High flow nasal cannula Oxygen : new evidence and application!

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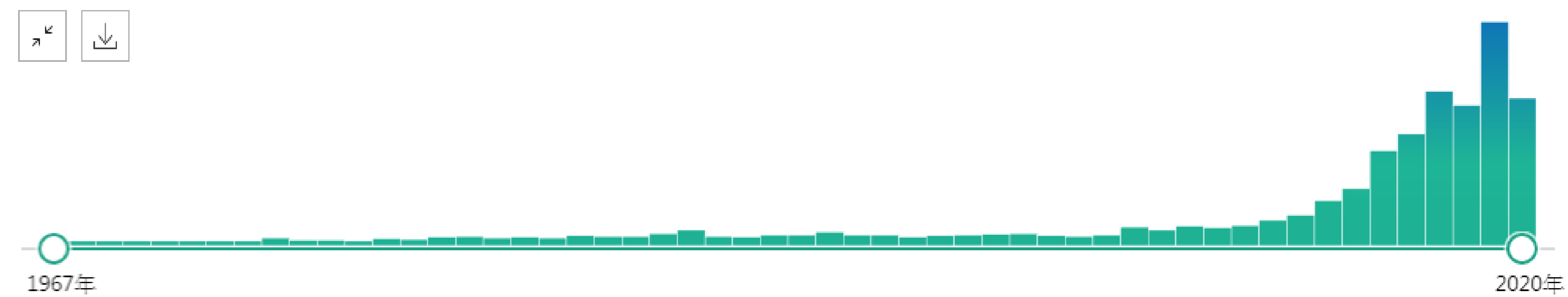
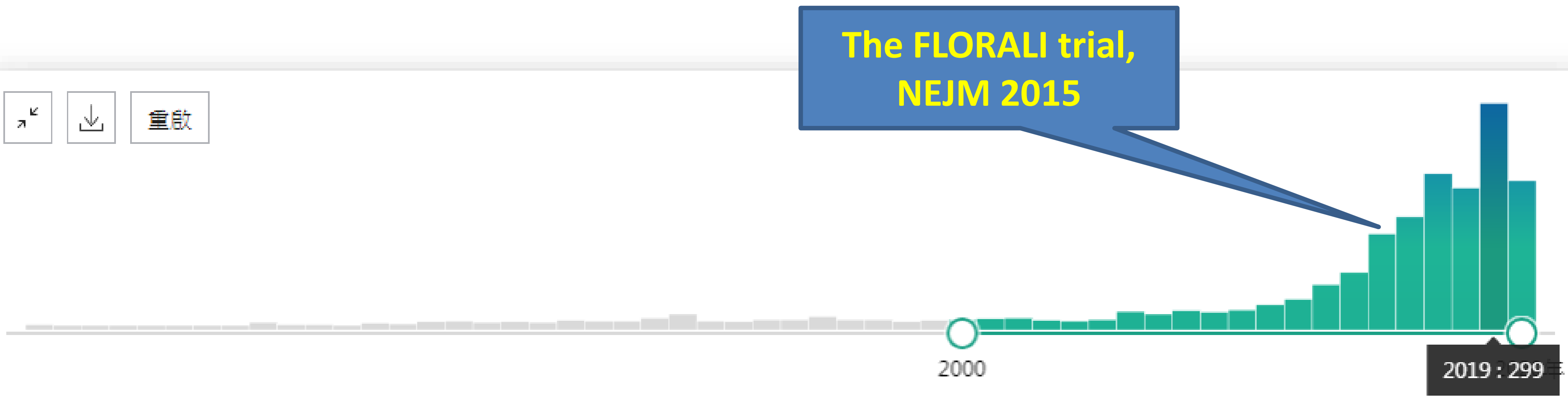
The key word “High Flow Nasal Cannula” on Pubmed search





