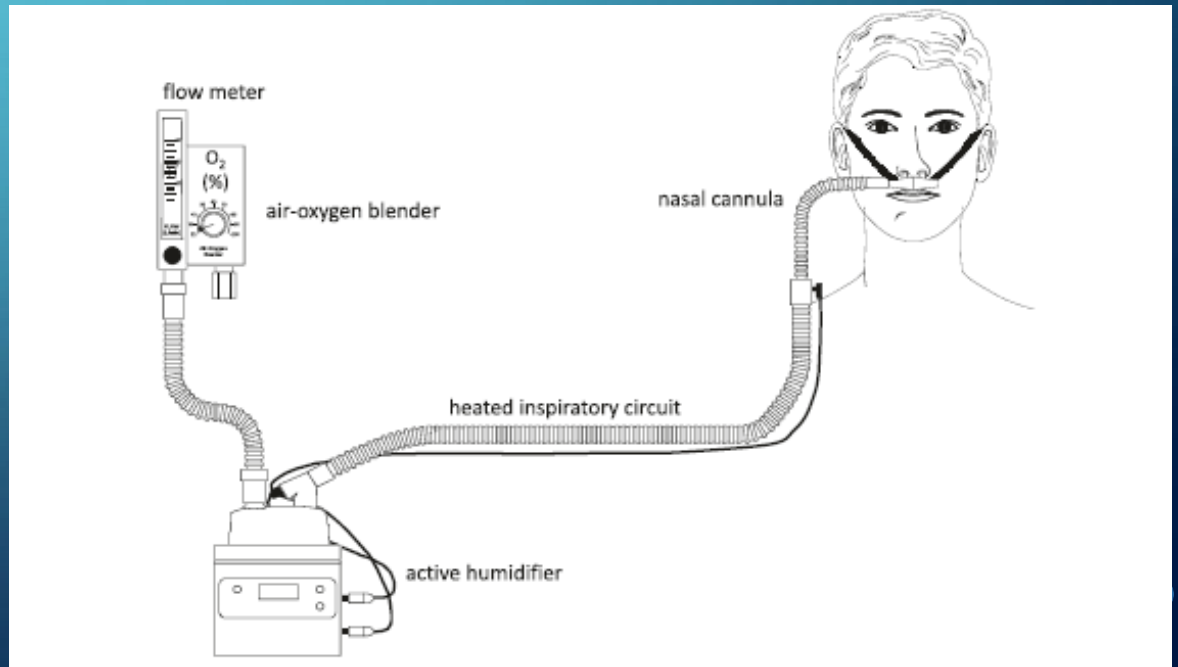
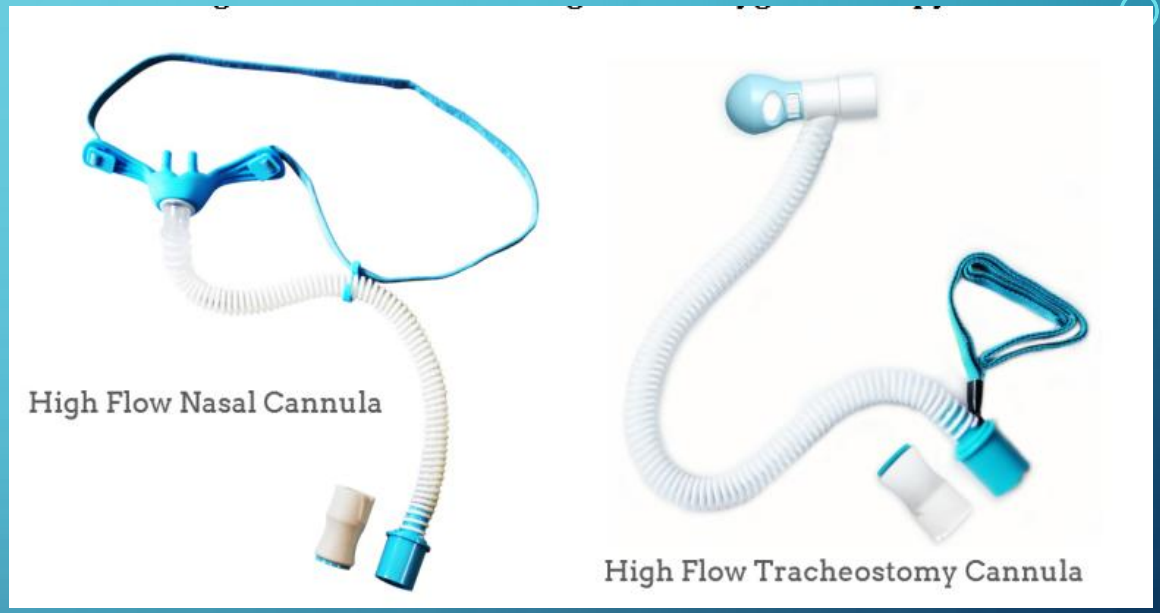
HIGH FLOW OXYGEN TERAPIE

JIŘÍ KARÁSEK

- Forma dechové podpory (částečně alternativa nebo doplnění NIV)
- Průtoky 30-40l/min (u dospělých až 60 l/min O2)
- Zvlhčená směs O2+vzduch
- Speciální nosní kanyla
- Nižší inspir.odpor/vyšší expirační odpor

