

# Oxygenoterapie od brýlí po high flow

TOMÁŠ TYLL



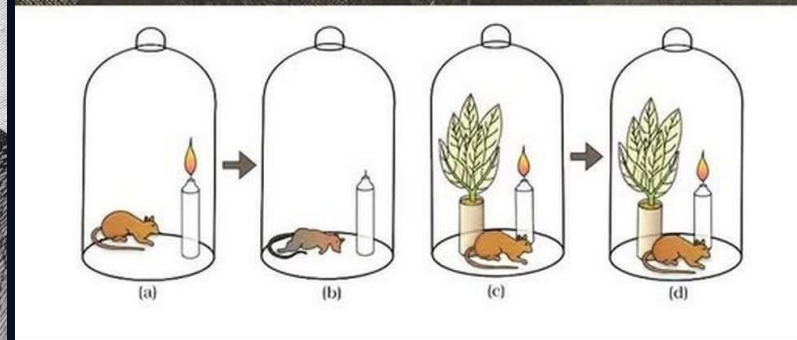
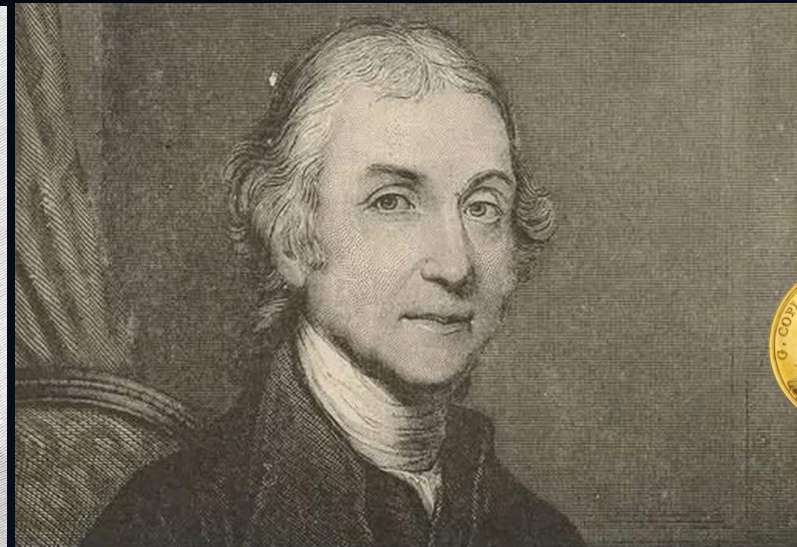
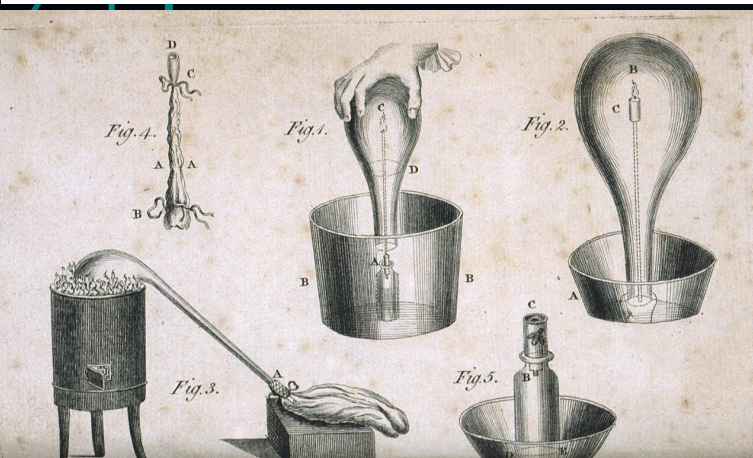
**ÚVN**

ÚSTŘEDNÍ VOJENSKÁ NEMOCNICE  
Vojenská fakultní nemocnice Praha

- Závan historie
- Konvenční OT
- Vysokoprůtoková OT
- Nežádoucí účinky
- Stručná fyziologie
- Závěr



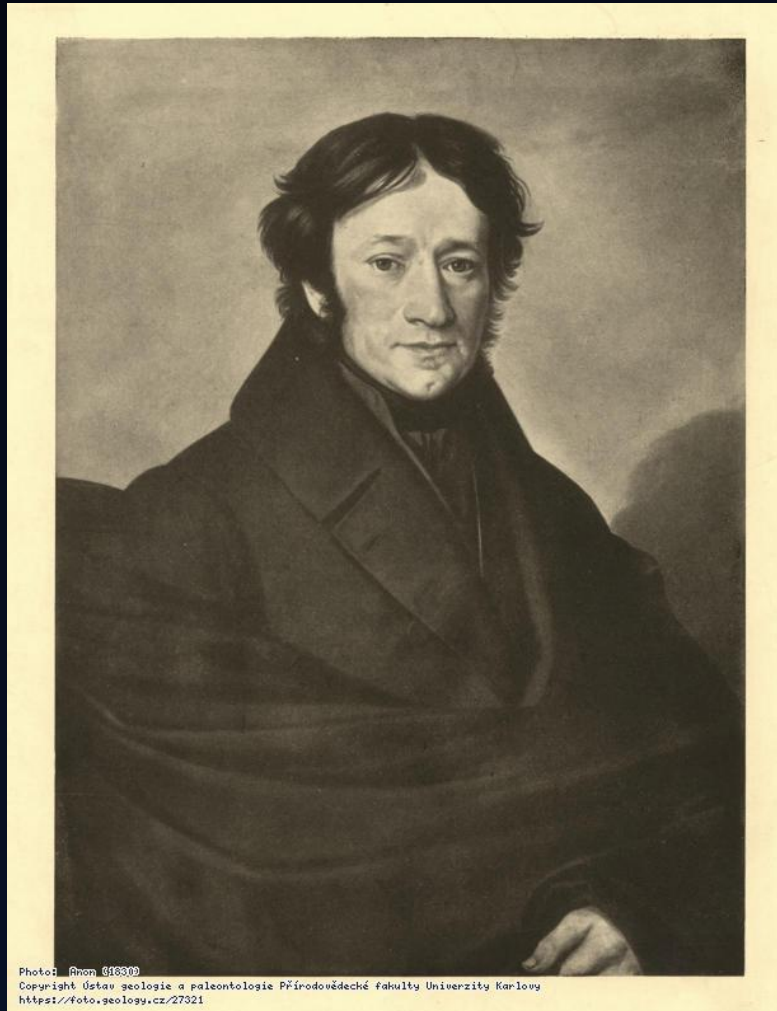
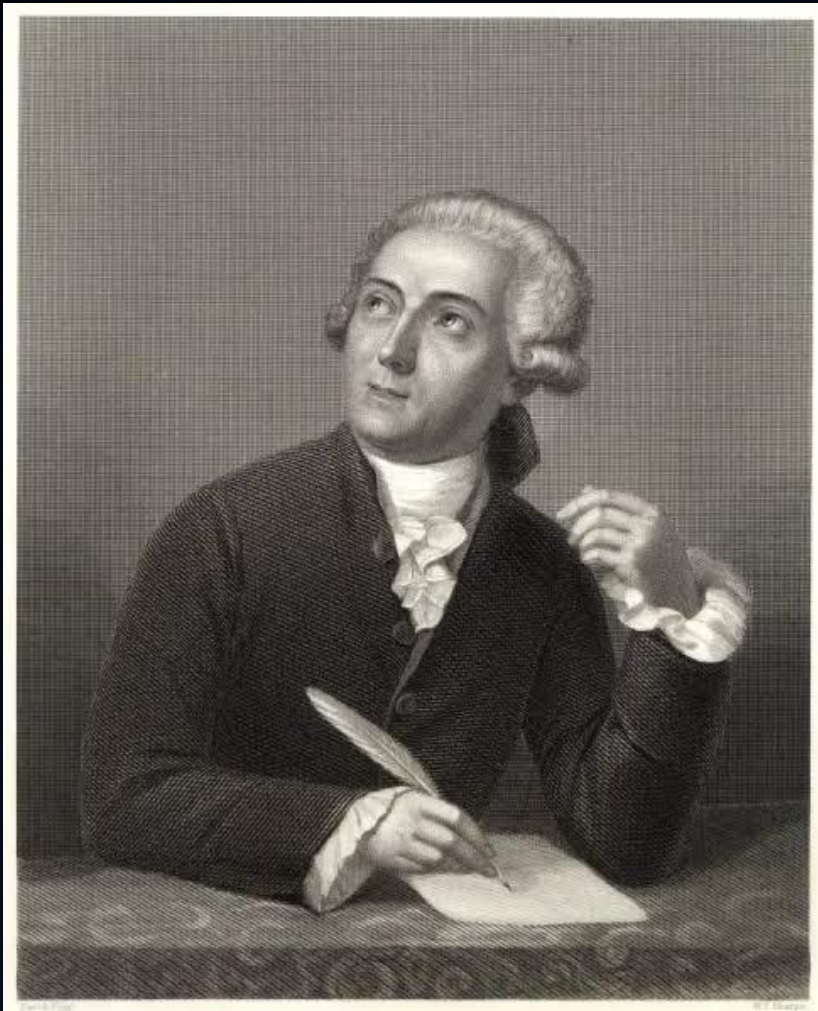
*Kde nemůže žít plamen, tam nemůže žít žádné zvíře, které dýchá.*



1772 C. W. Scheele objevuje kyslík a nazývá jej ohnivý vzduch. Objev však publikoval až r. 1777.

1774 J. Priestly objevuje kyslík o dva roky později nezávisle na Scheeleovi. Publikuje však svůj objev první.

**oxys** (ostrý, kyselý) a **geinas** (tvořit)



# THE HISTORY OF OXYGEN THERAPY\*



1885

The first recorded use of oxygen was used to treat a patient with pneumonia



1917

Oxygen is administered to treat gassed soldiers in World War I



1970s

Industrial gas suppliers start delivering large oxygen cylinders fitted with brass regulators to patients' homes



1772

Oxygen to be used as a drug is discovered by a Swedish chemist

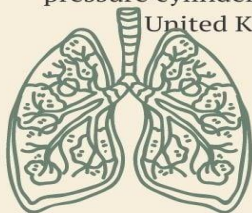


1887

Oxygen devices, capable of storing oxygen to be used intermittently, become available for use

1950

Oxygen begins to be prescribed to patients suffering from COPD with small, portable, high-pressure cylinders in the United Kingdom



1990s

Throughout the 90's physicians begin to prescribe oxygen more readily for patients and their diseases.