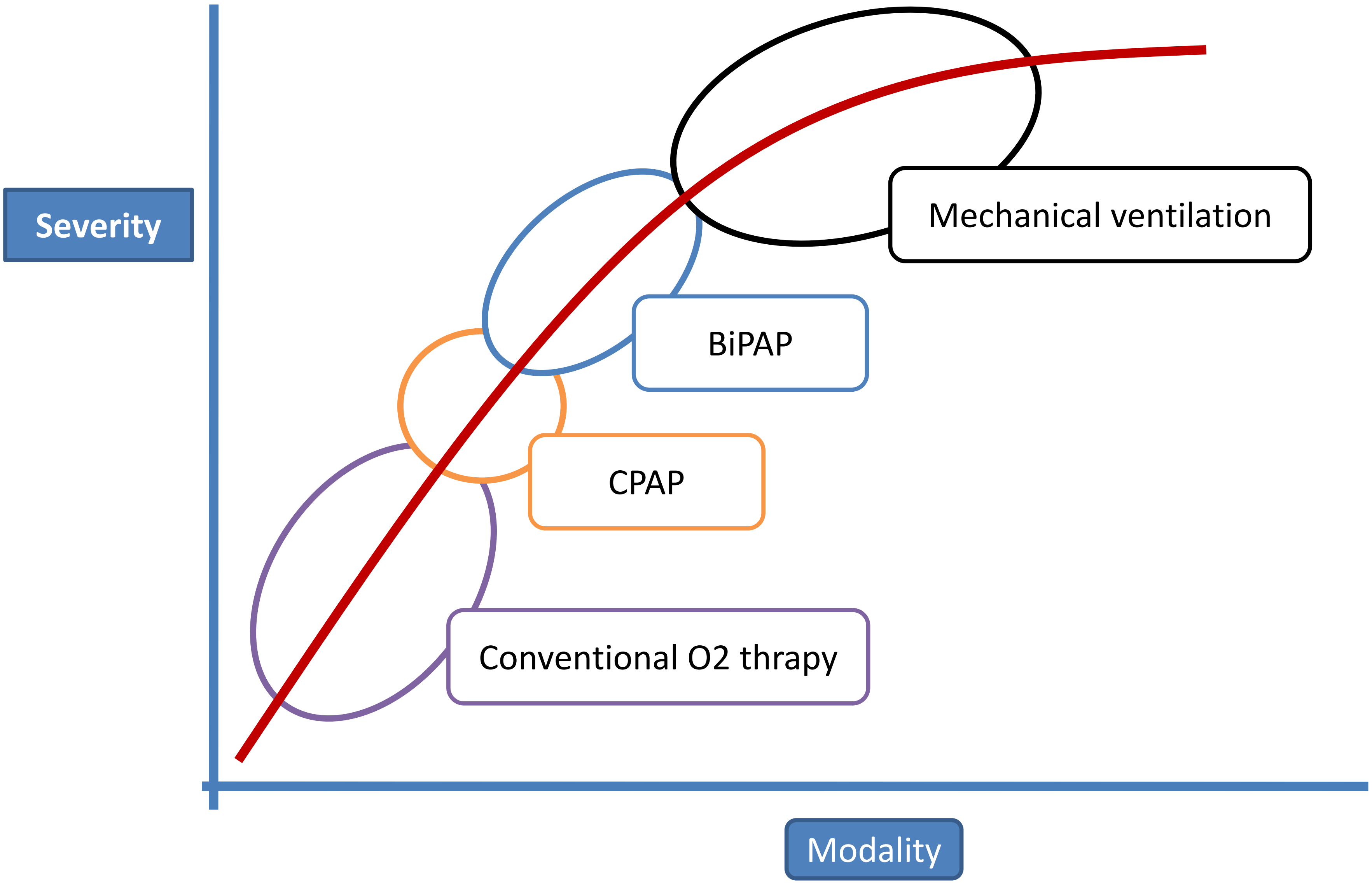
Oxygen therapy device

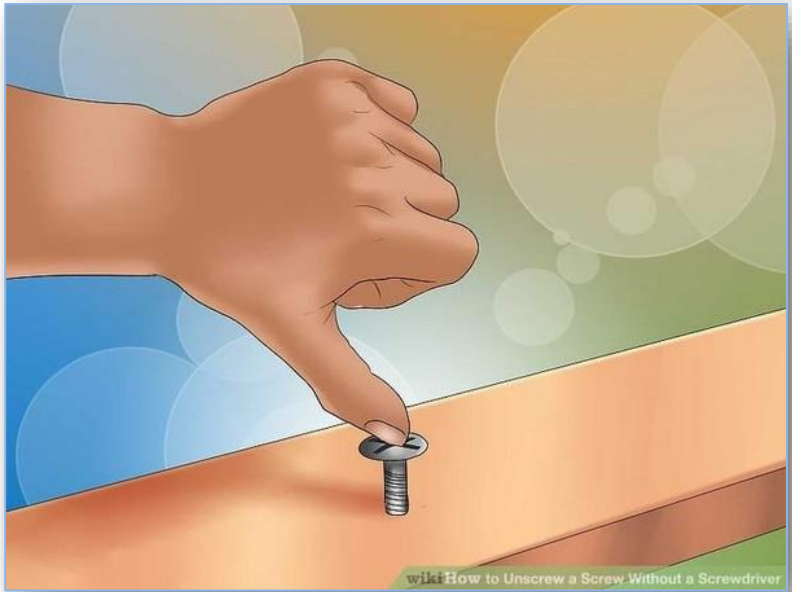
High flow system | **Low flow system**

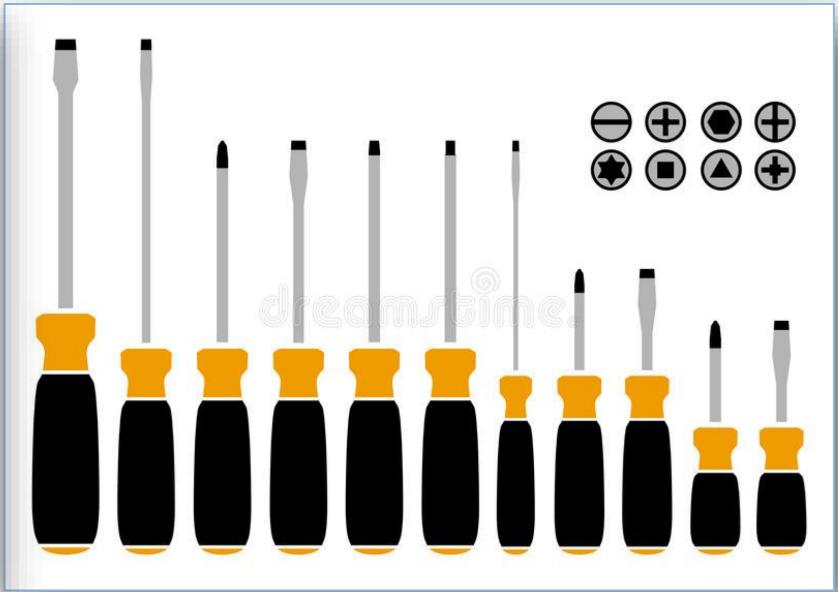
Device: Venturi Mask
Flow: 2 - 15 L/min
(based on valve)
FiO2: 24 - 60%
(precisely controlled)