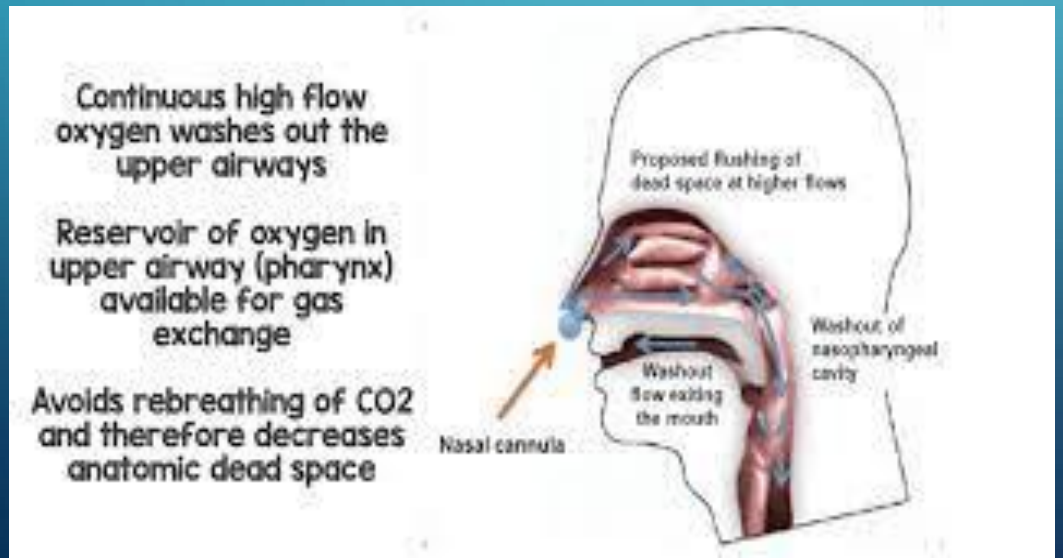


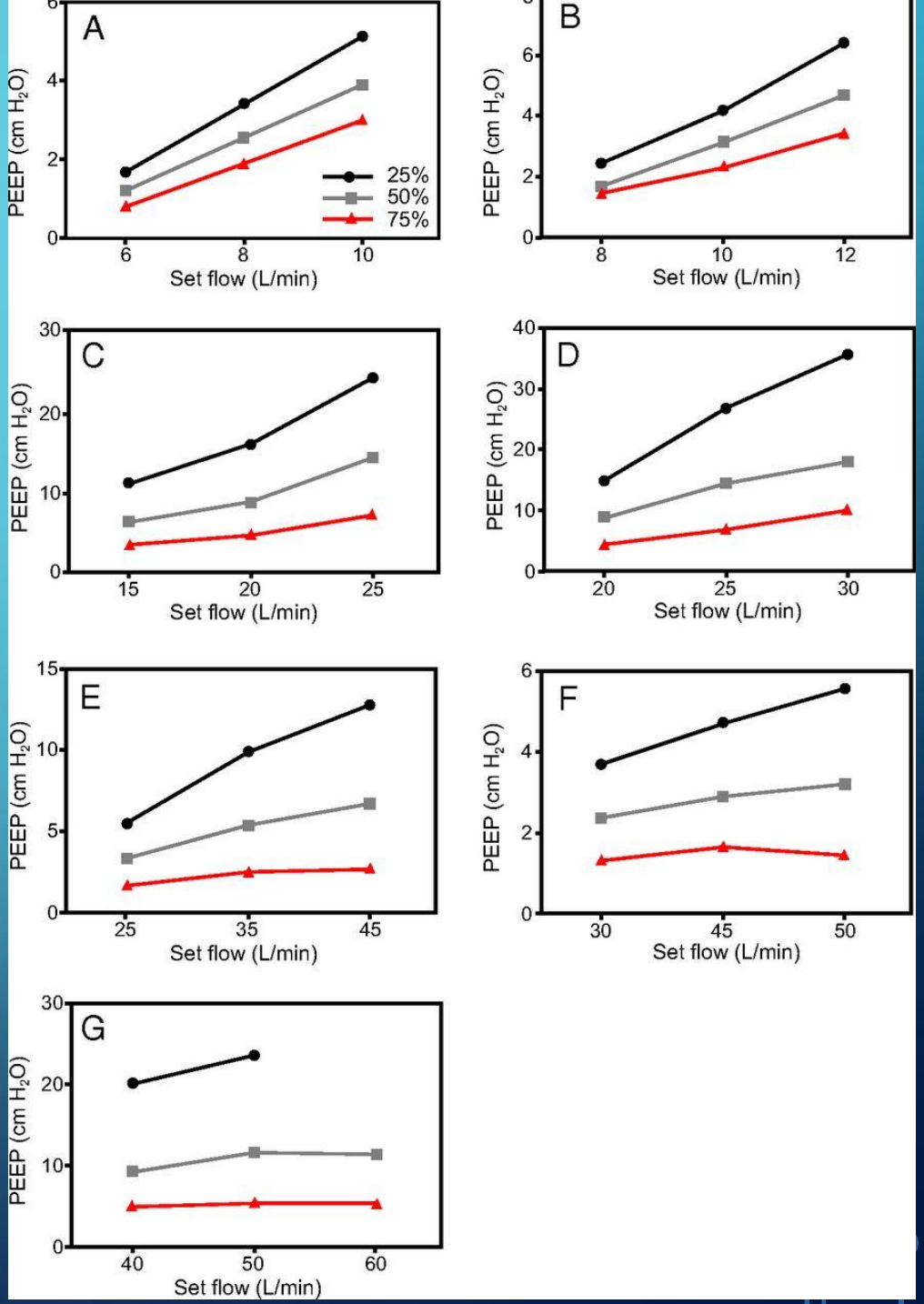
- Různé velikosti
- Varianta pro tracheostomii (weaning)
- Musí přiléhat k nosním dírkám



FYZIOLOGIE

- Stabilní hodnota FiO2 0,2-1,0)
- Snížení dechového úsilí, „wash out“ mrtvého prostoru, pokles CO2
- Generuje přetlak (PEEP)- vysoký průtok převyšuje odpor v DC (40l/min…1,5 60 l/min….3,1 cm H2O)
- Zvlhčení a ohřátí-mukociliární transport a viskozita v DC





INDIKACE

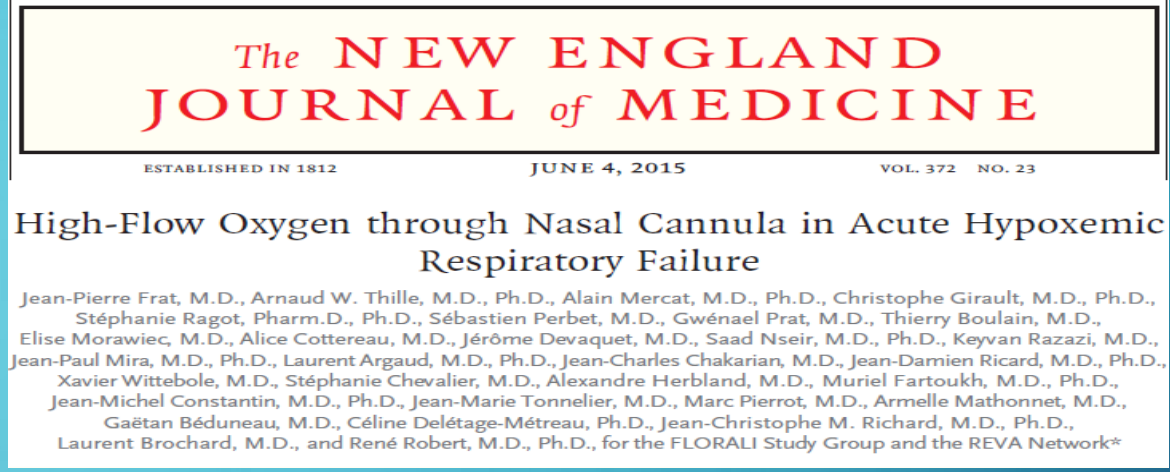
- Respir. Selhání I.typu-lehké a střední (pneumonie, inhal. trauma, srdeční selhání, CHOPN)
- Respir. Selhání II.typu (netoleruje nebo střídání s NIV)
- Postextubační období a weaning (nižší riziko reintubace)
- Před rizikovou intubací a ICU intubací
- Invazivní výkony ?