# Types of oxygen therapy



|                                              | Nasal cannula                       | Simple face mask                    | Reservoir mask          | Nasal high flow                            | CPAP                                                               | Ventilator                                             |
|----------------------------------------------|-------------------------------------|-------------------------------------|-------------------------|--------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------|
|                                              | Low oxygen flow                     | Moderate oxygen flow                | High oxygen flow        | Very high oxygen flow                      | Specialised form of pressure positive ventilation.                 | Invasive form of pressure positive ventilation         |
|                                              | For regular hospital and home care. | For regular hospital and home care. | For hospital care.      | Used in situations of respiratory failure. | Can be used for patients with apnea or to maintain an open airway. | Required when a patient's lungs are severely impaired. |
| <b>OXYGEN FLOW</b>                           | <b>1-6</b><br>Litres/min            | <b>5-10</b><br>Litres/min           | <b>15</b><br>Litres/min | <b>UP TO 70</b><br>Litres/min              | <b>15</b><br>Litres/min                                            | AS PER LIFE SUPPORT NEEDS                              |
| <b>FIO2*<br/>FRACTION OF INSPIRED OXYGEN</b> | <b>24-50%</b>                       | <b>40-60%</b>                       | <b>60-90%</b>           | <b>UP TO 100%</b>                          | <b>UP TO 100%</b>                                                  | <b>UP TO 100%</b>                                      |



# „Konvenční (Prostá) oxygenoterapie“



## Alveolar Arterial O<sub>2</sub> Gradient

FIO<sub>2</sub>= 21%

PAO<sub>2</sub>= 100

PaO<sub>2</sub>= 95

O<sub>2</sub> Sat= 99%

FIO<sub>2</sub>= 50%

PAO<sub>2</sub>= 331

PaO<sub>2</sub>= 326

O<sub>2</sub> Sat= 100%

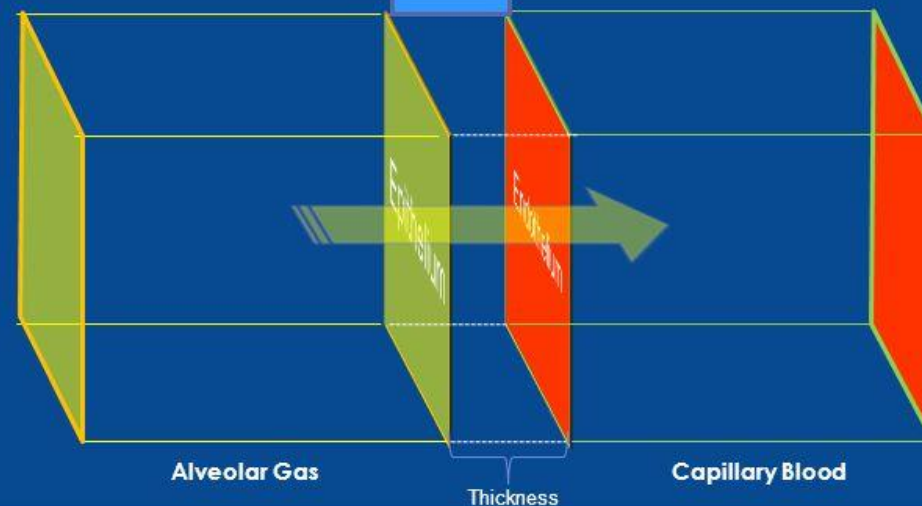
FIO<sub>2</sub>= 100%

PAO<sub>2</sub>= 663

PaO<sub>2</sub>= 657

O<sub>2</sub> Sat= 100%

5



Middle East Critical Care Assembly

# OXYGEN DELIVERY DEVICES

| Device                                                                                                     | Flow Rate (L/min) | FiO <sub>2</sub> (%) | Clinical Use                  |
|------------------------------------------------------------------------------------------------------------|-------------------|----------------------|-------------------------------|
| NASAL CANNULA            | 1–6 L/min         | 24–44%               | Mild hypoxia, stable patients |
| SIMPLE FACE MASK         | 5–10 L/min        | 40–60%               | Moderate hypoxia              |
| VENTURI MASK             | As per adapter    | 24–60% (fixed)       | COPD, precise oxygen control  |
| PARTIAL REBREATHER MASK  | 6–10 L/min        | 50–70%               | Moderate–severe hypoxia       |
| NON-REBREATHER MASK      | 10–15 L/min       | 60–95%               | Emergency, severe hypoxia     |

## CLINICAL TIP STRIP

- Always humidify oxygen >4 L/min
- Target SpO<sub>2</sub>: 94–98% (88–92% in COPD)

⚠ **Disclaimer** – For educational purposes only. Not medical advice. Consult a qualified healthcare professional.



@thereal.arjun18



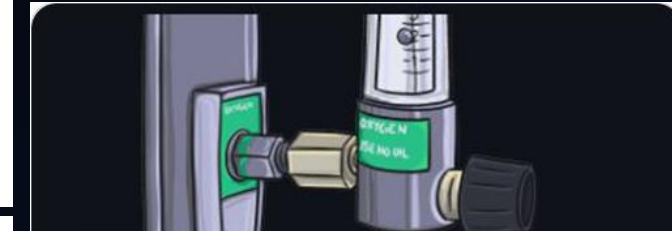
@Arjun kharadi



MedNurseAcademy97

# Oxygen Delivery With an Open Oxygen Mask and Other Conventional Masks: A Simulation-Based Study

Morgan E Sorg and Robert L Chatburn



## CLINICAL SCENARIO

A patient presents to the ED with:

RR = 40 breaths/min

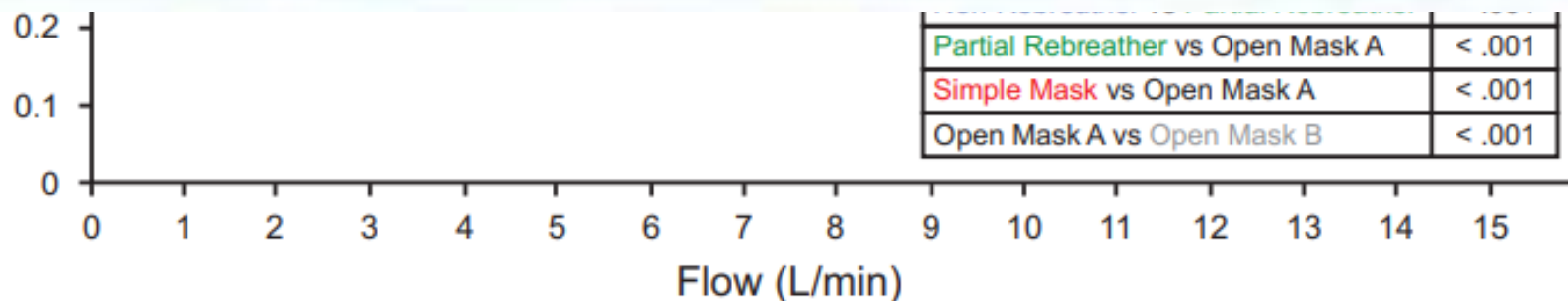
$V_T$  (Tidal Volume) = 750 mL

## MINUTE VENTILATION

$$\begin{aligned} &RR \times V_T \\ &= 40 \times 750 \text{ mL} \\ &= 30,000 \text{ mL/min} \\ &= 30 \text{ L/min} \end{aligned}$$



This means the patient  
**REQUIRES 30 L/min of TOTAL INSPIRATORY FLOW.**



## CLINICAL TIP STRIP

- Always humidify oxygen >4 L/min
- Target SpO<sub>2</sub>: 94–98% (88–92% in COPD)

- Efektivita ?



# Humidification in the Intensive Care Unit

- The human nose and upper respiratory tract have an exceptional ability to warm and humidify inspiratory gas before reaching the alveoli. Continued oxygen therapy without heating and humidification causes dryness and inflammation of the airway mucosa. This leads to impaired ciliary motility, impaired sputum excretion, and pneumonia due to the increased viscosity of secretions.
- In the worst cases, **fatal complications**, such as airway obstruction, may also occur. Thus, **proper heating and humidification are essential** for safe respiratory management.

The Essentials

Antonio M. Esquinas  
Editor

*Second Edition*

# Is humidified better than non-humidified low-flow oxygen therapy? A systematic review and meta-analysis

2017 <https://doi.org/10.1111/jan.13323>

- Meta 8876
- Bakteriální kontaminace
- Respirační infekce
- Suché sliznice
- Krvácení
- Dyskomfort
- Tlak na hrudi
- Zápach