Device: Non-Rebreather
Flow: 10 - 15 L/min
FiO2: 80 - 95%

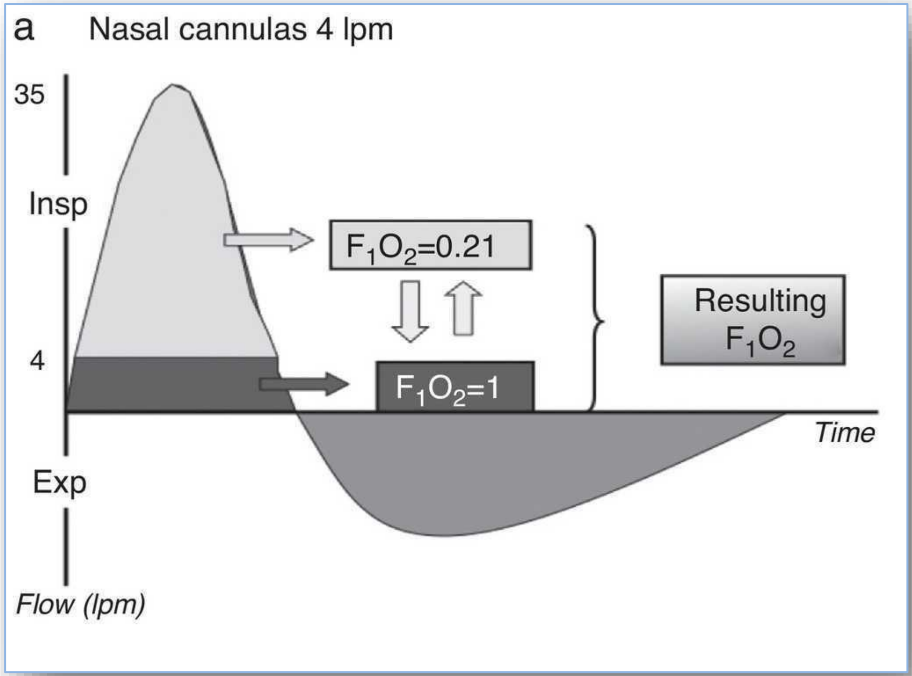
Device: High Flow
Nasal Cannula
Flow: up to 60 L/min
FiO2: 21 - 100%