NASTAVENÍ

Table 3 Practical recommendations. FI_{O_2}, fraction of inspired oxygen; Sa_{O_2}, arterial oxygen saturation; HFNO, high-flow nasal oxygen therapy

Settings	
Prongs	• Prongs should not totally occlude nostrils
Flow rate	• Start at 30-40 litres min^{-1} and increase to meet the patient's demand
Temperature	• Set at 37°C
FI_{O_2}	• Increase the FI_{O_2} until satisfactory Sa_{O_2} is achieved
Flow	• Increase the delivered flow until a reduction in respiratory rate and stable Sa_{O_2} is achieved
Water reservoir	• Place as high as possible above the humidifier
Monitoring	• Continuous monitoring of heart rate, respiratory rate, Sa_{O_2}
Positive response and weaning	• Gas flow rate and FI_{O_2} adjusted according to the clinical response (expected within 1 h).
	• Reduce FI_{O_2} by 5-10% and reassess after 1-2 h. Reduce the flow rate by 5 litres min^{-1} and reassess after 1-2 h.
	• Consider weaning from HFNO with flow rates ≤25 litres min^{-1} and FI_{O_2} <0.40.
Ineffective response	• If there is no improvement after 60-120 min, treatment escalation must be considered.

ventilation.[41] They reported that early indicators of HFNO failure could be lack of improvement in oxygenation and persistence of tachypnoea, as defined by a respiratory rate higher than 30 breaths min^{-1} and thoraco-abdominal asynchrony 30 min after HFNO initiation.[8,39] Other factors associated with failure are shock requiring administration of vasopressors, a Sepsis-related Organ Failure Assessment (SOFA) score of 4 or more, an Acute Physiology and Chronic Health Evaluation II (APACHE II) ≥12 on admission and a Pa_{O_2}/FI_{O_2} ratio <13.3 kPa after 6 h of treatment.[32,37]



- CRT: HFO vs. Stand.O2 vs. NIV k SpO2 92% a více

  Incl: RR nad 25/min, oxygen.index 300 mm Hg a méně při O2 10l/min po 15 min Exl.: paCO2 nad 45 mm Hg, astma, CHOPN, plicní edém, vasopresory
- Primární outcome: OTI do 28 dnů
- Sekundární outcome: ICU mortalita, 90 denní mortalita, ventilátor free days

ening respiratory failure as defined by at least two of the following criteria: a respiratory rate of more than 40 breaths per minute, a lack of improvement in signs of high respiratory-muscle workload, the development of copious tracheal secretions, acidosis with a pH of less than 7.35, an SpO_2 of less than 90% for more than 5 minutes without technical dysfunction, or a poor response to oxygenation techniques (details of the criteria

310 PTS.: 94 O2/106 HFO/110 NIV

Table 1. Characteristics of the Patients at Baseline, According to Study Group.*

Characteristic	High-Flow Oxygen (N=106)	Standard Oxygen (N=94)	Noninvasive Ventilation (N=110)
Age — yr	61±16	59±17	61±17
Male sex — no. (%)	75 (71)	63 (67)	74 (67)
Body-mass index†	25±5	26±5	26±6
SAPS II‡	25±9	24±9	27±9
Current or past smoking — no. (%)	34 (32)	36 (38)	40 (36)
Reason for acute respiratory failure — no. (%)			
Community-acquired pneumonia	71 (67)	57 (61)	69 (63)
Hospital-acquired pneumonia	12 (11)	13 (14)	12 (11)
Extrapulmonary sepsis	4 (4)	5 (5)	7 (6)
Aspiration or drowning	3 (3)	1 (1)	2 (2)
Pneumonia related to immunosuppression	6 (6)	4 (4)	10 (9)
Other	10 (9)	14 (15)	10 (9)
Bilateral pulmonary infiltrates — no. (%)	79 (75)	80 (85)	85 (77)
Respiratory rate — breaths/min	33±6	32±6	33±7
Heart rate — beats/min	106±21	104±16	106±21
Arterial pressure — mm Hg			
Systolic	127±24	130±22	128±21
Mean	87±17	89±15	86±16
Arterial blood gas			
pH	7.43±0.05	7.44±0.06	7.43±0.06
Pao_2 — mm Hg	85±31	92±32	90±36
FIO_2§	0.62±0.19	0.63±0.17	0.65±0.15
Pao_2:FIO_2 — mm Hg	157±89	161±73	149±72
$Paco_2$ — mm Hg	36±6	35±5	34±6