TABLE 1 The characteristics of included studies

| Study                                                         | Country | Sample (T/C) | Department                                         | Intervention                   |                                 |             | Outcomes               |
|---------------------------------------------------------------|---------|--------------|----------------------------------------------------|--------------------------------|---------------------------------|-------------|------------------------|
|                                                               |         |              |                                                    | Time for oxygen administration | Fluid for oxygen humidification | Oxygen flow |                        |
| Andres et al. (1997)                                          | Canada  | 126/111      | NA                                                 | >2 days                        | NA                              | <4 L/min    | a, b, c, d, e, f       |
| Campbell et al. (1988)                                        | USA     | 86/99        | Respiratory department                             | NA                             | NA                              | 5 L/min     | a, b, c, d, e          |
| Franchini et al. (2016)                                       | Brazil  | 10/8         | Basic health units/<br>Pulmonary outpatient clinic | >12 h                          | NA                              | NA          | f, g                   |
| Cai et al. (2013)                                             | China   | 51/29        | Veteran ward                                       | >4 days                        | SDW                             | NA          | a, b, j, k             |
| Zeng et al. (2009)                                            | China   | 30/30        | Neurosurgery department                            | >5 days                        | SDW                             | NA          | a, b                   |
| Chen and Guo (2015)                                           | China   | 328/352      | Emergency department                               | NA                             | SDW                             | NA          | a, b, c, d, i, k, l    |
| Chen et al. (2012)                                            | China   | 235/245      | Cadiovascular department                           | >12 h                          | SDW                             | <4 L/min    | a, b, c, d, e, h       |
| Han (2011)                                                    | China   | 400/400      | Respiratory department                             | >24 h                          | NA                              | 4 L/min     | a, b, k                |
| Huang et al. (2014)                                           | China   | 40/40        | Blood purification centre                          | NA                             | SDW                             | 1–4 L/min   | a, e, i, k             |
| Huang et al. (2014)                                           | China   | 507/490      | Cadiovascular department                           | >12 h                          | NA                              | <4 L/min    | a, b, c, l, m          |
| Li, Wang, Wang, et al. (2010), Li, Wang, Zhong, et al. (2010) | China   | 418/348      | Neurosurgery/<br>respiratory department            | >12 h                          | NA                              | < 4 L/min   | a, b, c, d, e, h       |
| Li et al. (2011)                                              | China   | 130/130      | NA                                                 | >7 days                        | SDW                             | NA          | a, b, i, k             |
| Li et al. (2015)                                              | China   | 173/168      | NA                                                 | >72 h                          | SDW                             | <4 L/min    | a, b, k                |
| Liu and Chen (2015)                                           | China   | 174/174      | The dialysis centre                                | 3–4.5 h                        | SDW                             | NA          | a, b, e, i             |
| Lou et al. (2016)                                             | China   | 101/99       | Orthopaedic department                             | NA                             | SDW                             | <4 L/min    | a, b, d, i, k, l       |
| Ning et al. (2014)                                            | China   | 201/199      | ICU                                                | >24 h                          | SDW                             | ≤4 L/min    | a, i, k, l             |
| Tian et al. (2012)                                            | China   | 316/218      | CCU                                                | ≥72 h                          | SDW                             | <4 L/min    | a, b, l                |
| Wu (2016)                                                     | China   | 90/90        | Respiratory department                             | 24–72 h                        | SDW                             | 1–4 L/min   | a, b, e, j, l, n, o    |
| Xia et al. (2014)                                             | China   | 86/99        | Emergency department                               | NA                             | NA                              | 1–2 L/min   | a, b, c, d             |
| Yang et al. (2014)                                            | China   | 165/65       | NA                                                 | >5 days                        | SDW                             | NA          | a, b, c, d, h, i       |
| Yang et al. (2015)                                            | China   | 184/201      | NA                                                 | >24 h                          | NA                              | <4 L/min    | a, b, d, h, i, k, l, m |
| Yang and Yu (2015)                                            | China   | 70/70        | Emergency department                               | <48 h                          | SDW                             | <4 L/min    | a, b, k, l             |
| Yuan et al., (2011)                                           | China   | 72/78        | Respiratory department                             | NA                             | SDW                             | ≤4 L/min    | a, b, d, i             |
| Yuan et al. (2013)                                            | China   | 256/230      | NA                                                 | >24 h                          | SDW                             | NA          | a, b, d, e, i          |
| Zheng et al. (2015)                                           | China   | 60/60        | Cadiovascular department                           | >24 h                          | SDW                             | <4 L/min    | a, b, d, e, g, h, i, l |
| Zhou et al. (2015)                                            | China   | 50/50        | Neurosurgery department                            | NA                             | SDW                             | 1–4 L/min   | k, m, p                |
| Yue et al. (2015)                                             | China   | 224/210      | Respiratory department                             | >5 days                        | SDW                             | 2 L/min     | a, b, d, h, i          |

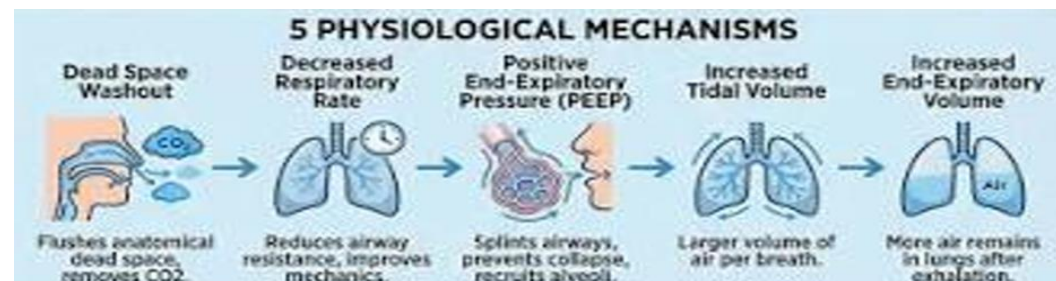
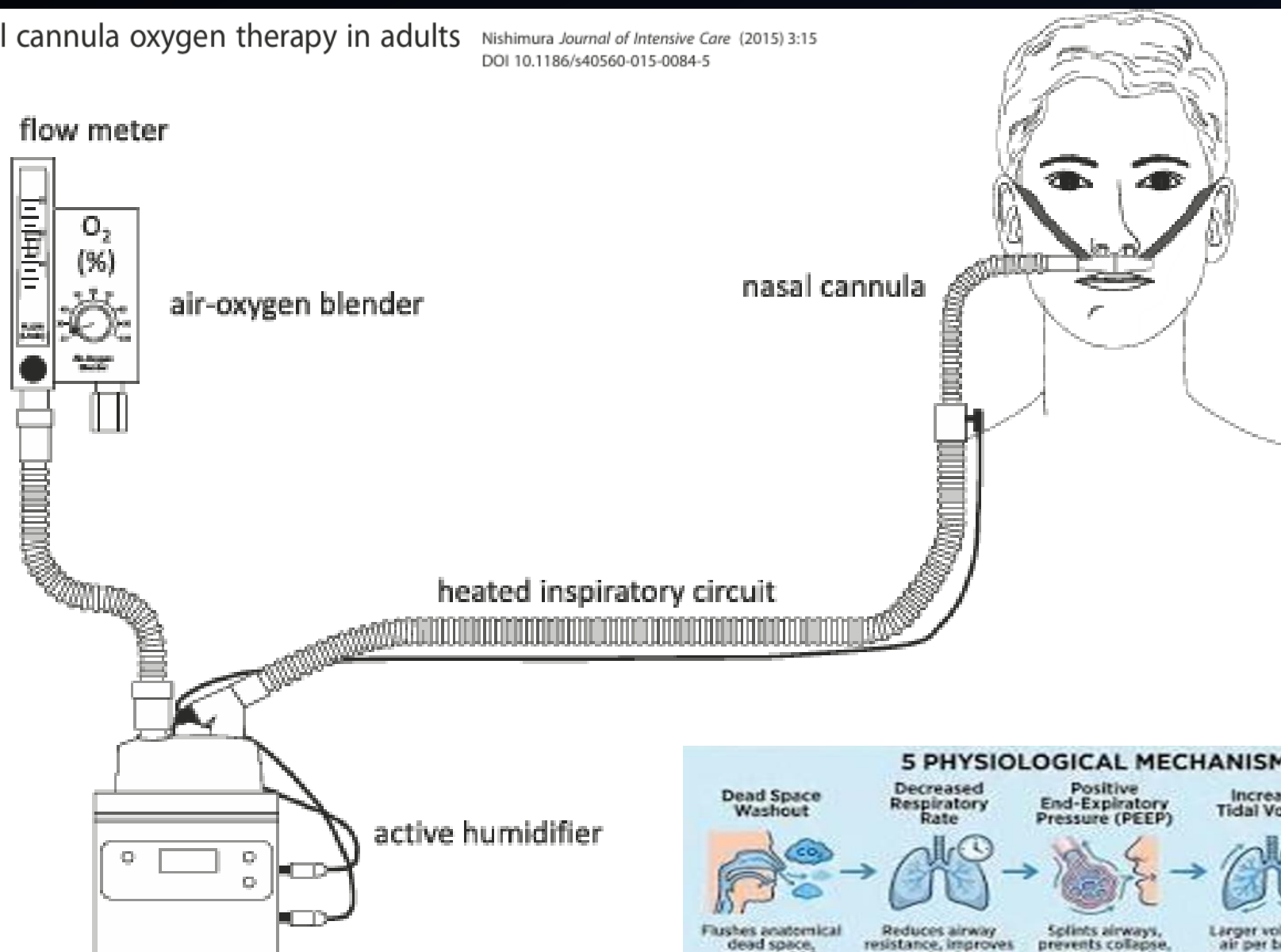
NA, not available; SDW, sterile distilled water; a, non-humidified nose; b, non-humidified throat and non-humidified mouth; c, headache; d, chest discomfort; e, nosebleed; f, cough; g, sleep problems; h, nausea; i, the smell of oxygen during oxygen therapy; j, SpO<sub>2</sub>; k, bacteria contaminations of humidifier bottles; l, the mean operating time for oxygen administration; m, respiratory infections; n, heart rate; o, respiratory rate; p, the cost of oxygen therapy.

The routine humidification of oxygen in low-flow oxygen therapy is not justifiable and non-humidified oxygen tends to be more beneficial. However, considering that the quality of most included studies is poor, rigorously designed, large-scale randomized controlled trials are still needed to identify the role of non-humidified oxygen therapy.

# Vysokoprůtoková oxygenoterpie

High-flow nasal cannula oxygen therapy in adults

Nishimura *Journal of Intensive Care* (2015) 3:15  
DOI 10.1186/s40560-015-0084-5



# OXYGEN DELIVERY DEVICES

| Device                                                                                                                | Flow Rate (L/min) | FiO <sub>2</sub> (%) | Clinical Use              |
|-----------------------------------------------------------------------------------------------------------------------|-------------------|----------------------|---------------------------|
|                                                                                                                       |                   |                      |                           |
| HIGH-FLOW NASAL CANNULA (HFNC)<br> | Up to 60 L/min    | Up to 100%           | Acute respiratory failure |
|                                                                                                                       |                   |                      |                           |

## CLINICAL TIP STRIP

- Always humidify oxygen >4 L/min
- Target SpO<sub>2</sub>: 94-98% (88-92% in COPD)

⚠ **Disclaimer** – For educational purposes only. Not medical advice. Consult a qualified healthcare professional.



