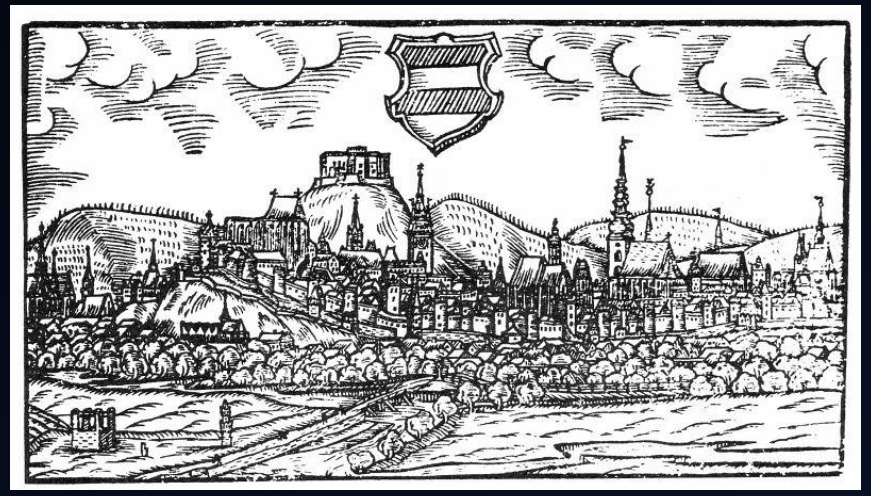
Jak zahájit neinvazivní ventilační podporu?



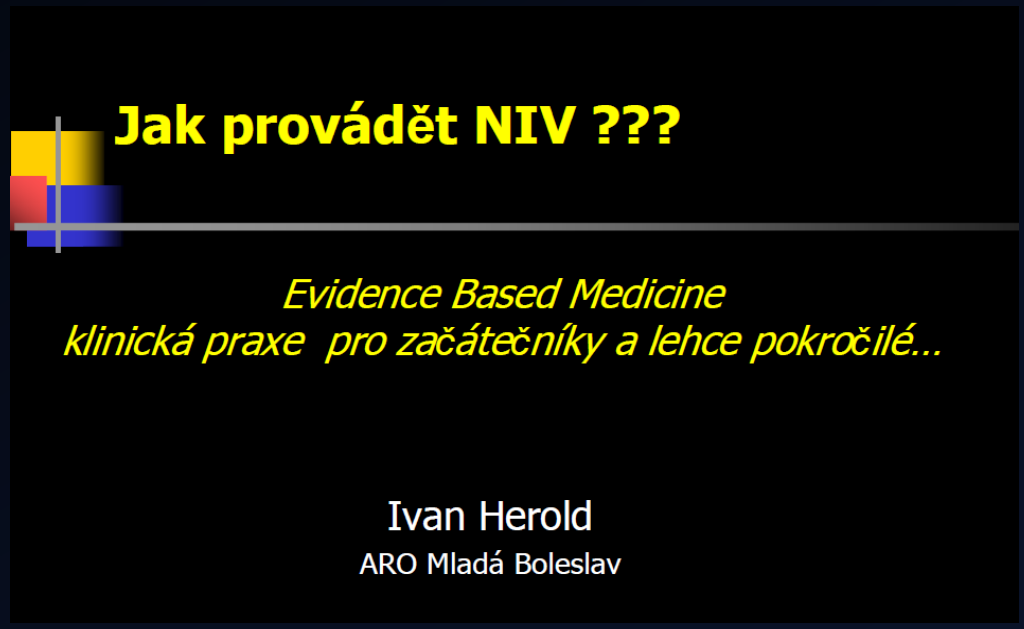
TOMÁŠ TYLL

ÚVN
ÚSTŘEDNÍ VOJENSKÁ NEMOCNICE
Vojenská fakultní nemocnice Praha

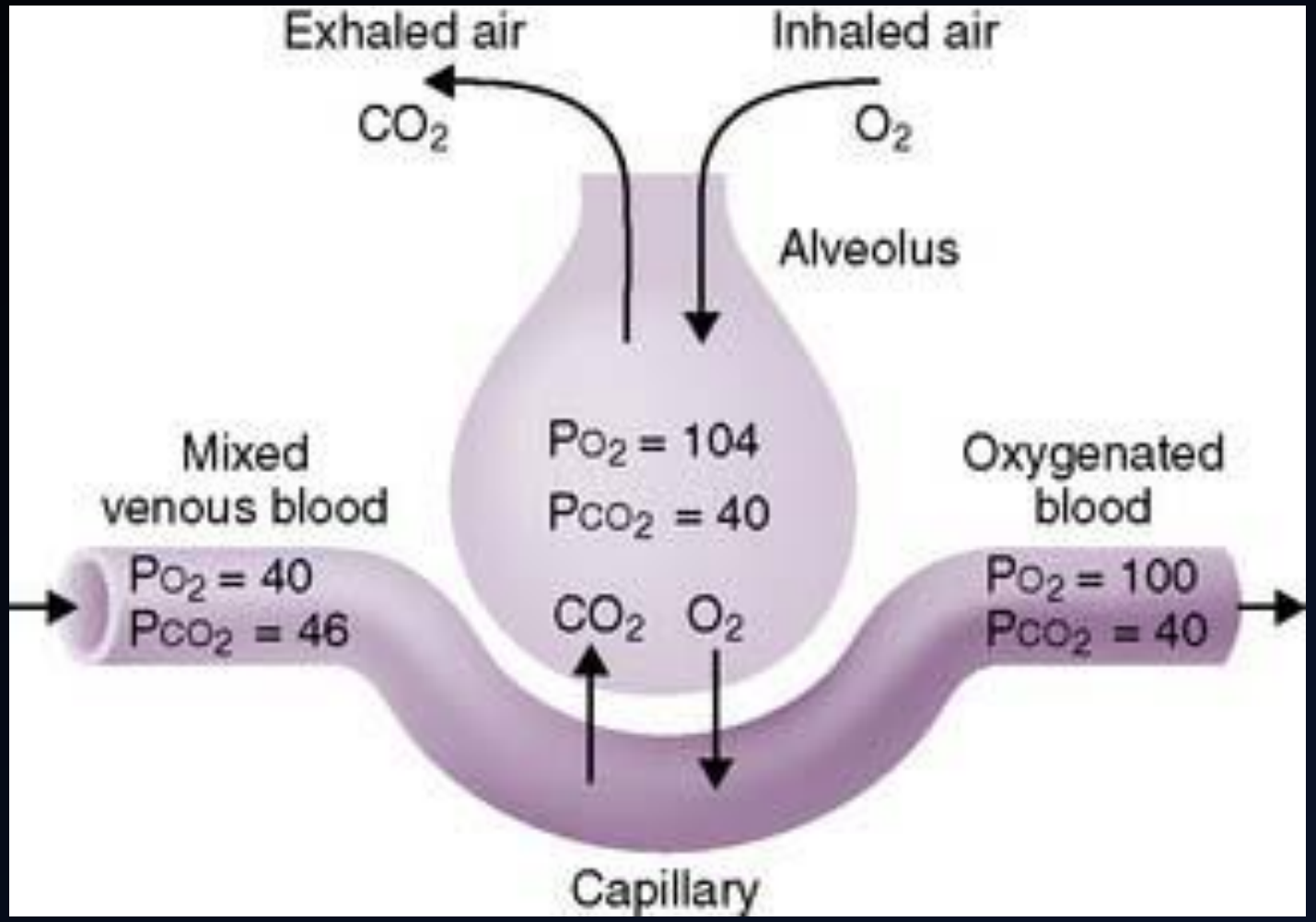
XII. Kongres ČSIM 20. – 22. června 2018

Osnova

- Pacient
- Metoda
- Přístroj
- Rozhraní
- Režim
- Sedace
- Výživa
- Nú a komplikace



Pacient 1



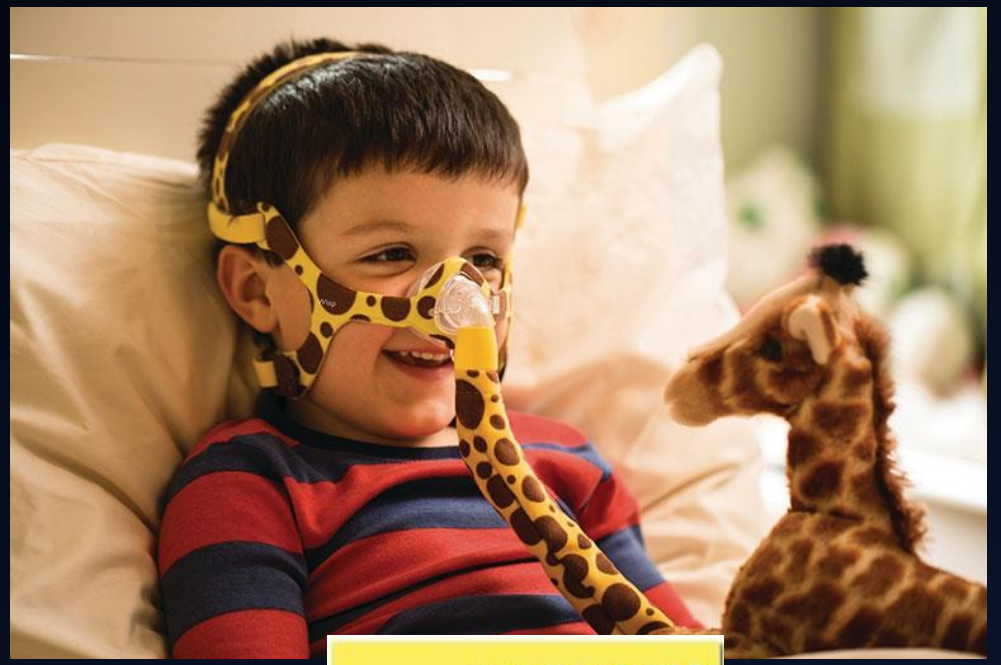
	pO_2	SO_2	pCO_2	BE	pH
arterial	95 mmHg 12.6 kPa	97%	40 mmHg 5.3 kPa	0	7.40
venous	40 mmHg 5.3 kPa	73%	46 mmHg 6.1 kPa	0	7.37

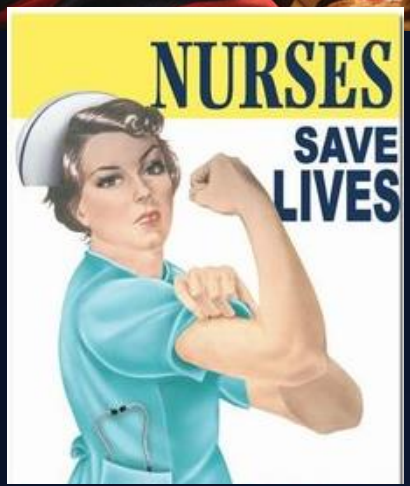
Pacient 2

DÝCHACÍ CESTY

- Průchodnost
- Ochrana
- Toileta
- Rozhraní

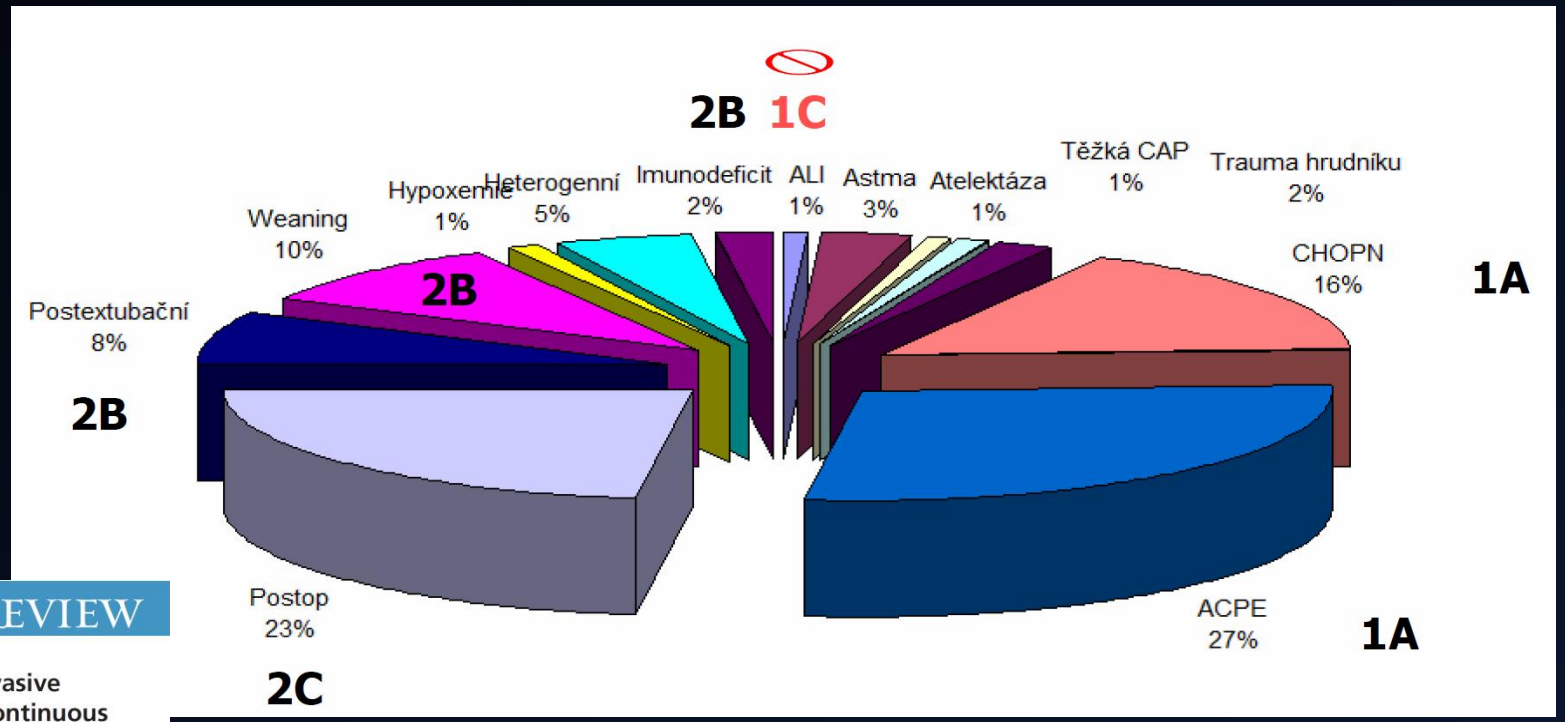
+…





Pacient 3 - Jak důležitá je diagnóza?

