Patient-Self Inflicted Lung Injury (P-SILI)

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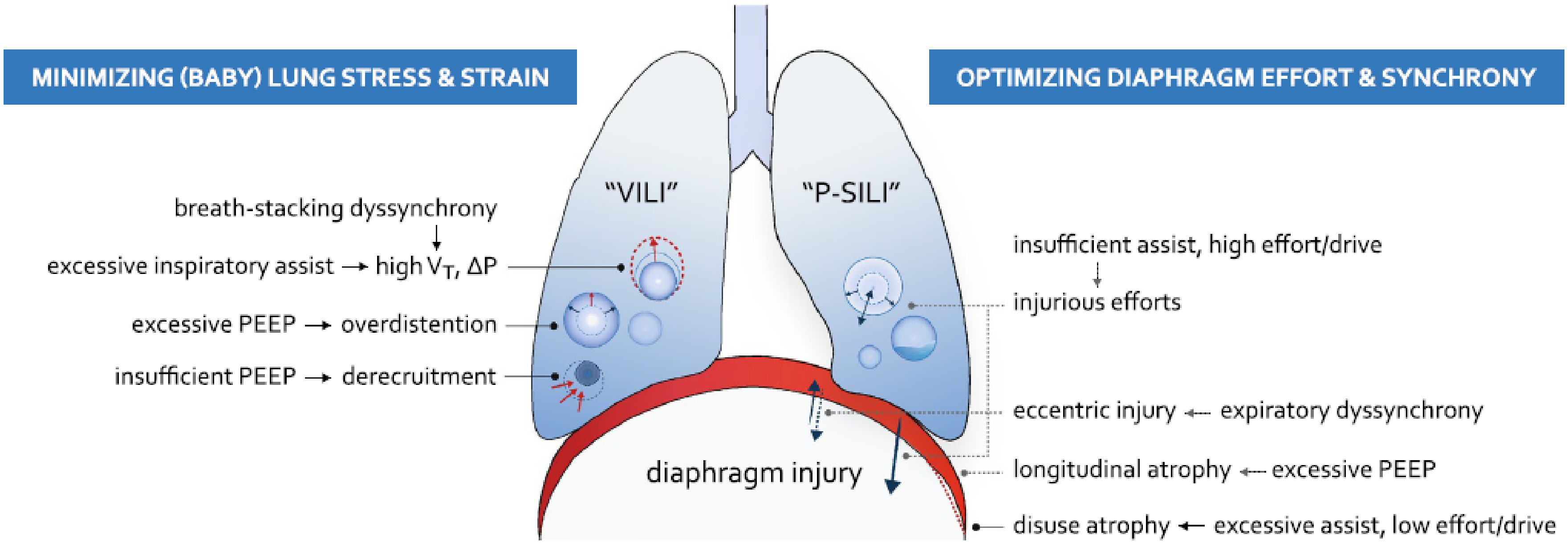
Nemám žiadny konflikt záujmov

Definícia P-SILI

„Adverse structural and functional changes in the lung arising from excessive global or regional lung stress and strain as a consequence of respiratory muscle action“

Nepriaznivé štrukturálne a funkčné zmeny pľúc vyplývajúce z excesívnych globálnych alebo regionálnych tlakových gradientov a objemov v dosledku činnosti respiračných svalov



Goligher EC, Intensive Care Med 2020

Patofyziológia P-SILI

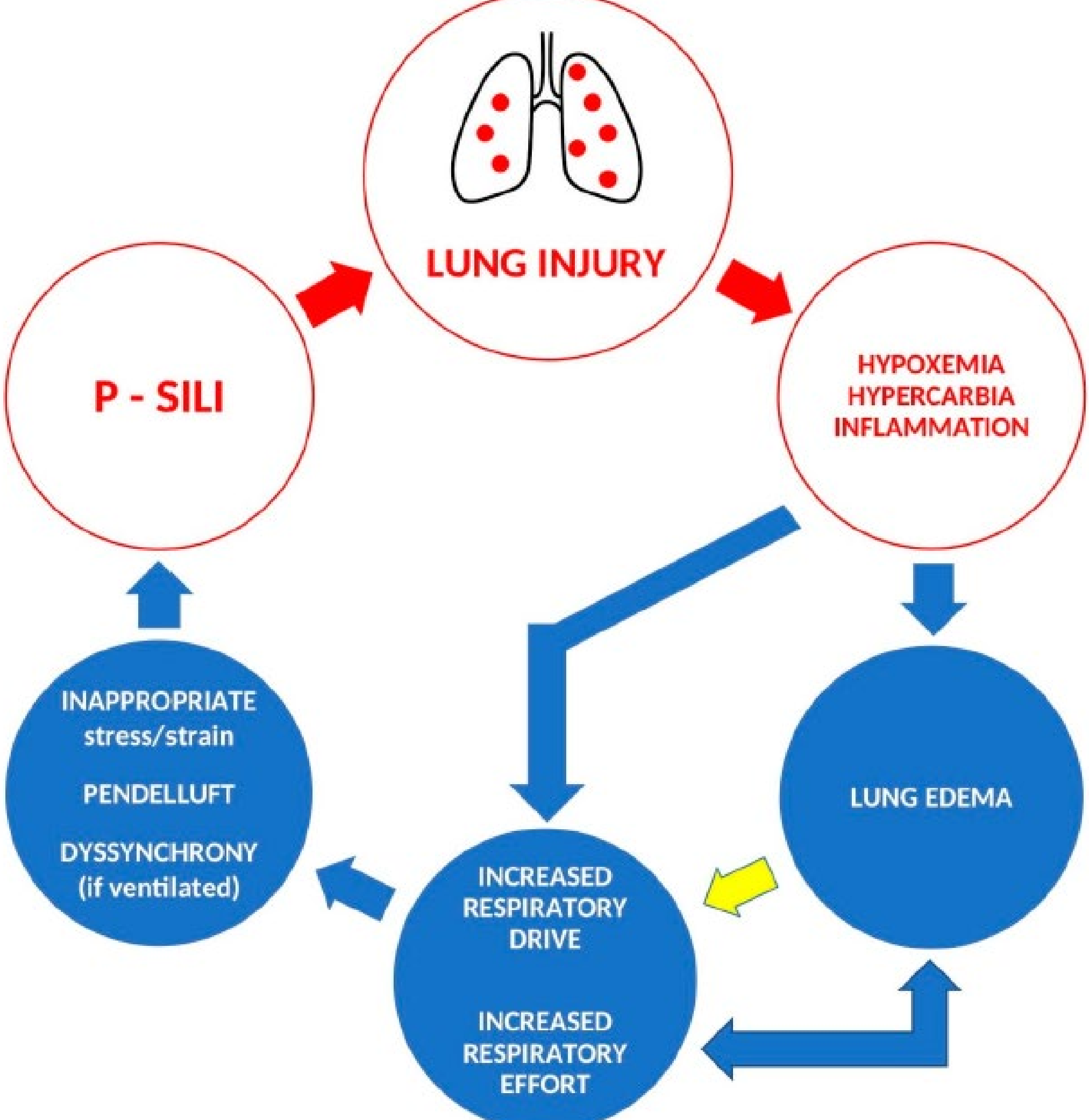
Vysoký respiračný drive + excesívna dychová práca:

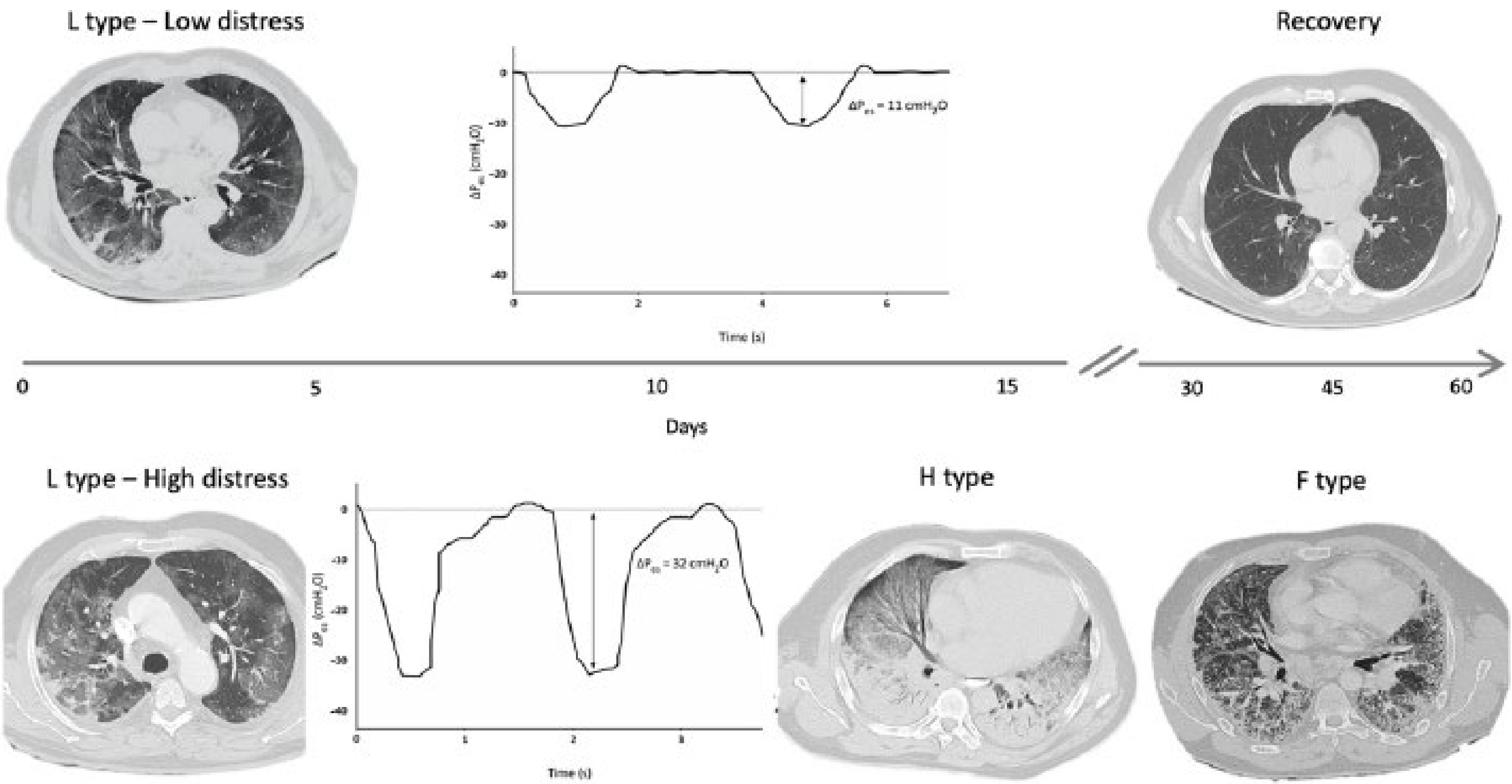
Excesívne transpulmonálne tlaky

- overdistenzia
- nehomogénna distribúcia objemov a tlakových gradientov
- cyklické otváranie / zatváranie a shear stress
- pendelluft