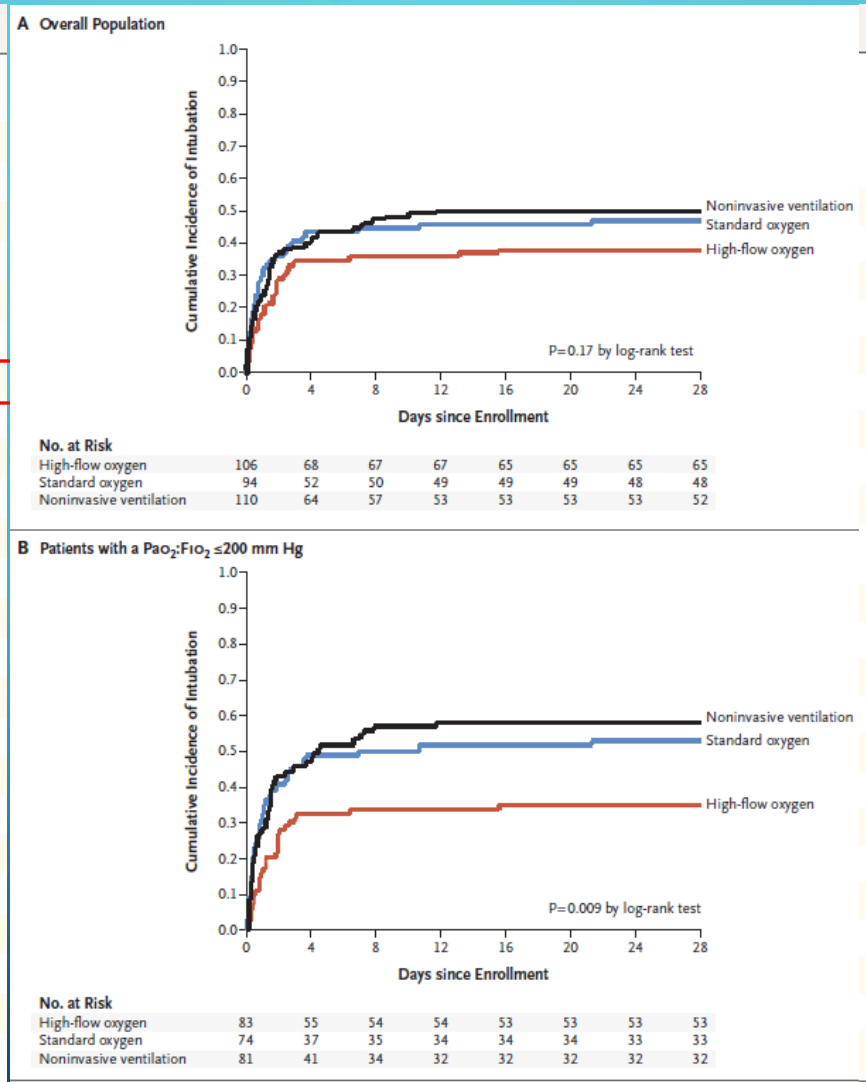


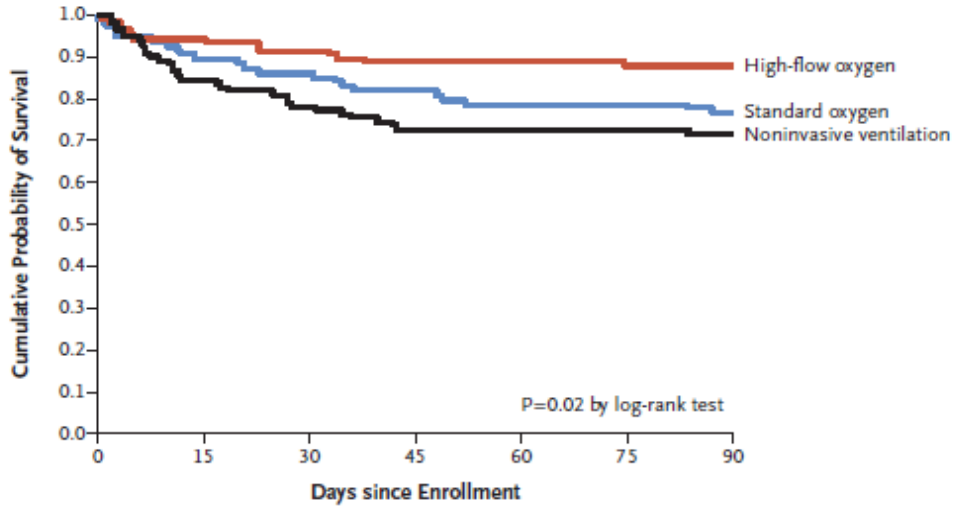
Table 2. Primary and Secondary Outcomes, According to Study Group.*

Outcome	Study Group			P Value†	Odds Ratio or Hazard Ratio (95% CI)	
	High-Flow Oxygen (N=106)	Standard Oxygen (N=94)	Noninvasive Ventilation (N=110)		Standard Oxygen vs. High-Flow Oxygen	Noninvasive Ventilation vs. High-Flow Oxygen
Intubation at day 28						
Overall population				0.18	1.45 (0.83–2.55)	1.65 (0.96–2.84)
No. of patients	40	44	55			
% of patients (95% CI)	38 (29–47)	47 (37–57)	50 (41–59)			
Patients with Pao_2:FIO_2 ≤200 mm Hg‡						
Unadjusted analysis				0.009	2.07 (1.09–3.94)	2.57 (1.37–4.84)
No. of patients/total no.	29/83	39/74	47/81			
% of patients (95% CI)	35 (26–46)	53 (42–64)	58 (47–68)			
Adjusted analysis§	—	—	—	0.01	2.14 (1.08–4.22)	2.60 (1.36–4.96)
Interval between enrollment and intubation — hr¶						
Overall population				0.27	—	—
Median	27	15	27			
Interquartile range	8–46	5–39	8–53			
Patients with Pao_2:FIO_2 ≤200 mm Hg				0.32	—	—
Median	26	17	27			
Interquartile range	11–46	5–41	7–52			
Reason for intubation — no./total no. (%)‖						
Respiratory failure	36/51 (71)	43/58 (74)	49/67 (73)	0.24	—	—
Circulatory failure	7/51 (14)	5/58 (9)	5/67 (7)	0.46	—	—
Neurologic failure	8/51 (16)	10/58 (17)	13/67 (19)	0.91	—	—
Ventilator-free days						
Overall population	24±8	22±10	19±12	0.02	—	—
Patients with Pao_2:FIO_2 ≤200 mm Hg	24±8	21±10	18±12	<0.001	—	—

Table 2. (Continued.)