- Ano aj…



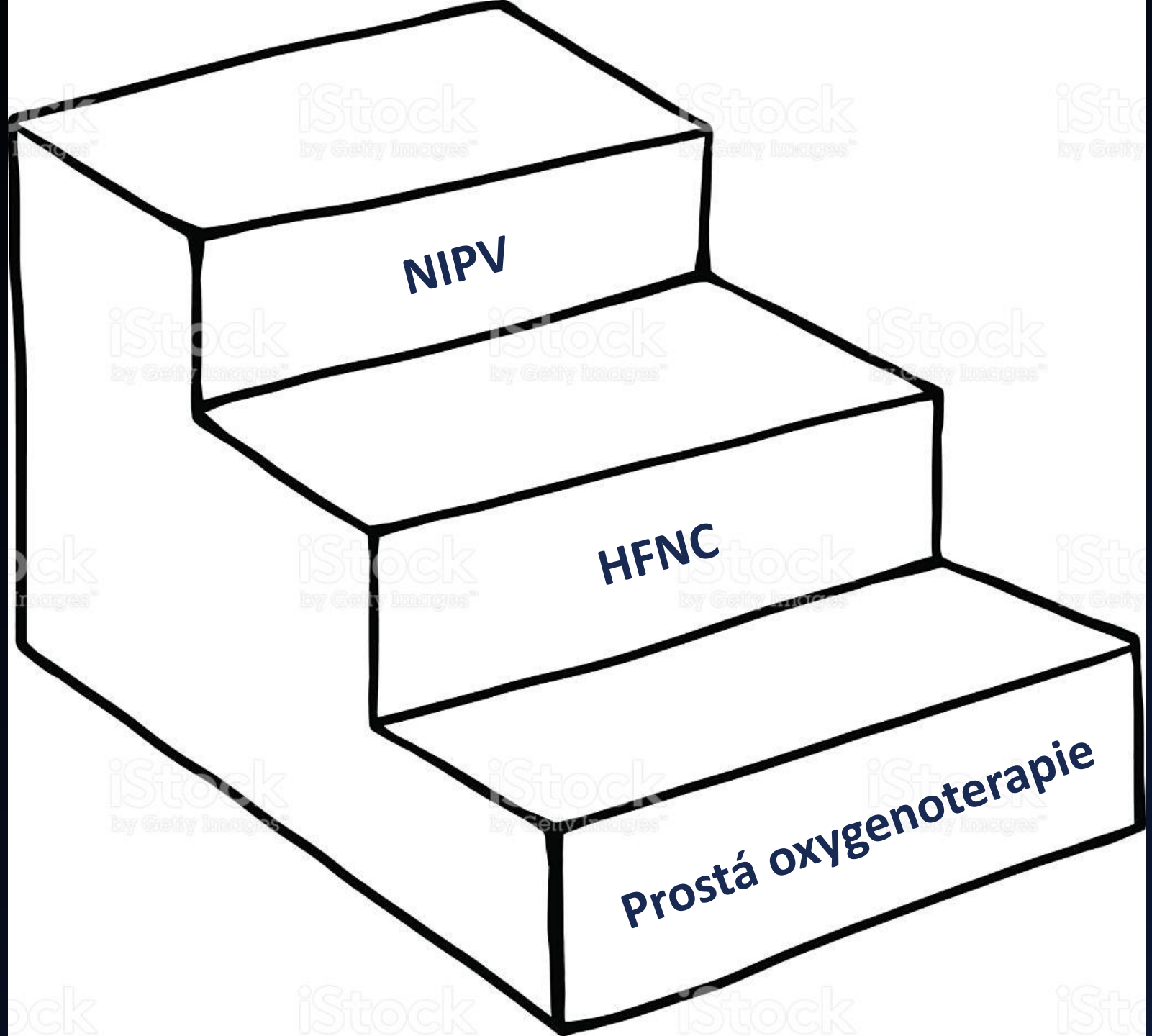
CMAJ REVIEW

Clinical practice guidelines for the use of noninvasive positive-pressure ventilation and noninvasive continuous positive airway pressure in the acute care setting

Sean P. Keenan MD MSc, Tasnim Sinuff MD PhD, Karen E.A. Burns MD MSc, John Muscedere MD, Jim Kutsogiannis MD, Sangeeta Mehta MD, Deborah J. Cook MD MSc, Najib Ayas MD, Neill K.J. Adhikari MD CM MSc, Lori Hand BSc RRT, Damon C. Scales MD PhD, Rose Pagnotta RRT, Lynda Lazosky RRT, Graeme Rocker MD, Sandra Dial MD, Kevin Laupland MD MSc, Kevin Sanders MD, Peter Dodek MD MHSc, as the Canadian Critical Care Trials Group / Canadian Critical Care Society Noninvasive Ventilation Guidelines Group

An abridged version of this article appeared in the February 22, 2011 issue of *CMAJ*

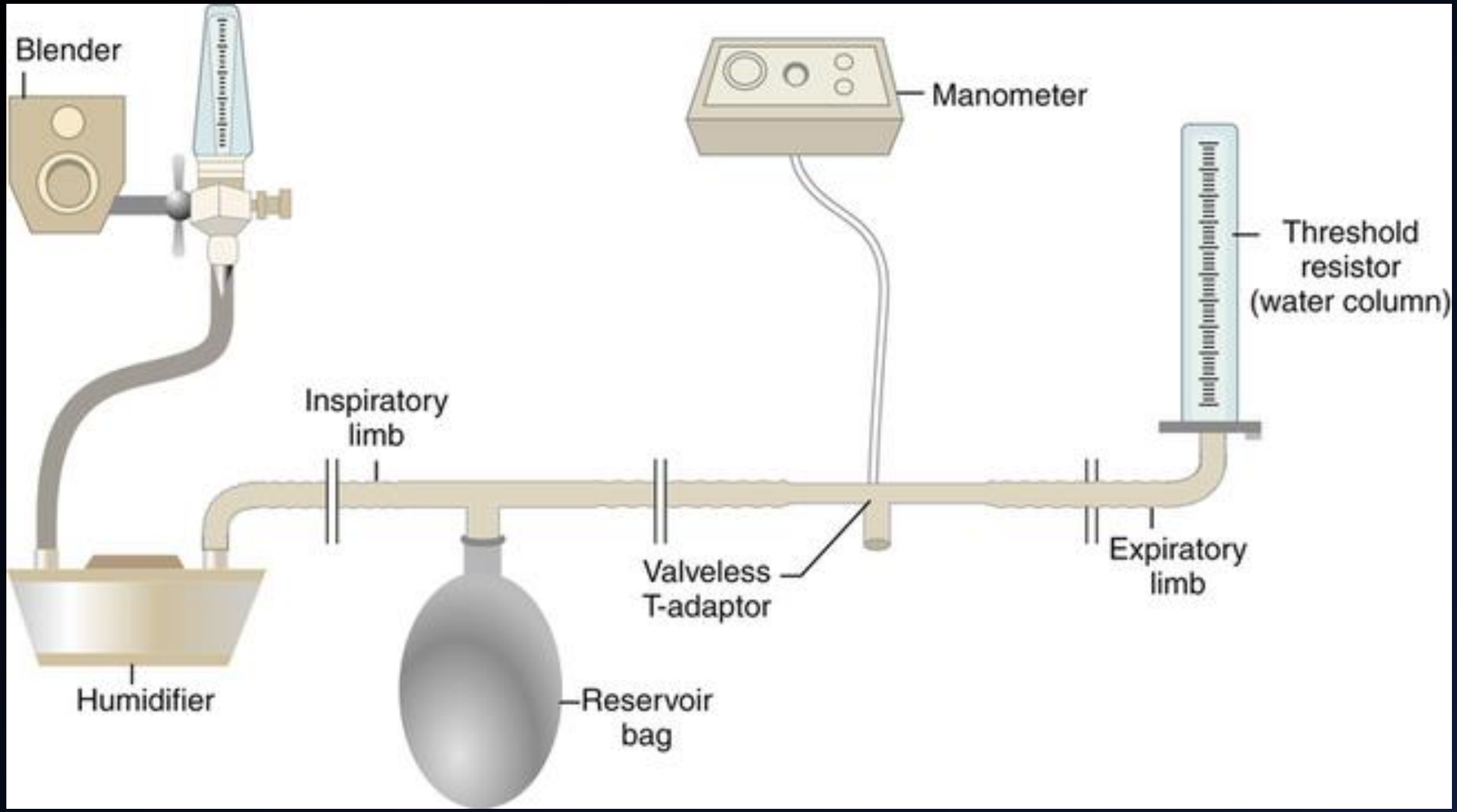
EFEKTIVITA



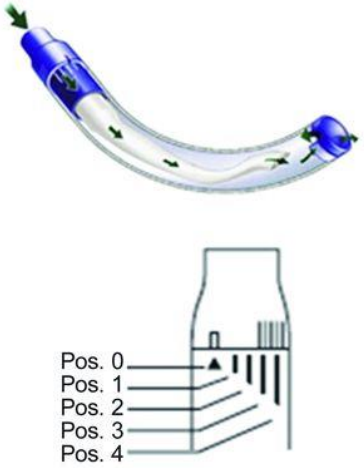
INVAZIVITA

Prostá oxygenoterapie

- Málo efektivní.
- „Každý ji stejně má.“


Blender
Manometer
Threshold resistor (water column)
Inspiratory limb
Valveless T-adaptor
Expiratory limb
Humidifier
Reservoir bag

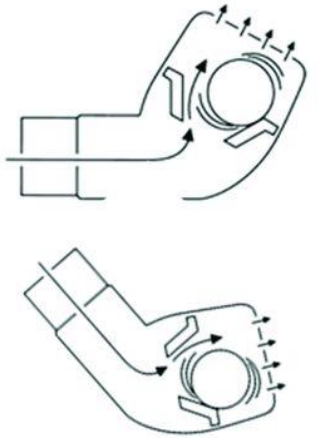
RC-Cornet



Exhaled gas passes through a curved plastic tube containing a flexible, latex free hose and sound damper. During exhalation, the latex free hose erratically strikes the top and bottom of the curved plastic tube, intermittently occluding flow, creating oscillations and PEP.

Settings on the mouthpiece can be adjusted to twist the tube and change the size of the expiratory resistor, which adjusts the frequency, amplitude and mean pressure.

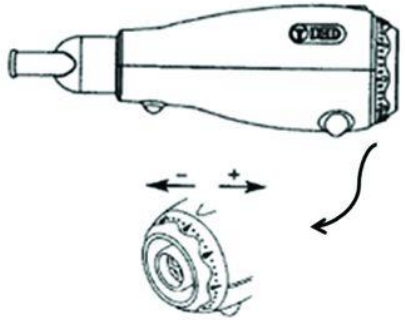
Flutter



Exhaled air passes through the hollow tube, by the metal ball, then vertically within the housing, cone and perforated cap to create the airflow oscillations.

This device is gravity dependent. Therefore, the angle at which it is held by the patient affects the amount of effort needed to cause the metal ball to vibrate, influencing the frequency and amplitude of the oscillations and PEP.

Acapella



High-frequency oscillations and PEP are created as exhaled gas passes through a cone, which is intermittently occluded by a plug attached to the lever.

A knob located at the distal end of the device adjusts the proximity of the magnet and counterweighted plug, thereby adjusting the frequency, amplitude and mean pressure.

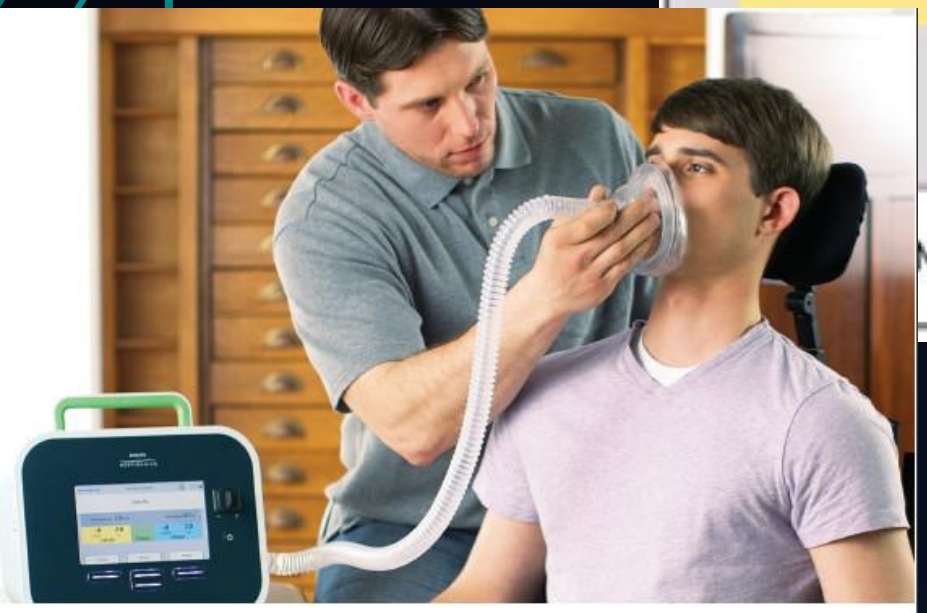
The closer the magnet is to the plug the more expiratory resistance, PEP and amplitude are generated.

The Blue and Green versions differ by manufacturer limitations with respect to the patient's expiratory flow.

Aerobika

Exhaled gas passes through a one-way valve housed within a chamber, creating airflow oscillations and PEP as the valve chatters.

A dial on the chamber adjusts the resistance setting, or the ease with which the one-way valve opens and closes.