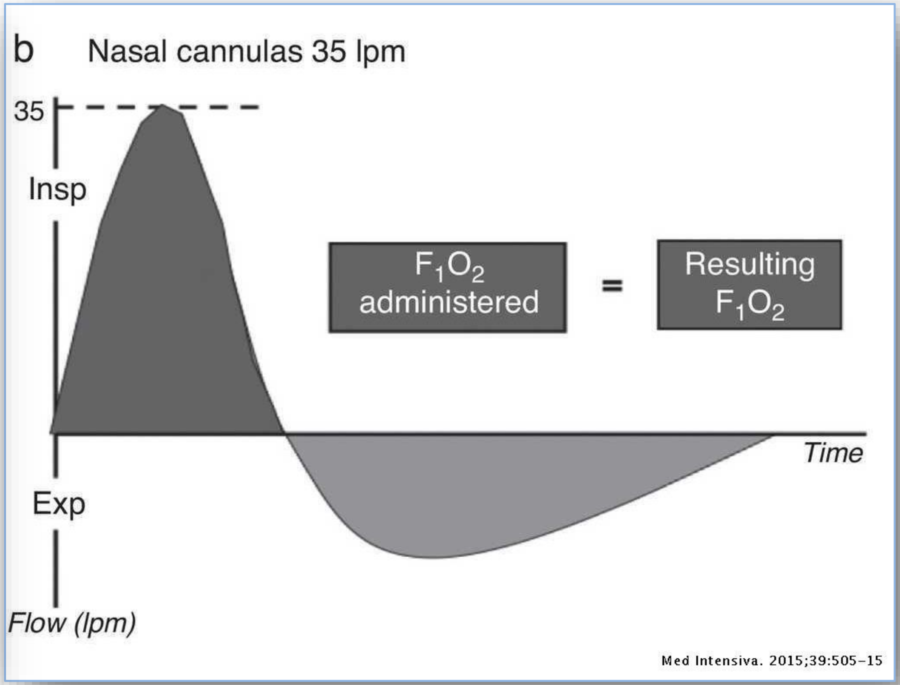

Severity
Mechanical ventilation
BiPAP
CPAP
Conventional O2 thrapy
Modality


wikiHow to Unscrew a Screw Without a Screwdriver



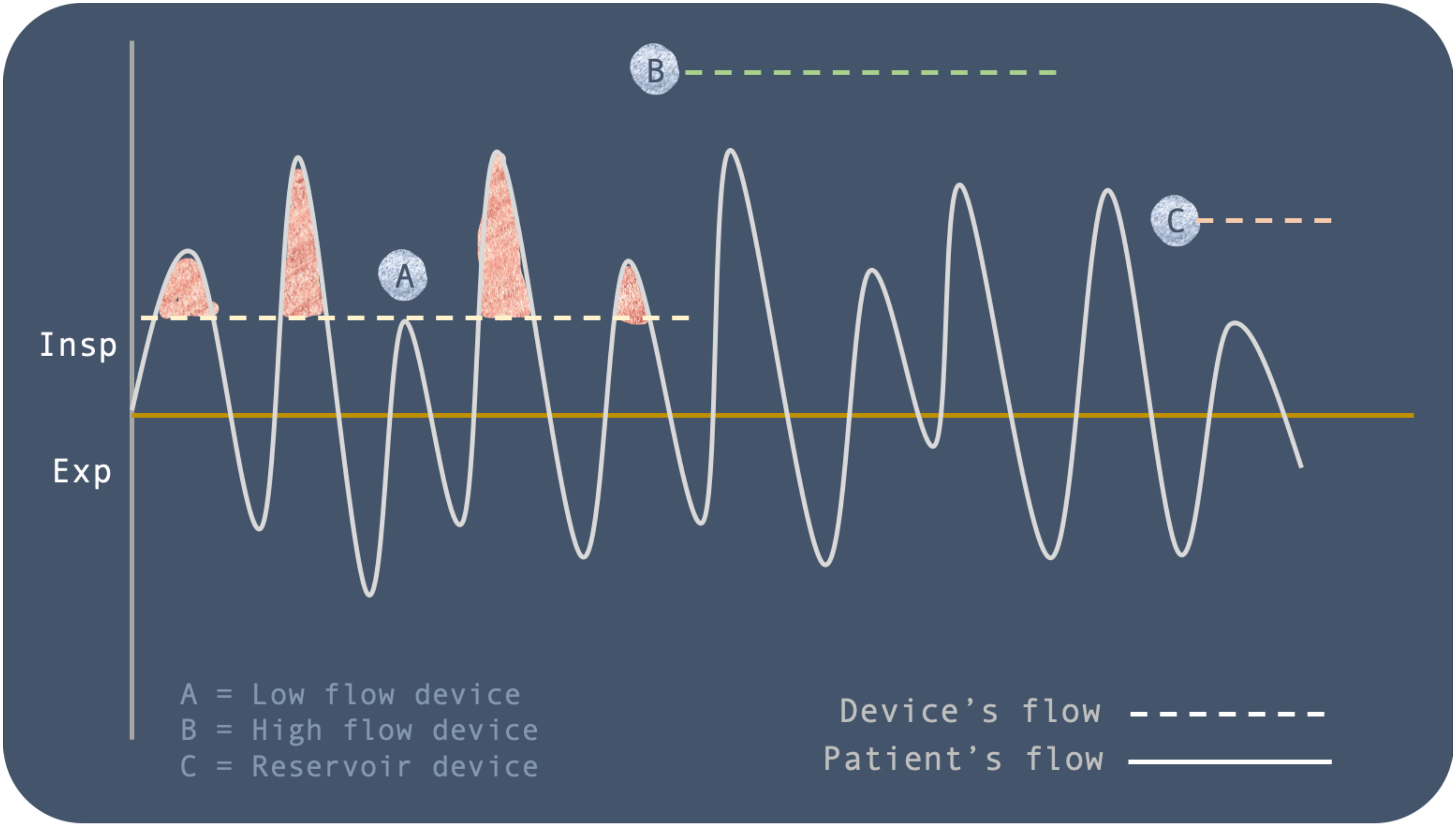
O2 delivery system: Low vs high-flow





Conventional oxygen therapy, COT

- FiO2 was limited if inspiratory flow exceeds the delivered O2 flow, resulting in entrainment of ambient air.
- Conventional high flow system induced mucosal injury and patient discomfort.