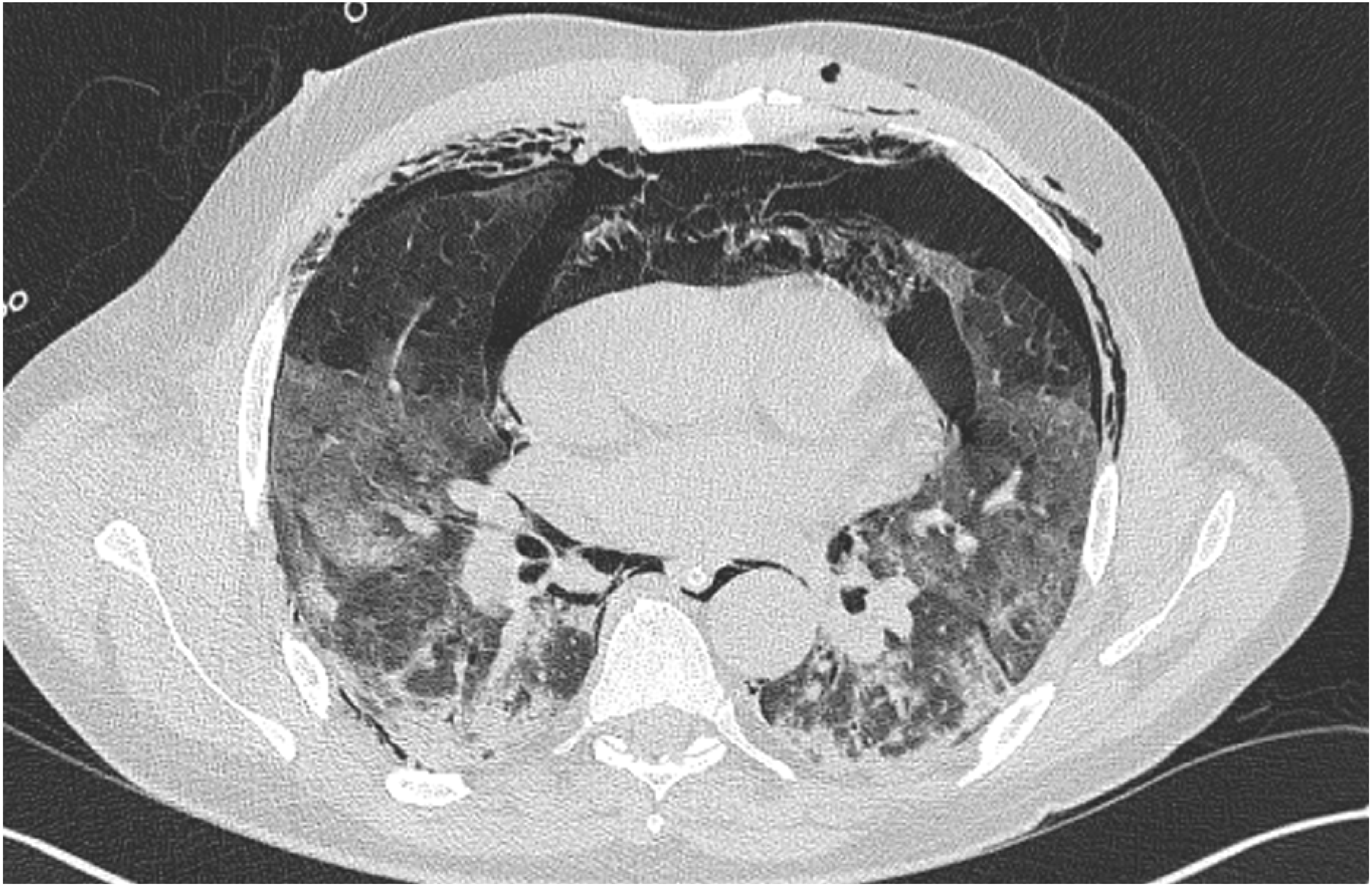
Vzostup transvaskulárnych tlakových gradientov