1 : Automatický

03/29/2012 05:52 PM

60 40 20 0 20 40 60 cmH2O

Nejvyšší tok při kašli 278 l/min

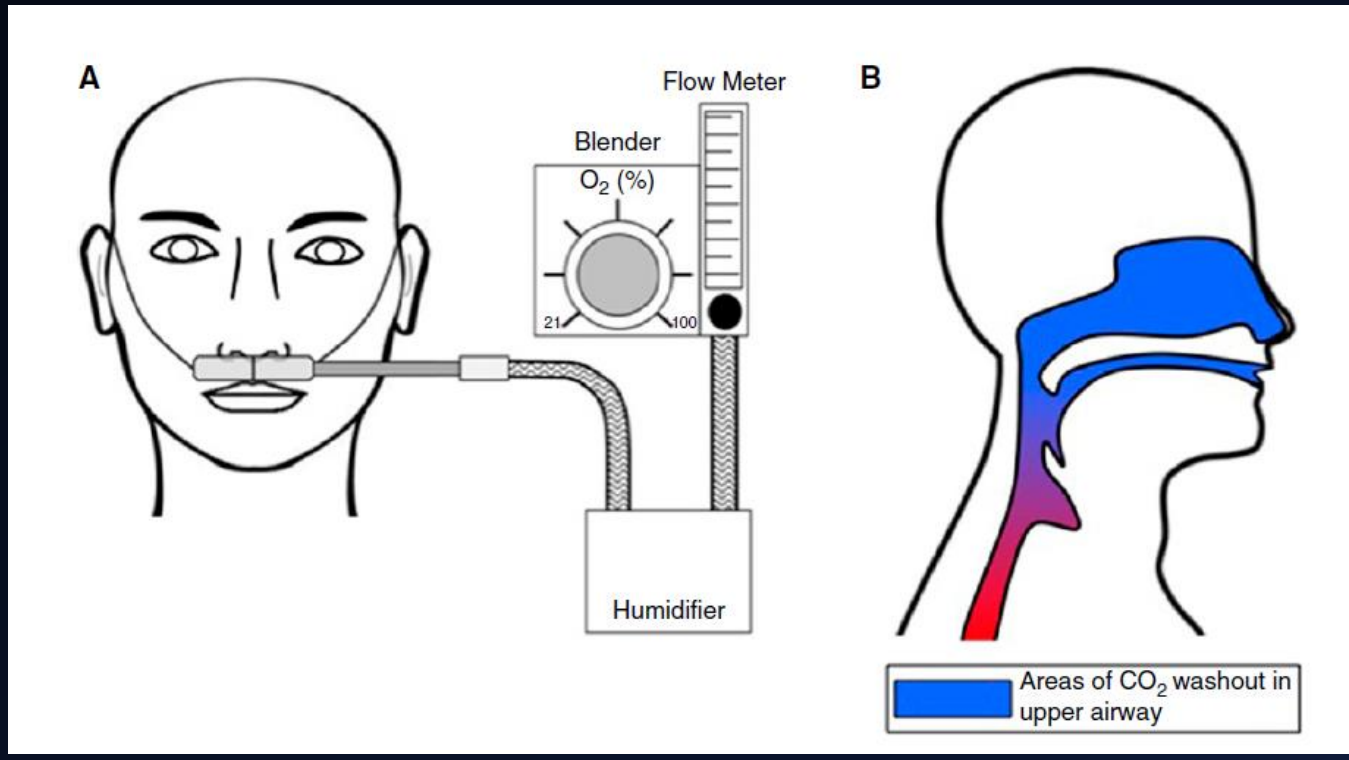
Dechový objem 510 ml

Výdech		Přestávka	Nádech	
-40 cmH2O	2.0 s	2.0 s	+40 cmH2O	2.0 s

Nastavení | Nabídka▲ | Pohotovostní režim

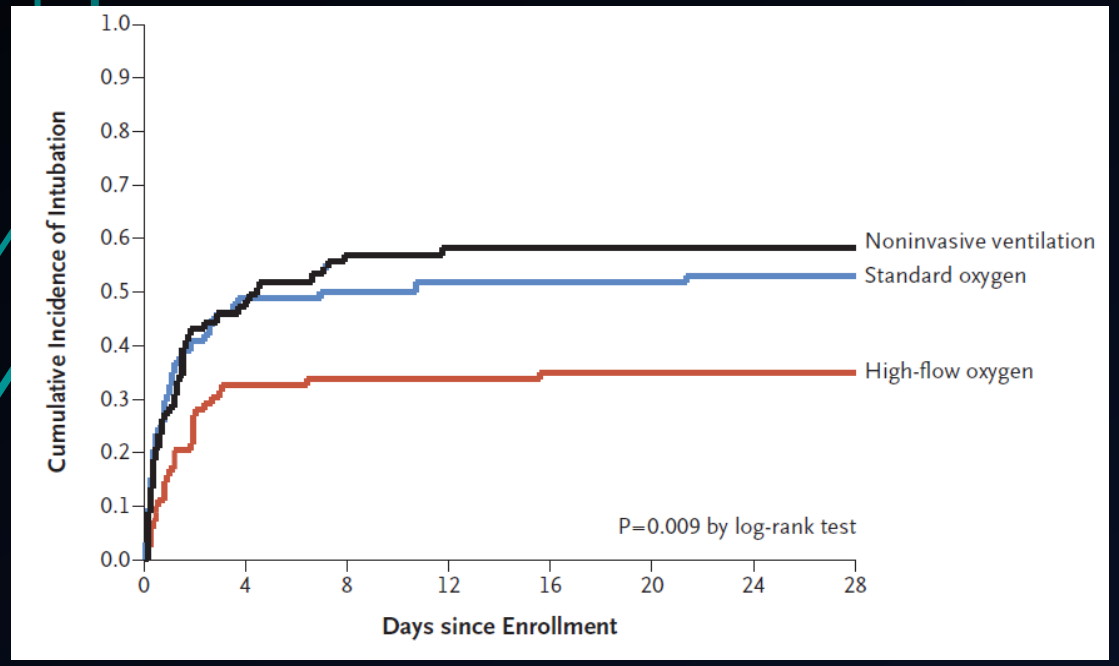
HFOT

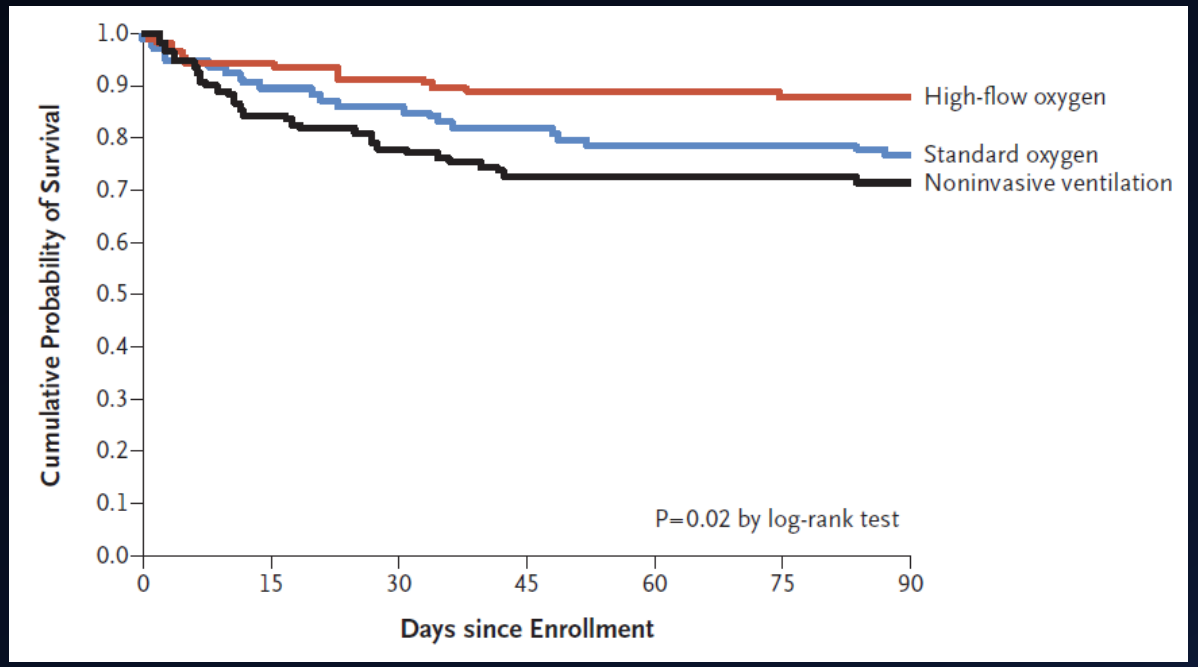
- Možná trochu i ventilace
  - FiO2
  - PEEP
  - WOB
  - Vd



High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

N ENGL J MED 372;23 NEJM.ORG JUNE 4, 2015

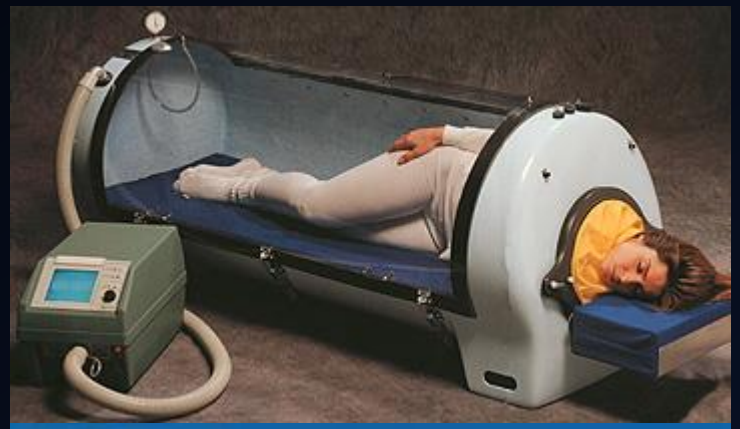




Noninvasive positive-pressure ventilation

- Integrální část ventilační podpory akutních i chronických respiračních poruchách.
- Soubor postupů, které umožňují podpořit či nahradit selhávající respirační systém.
- Provádění těchto postupů bez invazivního zajištění dýchacích cest.

Na okraj
Negative-pressure ventilation



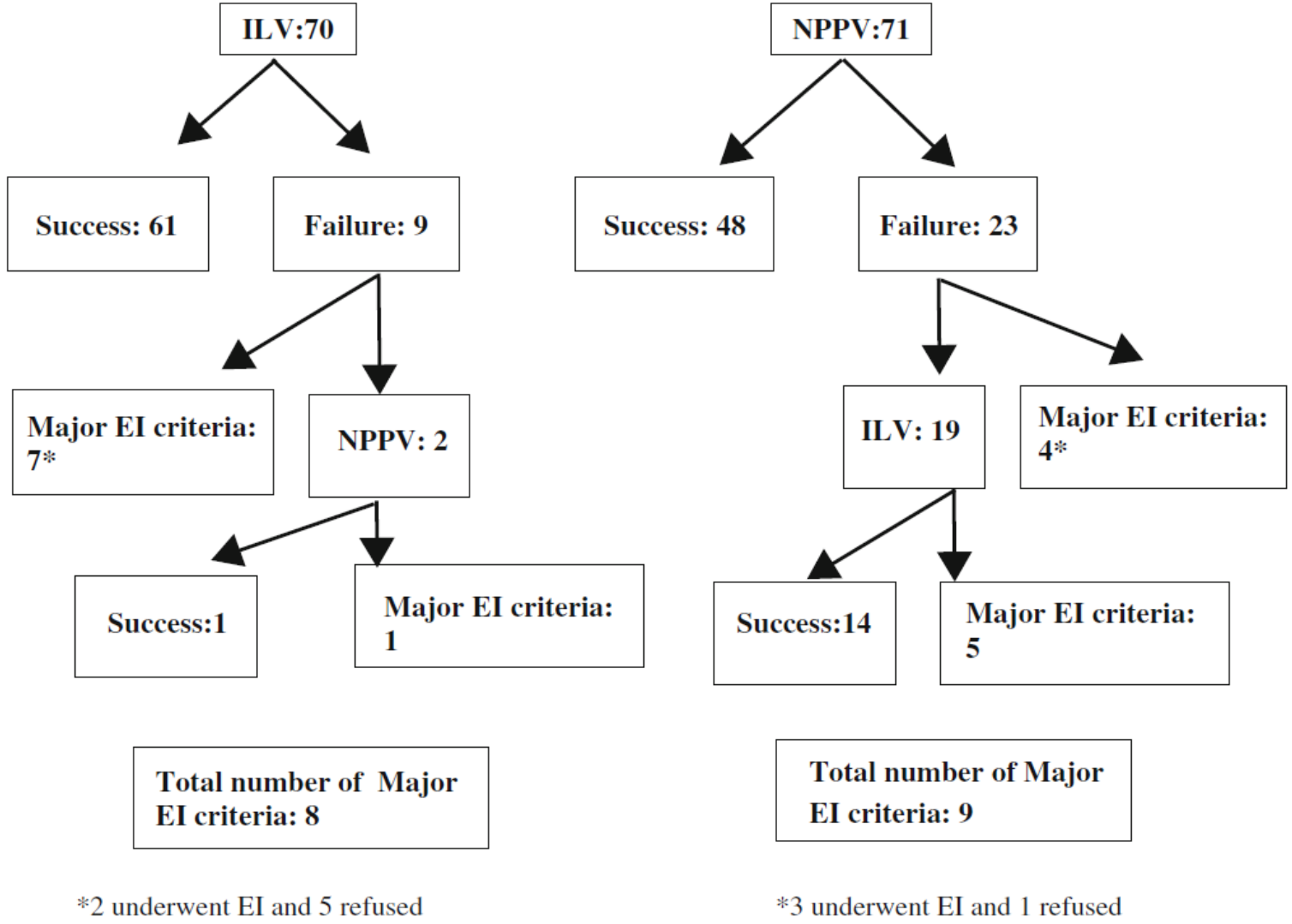
- Fyziologický efekt =
- ! Kardiovaskulární