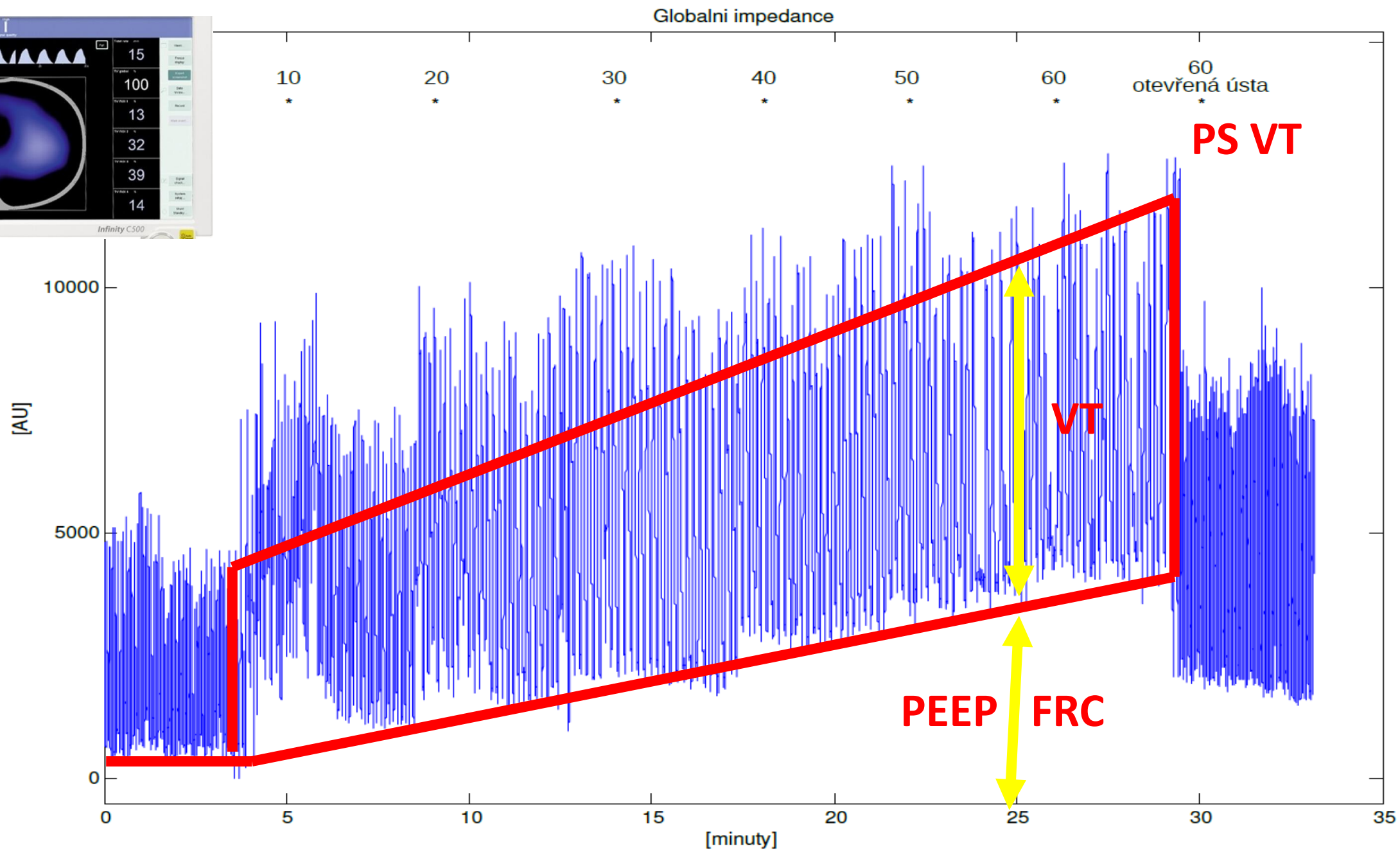
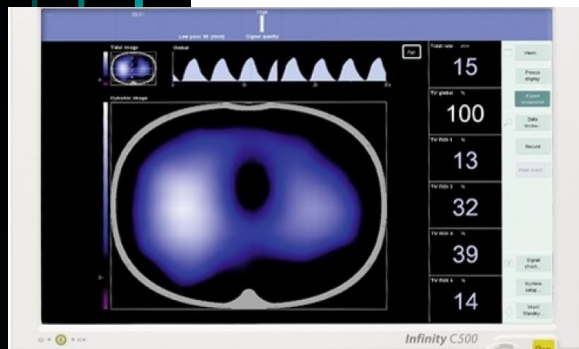
@thereal.arjun18