Egan's fundamentals of respiratory care. 11th ed. (2017). Elsevier

Adequate heat and moisture of inspired medical gases

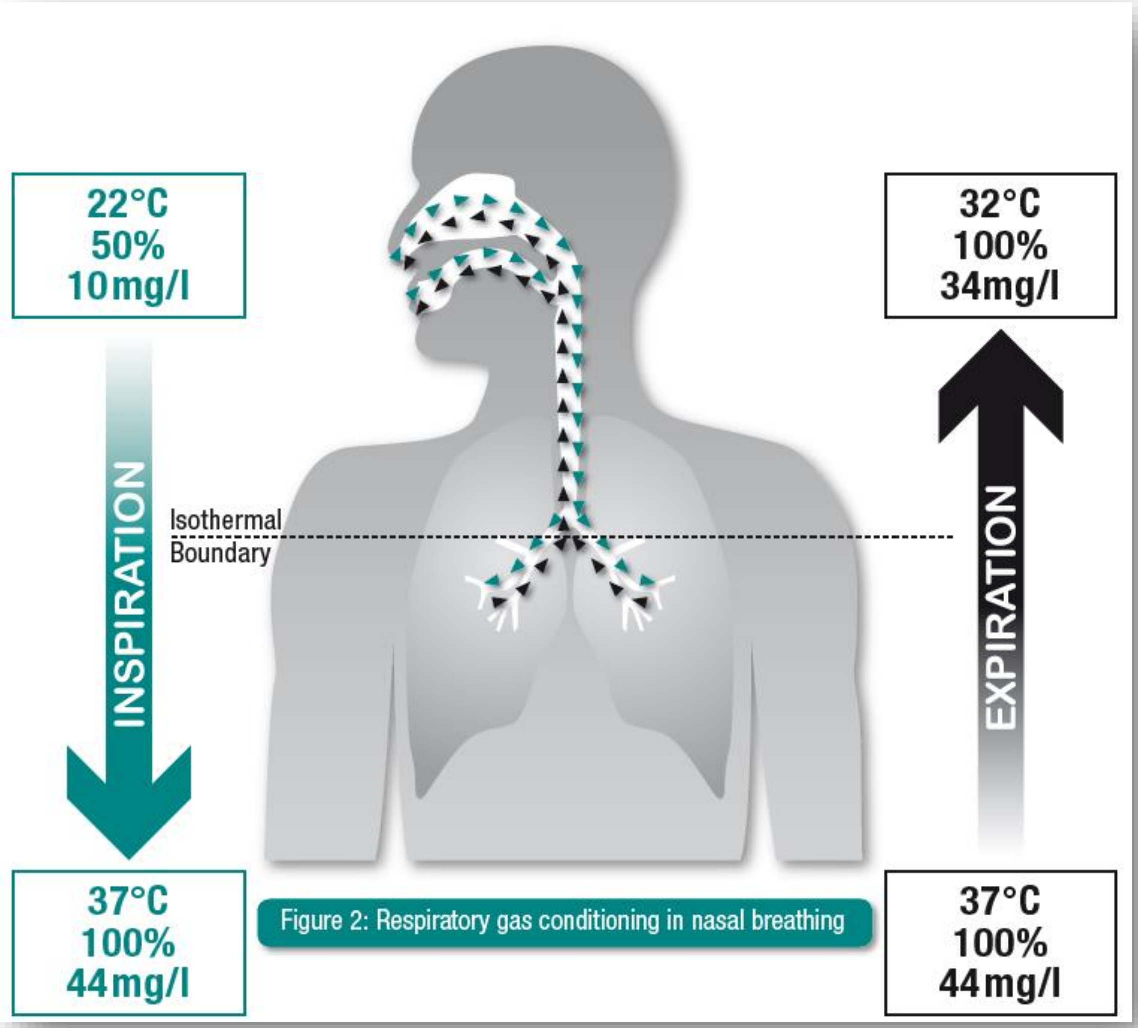


Figure 2: Respiratory gas conditioning in nasal breathing

www.wilamed.com

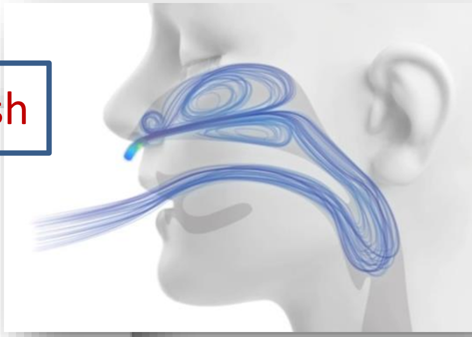
HFNC system (Fisher & Paykel).