Am Rev Respir Dis. 1977 Jan;115(1):39-45.
Comparison of the effects of continuous negative external chest pressure and positive end-expiratory pressure on cardiac index in dogs
Krumpe PE, Zidulka A, Urbanetti J, Anthonisen NR

A. Corrado
M. Gorini
R. Melej
S. Baglioni
C. Mollica
G. Villella
G. F. Consigli
M. Dottorini
D. Bigioni
M. Toschi
A. Eslami

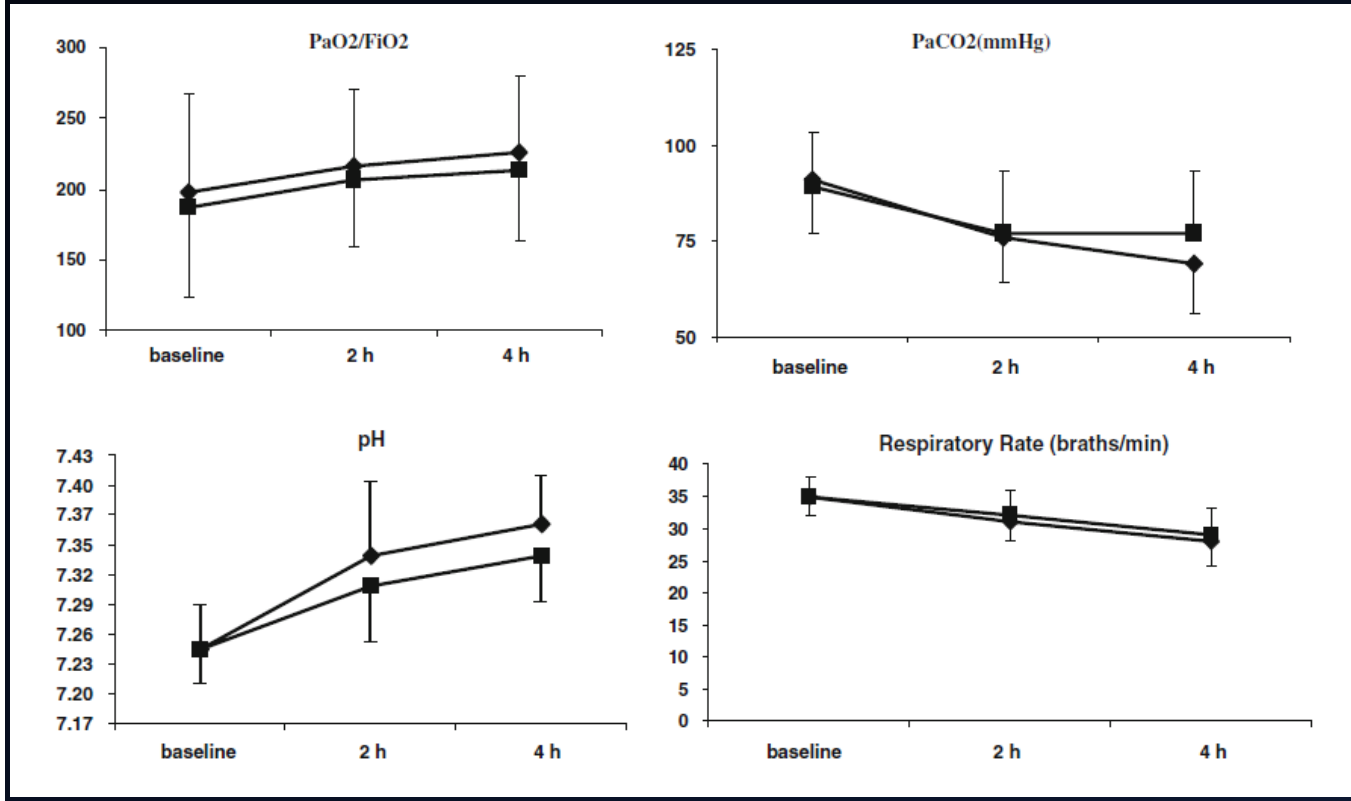
Iron lung versus mask ventilation in acute exacerbation of COPD: a randomised crossover study

Intensive Care Med (2009) 35:648–655
DOI 10.1007/s00134-008-1352-9



The total rate of success using both techniques increased from 77.3 to 87.9% ($P = 0.028$).

Conclusions: The sequential use of NPPV and ILV avoided EI in a large percentage of COPD patients with ACRF; ILV was more effective than NPPV on the basis of minor criteria for EI but after the crossover the need of EI on the basis of major criteria and mortality was similar in both groups of patients.



Barach Alvan 1938

- Akutní plicní edém

POSITIVE PRESSURE RESPIRATION AND ITS APPLICATION TO THE TREATMENT OF ACUTE PULMONARY EDEMA *

By Alvan L. Barach, M.D., F.A.C.P., John Martin, M.D., and Morris Eckman, B.S., *New York, N. Y.*

The purpose of this paper is to present observations we have made which provide a physiologic basis for the use of positive pressure respiration in the treatment of acute pulmonary edema. For the most part positive pressure has been thought of as a method of resuscitation such as that accomplished by the pulmotor in accidental asphyxia. The function of pressure in the respired air has, however, a broad physiological significance, being employed by the human organism itself as a compensatory mechanism as well as lending itself to therapeutic application in inhalational therapy. We wish to present the subject from the following points of view: (1) A critical discussion of the pertinent literature. (2) Animal experimentation on the development and treatment of acute pulmonary edema. (3) Physiological studies on the effect of positive pressure respiration in human subjects. (4) The clinical results of treatment with positive pressure in patients with acute pulmonary edema.

1. Discussion of Literature

In 1878 Welch [1] presented his theory of the origin of pulmonary edema in the following words: "A disproportion between the working power of the left ventricle and of the right ventricle of such character that the resistance being the same the left heart is unable to expel in a unit of time the same quantity of blood as the right heart." By squeezing the left ventricle of rabbits between his fingers, Welch observed in many instances forcible contraction of the right ventricle with diminished force of the left ventricle, as indicated by the pressure in the carotid artery, with the result that well marked pulmonary edema took place.

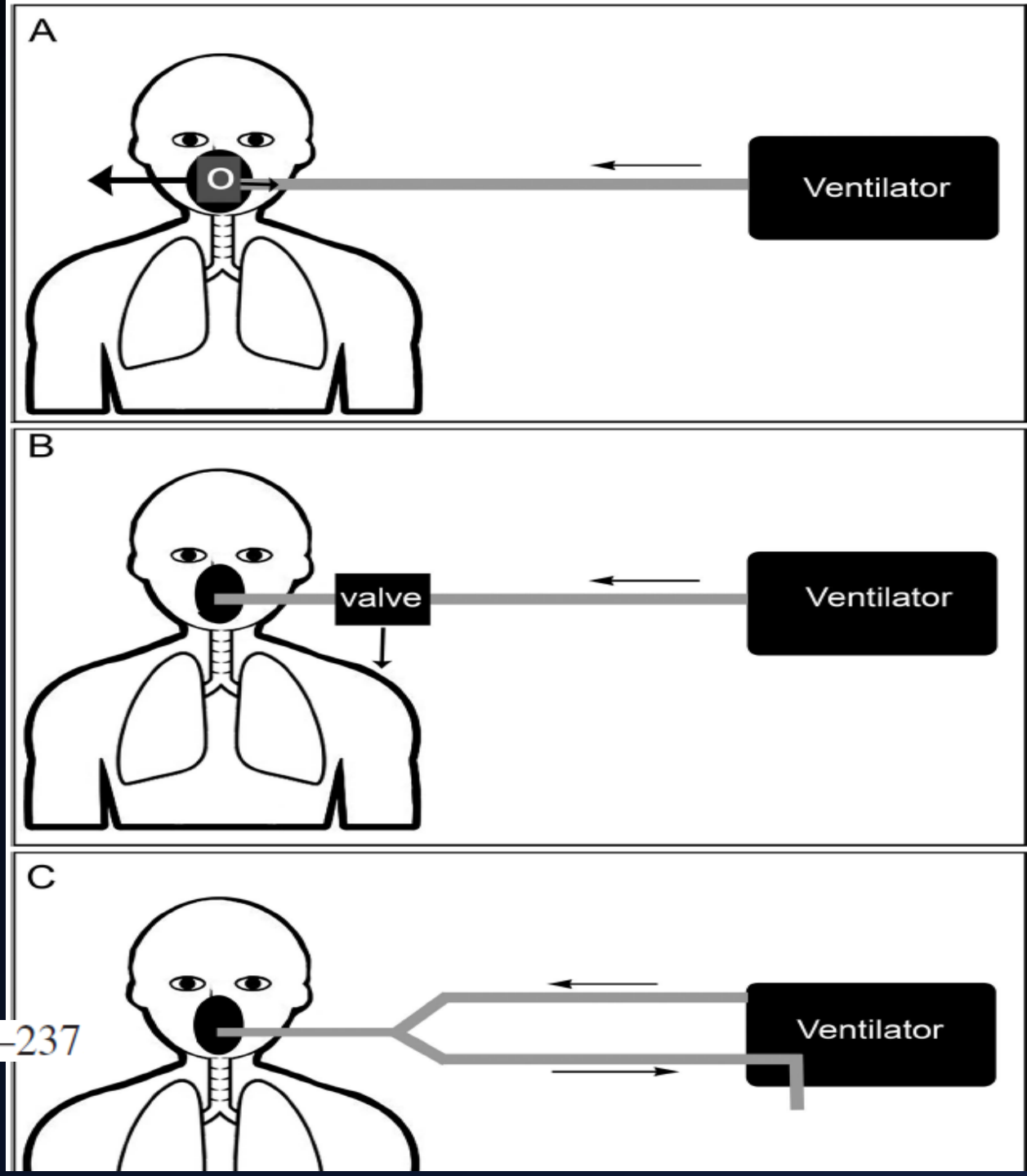
Meltzer [2] brought apparent confirmation to this hypothesis by producing pulmonary edema in rabbits through the intravenous injection of adrenalin. He explained this occurrence as a result of the considerable constriction of the smaller systemic blood vessels, which presented such an increased burden to the left ventricle that it became unable to expel all the blood which it received from the pulmonary veins, while on the other hand the right ventricle unloaded with increased energy upon the lungs all the blood which the contracting vessels drove into it.

Haven Emerson [3] in 1909 showed that pulmonary edema produced by adrenalin could be consistently removed by applying artificial respiration

* Received for publication October 18, 1937.
From the Department of Medicine, Columbia College of Physicians and Surgeons, the Presbyterian Hospital, New York, and the Lakeside Hospital, Cleveland, Ohio.

Přístroj

- Široké spektrum
- „Resuscitační“ ventilátor
  - NIV mode
  - Kompenzace úniku
  - Monitorace, trigger, alarmy
- Bilevel ventilátory



Respir Care 2018;63(2):227–237

Rozhraní

Choosing the Proper Interface for Positive Airway Pressure Therapy in Subjects With Acute Respiratory Failure

Ahmed S BaHammam MD FRCP, Tripat Deep Singh MD RPSGT, Ravi Gupta MD PhD, and Seithikurippu R Pandi-Perumal MSc

[Respir Care 2018;63(2):227–237. © 2018 Daedalus Enterprises]