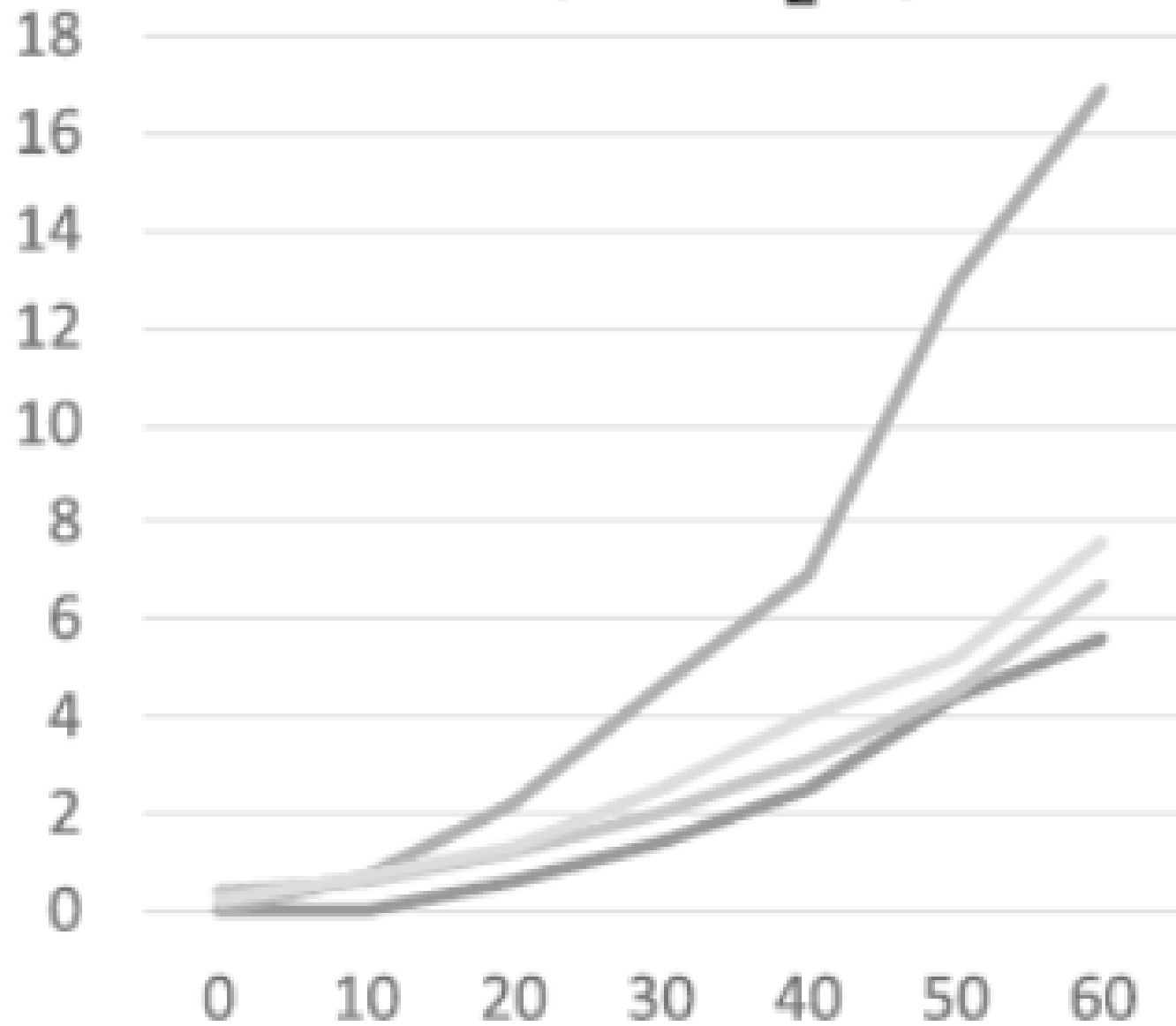
@Arjun kharadi



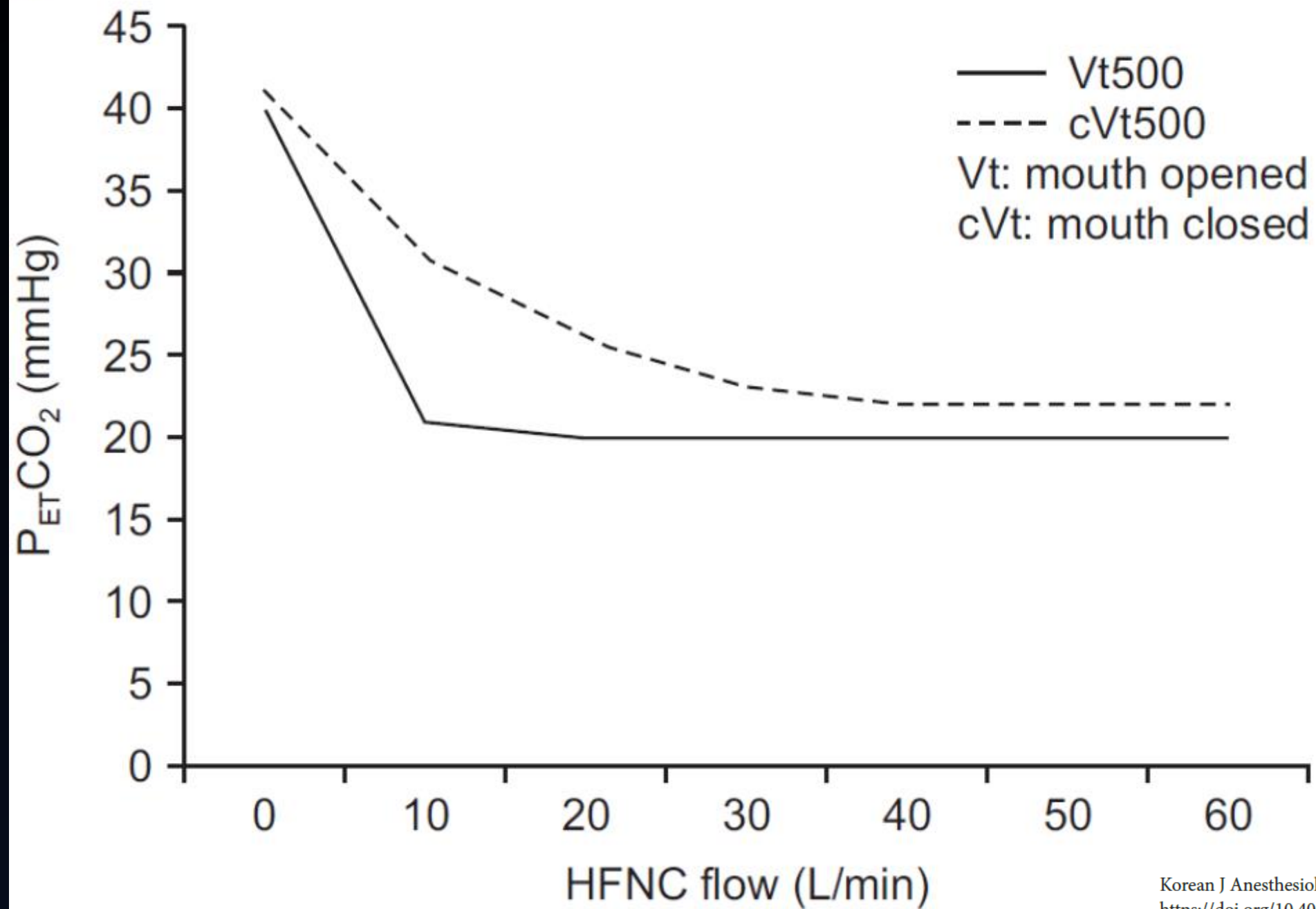
MedNurseAcademy97

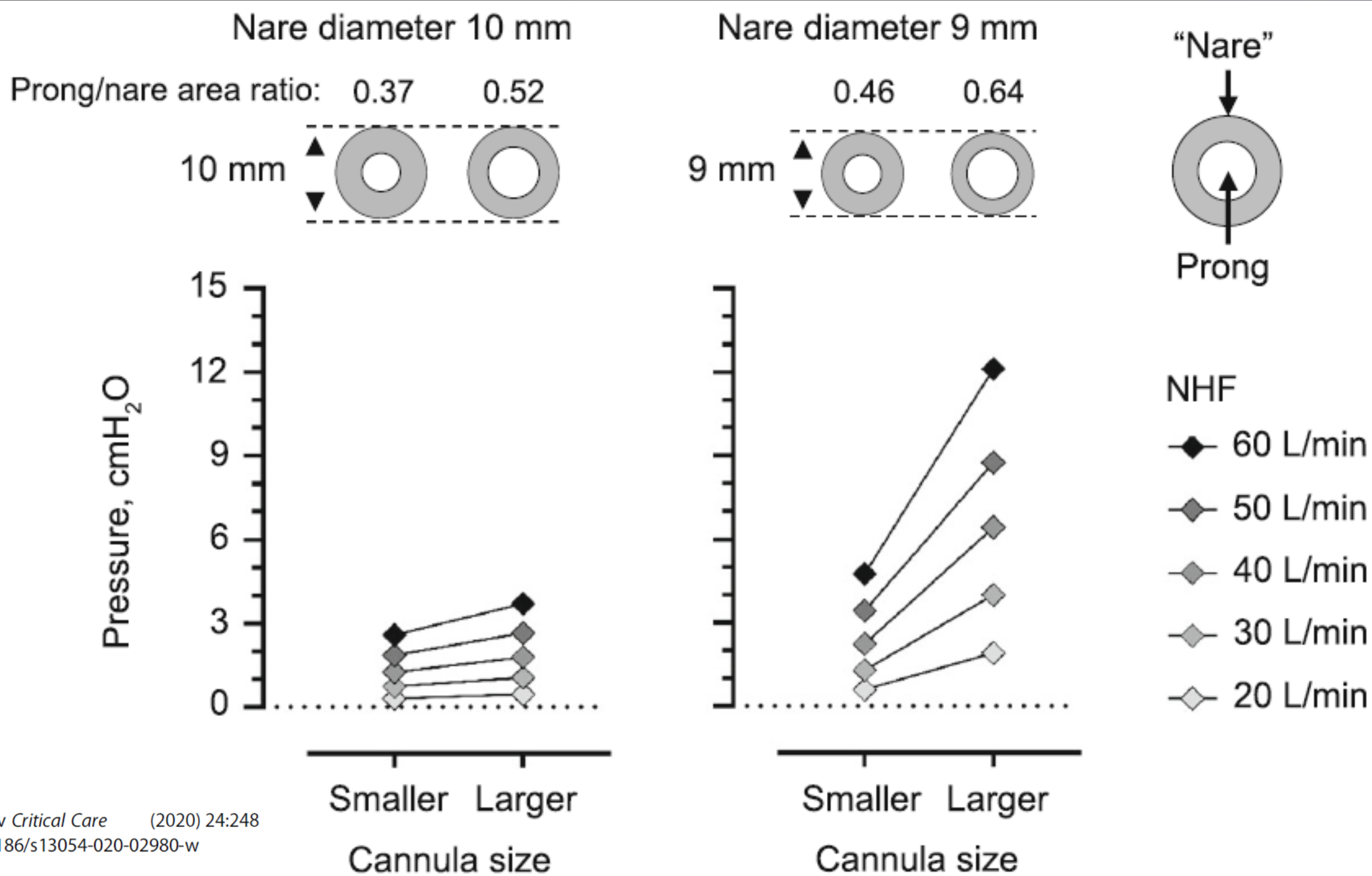


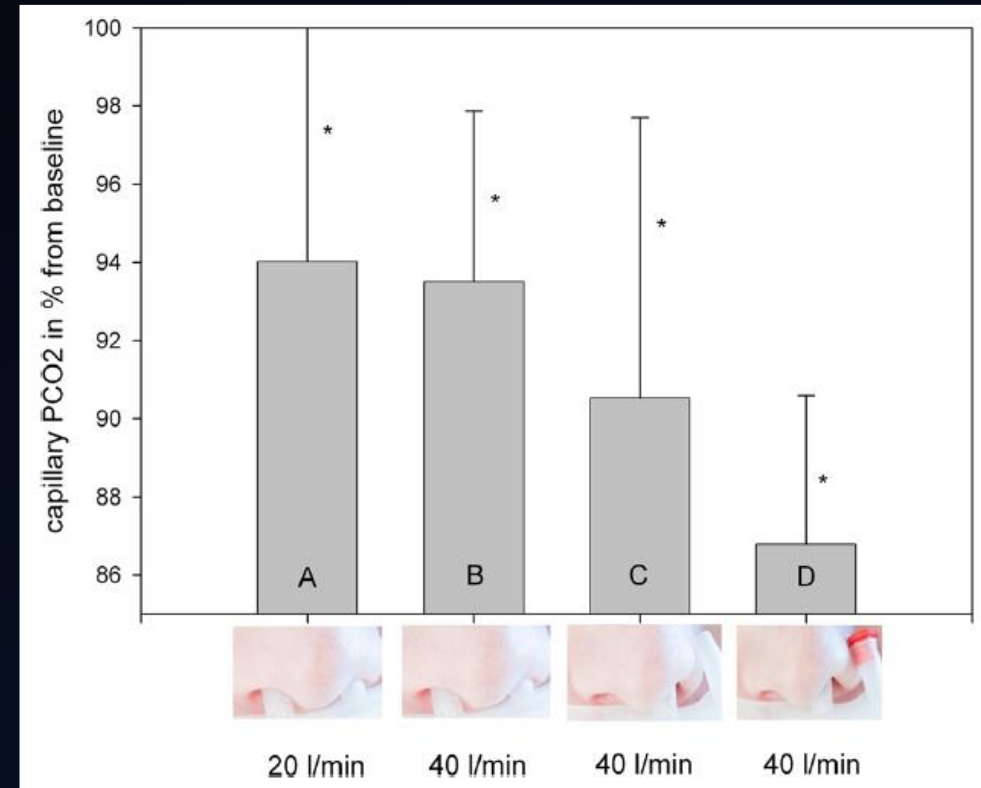
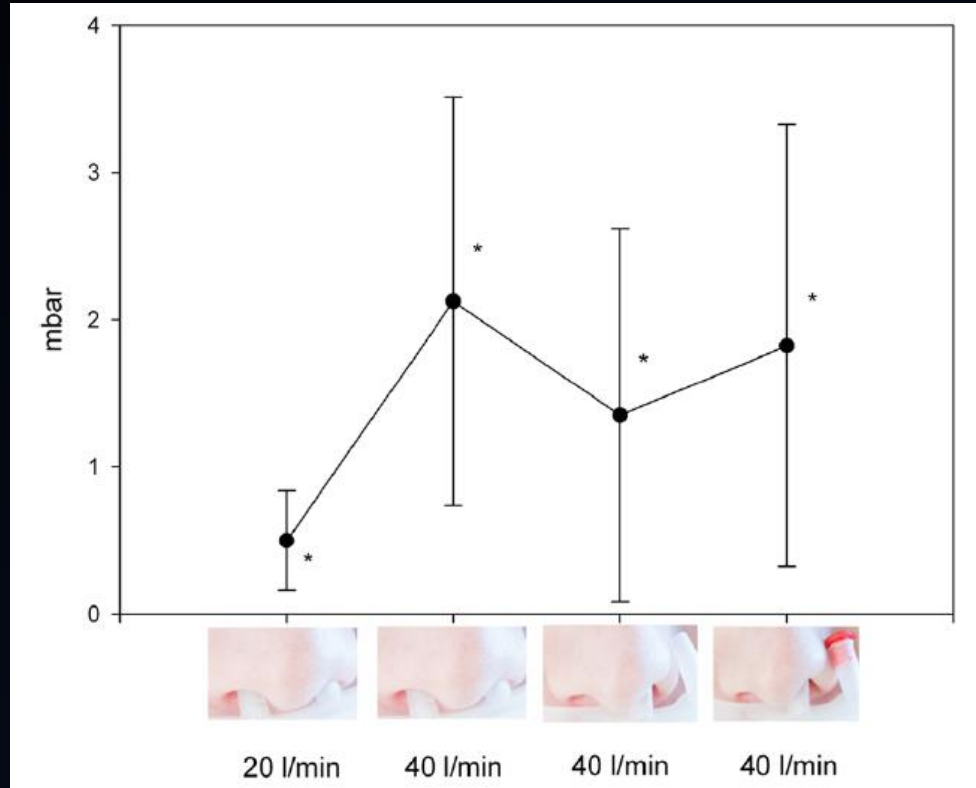
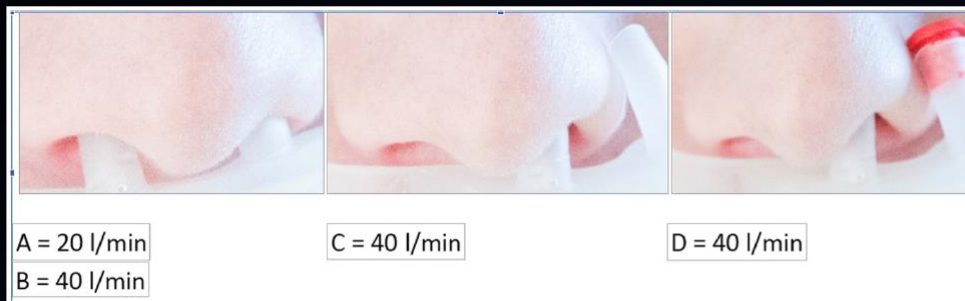
# PEEP (cmH<sub>2</sub>O)



