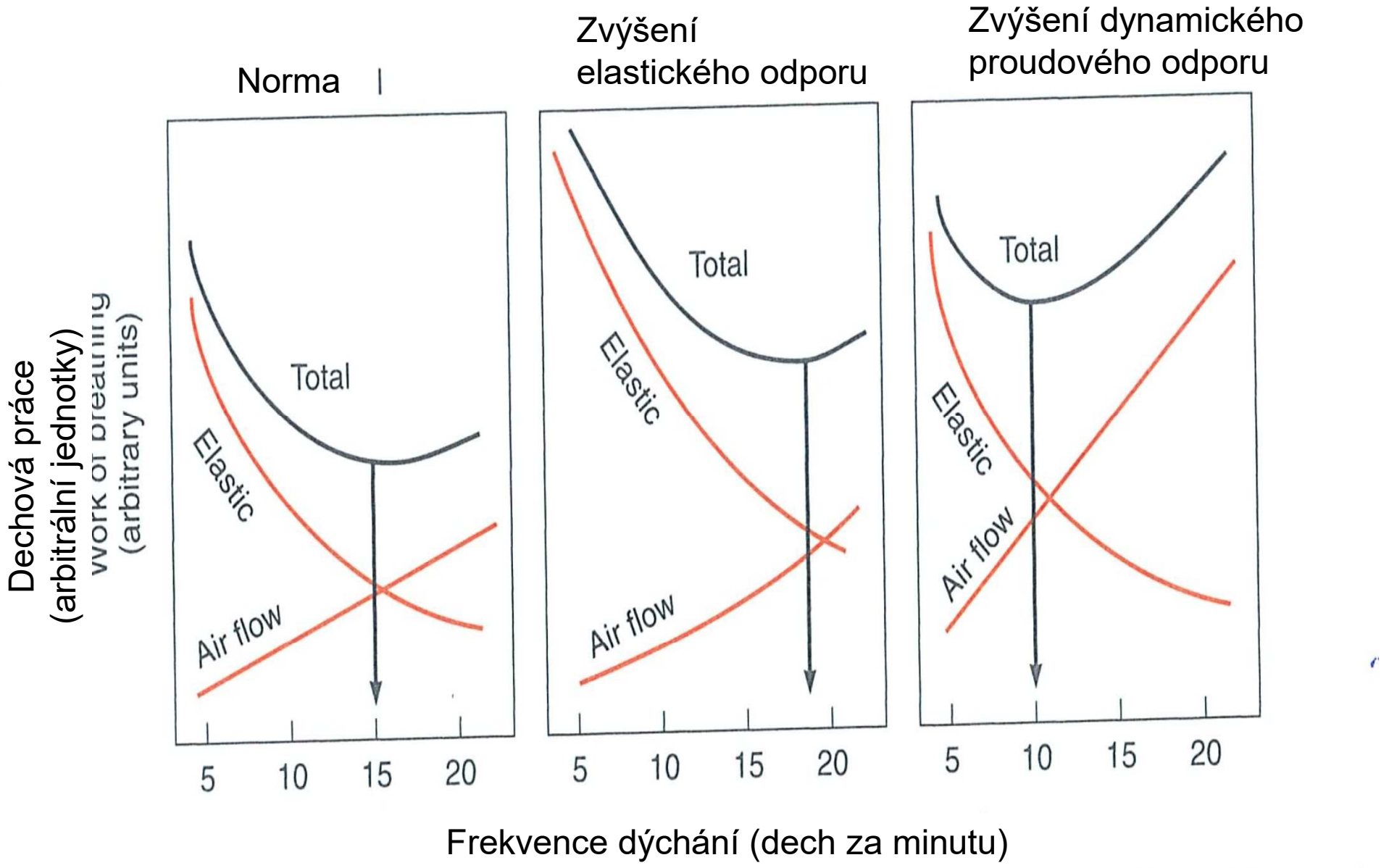


- Je uskutečňována respiračními svaly a bránicí, které mění nitrohrudní objem.
- Objemové změny způdonují změny tlaků
- Změna tlaků vedou k průtoku vzduchu
- (↑ tlak – expirium;
- ↓ tlak – inspirium) podle Ohmova zákona