– agravácia pľúcneho edému

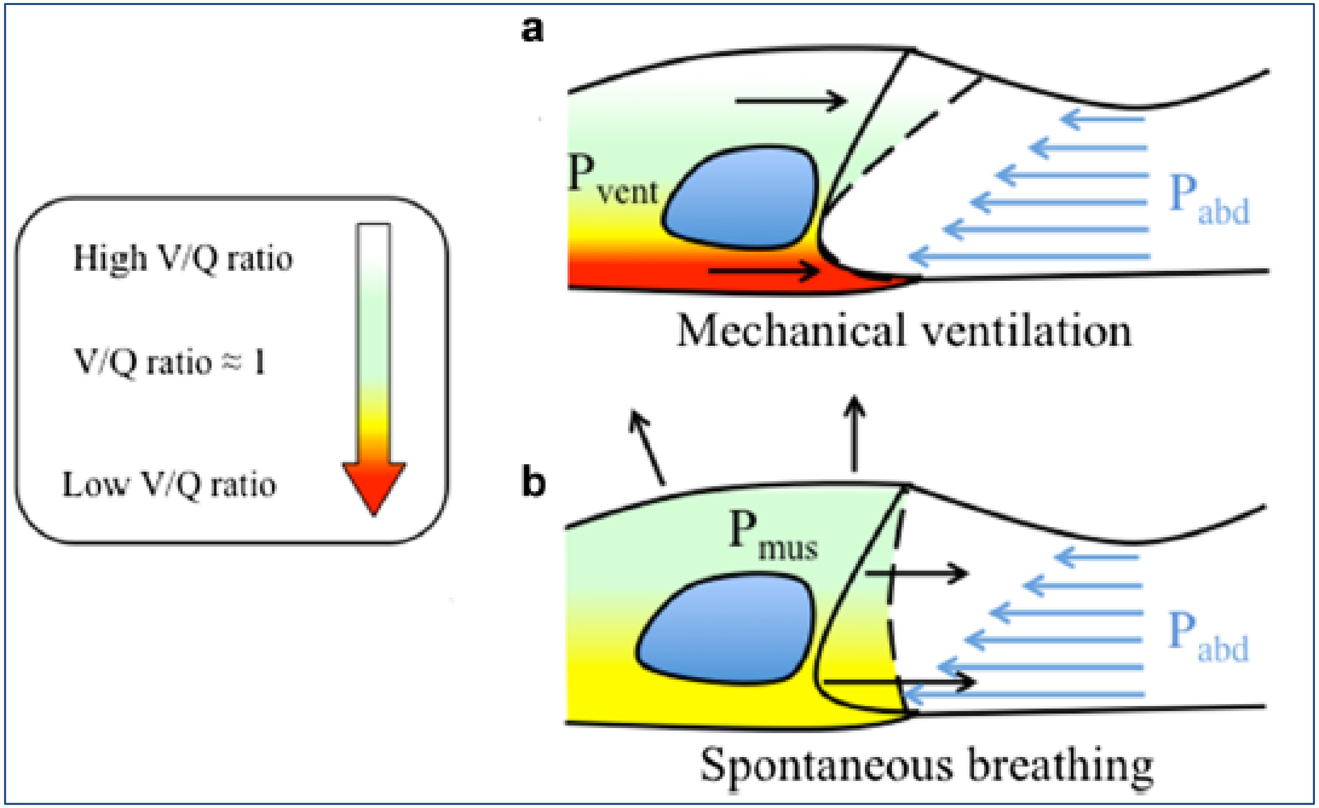

LUNG INJURY
P - SILI
HYPOXEMIA
HYPERCARBIA
INFLAMMATION
INAPPROPRIATE
stress/strain
PENDELLUFT
DYSSYNCHRONY
(if ventilated)
INCREASED
RESPIRATORY
DRIVE
INCREASED
RESPIRATORY
EFFORT
LUNG EDEMA



Tonelli S, J Clin Med 2021



Prečo spontánna ventilácia u ARDS?



Langer T, Critical Care 2016

Early spontaneous breathing for acute respiratory distress syndrome in individuals with COVID-19 (Review)

Cochrane Library
Cochrane Database of Systematic Reviews

What are the advantages of early spontaneous breathing in ARDS?

The advantage of spontaneous breathing during mechanical ventilation is the preserved movement of the diaphragm (the major muscle for breathing located under the lungs). It leads to better distribution of the inhaled air, especially in the pulmonary alveoli close to the diaphragm.

Can early spontaneous breathing be harmful in the treatment of ARDS?

During spontaneous breathing under mechanical ventilation, increased pressure fluctuations in the lungs may occur.

Hohmann F, Cochrane Database of Systematic Reviews 2022

Early spontaneous breathing for acute respiratory distress syndrome in individuals with COVID-19 (Review)

Cochrane
Library
Cochrane Database of Systematic Reviews

Is early spontaneous breathing beneficial in the treatment of lung failure in individuals with COVID-19?

People with severe COVID-19 can present with lung failure, which is called acute respiratory distress syndrome (ARDS). This requires invasive mechanical ventilation through a breathing tube. It is possible to allow breathing, triggered by the patient (called spontaneous breathing), whilst being on a ventilator. However, it is unclear whether this is beneficial for such individuals, especially in the early phase of ventilation.

Hohmann F, Cochrane Database of Systematic Reviews 2022

REVIEW Open Access

Formal guidelines: management of acute respiratory distress syndrome

Laurent Papazian[1*], Cécile Aubron[2], Laurent Brochard[3], Jean-Daniel Chiche[4], Alain Combes[5], Didier Dreyfuss[6], Jean-Marie Forel[1], Claude Guérin[7], Samir Jaber[8], Armand Mekontso-Dessap[9], Alain Mercat[10], Jean-Christophe Richard[11], Damien Roux[6], Antoine Vieillard-Baron[12] and Henri Faure[13]

R4.2.2 – After the acute phase of ARDS, the experts suggest that ventilation with a pressure mode allowing spontaneous ventilation can be used when ensuring that the tidal volume generated is close to 6 mL/kg PBW and does not exceed 8 mL/kg PBW.