HFNC Flow

**B**





$$\text{ROX Index} = \frac{\text{SPO}_2/\text{FIO}_2}{\text{Respiratory Rate}}$$

Respiratory rate - **OX**ygenation

## Prediction of high-flow nasal cannula failure in critically ill patients: a narrative review

Yaxiaerjiang Muhetaer<sup>1,2†</sup>, Shi-min Zhang<sup>1†</sup>, Amanguli Moming<sup>1†</sup>, Kai Liu<sup>1\*</sup> and Ming Zhong<sup>1,2,3,4\*</sup>

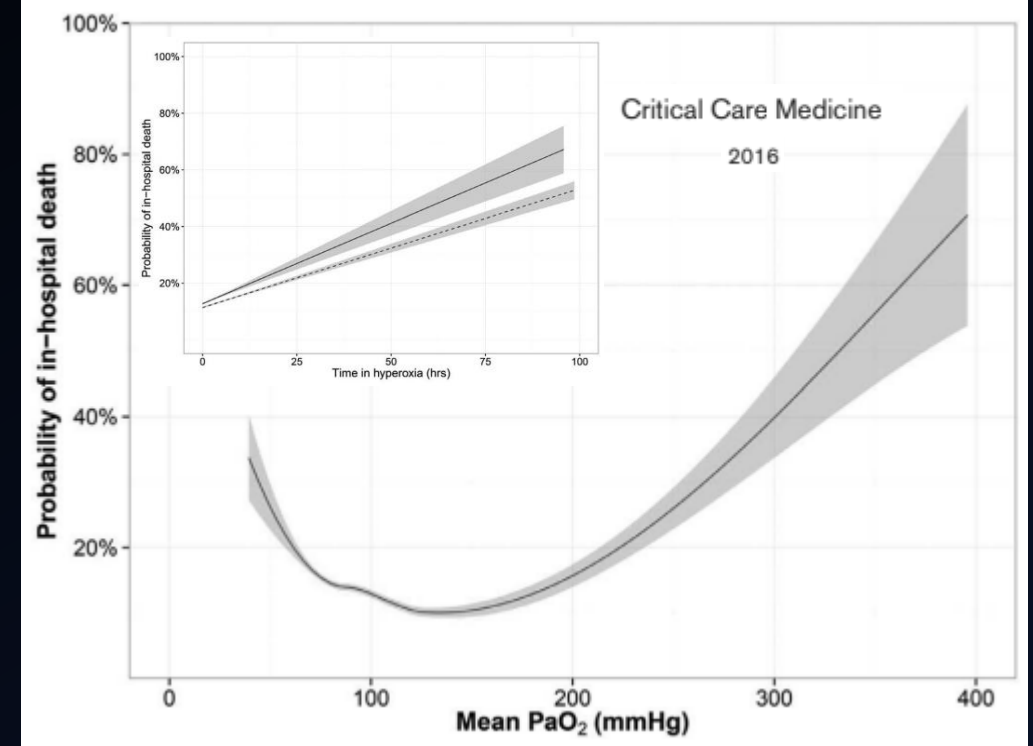
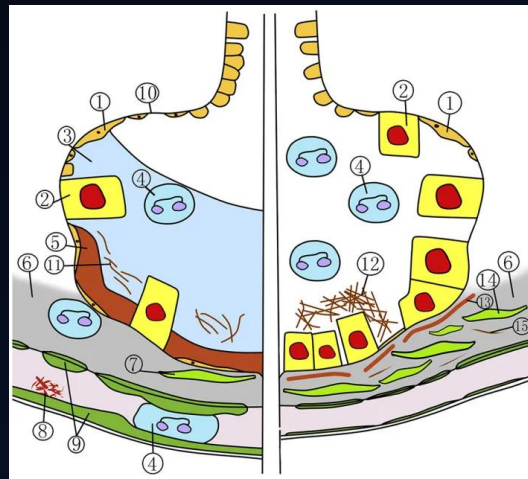
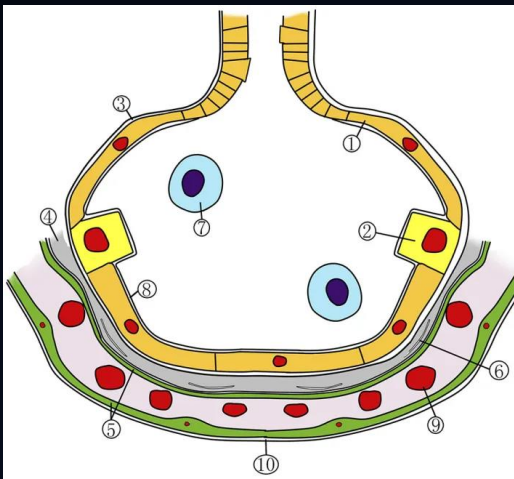
Muhetaer *et al. Journal of Intensive Care* (2026) 14:27

| Predictors score | Formula                                                        |             |
|------------------|----------------------------------------------------------------|-------------|
| ROX              | $(\text{SpO}_2/\text{FiO}_2)/\text{RR}$                        |             |
| ROX-HR           | $(\text{ROX}/\text{HR}) \times 100$                            |             |
| mROX             | $(\text{PaO}_2/\text{FiO}_2)/\text{RR}$                        |             |
| mROX-HR = POX-HR | $[(\text{PaO}_2/\text{FiO}_2)/\text{RR}]/\text{HR} \times 100$ |             |
| VOX              | $(\text{SpO}_2/\text{FiO}_2)/\text{VT}$                        |             |
| MOX              | $(\text{SpO}_2/\text{FiO}_2)/\text{MV}$                        |             |
| FOX              | $(\text{Flow} * \text{FiO}_2)/\text{SpO}_2$                    |             |
| HACOR            | Heart rate                                                     | <120 0      |
|                  |                                                                | ≥121 1      |
|                  | Acidosis (PH)                                                  | ≥7.35 0     |
|                  |                                                                | 7.30–7.34 2 |
|                  |                                                                | 7.25–7.29 3 |
|                  |                                                                | <7.25 4     |
|                  | Consciousness (GCS)                                            | 15 0        |
|                  |                                                                | 13–14 2     |
|                  |                                                                | 11–12 5     |
|                  |                                                                | ≤10 10      |
|                  | Oxygenation ( $\text{PaO}_2/\text{FiO}_2$ )                    | ≥201 0      |
|                  |                                                                | 176–200 2   |
|                  |                                                                | 151–175 3   |
|                  |                                                                | 126–150 4   |
|                  |                                                                | 101–125 5   |
|                  |                                                                | ≤100 6      |
|                  | Respiratory rate                                               | ≤30 0       |
|                  |                                                                | 31–35 1     |
|                  |                                                                | 36–40 2     |
|                  |                                                                | 41–45 3     |
|                  |                                                                | ≥46 4       |

| Population                         | Primary predictive tool(s) | Key cut-off/timepoint                                                            | Clinical notes                                                                          |
|------------------------------------|----------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| AHRF/pneumonia                     | ROX index                  | 2 h < 2.85<br>6 h < 3.47<br>12 h < 3.85                                          | Widely cited benchmark for non-COVID-19 pneumonia with hypoxemia                        |
| COVID-19 patients                  | ROX index                  | 12 h < 3.85 (highly specific)                                                    | Most validated threshold for this population. ROX index shows high sensitivity          |
|                                    | HACOR score                | ≈5.5                                                                             | Predictive performance comparable to ROX index (AUROC ~0.71)                            |
| Post-extubation patients           | ROX index                  | 1 h < 6.06 (predicts failure);<br>2/6 h > 8.7 and 12 h > 10.4 (predicts success) | Higher thresholds are generally required to predict success in sequential therapy       |
|                                    | ROX-HR index               | 10 h > 8.00 (predicts success)                                                   | Incorporates heart rate; strongly correlates with outcomes in this group                |
| COPD patients (acute exacerbation) | ROX index                  | >6.88 (indicates low failure risk)                                               | This population requires a much higher ROX index to indicate a low risk of intubation   |
| Emergency department               | ROX index                  | 6 h < 4.88                                                                       | Demonstrates superior discriminatory ability compared to HACOR score in this setting    |
|                                    | HACOR score                | 1 h > 6 (predicts failure)                                                       | Reliable predictor in general AHRF but may be less discriminative in emergency settings |