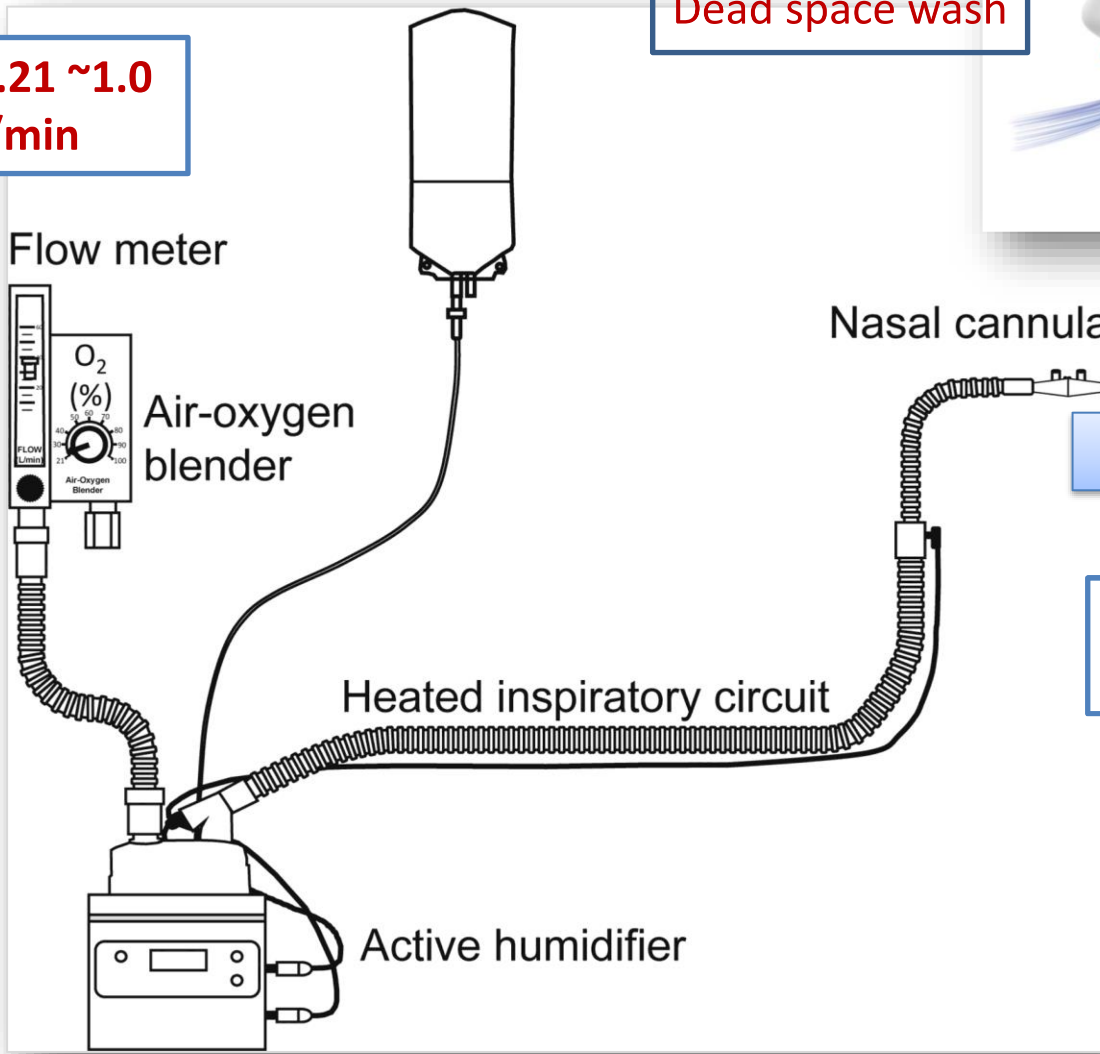
HFNCa on an adult

- Respiratory Investigation, 2014/09/01, Vol 52, Issue 5, Pages 310-314

FIO2 between 0.21 ~1.0
Flow up to 60 L/min

Dead space wash





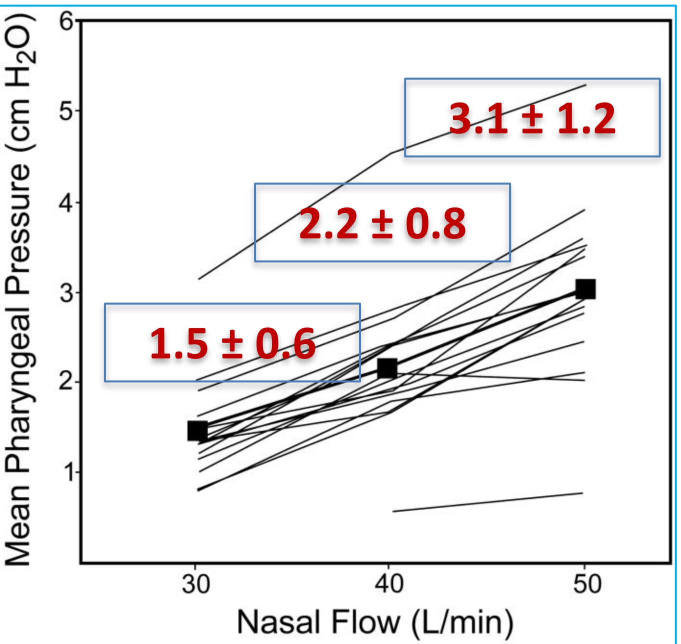
open circuit

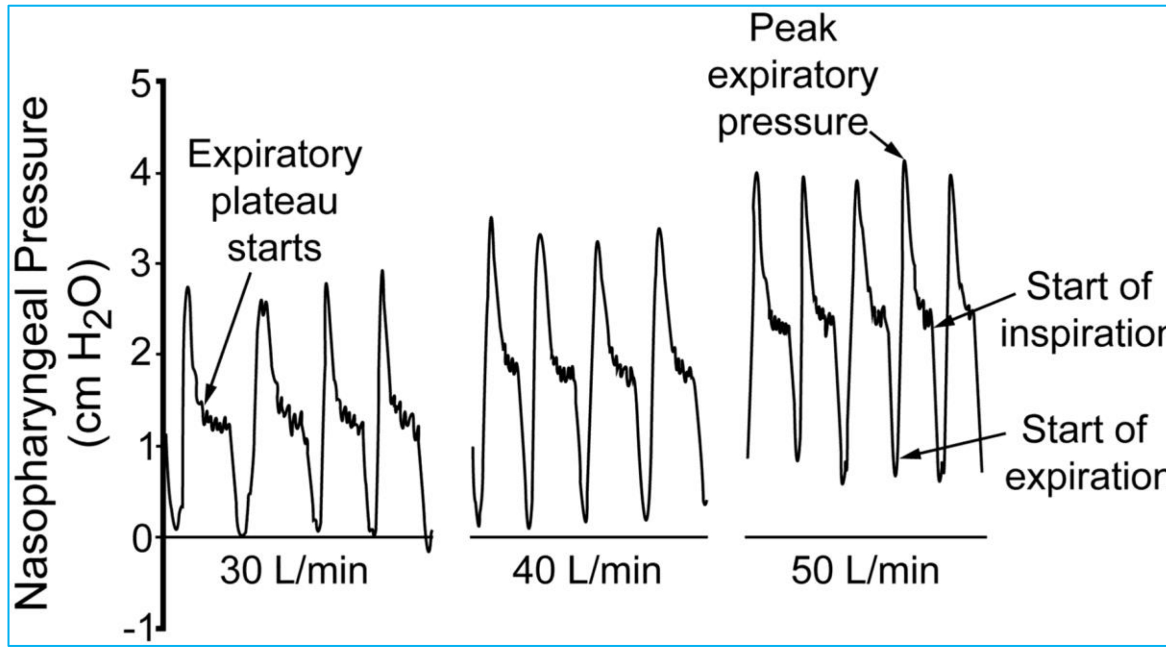
PEEP Effect
≈ 3 -5cm H2O

In high low of 60 L/min, electrical output humanity can be 100% (F&P)