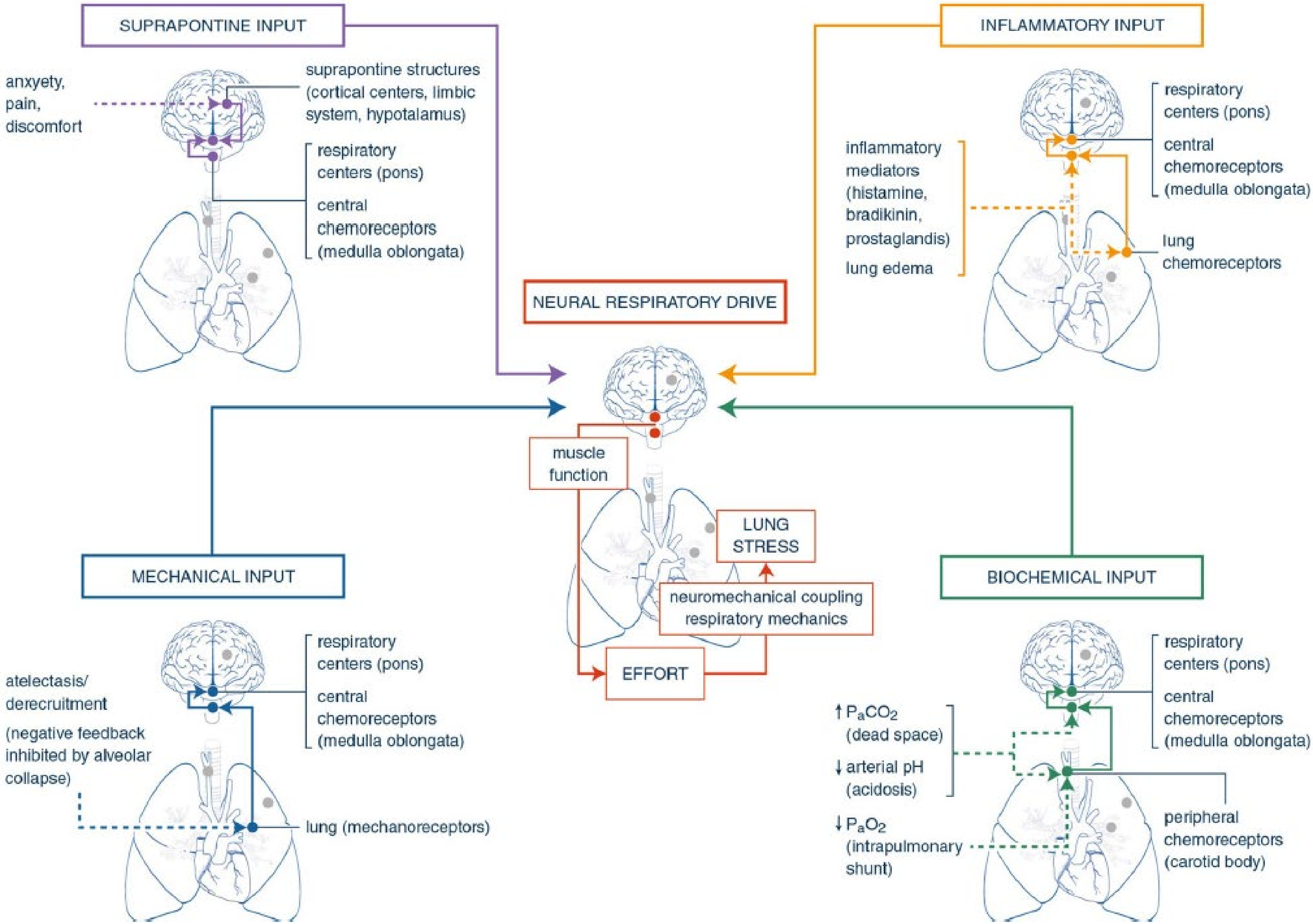
EXPERT OPINION

ESICM guidelines on acute respiratory distress syndrome: definition, phenotyping and respiratory support strategies

Možnosti monitorovania

…čo chcem monitorovať?