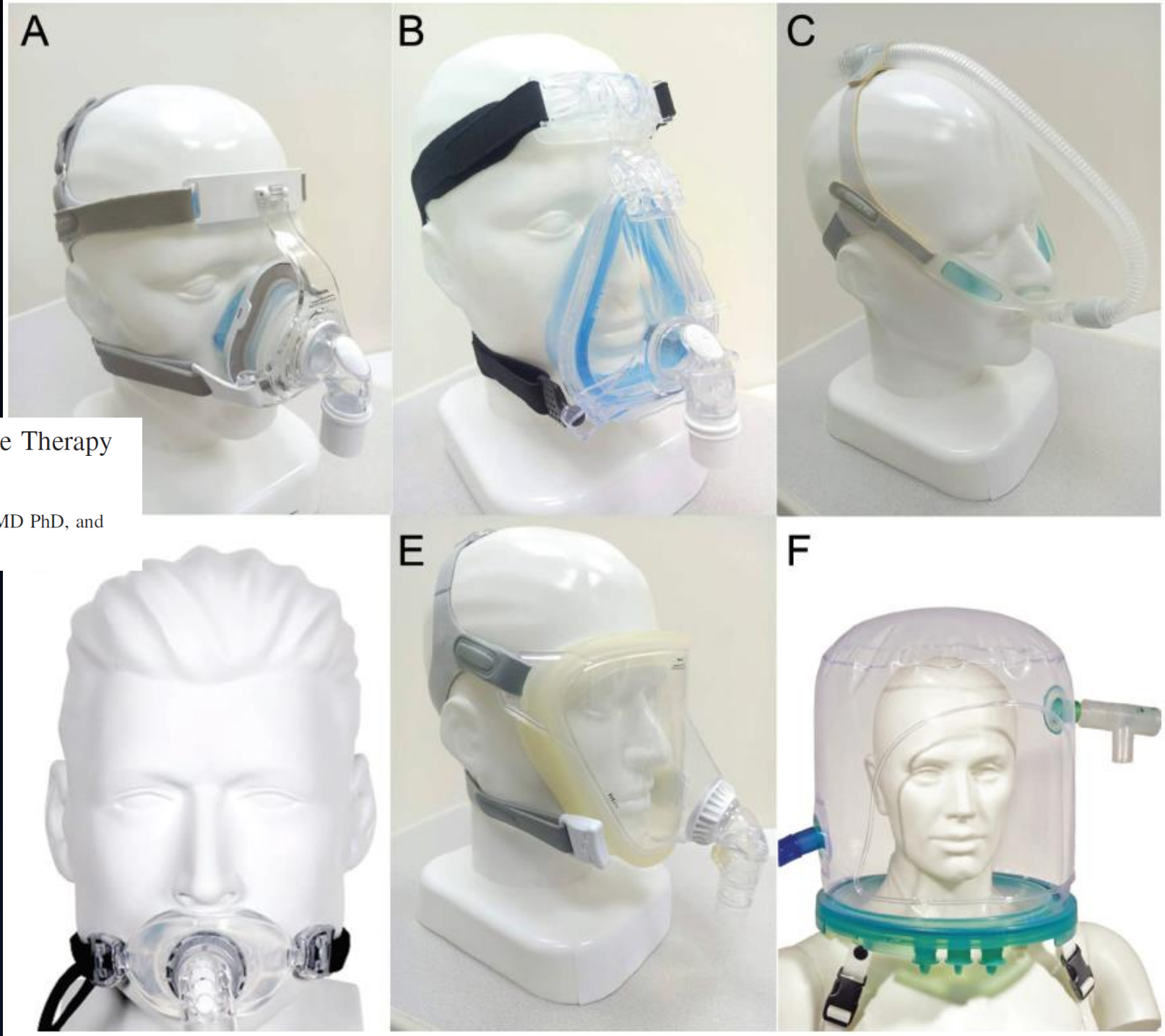
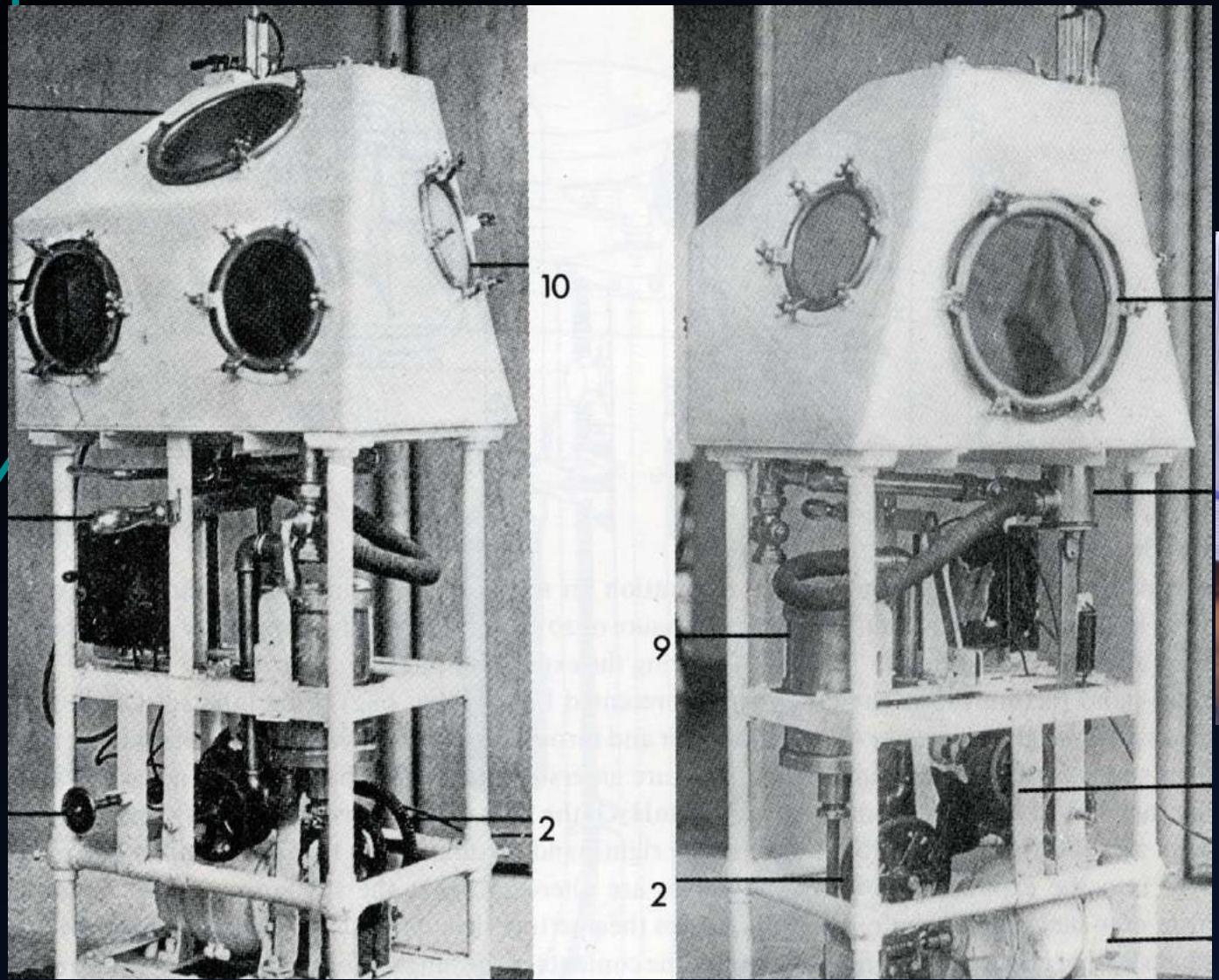


Table 1. Summary of the Main Randomized Controlled Trials That Compared Interfaces During NIV in Subjects With ARF

Author	Study Design	Study Population	Interventions	Findings
Kwok et al[12]	Randomized controlled trial	70 subjects with ARF as evidenced by clinical or blood gas criteria	Subjects randomly received either a disposable nasal mask or an oro-nasal mask.	Both masks performed similarly with regard to improving vital signs and gas exchange and avoiding intubation. The nasal mask was less well tolerated than the oro-nasal mask in subjects with ARF.
Giraultet al[13]	Randomized controlled trial	90 subjects with underlying chronic lung disease in the ICU	Subjects randomly received a face mask or nasal mask.	Mask failure occurred significantly more often in the nasal mask group ($P < .001$). Improvement in respiratory parameters was similar in the 2 groups. Air leaks were more frequent in the nasal mask group ($P < .05$). For prolonged use, switching to a nasal mask may improve comfort and reduce face-mask complications.
Antón et al[14]	Randomized controlled trial	14 subjects with exacerbations of COPD	Subjects randomly received a nasal mask or a full-face mask.	Neither group had a significant difference in ABGs or the indices of respiratory effort. The full-face mask group had a greater decrease in breathing frequency.
Sadeghi et al[15]	Randomized controlled trial	48 subjects with ARF	Subjects randomly received an oro-nasal mask or a total face mask.	No differences in venous blood gas values were noted between the 2 groups. At 6 h, the total face mask reduced the P_{aCO_2} ($P = .04$). Subject comfort and acceptance were similar in both groups.
Pisani et al[33]	A multicenter, short-term, physiological, randomized trial	80 COPD subjects with acute hypercapnic respiratory failure or use of an antidepressant	Subjects randomly received a new helmet or an oro-nasal mask.	NIV improved ABGs, dyspnea, and breathing frequency in both groups. Changes in ABGs and discomfort were similar with the 2 groups, while dyspnea decreased more ($P < .005$) using the mask. The rate of intubation was similar in both groups.
Özlem et al[22]	Randomized controlled trial	50 subjects admitted to the ICU with exacerbations of COPD	Subjects randomly received a full face mask or a helmet.	The decrease in P_{aCO_2} was statistically significant at 60 min in the face-mask group ($P < .05$).
Antonaglia et al[32]	Randomized controlled trial	50 subjects with exacerbation of COPD	Subjects were ventilated for the first 2 h with NIV via face mask. If gas exchange and clinical status improved, they randomly continued with the face mask or received a helmet.	At 4 h after randomization, P_{aCO_2} was lower in the face-mask group than in the helmet group. Duration of NIV and length of stay were lower in the face-mask group.
Patel et al[24]	Randomized controlled trial	83 subjects with ARDS requiring NIV	Subjects received NIV by face mask for at least 8 h, then they randomly continued with the face mask or received a helmet.	The intubation rate was 61.5% for the face-mask group and 18.2% for the helmet group ($P < .001$). Ventilator-free days were significantly higher in the helmet group (28 vs 12.5, $P < .001$). At 90 d, 34.1% in the helmet group died compared 56.4% in the face-mask group ($P = .02$).

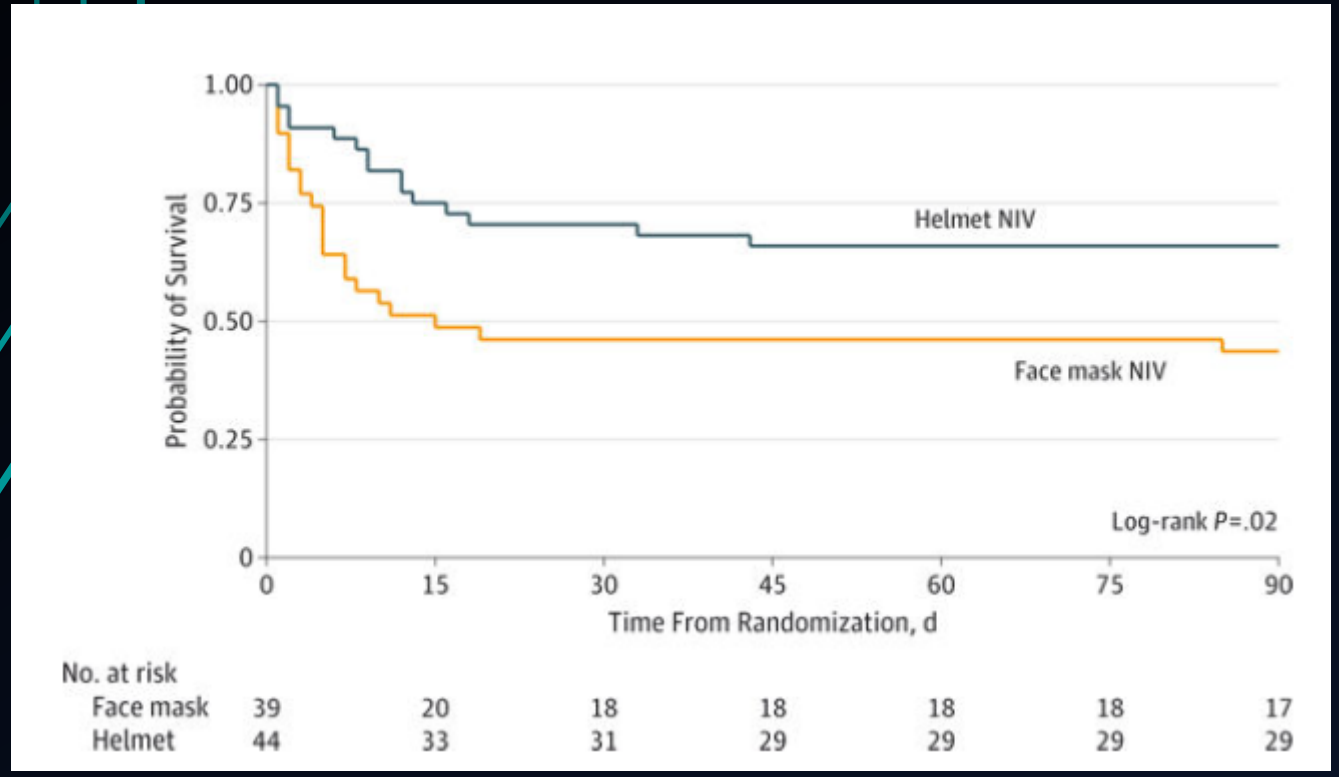
Green and Janeway Rhythmic Inflation Apparatus, 1910



Effect of Noninvasive Ventilation Delivered by Helmet vs Face Mask on the Rate of Endotracheal Intubation in Patients With Acute Respiratory Distress Syndrome:

A Randomized Clinical Trial

JAMA. 2016 June 14; 315(22): 2435–2441



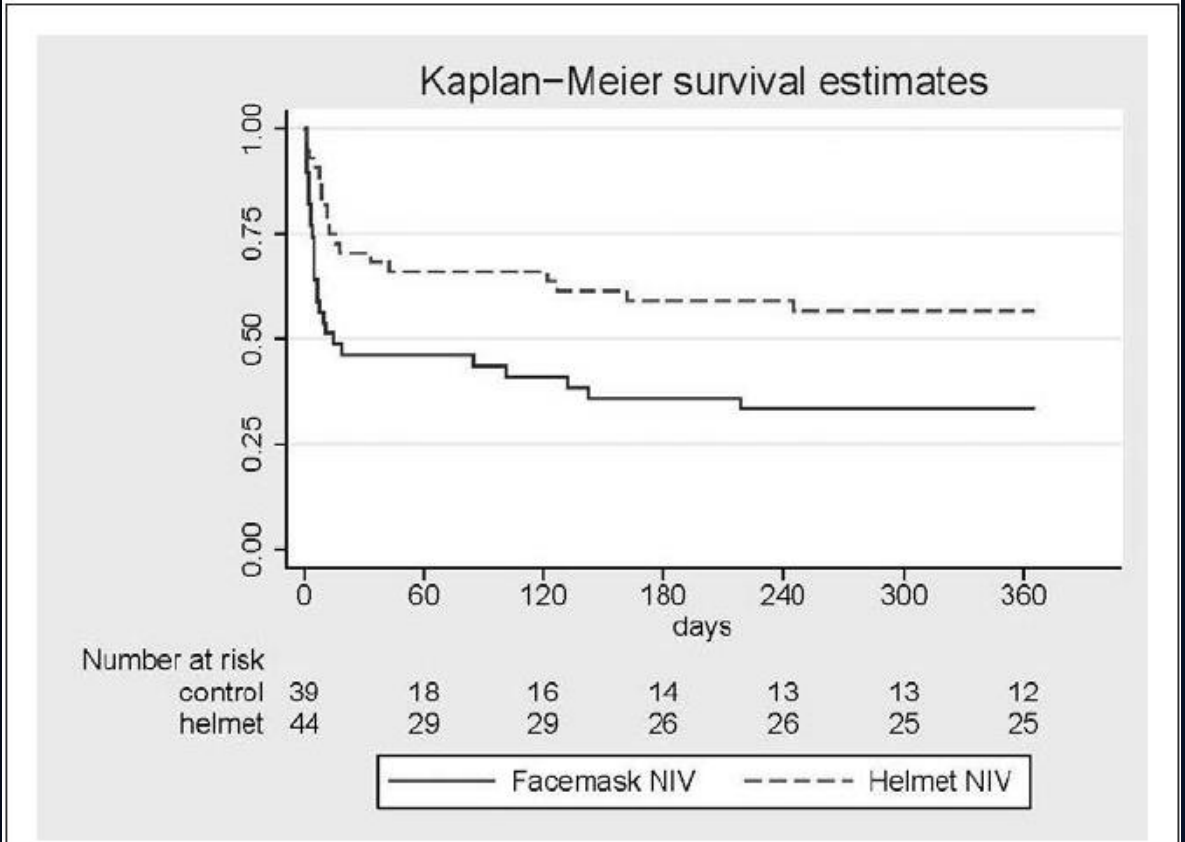
Primary and Secondary Outcomes and Adverse Events