- Respiratory Care, Apr 2016, 61(4) 529-541

Airway Pressures Delivered With Nasal High Flow Oxygen





- Respiratory Care October 2013, 58 (10) 1621-1624

THE AMERICAN JOURNAL OF
RESPIRATORY AND CRITICAL CARE MEDICINE

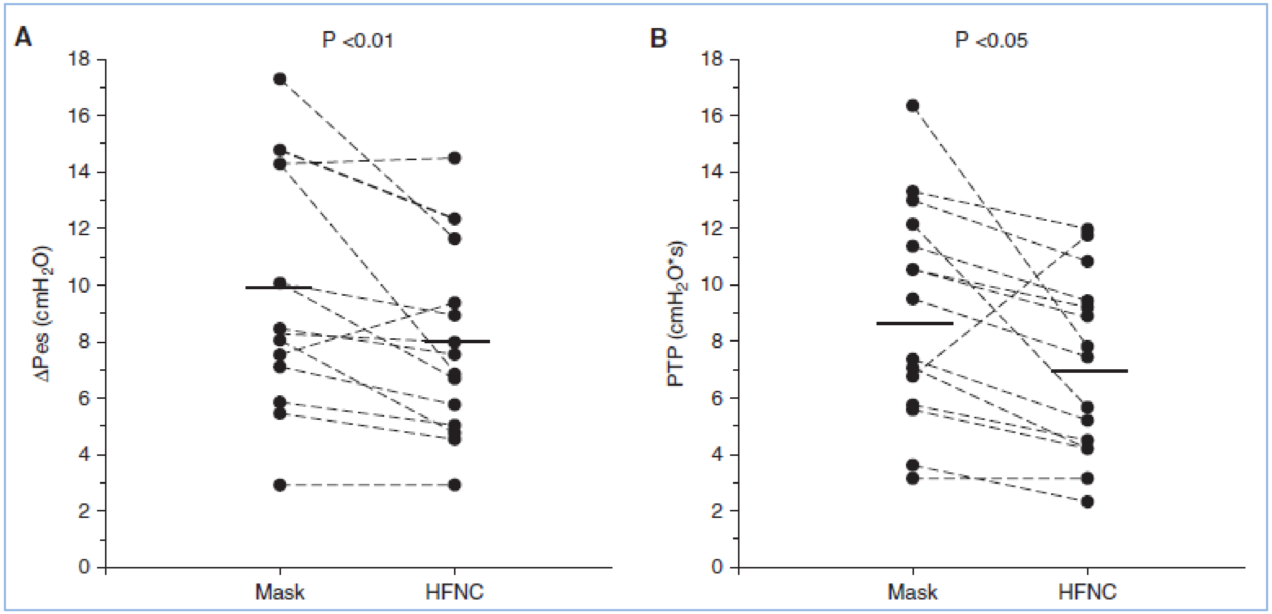
ORIGINAL ARTICLE

Physiologic Effects of High-Flow Nasal Cannula in Acute Hypoxemic Respiratory Failure

- Prospective randomized crossover study in non-intubated AHRF with $PaO_2/FiO_2 < 300$ mm Hg , ICU

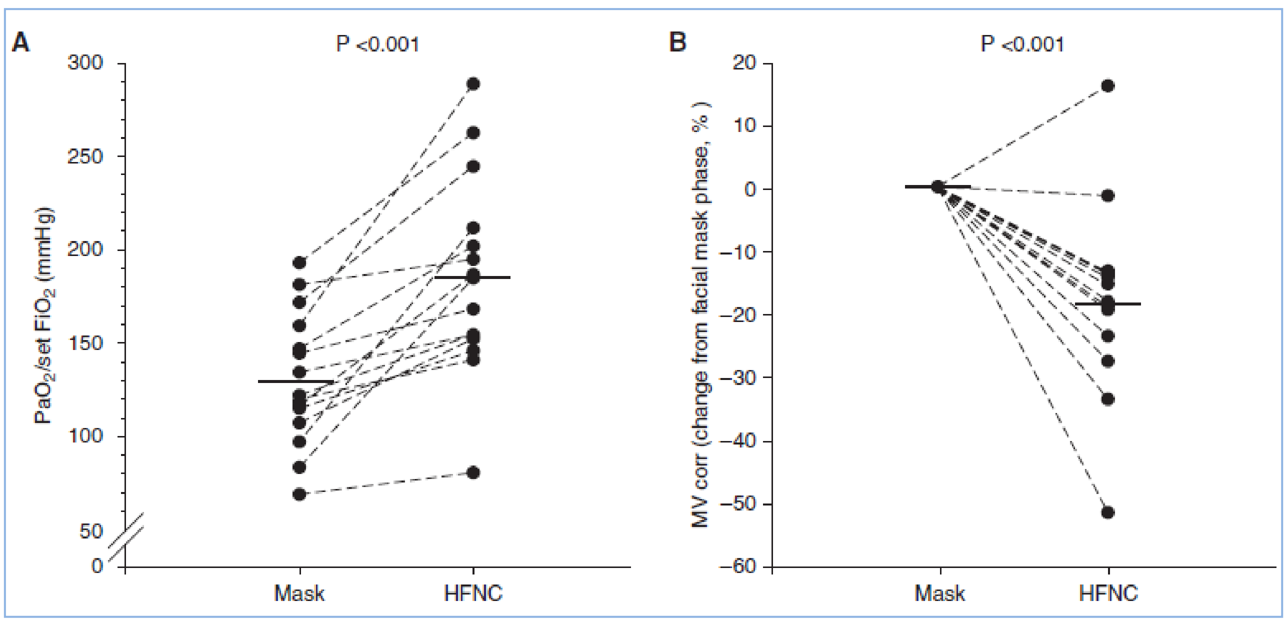
- Randomly applied HFNC set at 40 L/min compared with a standard non-occlusive facial mask at the same clinically set FiO_2 (O_2 flow 12L/min)