1. Respiračný drive – neurálny respiračný signál z CNS

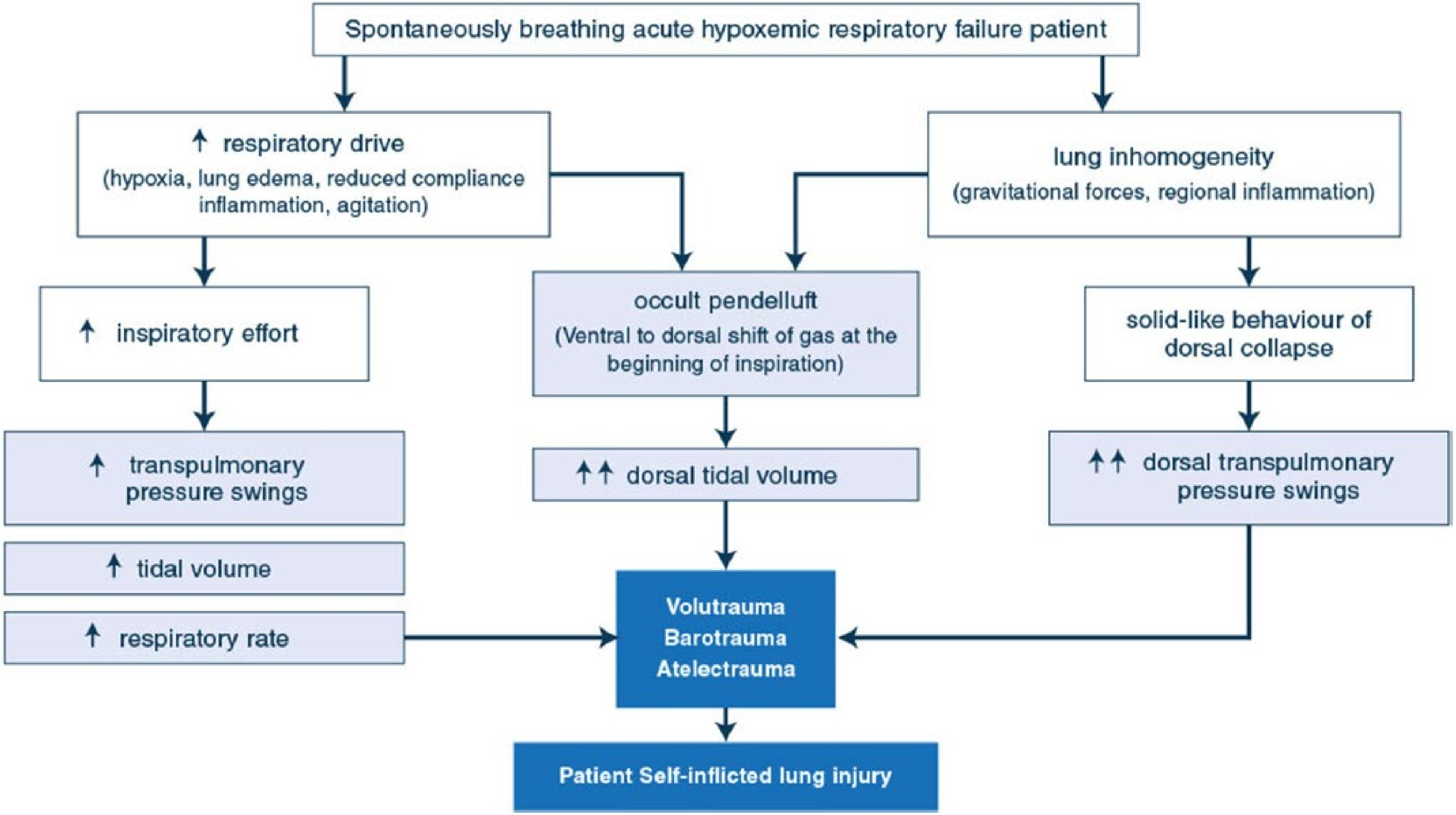


Spinelli E, Intensive Care Med 2020

Možnosti monitorovania

…čo chcem monitorovať?

1. Respiračný drive – neurálny respiračný signál z CNS
2. Svalová aktivita respiračných svalov (a jej efekt na respiračný systém)



Grieco DL, Intensive Care Med 2021

Parameter	Clinical meaning	Caveats as measure of respiratory drive	Caveats as measure of inspiratory effort
Require activation of the muscle		**Not useful during paralysis**	**Respiratory muscle weakness: overestimation of inspiratory effort**
$Eadi_{peak}$ (μV)	Maximal electrical activation of the diaphragm during tidal breathing	Only if diaphragm is the main inspiratory muscle Variable between patients	$EAdi_{peak} \times NME_{occ}$ to estimate Pmus

Telias I, Curr.Opin.Crit.Care 2020

Parameter	Clinical meaning	Caveats as measure of respiratory drive	Caveats as measure of inspiratory effort
Require muscle contraction		**Muscle weakness: underestimation of respiratory drive (except P0.1)** **Not useful during paralysis**	
ΔPeso (cmH_2O)	Negative deflection in pleural pressure during inspiration		Some underestimation of effort
Pmus–PTPes (cmH_2O–cmH_2O s/min)	Pressure generated by all inspiratory muscles		Require calculations and Ecw
Pdi–PTPdi (cmH_2O–cmH_2O s/min)	Pressure generated by the diaphragm		Requires calculation
WOB (J/l)	Patient's work during inspiration		Require calculations and Ecw. Work only during volume

Telias I, Curr.Opin.Crit.Care 2020

Parameter	Clinical meaning	Caveats as measure of respiratory drive	Caveats as measure of inspiratory effort
Require muscle contraction		**Muscle weakness: underestimation of respiratory drive (except P0.1) Not useful during paralysis**	
Tfdi (%)	Reflects diaphragmatic contraction. Association with clinical outcomes		Diaphragmatic contribution to inspiration. Not continuous
EXdi (cm)	Vertical displacement the diaphragm		Idem + valid during unassisted breathing
P0.1 (cmH_2O)	Drop in Paw during first 100 ms of occluded breath. Available in most ventilators	Not influenced by mechanics and muscle dysfunction; however, some muscle contraction required (i.e., absence of paralysis)	Muscle weakness: overestimation of inspiratory effort. Still useful for low and high effort
RR, VT	Interaction: inspiratory effort, ventilator and mechanics	RR: not variable $PaCO_2$ 23–45 mmHg, decreases with opiods and insufflation. VT: Influenced by settings and mechanics.	Dependent on settings and mechanics.
Paw and flow waveform	Patient–ventilator interaction results in unique waveform patterns	Informative on the status of drive	

Why Physiology Is Critical to the Practice of Medicine

A 40-year Personal Perspective

Martin J. Tobin, MD

Clin Chest Med 40 (2019) 243–257
https://doi.org/10.1016/j.ccm.2019.02.012

WORK OF BREATHING

P-SILI pri UPV - monitorovanie

Vizuálna analýza tlakovej a prietokovej krivky na ventilátore

„...visual analysis of flow/time and pressure/time curves alongside clinical examination provide crucial information on patient–ventilator interaction and dyssynchrony“