- Oční toxicita
- CNS
- Plíce

In diving and hyperbaric environments,

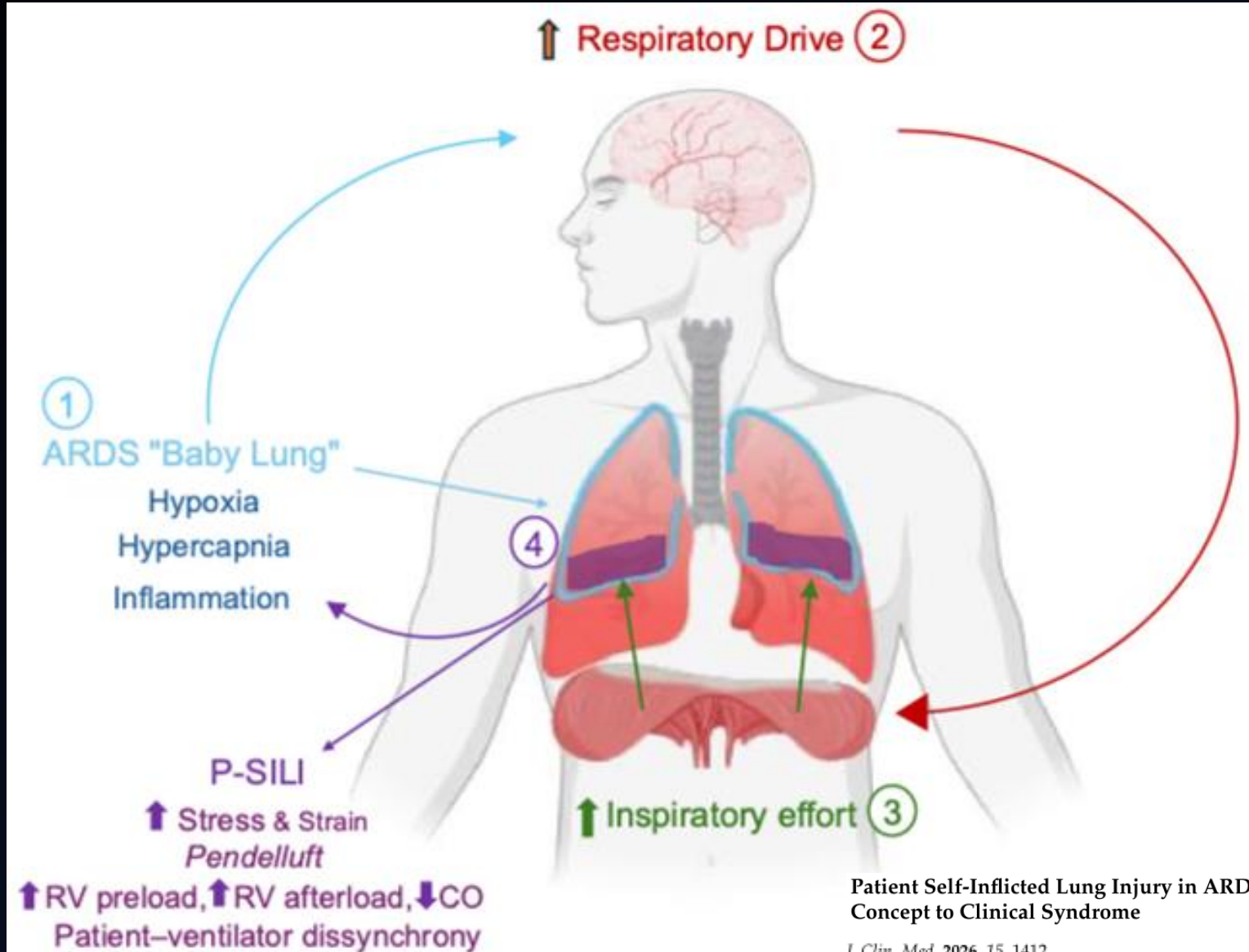


| Depth<br>(fsw/msw) | Limit US Navy<br>(United States Department<br>of the Navy NSSC, 2008)<br>(min) | Risk of CNS<br>toxicity (Arieli<br>et al., 2002)(%) | Limit Arieli<br>et al. <5%<br>(min) |
|--------------------|--------------------------------------------------------------------------------|-----------------------------------------------------|-------------------------------------|
| 25/7.7             | 240                                                                            | 13.1                                                | 83                                  |
| 30/9.2             | 80                                                                             | 6.3                                                 | 63                                  |
| 35/10.7            | 25                                                                             | 2.4                                                 | 48                                  |
| 40/12.3            | 15                                                                             | 1.7                                                 | 38                                  |
| 50/15.3            | 10                                                                             | 1.8                                                 | 24                                  |

**Oxygen Toxicity and Special Operations Forces Diving: Hidden and Dangerous**

Wingelaar TT, van Ooij P-JAM and van Hulst RA (2017) Oxygen Toxicity and Special Operations Forces Diving: Hidden and Dangerous. *Front. Psychol.* 8:1263. doi: 10.3389/fpsyg.2017.01263

# P - SILI



Patient Self-Inflicted Lung Injury in ARDS: From Physiological Concept to Clinical Syndrome

J. Clin. Med. 2026, 15, 1412

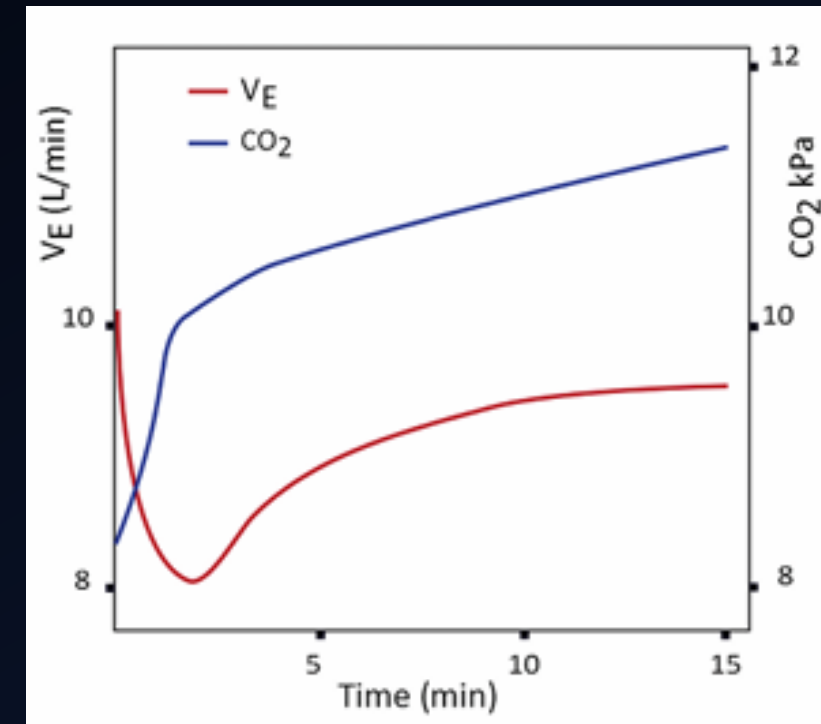
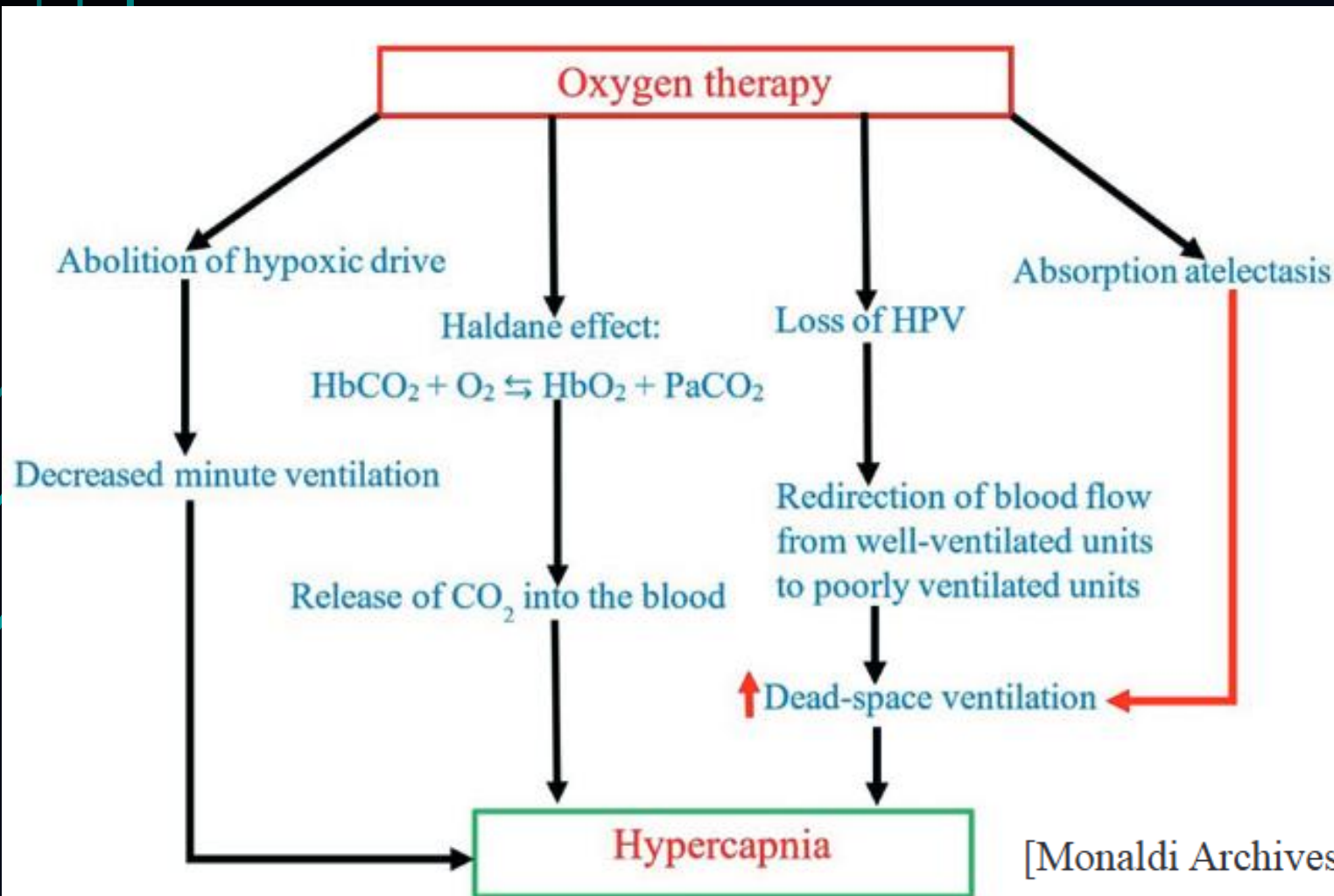
# Kdy přejít na invazivní resp. protektivní ventilaci ?