	Face Mask (n = 39)	Helmet (n = 44)	Absolute Difference (95% CI)	*P* Value
Primary outcome, No. (%)				
Endotracheal intubation	24 (61.5)	8 (18.2)	−43.3 (−62.4 to −24.3)	<.001
Reason for intubation				
Respiratory failure	20 (83.3)	3 (37.5)	−45.3 (−82.5 to −9.1)	.01
Circulatory failure	3 (12.5)	0 (0)	−12.5 (−25.7 to 0.7)	.55
Neurologic failure	1 (4.2)	5 (62.5)	58.3 (24.8 to 92.8)	.001
Secondary outcomes, median (IQR), d				
Ventilator-free days	12.5 (0.49–28)	28 (13.7–28)	8.4 (13.4 to 3.4)	<.001
ICU length of stay	7.8 (3.9–13.8)	4.7 (2.5–8.7)	−2.76 (−6.07 to 0.54)	.04
Hospital length of stay	15.2 (7.8–19.7)	10.1 (6.5–15.9)	−2.92 (−8.47 to 2.63)	.16
Mortality, No. (%)				
Hospital	19 (48.7)	12 (27.3)	−21.4 (−41.9 to −1.0)	.04
90 d[a]	22 (56.4)	15 (34.1)	−22.3 (−43.3 to −1.4)	.02
Adverse events				
Mask deflation	0 (0)	2 (4.5)		
Skin ulceration	3 (7.6)	3 (6.8)		

Abbreviations: ICU, intensive care unit; IQR, interquartile range.

One-Year Outcomes in Patients With Acute Respiratory Distress Syndrome Enrolled in a Randomized Clinical Trial of Helmet Versus Facemask Noninvasive Ventilation

(*Crit Care Med* 2018; XX:00–00)

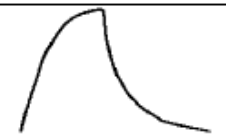


Režim a nastavení

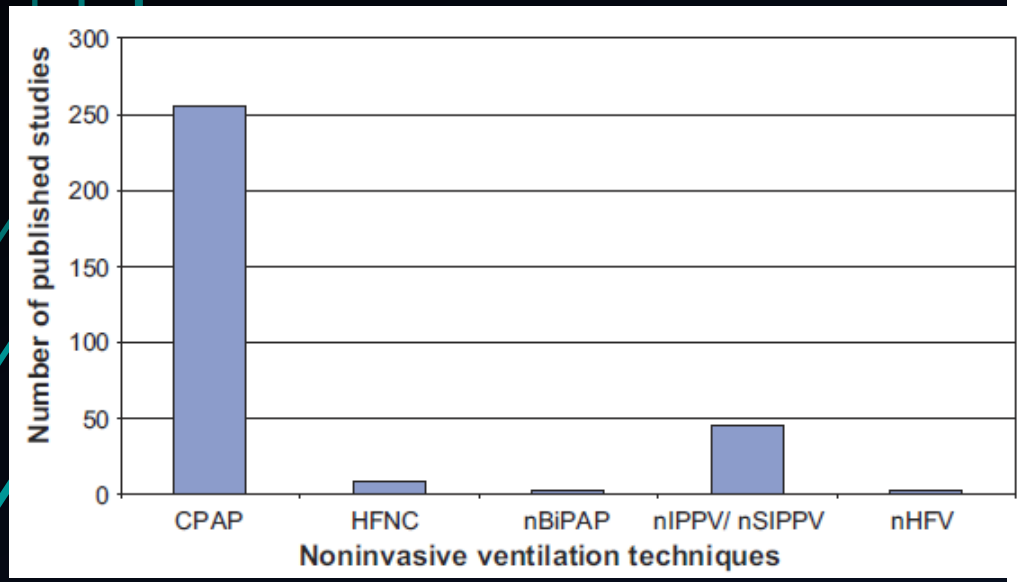
Ventilator modes and settings during non-invasive ventilation: effects on respiratory events and implications for their identification

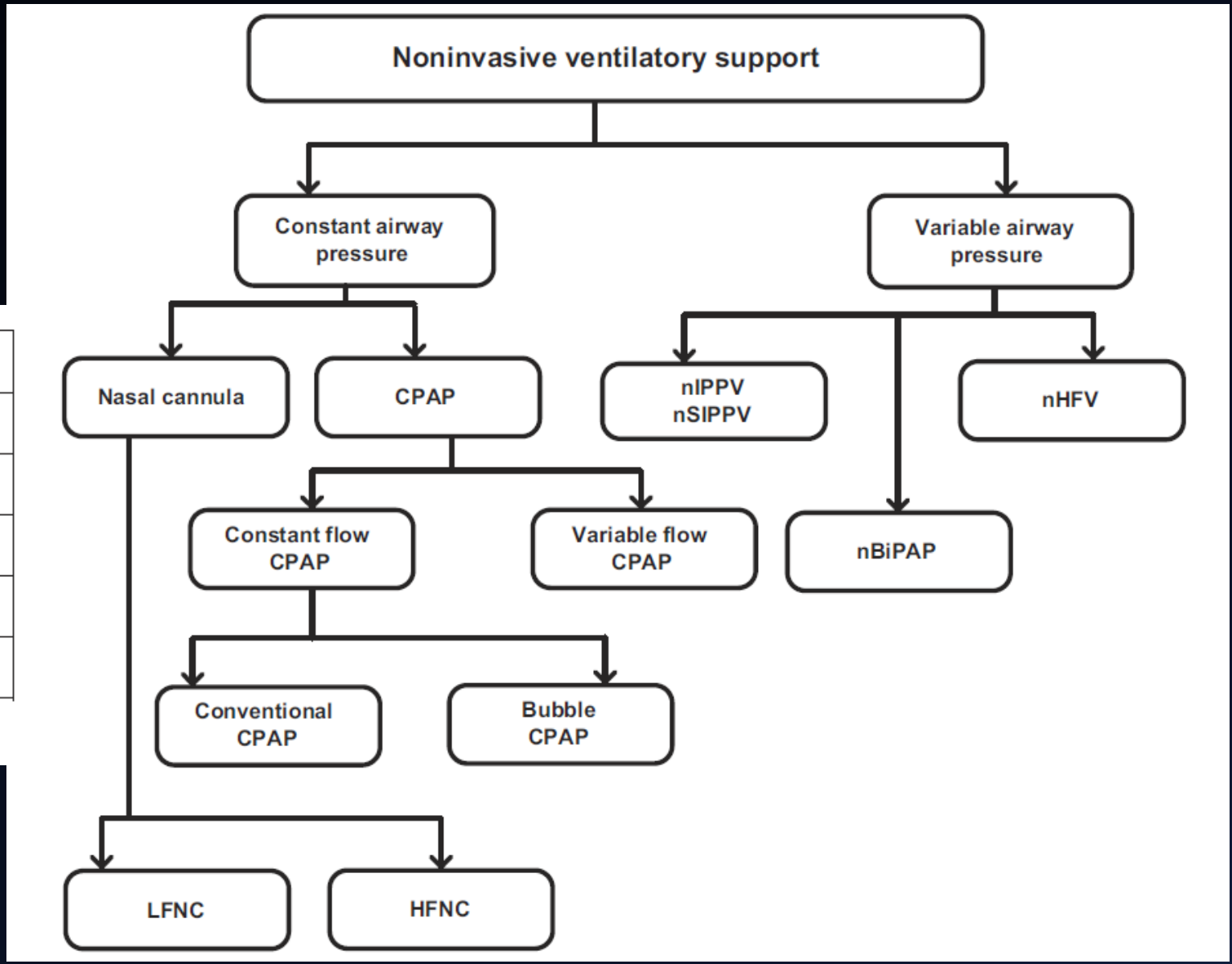
Thorax 2011;**66**:170–178. doi:10.1136/thx.2010.142661

CPAP + PPS

	Volume-targeted	Pressure-targeted
Pressure curve pattern		
Flow curve pattern		
Type of ventilatory assistance delivered	Fixed volume in spite of changing resistance (R) and compliance (C)	Fixed pressure. Tidal volume may vary with changes in C and R
Controlled variable	Maintains a constant inspiratory preset flow	Maintains a constant inspiratory preset pressure
Breath-to-breath adjustments	Not possible: ventilator delivers a fixed assistance	Possible: flow and volume can be varied in a breath-to-breath basis
Possibility to guarantee a fixed delivered tidal volume	Yes (if no leaks)	No
Peak airway pressure	Not limited*	Limited (useful in patients at risk of barotrauma or gastric distension
Leak compensation	Poor, leaks may significantly reduce delivered volume and induce hypoventilation	Good for mild to moderate leaks

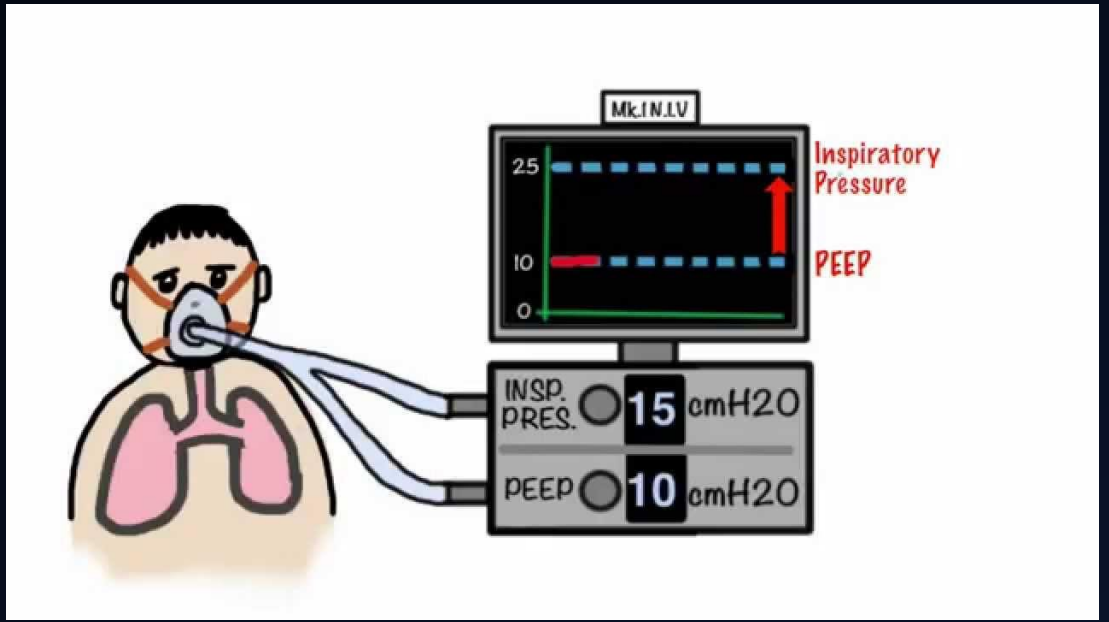
Režim a nastavení





Režim a nastavení

- PSV
- High-low vs. Low-high approach
- IP 8 – 25 (12 – 20) cmH_2O
- PEEP 4 – 8 cmH_2O
- FiO_2
- Zvlhčení



CMAJ, February 22, 2011, 183(3)

Preferred mode for NPPV		
NPPV	We make no recommendation about the use of proportional assist ventilation versus pressure support ventilation in patients who are receiving NPPV for acute respiratory failure, because of insufficient evidence	NA

Jean-Damien Ricard
Alexandre Boyer

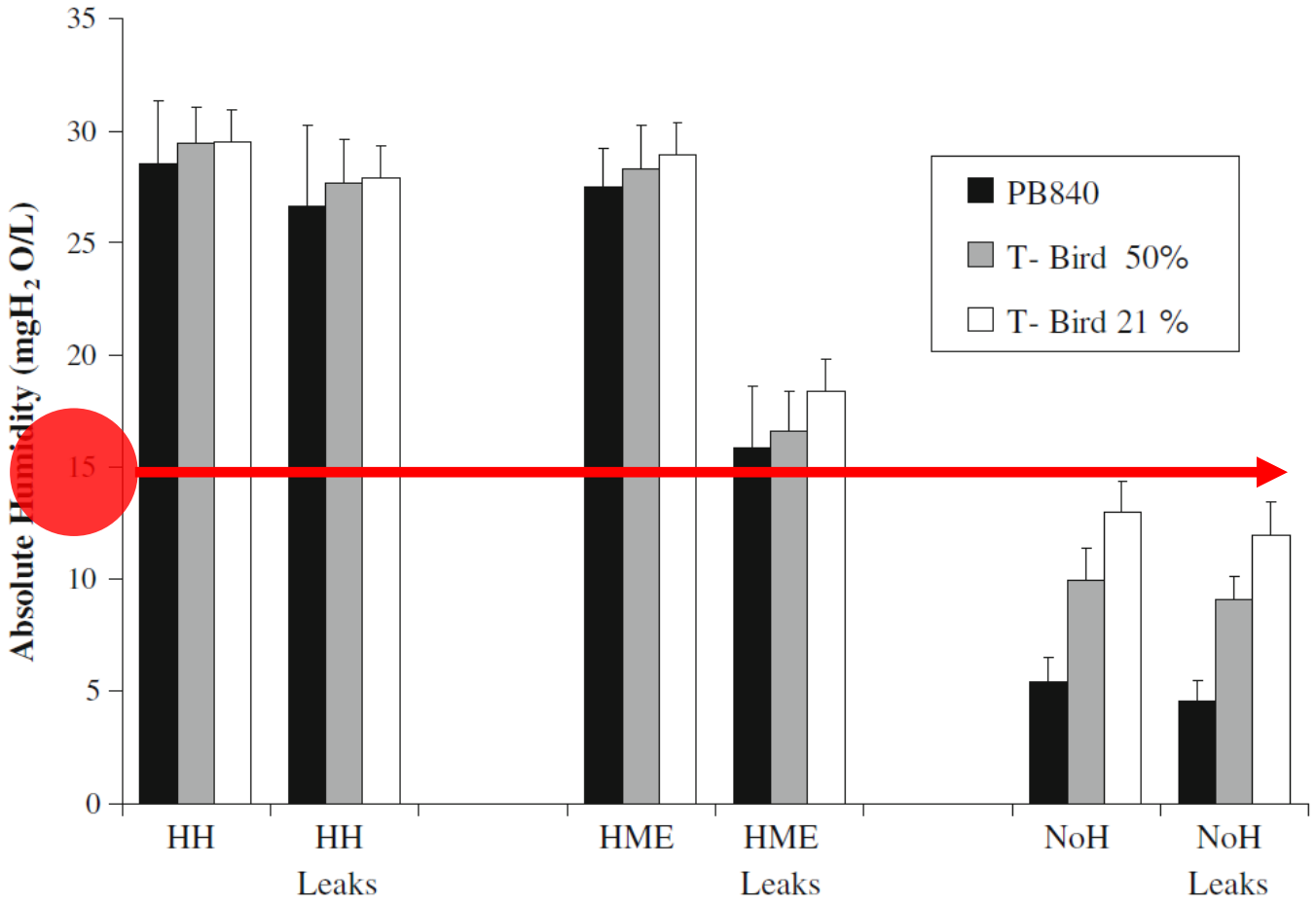
Humidification during oxygen therapy and non-invasive ventilation: do we need some and how much?