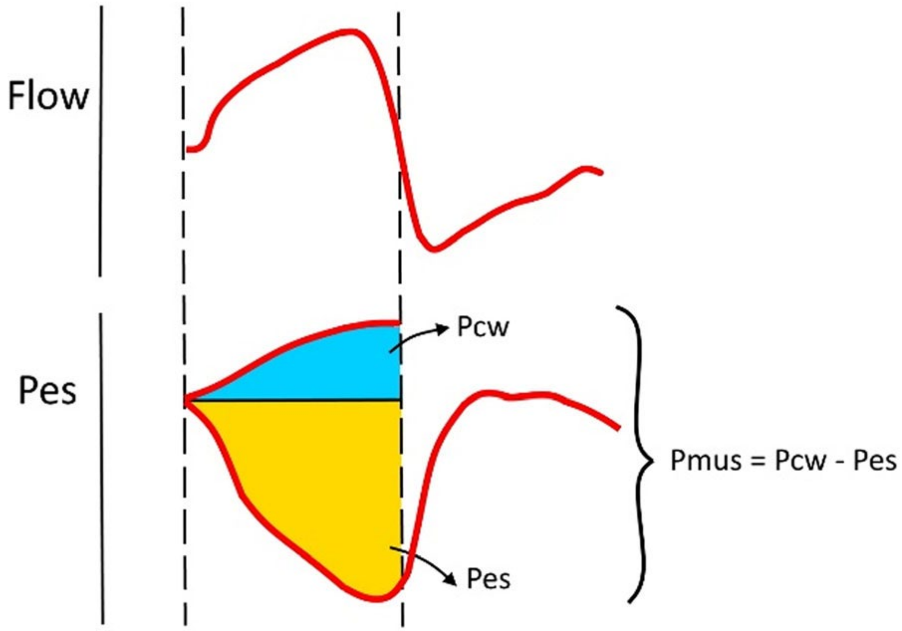
P-SILI pri UPV - monitorovanie

Esofageálny ($P_{es)}$ **a transpulmonálny tlak (**P_{tp}**)**

- „zlatý štandard" monitorovania tlakových gradientov respiračního systému generovaných respiračnými svalmi (respiratory muscle pressure, P_{mus})
- zmeny P_{es} (esophageal pressure swings; DP_{es}) – odrážajú zmeny v pleurálnom tlaku – možnosť výpočtu transpulmonálneho driving pressure (P_{aw} – P_{es})
- invazívna metóda

P-SILI pri UPV - monitorovanie

Pressure-time product (PTP)



PTP

Bertoni M, Critical Care 2020

P-SILI pri UPV - monitorovanie

Airway occlusion pressure v 100 ms ($P_{0.1}$)

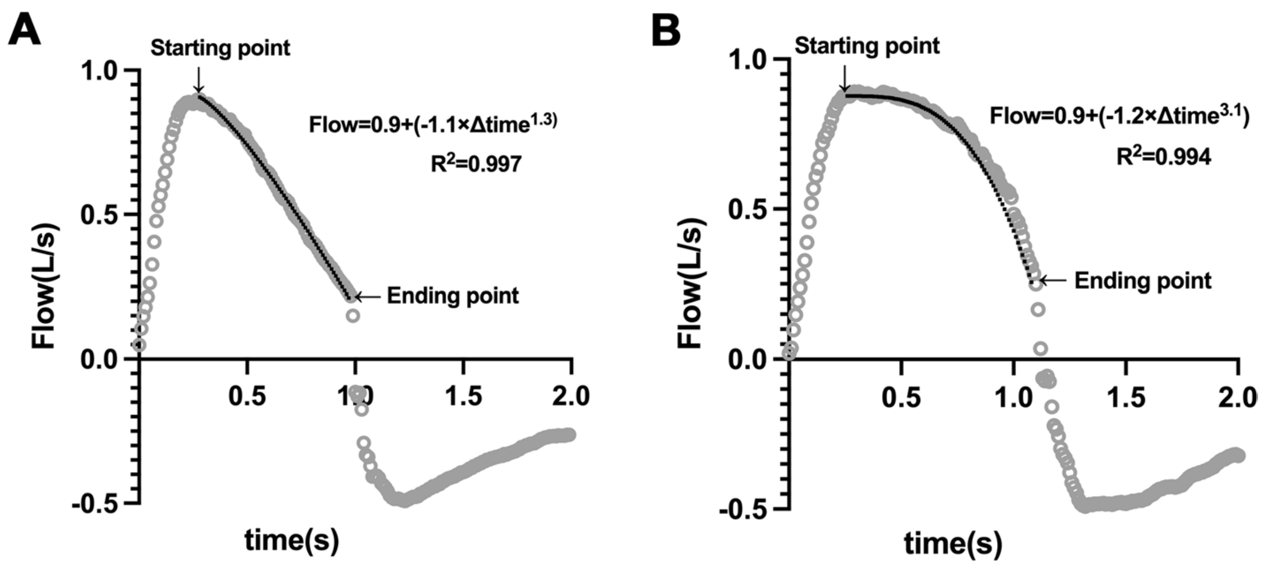
- hodnota tlaku v dýchacích cestách při krátkej oklúzii 100 ms po začatí inspíria