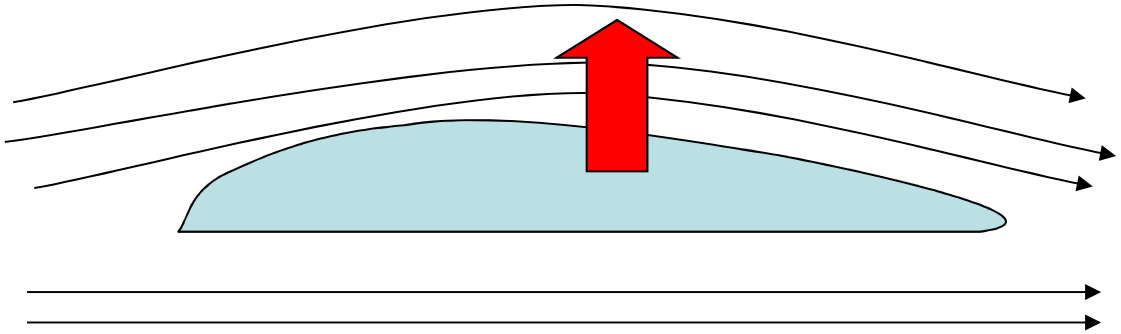
Poruchy ventilace

- **Zhoršení mechanických vlastností plic**
  - **Obstrukční choroby** - zvyšuje se odpor R dýchacích cest vůči proudění (odpor R = dynamický odpor plic)
  - **Restrikční poruchy** – snižuje se poddajnost plic C (poddajnost C = 1/ statický odpor plic)
- **Nedostatečná aktivita dýchacích svalů** (poruchy inervace či síly svalů, poruchy řízení ze strany CNS) – Př. Útlum dechového centra při otravě barbituráty, myasthenia gravis

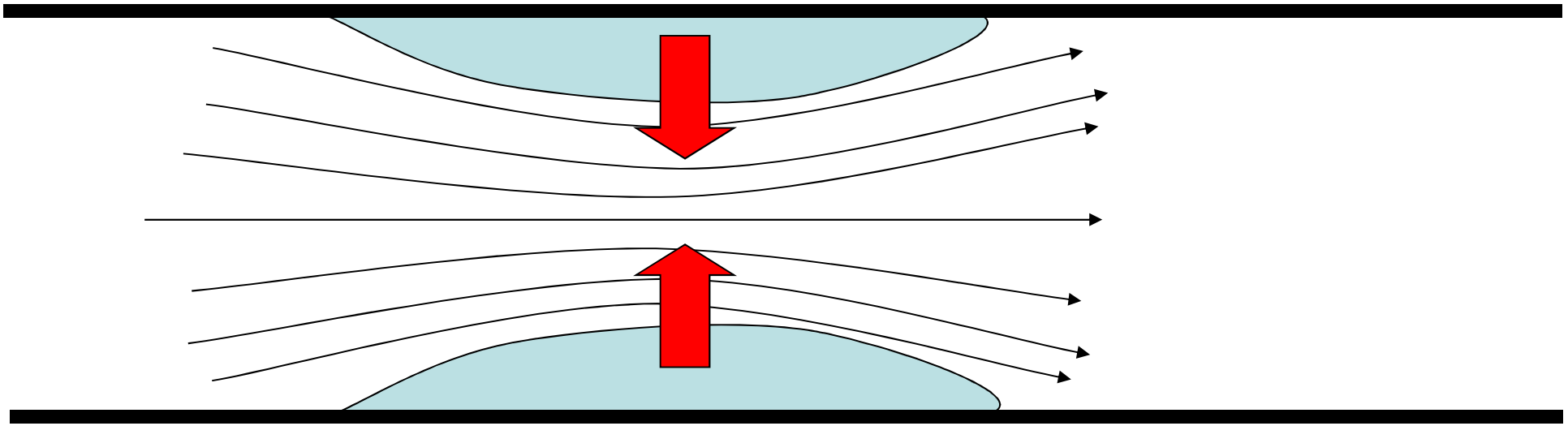
Norma Restrikční Obstrukční



Proč létá letadlo?



Zúžení bronchiolu (bronchokonstrikce, hlen…)



Shrnutí

- **Plicní poruchy podle cesty dýchacích plynů do krve –** poruchy 1) ventilace, 2) difúze

3) perfúze/ plus ventilačně perfusní nehomogenity,

4) ostatní a mimoplicní poruchy

- **Statické parametry** – intrapleurální tlak, surfaktant, **restrikční poruchy**
- **Dynamické parametry** – **obstrukční poruchy,** viz další přednáška
- **Typické restrikční** poruchy – **edém plic, ARDS/ atelektáza, plicní fibróza, hrudní deformity, pneumothorax, atd**
- **Posouzení** ventilační funkce = **spirometrie, pletysmografie –** budou podrobněji na vyšetřovacím semináři další týden

Děkuji

Vám za pozornost

-Toto je v jakékoliv formě (PDF, PPT, PPTX atd.) neoficiální výukový materiál

- pro interní potřebu
- nešířit
- pro dotazy kontaktujte: Petr.Marsalek@LF1.CUNI.CZ

Nadpis...