Intensive Care Med (2009) 35:987–995
DOI 10.1007/s00134-009-1455-y

ORIGINAL

François Lellouche
Salvatore Maurizio Maggiore
Aissam Lyazidi
Nicolas Deye
Solenne Taillé
Laurent Brochard

Water content of delivered gases during non-invasive ventilation in healthy subjects



Humidification During Invasive and Noninvasive Mechanical Ventilation: 2012

14.2 Active humidification is suggested for NIV, as it may improve adherence and comfort. (2B)

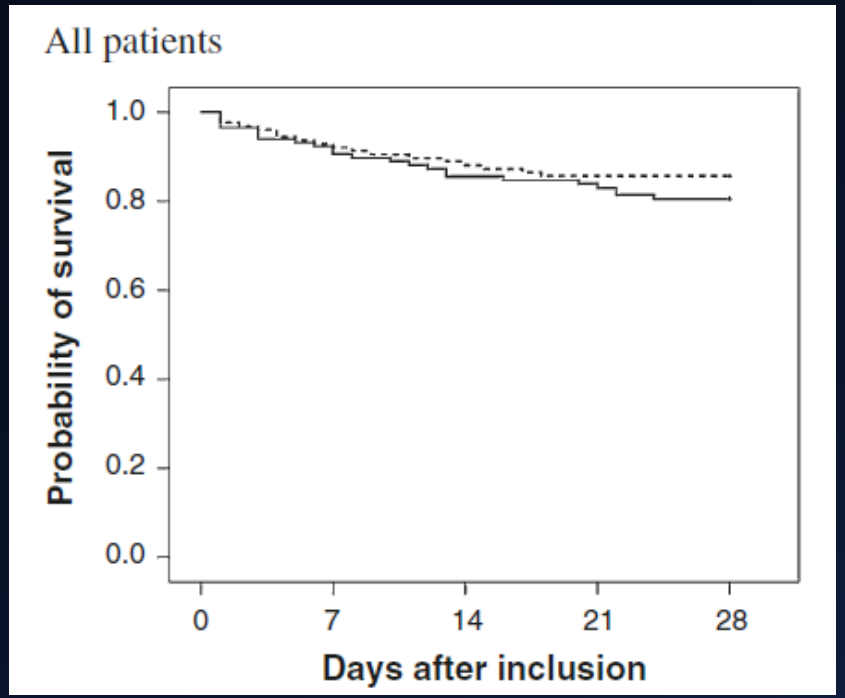
14.5 Passive humidification is not recommended for NIV. (2C)

[Respir Care 2012;57(5):782–788. © 2012 Daedalus Enterprises]

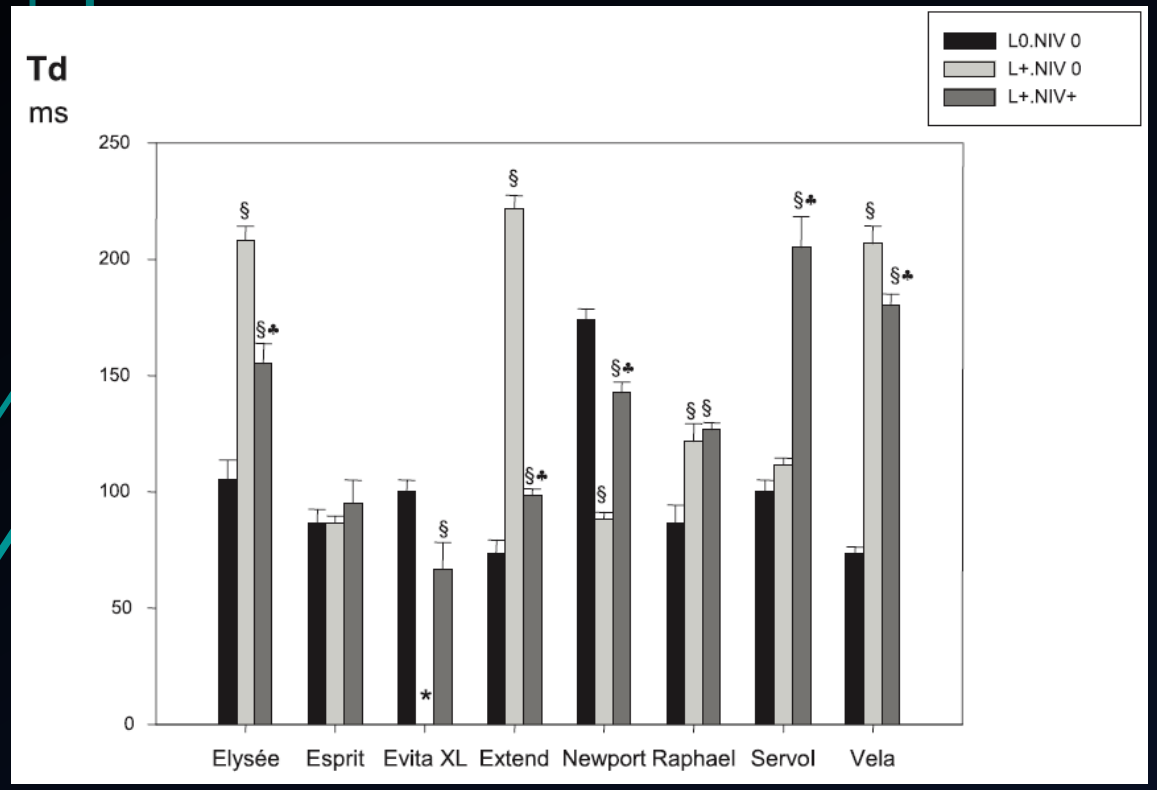
Impact of the humidification device on intubation rate during noninvasive ventilation with ICU ventilators: results of a multicenter randomized controlled trial

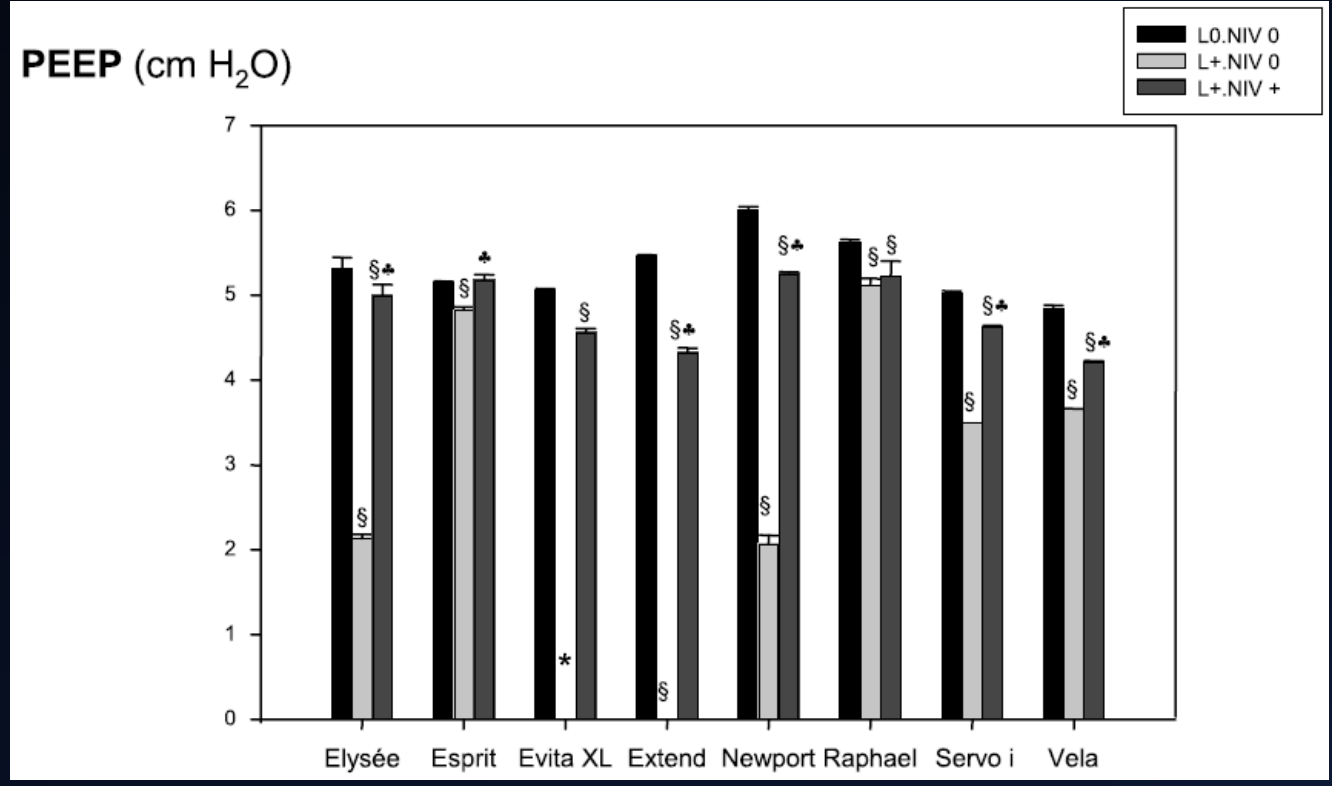
Intensive Care Med (2014) 40:211–219
DOI 10.1007/s00134-013-3145-z

cal benefits of HH in comparison with HME during NIV with ICU ventilators were not observed, and no



Performance of noninvasive ventilation modes on ICU ventilators during pressure support: a bench model study





Intensive Care Med (2007) 33:1444–1451
DOI 10.1007/s00134-007-0713-0

Monitorace

- Subjektivně
- Fyziologické parametry
- Spánek

Prediktory úspěchu

- APACHE
- Spolupráce
- Schopnost synchronie
- Zuby, nízký únik
- DF 24 – 35/min.
- Hyperkapnie 45 – 92 mmHg
- RAC
- **Efekt do 2 hodin?**

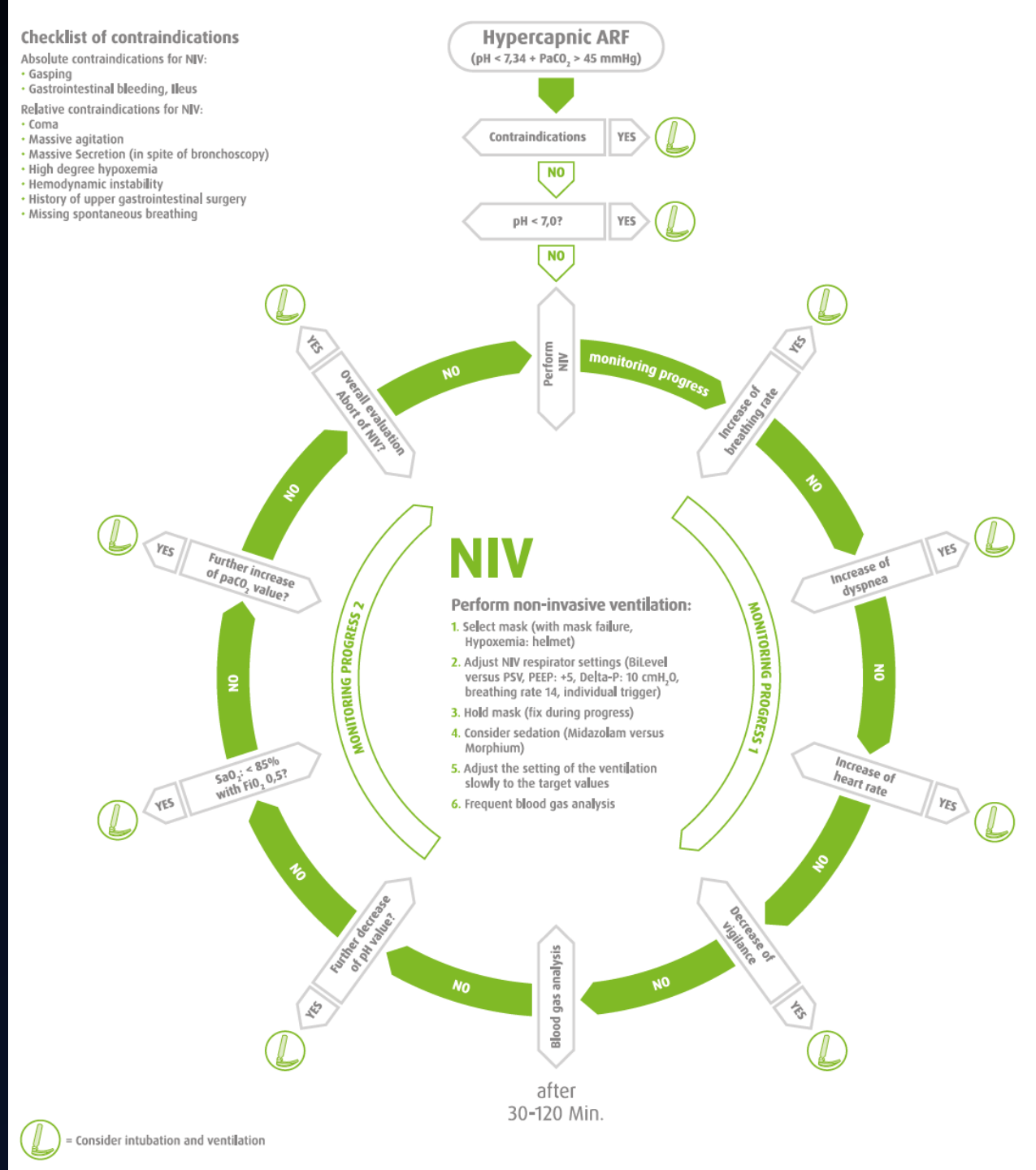
Predictors of Intubation in Patients With Acute Hypoxemic Respiratory Failure Treated With a Noninvasive Oxygenation Strategy*