- Pacienti, u nichž selže neinvazivní ventilace (NIV) nebo vysokoprůtoková nosní kanyla (HFNC) a **musí podstoupit pozdní intubaci**, vykazují **vyšší mortalitu** (v některých studiích 56 % vs. 36 % u časně intubace).
- U části pacientů s COVID-19 a počáteční dobrou plicní kompliancí (poddaností plic) při těžké hypoxémii **neznamenal časná intubace** automatický **přínos** v přežití.
- Vysoká dechová frekvence, tepová frekvence a vysoké skóre selhání (např. HACOR) signalizují nutnost včasné eskalace péče.
- **Individuální přístup.**

hyperkapnie

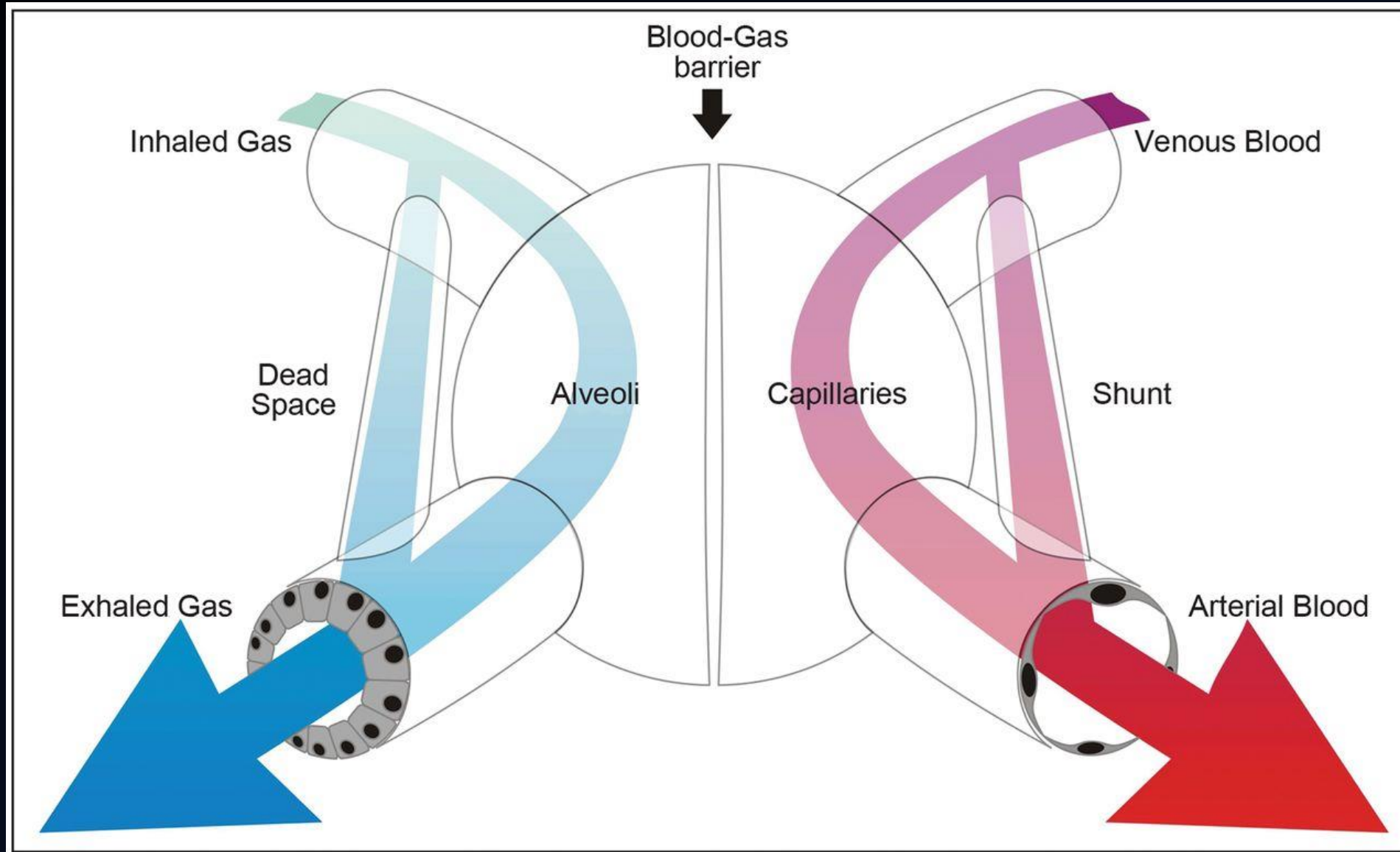
# Oxygen-induced hypercapnia in COPD: myths and facts

Abdo and Heunks *Critical Care* 2012, 16:323  
<http://ccforum.com/content/16/5/323>



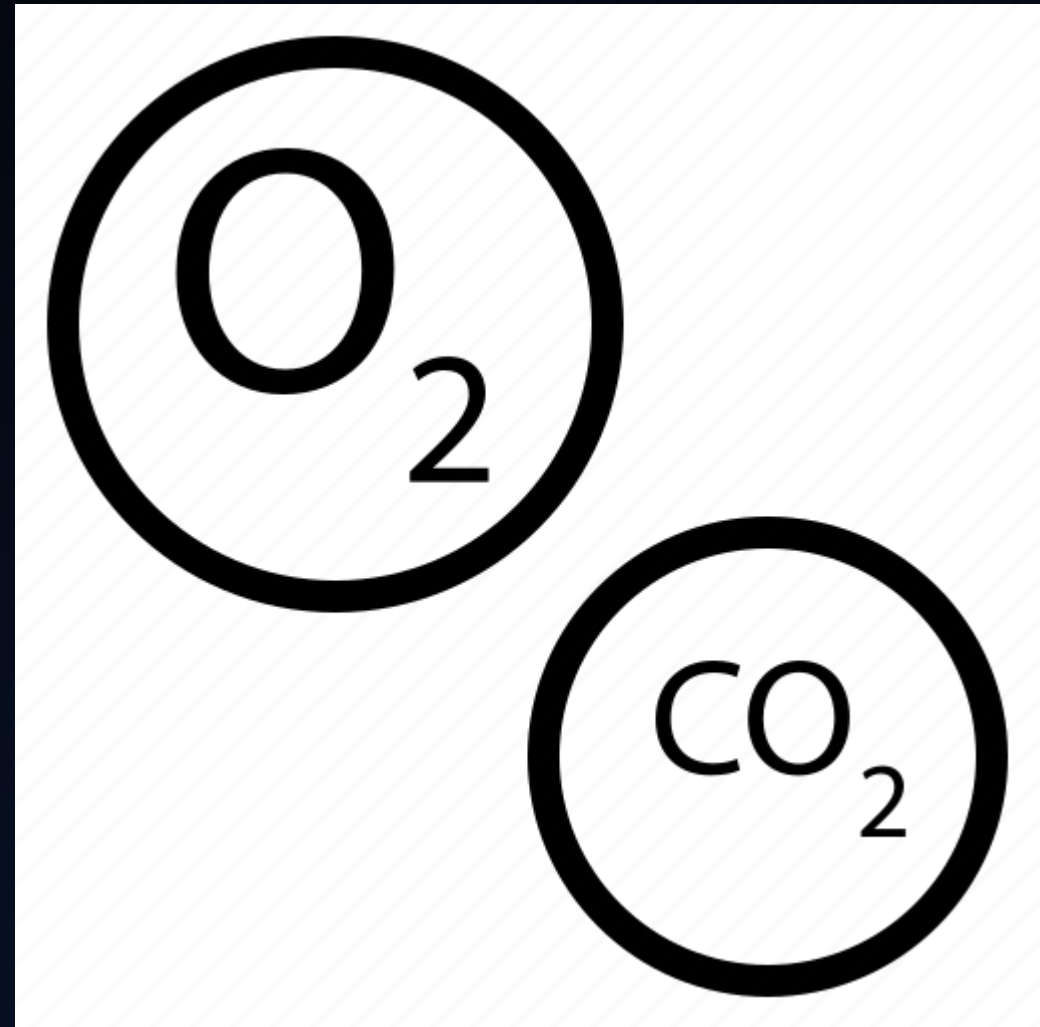
[Monaldi Archives for Chest Disease 2023; 93:2399]

- Ventilace
- Difúze
- Perfúze



# Podpora respiračního systému

- Podpora výměny plynů
  - Ovlivnění plicních objemů
  - Dechová práce
- 
- Akceptovatelné parametry
  - Minimalizace poškození



**ACCP CONSENSUS CONFERENCE: CONSENSUS DEVELOPMENT CONFERENCE**

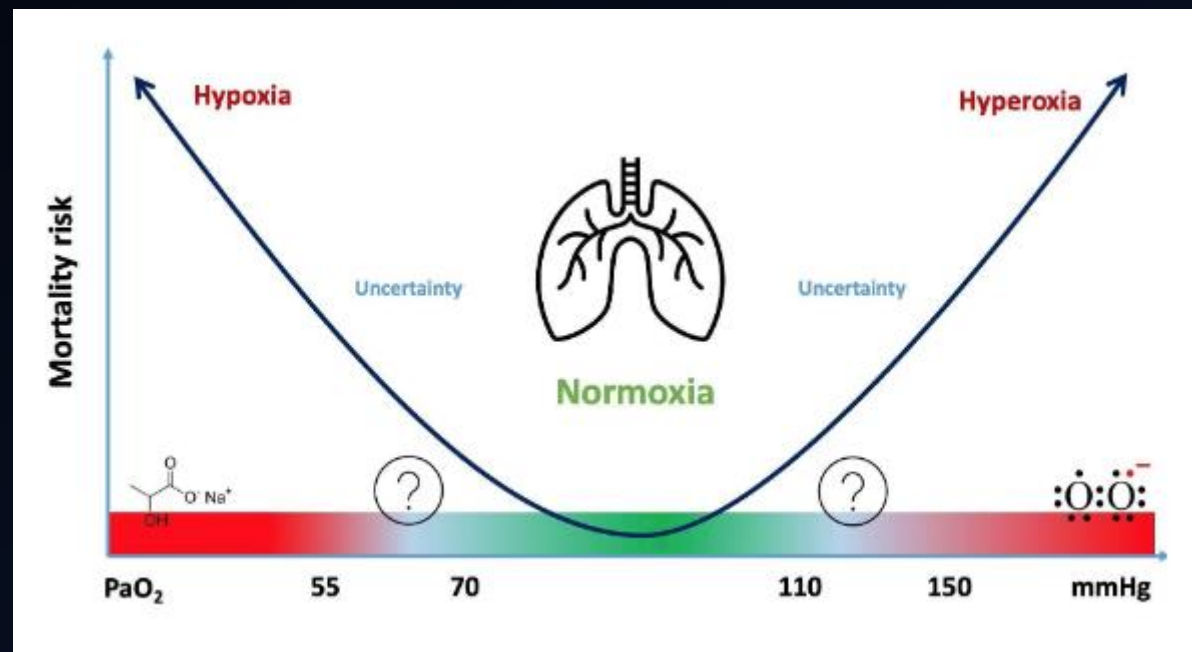
CHEST VOLUME 104, ISSUE 6, P1833-1859, DECEMBER 01, 1993

# Kyslík - lék

- Indikace
- Nežádoucí účinky

- Když není indikován, je kontraindikován!

## Oxygen: Too Much is Bad



ICU Management & Practice 3 - 2021

London 1930



<https://museum.aarc.org/galleries/oxygen-therapy/>