Outcome	Study Group			P Value†	Odds Ratio or Hazard Ratio (95% CI)	
	High-Flow Oxygen (N=106)	Standard Oxygen (N=94)	Noninvasive Ventilation (N=110)		Standard Oxygen vs. High-Flow Oxygen	Noninvasive Ventilation vs. High-Flow Oxygen
Death						
In ICU						
Unadjusted analysis				0.047	1.85 (0.84–4.09)	2.55 (1.21–5.35)
No. of patients	12	18	27			
% of patients (95% CI)	11 (6–19)	19 (12–28)	25 (17–33)			
Adjusted analysis**	—	—	—	—	2.55 (1.07–6.08)	2.60 (1.20–5.63)
At day 90						
Overall population						
Unadjusted analysis				0.02	2.01 (1.01–3.99)	2.50 (1.31–4.78)
No. of patients	13	22	31			
% of patients (95% CI)	12 (7–20)	23 (16–33)	28 (21–37)			
Adjusted analysis**	—	—	—	—	2.36 (1.18–4.70)	2.33 (1.22–4.47)
Intubated patients				0.16		
No. of patients/total. no.	12/40	20/44	27/55			
% of patients (95% CI)	30 (18–46)	45 (32–60)	49 (36–62)			
Cause of death — no./total no. (%)						
Refractory shock	6/13 (46)	12/22 (55)	18/31 (58)	0.04		
Refractory hypoxemia	5/13 (38)	6/22 (27)	8/31 (26)	0.73		
Cardiac arrest	1/13 (8)	1/22 (5)	3/31 (10)	0.52		
Other	1/13 (8)	3/22 (14)	2/31 (6)	0.52		

or the reasons for intubation. In our study, noninvasive ventilation that was administered to patients with severe lung injury could have increased the incidence of ventilator-induced lung injury by increasing tidal volumes that exceeded 9 ml per kilogram of predicted body weight.[32-34]



No. at Risk							
High-flow oxygen	106	100	97	94	94	93	93
Standard oxygen	94	84	81	77	74	73	72
Noninvasive ventilation	110	93	86	80	79	78	77

Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients

A Randomized Clinical Trial

Gonzalo Hernández, MD, PhD; Concepción Vaquero, MD; Paloma González, MD; Carles Subira, MD; Fernando Frutos-Vivar, MD; Gemma Rialp, MD; Cesar Laborda, MD; Laura Colinas, MD; Rafael Cuena, MD; Rafael Fernández, MD, PhD

criteria for low risk of reintubation: younger than 65 years[4,5]; absence of heart failure as the primary indication for mechanical ventilation[4,5]; absence of moderate-to-severe chronic obstructive pulmonary disease[15]; Acute Physiology and Chronic Health Evaluation (APACHE) II score less than 12 points on day of extubation[4,5]; body mass index less than 30 (calculated as weight in kilograms divided by height in meters squared)[2,16]; absence of airway patency problems, including high risk of developing laryngeal edema (eAppendix 2 in Supplement 2)[5]; ability to manage respiratory secretions (adequate cough reflex or suctioning <2 times within 8 hours before extubation)[5,17]; simple weaning (eAppendix 3 in Supplement 2)[5]; fewer than 2 comorbidities (eAppendix 4 in Supplement 2)[5]; and no prolonged mechanical ventilation, defined as longer than 7 days.[18]

High-flow oxygen therapy (Optiflow; Fisher & Paykel Healthcare) was applied immediately after extubation through nasal cannula. Flow was initially set at 10 L/min and titrated upward in 5-L/min steps until patients experienced discomfort. Temperature was initially set to 37°C, unless reported too hot by patients, and FIO_2 was regularly adjusted to target peripheral capillary oxygen saturation (SpO_2) greater than 92%. After 24 hours, high-flow therapy was stopped and, if necessary, patients received conventional oxygen therapy.

Conventional oxygen therapy was applied continuously through nasal cannula or nonrebreather facemask, and oxygen flow was adjusted to maintain SpO_2 greater than 92%.

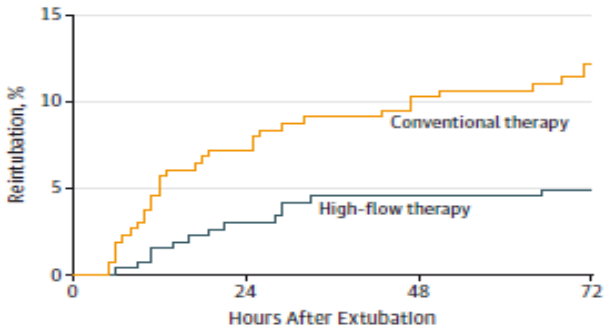
264 Included in primary analysis

263 Included in primary analysis

Table 2. Primary and Secondary Outcomes

Variable	Oxygen Therapy: High-Flow (n = 264)	Oxygen Therapy: Conventional (n = 263)	Difference Between Groups (95% CI)	*P* Value
Primary Outcome				
All-cause reintubation, No. (%)	13 (4.9)	32 (12.2)	7.2 (2.5 to 12.2)	.004[a]
Secondary Outcomes				
Postextubation respiratory failure, No. (%)	22 (8.3)	38 (14.4)	6.1 (0.7 to 11.6)	.03[a]
Respiratory infection, No. (%)	6 (2.3)	13 (4.9)	2.7 (−0.6 to 6.2)	.07[a]
Ventilator-associated tracheobronchitis	3 (1.1)	7 (2.6)	1.5 (−1.0 to 4.4)	.22[a]
Ventilator-associated pneumonia	3 (1.1)	6 (2.3)	1.2 (−1.3 to 3.9)	.31[a]
Causes of postextubation respiratory failure, No. (%)				
Respiratory acidosis[c]	1 (4.5)	4 (10.5)		
Hypoxia[c]	7 (31.8)	6 (15.8)		
Unbearable dyspnea	9 (40.9)	14 (28.9)		.10[b]
Decreased level of consciousness	2 (9)	0		
Inability to clear secretions	3 (13.6)	14 (36.8)		

Figure 2. Kaplan-Meier Analysis of Time From Extubation to Reintubation



AKUTNÍ SRDEČNÍ SELHÁNÍ

Study	Study population	Intervention/Experimental group	Control group	Outcome
Ko et al. [36] (Randomized controlled trial)	Patient suspected of pulmonary edema due to heart failure	HFNC (n = 36)	COT (n = 33)	Significant difference in respiratory rate, SpO_2 at 30 and 60 minutes (improved in HFNC group) Significant difference in ABG parameters (PaO_2 and SpO_2) at 30 and 60 minutes (improved in HFNC group)
Makdee et al. [37] (Randomized controlled trial)	ED patients with cardiogenic pulmonary edema	HFNC (n = 63)	COT (n = 65)	60-minute respiratory rate significantly lower in HFNC group Lower respiratory rate at 15 and 30 minutes in HFNC group
Sener et al. [4] (Prospective observational study)	Patients with hypertensive pulmonary edema	HFNC (n = 62)	COT (n = 50)	HFNC shortens the length of stay in both emergency and intensive care unit HFNC shows better results in terms of heart rate, respiratory rate, and ABG parameters
Chang et al. [38] (Cohort study)	Post-extubated patients with heart failure with ejection fraction <50%	HFNC (n = 58)	NIPPV (n = 46)	No significant difference in treatment failure between two groups in 72 hours