(*Crit Care Med* 2018; 46:208–215)

TABLE 3. Multivariate Logistic Regression Analyses of Factors Associated With Intubation

Risk Factors	OR (95% CI)	*p*
In patients treated with conventional O_2 therapy by nonrebreathing mask[a]		
Respiratory rate ≥ 30 breaths/min at H1	2.76 (1.13–6.75)	0.03
In patients treated with high-flow nasal cannula oxygen therapy[a]		
Heart rate at H1 (per beat/min)	1.03 (1.01–1.06)	< 0.01
In patients treated with noninvasive ventilation[ab]		
Tidal volume > 9 mL/kg of predicted body weight at H1	3.14 (1.22–8.06)	0.02
Pao_2/Fio_2 ≤ 200 mm Hg at H1	4.26 (1.62–11.16)	0.003

- Tolerance
- Úleva
- Úprava fyziologických parametrů



Giorgio Conti
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Is sedation safe and beneficial in patients receiving NIV? No

Intensive Care Med (2015) 41:1692–1695
DOI 10.1007/s00134-015-3915-x

Gilles Hilbert
Paolo Navalesi
Christophe Girault

Is sedation safe and beneficial in patients receiving NIV? Yes

Intensive Care Med (2015) 41:1688–1691
DOI 10.1007/s00134-015-3935-6

Table 1 Clinical studies assessing the use of sedation/analgesia during NIV

References	Type	Patients (*n*)	Reason for NPPV (*n*)	Reason for sedation/ analgesia	Sedative and/or analgesic drugs used (*n*)	NIV tolerance/ sedation	NPPV success rate (%)
Rocker et al. [7]	Prospective observational	9/12	Hypoxemic ARF (ALI/ARDS)	Preventive NIV intolerance	Midazolam (6)/morphine (8)	Adequate tolerance	50
Constantin et al. [8]	Prospective observational	13	Hypoxemic (10) or hypercapnic ARF (3)	Curative NIV intolerance	Propofol (3)/ remifentanil (13)	Adequate tolerance	69
Akada et al. [9]	Prospective observational	10	Hypercapnic ARF	Curative NIV intolerance	Dexmedetomidine	Adequate tolerance	100
Rocco et al. [10]	Prospective observational	36	Persistent hypoxemic ARF	Curative NIV intolerance	Remifentanil	Adequate tolerance	61
Clouzeau et al. [11]	Prospective observational	10	Hypoxemic (7) or hypercapnic ARF (3)	Curative NPPV intolerance	Propofol	Adequate tolerance	70
Senoglu et al. [12]	Prospective randomized double-blind	40	Hypercapnic ARF (COPD)	Curative NIV intolerance	Dexmedetomidine (20) vs midazolam (20	Adequate tolerance/ sedation	100 vs 100 (during first 24 h)
Huang et al. [13]	Prospective randomized	62	Hypercapnic ARF (CPE)	Curative NIV intolerance	Dexmedetomidine (33) vs midazolam (29)	Adequate tolerance/ sedation	79 vs 55 ($p = 0.043$)
Devlin et al. [14]	Prospective randomized double-blind	33	Hypercapnic ARF	Preventive NIV intolerance	Dexmedetomidine (16) vs placebo (17) ±midazolam (agitation) and/or fentanyl (pain)	No adequate tolerance/sedation	69 vs 71

NIV noninvasive ventilation, *ARF* acute respiratory failure, *ALI* acute lung injury, *ARDS* acute respiratory distress syndrome, *COPD* chronic obstructive pulmonary disease, *CPE* cardiogenic pulmonary edema, *preventive NIV intolerance* at start of NIV to prevent NIV intolerance, *curative NIV intolerance* for poor tolerance (pain, discomfort, agitation, refusing to continue) during NIV

Do not sedate your patients unless non-pharmacologic approaches to achieving patient tolerance have been tried first

Sedation is not used in the large majority of patients

Do not use analgesia and sedation for NIV without appropriate monitoring by experienced staff

Dangerous side effects of sedation

To eat or to breathe? The answer is both! Nutritional management during noninvasive ventilation

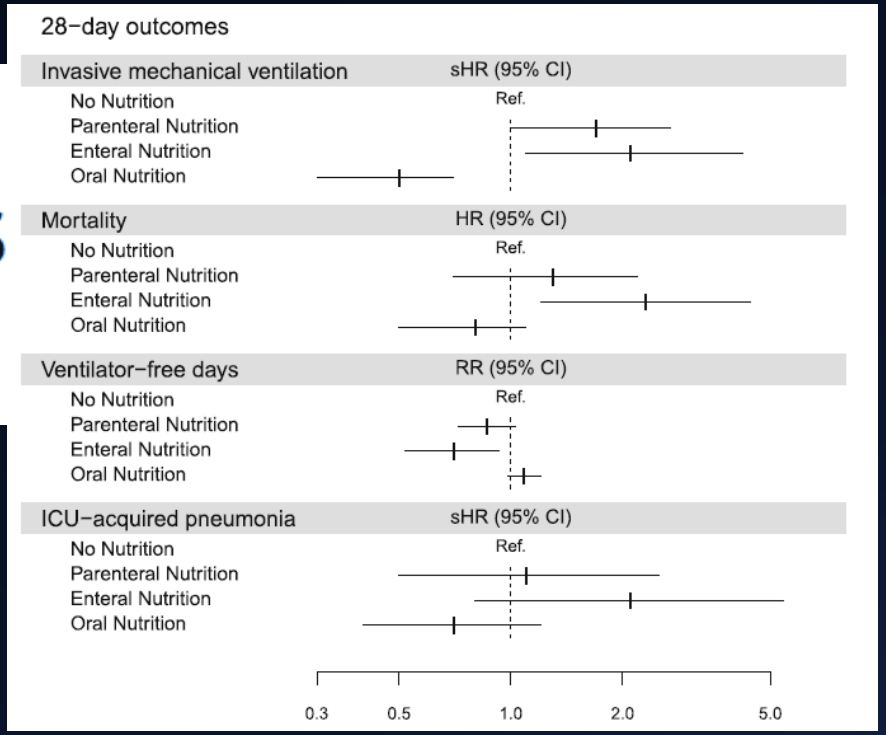
Pierre Singer[1*] and Sornwichate Rattanachaiwong[2]

Singer and Rattanachaiwong *Critical Care* (2018) 22:27

Initial nutritional management during noninvasive ventilation and outcomes a retrospective cohort study

Terzi *et al. Critical Care* (2017) 21:293

Most patients received no nutrition at all during the first 2 days of first-line NIV. Early EN in a heterogeneous population was independently associated with higher 28-day mortality and fewer ventilator-free days.



Komplikace

- Selhání
- „Velké komplikace“

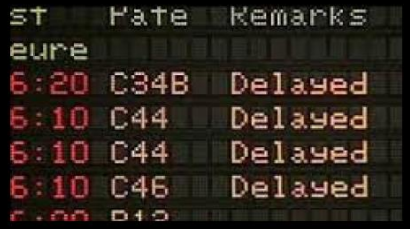
PROČ NIV ???

Respiratory Protective Strategy

Endotracheal tube

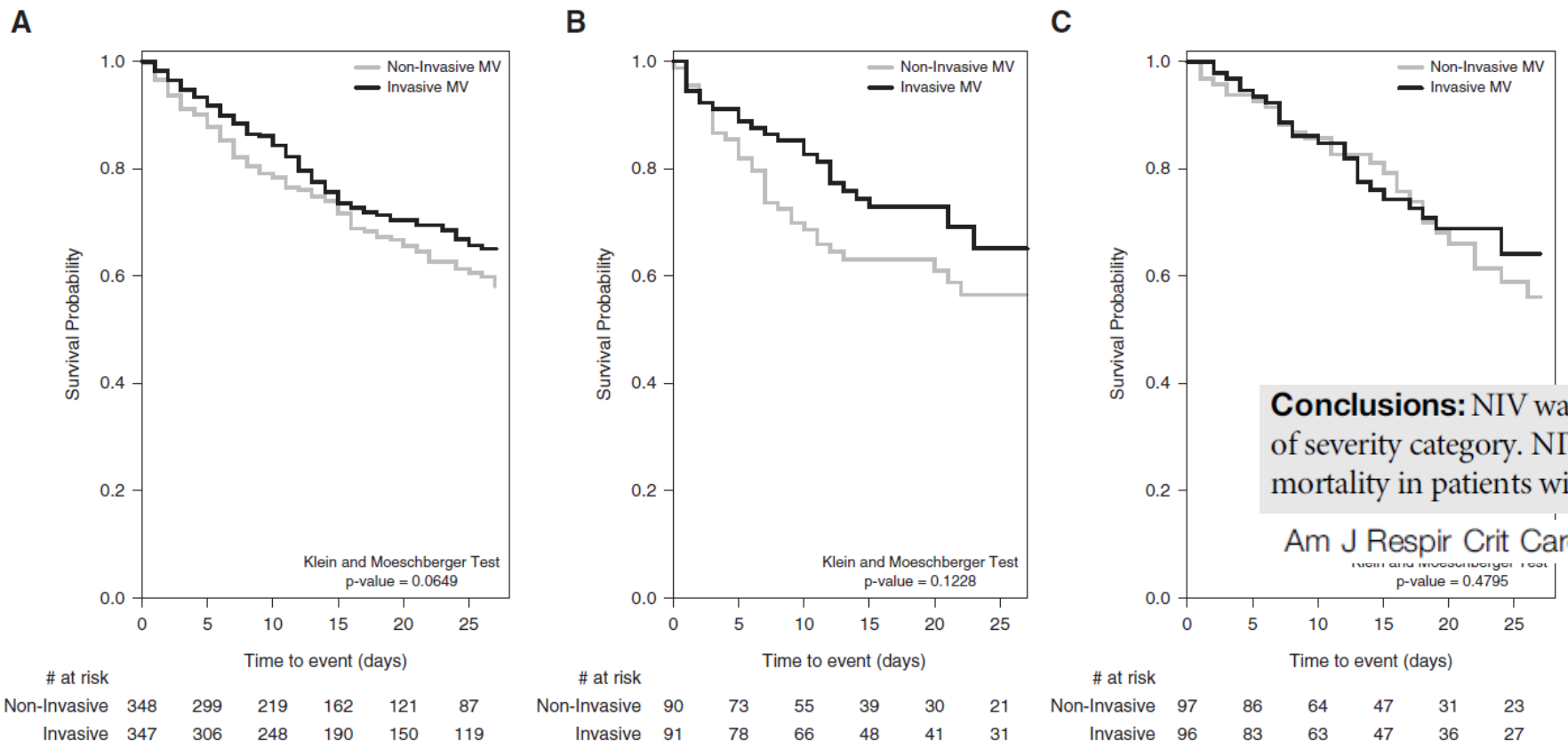
INTUBATION CANCELED , NOT DELAYED

- **Fyziologické účinky (WOB, CO2, O2)**
- **Eliminace komplikací TI (bez obejití HCD)**
- **Komfort pacienta – eliminace sedace/relaxace**
- **Zkrácení hospitaliace / snížení morbidity- mortality**
- **Neúspěch NIV = odklad intubace**



Noninvasive Ventilation of Patients with Acute Respiratory Distress Syndrome

Insights from the LUNG SAFE Study



Conclusions: NIV was used in 15% of patients with ARDS, irrespective of severity category. NIV seems to be associated with higher ICU mortality in patients with a Pa_{O_2}/FI_{O_2} lower than 150 mm Hg.

Am J Respir Crit Care Med Vol 195, Iss 1, pp 67–77, Jan 1, 2017

Figure 3. Kaplan-Meier survival curves in the propensity score matched samples of patients managed with noninvasive and invasive ventilation. (*A–C*) Survival over time in the entire sample (n = 706) (*A*), in matched sample with Pa_{O_2}/FI_{O_2} ratio <150 mm Hg (n = 184) (*B*), and in matched sample for Pa_{O_2}/FI_{O_2} ratio ≥150 mm Hg (n = 194) (*C*). Vital status was evaluated at hospital discharge. Patients were censored on Day 28 from acute hypoxemic respiratory failure (AHRF) onset. Patients discharged alive from hospital before the Day 28 from AHRF onset were considered alive at Day 28. MV = mechanical ventilation.

Noninvasive Treatment of Hypoxemic Respiratory Failure: Give It a Try… But Do Not Push Too Hard*

February 2018 • Volume 46 • Number 2

Given current evidence, it seems reasonable for clinicians to initiate a noninvasive oxygenation technique in patients with AHRF (perhaps with a slight preference for nasal high-flow oxygen given its positive effect on patient comfort), but only under strict monitoring and with predefined criteria for failure that will prompt timely conversion to invasive support.