- $P_{0.1}$ < 1.0 cm H_2O – nedostatočné dychové úsilie
- $P_{0.1}$ > 3.5 cm H_2O – excesívne dychové úsilie
- rutinný parameter dostupný na väčšine moderných ventilátorov

Expiratory occlusion pressure (DP_{occ}) – celková výchylka P_{aw} pri oklúzii DC

P-SILI pri UPV - monitorovanie

Flow index – algoritmus (software) analýzy inspiračnej prietokovej krivky



Miao MI, Annals of Intensive Care 2022

P-SILI pri UPV - monitorovanie

P_{mus}/EAdi (PEI) index – tlak generovaný inspiračnými svalmi vo vzťahu k elektrickej aktivite bránice

Electrická impedančná tomografia (EIT) - detekcia non-homogénnej distribúcie, asynchrónií, pendelluftu

Esophageal pressure	Peak end-inspiratory transpulmonary pressure (P_L)	≤20 cmH_2O
	Swing in transpulmonary pressure (ΔP_L)	≤15 cmH_2O
	Peak inspiratory muscle pressure (P_{mus})	5–10 cmH_2O
	Esophageal pressure swing (ΔP_{es})	3–8 cmH_2O
	Transdiaphragmatic pressure swing (ΔP_{di})	5–10 cmH_2O
	Pressure time product (PTP)	50–100 cmH_2O/s/min
Occlusion maneuvers	Inspiratory occlusion for plateau airway pressure (P_{plat})	≤30 cmH_2O
	Inspiratory occlusion for driving pressure ($\Delta P_{aw} = P_{plat} - PEEP$)	≤15 cmH_2O
	Expiratory occlusion for estimated P_{mus}	5–10 cmH_2O
	Airway occlusion pressure ($P_{0.1}$)	1.5–3.5 cmH_2O
Electromyography	Diaphragm electrical activity (EA_{di})	Uncertain

Bertoni M, Critical Care 2020

P-SILI – možnosti intervencií

Analgosedácia – redukcia respiračního drive; “lung-protective sedation”

CAVE – škály monitorovania hĺbky sedácie neodrážajú intenzitu respiračného drive!

- inhalačná sedácia

Parciálna neuromuskulárna blokáda – redukcia excesívneho respiračního úsilia

P-SILI – možnosti intervencií

Nastavenie ventilačných parametrov – manipulácia so všetkými (!)

parametrami definujúcimi dychový cyklus

Asynchrony	Action
Inspiratory flow mismatching	Increase gas flow; decrease respiratory drive and assess adequacy of analgesia and sedation; check for dyspnea.
Short or prolonged cycling	Increase or decrease inspiratory period; check cycling off in pressure support; use proportional modes.
Double triggering	Increase ventilator inspiratory time; try pressure support, titrating flow termination criteria to improve synchrony, or proportional modes; consider paralyzing agents if tidal volume is too elevated (> 8 mL/kg) in ARDS or in patients with risk factors for developing lung injury.
Double triggering due to reverse triggering	Decrease sedation; check breathing frequency; consider paralyzing agents if tidal volume is too elevated (> 8 mL/kg) in ARDS or in patients with risk factors for developing lung injury.
Expiratory muscle contraction due to prolonged cycling	Reduce inspiratory period by checking cycling off and tidal volume; check for comfort.
Ineffective inspiratory efforts	Check trigger sensitivity and excessive air trapping; check for excessive assistance (excessive set frequency and or inspiratory time during controlled modes or excessive pressure support ventilation level); counterbalance auto-PEEP by using external PEEP; check for dyspnea; consider proportional modes.
Auto-triggering	Check trigger sensitivity; check for leaks and water in the ventilator circuit.
Expiratory muscle contraction during expiration	Check for excessive assistance; check for air trapping and auto-PEEP.

Subirá C, Respiratory Care 2018

P-SILI – možnosti intervencií

Nastavenie ventilačných parametrov – manipulácia so všetkými (!)

parametrami definujúcimi dychový cyklus

Poloha

Tekutinová terapia

Teplotný management

Nutričné parametre

Závery

P-SILI je závažný patofyziologický proces vyplývajúci z excesívneho respiračního úsilia

Monitoring sa opiera o základné klinické zhodnotenie známok zvýšenej dychovej práce a vizuálnu analýzu tlakovej a prietokovej krivky ventilátoru

Moderné ventilátory umožňujú monitorovanie niektorých parametrov zvýšeného dychového úsilia ($P_{0.1}$; P_{occ}) bez nutnosti ďaľších intervencií

EIT a softwarové nástavby (flow index) predstavujú neinvazívne metódy pokročilého monitoringu

Monitorovanie esofageálneho tlaku a derivovaných hodnot umožňuje invazívne hodnotenie transpulomálneho driving pressure

Závery

Prevencia a terapia sa opierajú o cielenú analgosedáciu, prisposobenie ventilačních parametrov, a celkový management pacienta s ARDS

Inhalačná sedácia a parciálna nervová blokáda možu byť využité pri prevencii a terapii P-SILI

Pokiaľ známky excesívneho dychového úsilia pretrvávajú i pri dostatočnej analgosedácii a úprave ventilačních parametrov, pravdepodobne to znamená že stav ešte nie je zvládnutý dostatočne k zahájeniu weaningu

BE CAREFUL

THIS MACHINE HAS NO BRAIN... USE YOUR OWN