HFNC, high-flow nasal cannula, COT, conventional oxygen therapy; NIPPV, non-invasive positive-pressure ventilation; ABG, arterial blood gas; SpO_2, oxygen saturation; PaO_2, partial pressure of oxygen; n, number of participants; ACPE, acute cardiogenic pulmonary edema

Journal of Clinical Medicine

MDPI

Article

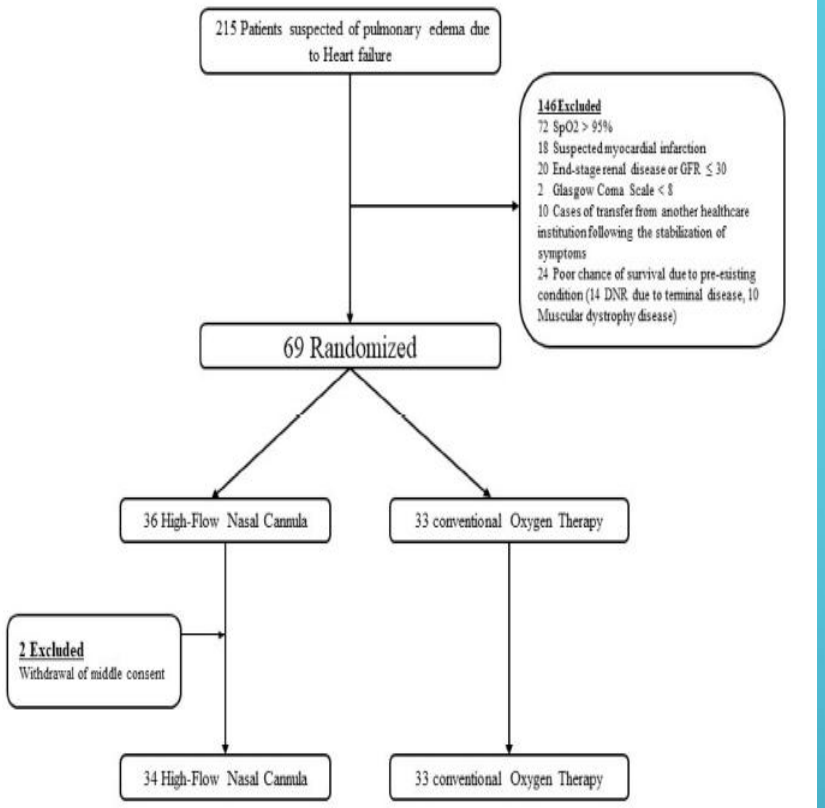
Benefits of High-Flow Nasal Cannula Therapy for Acute Pulmonary Edema in Patients with Heart Failure in the Emergency Department: A Prospective Multi-Center Randomized Controlled Trial

Dong Ryul Ko [1,2,†], Jinho Beom [1,†], Hye Sun Lee [3], Je Sung You [1,*], Hyun Soo Chung [1,*] and Sung Phil Chung [1]

- Incl: AHF s plicním edémem na RTG Excl.:AHF de novo, GCS 8, susp. AIM, CHD, CHRI 4,5
- Primární outcome: změny RR, ABR a laktát clearance
- Sekundární outcome: intubace do 24h, ICU, 28 denní mortalita

In the conventional oxygen therapy group, oxygen therapy was commenced using a conventional nasal cannula at a flow rate of >2 L/min. The flow rate was continuously adjusted within the conventional nasal cannula or face mask to maintain an SpO_2 of >93%. In the HFNC group, oxygen therapy was applied using large-bore binasal prongs and a heated humidifier (MR850, Fisher & Paykel Healthcare Limited, Auckland, New Zealand) with a flow rate of 45 L/min and fraction of inspired oxygen (FiO_2) of 1.0 at initiation (Optiflow, Fisher and Paykel Healthcare, Auckland, New Zealand). The FiO_2 (from 21% to 100%) and flow rate (up to 60 L/min) in the system were adjusted to maintain an SpO_2 of >93%. In the study protocol, all patients had to undergo treatment with the assigned modality

oxygen therapy with either the conventional nasal cannula or HFNC. Early termination criteria included failure to tolerate the therapy (respiratory rate > 35 breaths/min, SpO_2 < 90%, PaO_2/FiO_2 < 200 mmHg, pulse rate > 120 beats/min or a > 30% increase above the baseline and a noninvasively measured pre-intervention mean arterial pressure > 30% higher than that at the baseline or signs of respiratory distress (e.g., tachypnea, use of accessory muscles of respiration, and abdominal paradox), and clinician judgements (when immediate intervention was required due to worsening of the levels of anxiety, agitation, and consciousness compared to those at the pre-intervention timepoint). If one or



Variable	Total (n = 72)	Conventional O_2 Therapy Group	High-Flow Nasal Cannula Group	p-Value
	Mean ± SD or n (%)	(n = 33, 49.3%)	(n = 34, 50.7%)	
Respiratory rate (bpm)				
Initial	26.78 ± 3.99	25.18 ± 3.51	28.32 ± 3.86	0.001 *
30 min	23.75 ± 3.50	24.85 ± 3.19	22.68 ± 3.49	0.010 *
60 min	22.79 ± 3.72	24.30 ± 3.55	21.32 ± 3.32	0.001 *
SpO_2 (%)				
Initial	91.41 ± 5.89	92.55 ± 3.78	90.31 ± 7.29	0.120
30 min	95.69 ± 3.31	94.15 ± 3.26	97.18 ± 2.65	<0.001 *
60 min	95.94 ± 3.27	94.12 ± 3.25	97.71 ± 2.14	<0.001 *

Table 2. *Cont.*

Variable	Total (n = 72)	Conventional O_2 Therapy Group	High-Flow Nasal Cannula Group	p-Value
	Mean ± SD or n (%)	(n = 33, 49.3%)	(n = 34, 50.7%)	
Arterial Blood Gas Analysis				
pH, initial	7.36 ± 0.09	7.38 ± 0.07	7.34 ± 0.11	0.063
pH, 30 min	7.39 ± 0.07	7.39 ± 0.06	7.39 ± 0.07	0.788
pH, 60 min	7.40 ± 0.06	7.40 ± 0.06	7.40 ± 0.06	0.595
PaO_2, initial	70.86 ± 17.32	71.91 ± 19.78	69.84 ± 14.79	0.629
PaO_2 30 min	87.79 ± 34.46	75.23 ± 19.87	99.98 ± 41.00	0.003 *
PaO_2 60 min	90.62 ± 36.79	73.25 ± 13.02	107.47 ± 44.15	<0.001 *
$PaCO_2$, initial	32.85 ± 10.44	30.89 ± 6.18	34.76 ± 13.17	0.129
$PaCO_2$, 30 min	31.97 ± 8.21	32.61 ± 7.13	31.35 ± 9.20	0.532
$PaCO_2$, 60 min	31.91 ± 7.22	32.30 ± 6.22	31.54 ± 8.14	0.670
SpO_2 (%), initial	92.69 ± 3.79	92.55 ± 4.01	92.83 ± 3.63	0.765
SpO_2, 30 min	95.30 ± 3.55	93.86 ± 3.38	96.71 ± 3.17	0.001 *
SpO_2, 60 min	95.71 ± 3.07	93.99 ± 2.64	97.38 ± 2.51	<0.001 *
Lactate (mmol/L)				
Initial	2.39 ± 2.02	2.01 ± 1.78	2.77 ± 2.20	0.126
60 min	1.82 ± 1.31	1.89 ± 1.55	1.75 ± 1.04	0.666
Echocardiography After ED visit				
Ejection fraction (%)	40.15 ± 13.12	40.36 ± 15.23	39.94 ± 10.92	0.896
Valve disease	18(26.87)	8(24.24)	10(29.41)	0.633
Intubation	2(2.99)	1(3.03)	1(2.94)	0.999
ICU admission	18(26.87)	8(24.24)	10(29.41)	0.633

* $p < 0.05$, PaO_2: partial pressure of oxygen, $PaCO_2$: partial pressure of carbon dioxide, SpO_2: peripheral oxygen saturation.

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RESEARCH ARTICLE

Asymmetrical nasal high flow ventilation improves clearance of CO_2 from the anatomical dead space and increases positive airway pressure

Stanislav Tatkov,[1] Monique Rees,[1] Anton Gulley,[1] Lotte G. T. van den Heuij,[1] and Georg Nilius[2,3]

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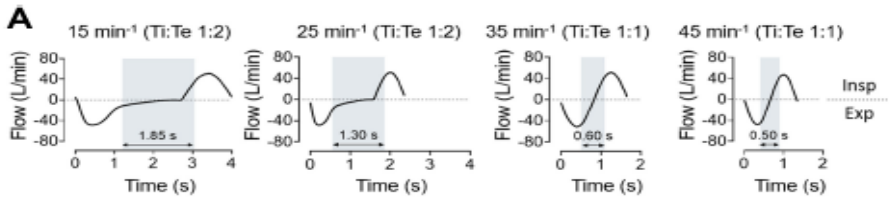
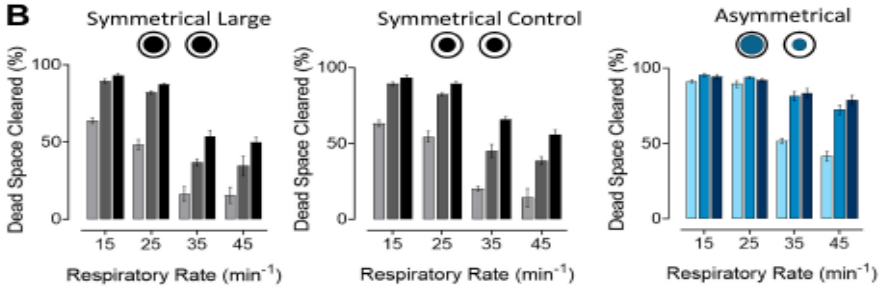
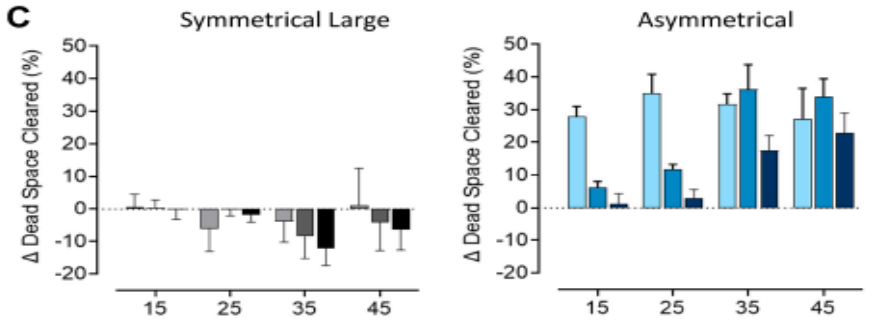


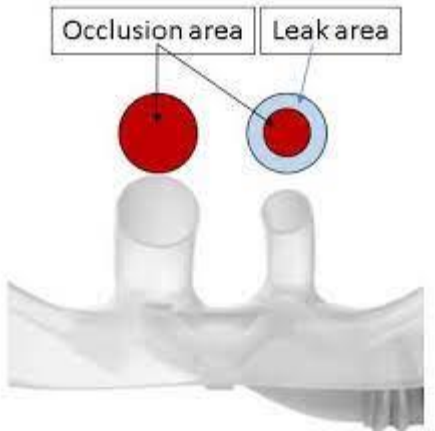


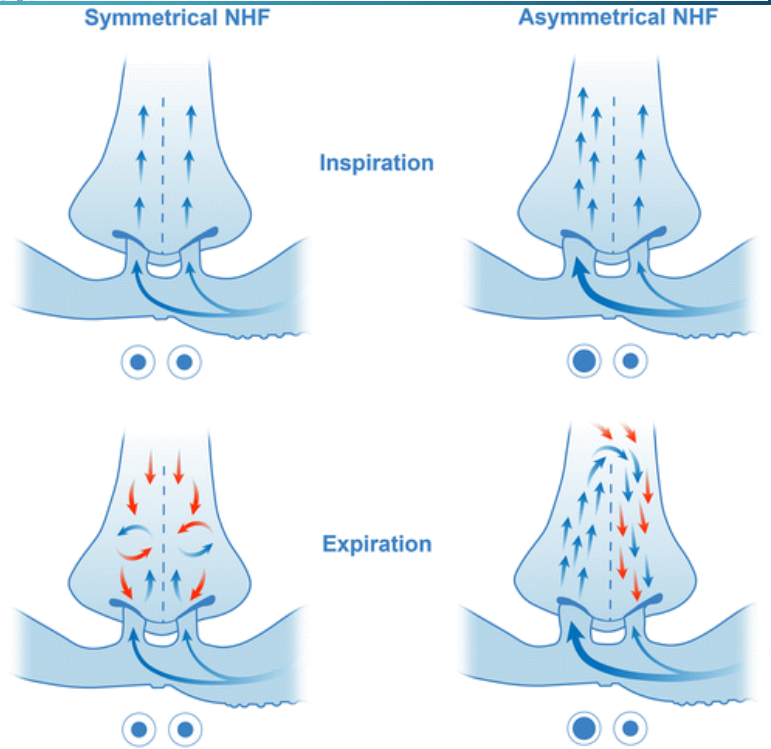


	15	25	35	45
NHF 20	p=1.00	p=0.01	p=0.27	p=0.99
NHF 40	p>0.99	p>0.99	p<0.01	p=0.21
NHF 60	p>0.99	p=0.91	p<0.01	p=0.01

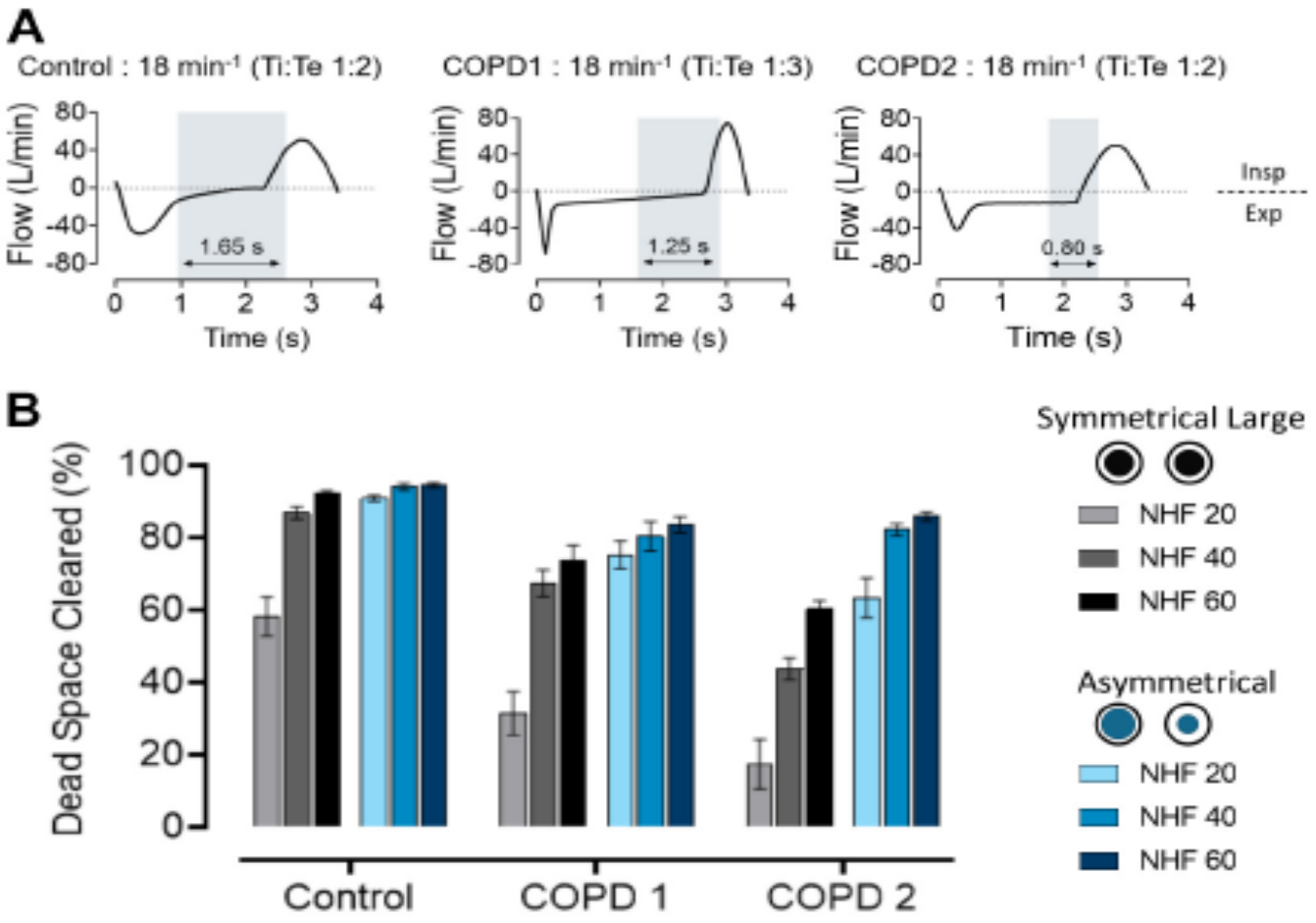
	15	25	35	45
NHF 20	p<0.01	p<0.01	p<0.01	p<0.01
NHF 40	p=0.01	p<0.01	p<0.01	p<0.01
NHF 60	p=0.97	p=0.35	p<0.01	p<0.01

Fig. 2C. Note that increased symmetrical nare occlusion does not improve dead-space clearance, and significantly worsens it at higher RRs ($P < 0.05$). However, a similar increase in nare occlusion with the AI significantly improves dead-space clearance ($P < 0.05$). The dead space cleared at a RR of 15 min^{-1} and NHF 60 L/min was not significantly different between the SI and the AI [−1.40 ± 6.25% ($P > 0.05$)]. Nevertheless, at an RR of 35 min^{-1} the SI clearance decreased compared with the control, and the AI clearance increased, resulting in a significant difference of 29.64 ± 9.96% ($P < 0.05$).





COPD 1 with a prolonged expiration (Ti:Te 1:3) and COPD 2 (Ti:Te 1:2) with intrinsic PEEP, characterized by a higher expiratory flow just before expiration ended. A normal breathing pattern (Ti:Te 1:2) was taken as the control. The time to



	Control ΔMean (Std) %	COPD 1 ΔMean (Std) %	COPD 2 ΔMean (Std) %
NHF 20	32.62 (6.15) p<0.0001	43.59 (9.8) p<0.0001	45.93 (12.21) p<0.0001
NHF 40	7.39 (2.73) p=0.0069	13.09 (7.72) p<0.0001	38.47 (4.66) p<0.0001
NHF 60	2.41 (1.53) p=0.8492	9.63 (6.15) p=0.0001	25.48 (3.38) p<0.0001