- AJRCCM, Vol 195, Iss 9, pp 1207–1215, May 1, 2017



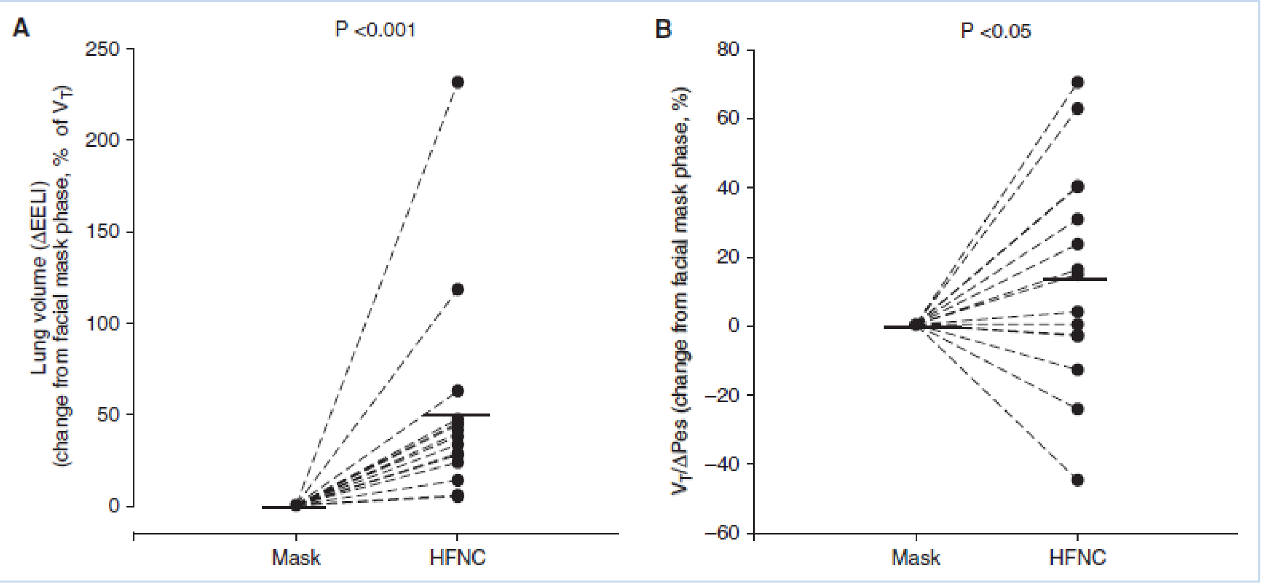
Inspiratory effort

Work of breathing



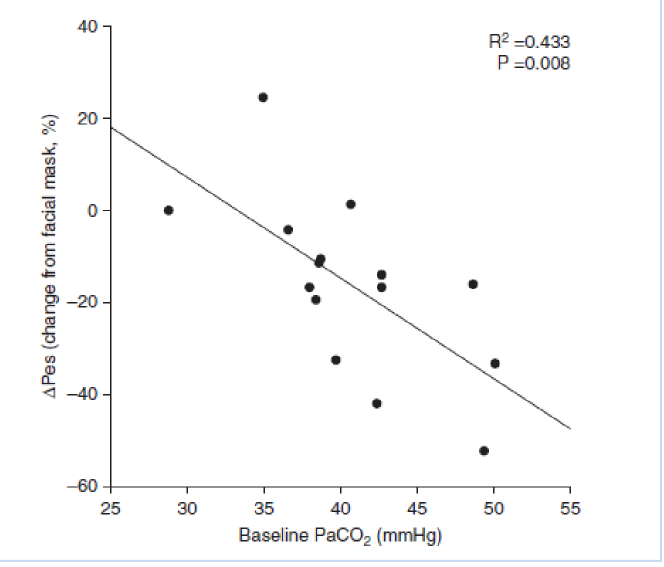
Qxygenation

Minute ventilation



Lung volume

Ratio of VT to inspiratory effort



Baseline arterial CO2 tension is correlated with changes in inspiratory effort.

Effects of HFNC on Lung Aeration, Homogeneity, and Respiratory Pattern

Variable	Oxygen Facial Mask	High-Flow Nasal Cannula	*P* Value*
$\Delta EELI_{glob}$ (change from facial mask), % of baseline V_T	—	51 ± 57	<0.001
$\Delta EELI_{non\text{-}dep}$ (change from facial mask), % of baseline V_T	—	29 ± 36	≤0.001
$\Delta EELI_{dep}$ (change from facial mask), % of baseline V_T	—	26 ± 33	≤0.01
GI index	0.50 (0.49 to 0.57)	0.47 (0.43 to 0.60)	<0.01
PIF_{glob} (change from facial mask), %	—	−15 ± 23	0.07
PEF_{glob} (change from facial mask), %	—	−27 ± 22	≤0.001
$PIF_{non\text{-}dep}$ (change from facial mask), %	—	−11 ± 29	0.29
PIF_{dep} (change from facial mask), %	—	−20 ± 19	<0.01
$PEF_{non\text{-}dep}$ (change from facial mask), %	—	−19 ± 32	0.07
PEF_{dep} (change from facial mask), %	—	−34 ± 18	<0.001
Ti, s	1.2 ± 0.2	1.2 ± 0.3	0.84
Te, s	1.3 ± 0.2	1.5 ± 0.6	<0.05
Ti/Ttot	0.5 ± 0.0	0.4 ± 0.0	<0.05

***In AHRF, HFNC exerts multiple physiologic effects including less inspiratory effort and improved lung volume and compliance.**

Physiologic benefits of high-flow nasal cannula compared with conventional low-flow oxygenation

- Improved oxygenation
- Decreased anatomic dead space owing to washout of upper airway
- Decreased metabolic cost of breathing/reduced carbon dioxide generation
- Generation of positive nasopharyngeal and tracheal airway pressure
- Improved work of breathing
- Preconditioning of inspired gas (heated and humidified)
- Better secretion clearance
- Superior comfort
- Reduced room air entrainment

- StatPearls Publishing; 2020 Jan

Clinical applications of HFNC

1.Acute Hypoxemic Respiratory Failure
2.Post Surgical Respiratory Failure
3. Acute Heart Failure /Pulmonary edema
4.Hypercapnic Respiratory Failure, COPD
5.Pre intubation & Post extubation Oxygenation
6.Obstructive Sleep Apnea
7. Use in the emergency department
8. Do Not Intubate the patient

Main indications to HFNC utilization

Indications	Levels of recommendations	***References***
Hypoxemic respiratory failure - ARDS - Pneumonia - Cardiogenic pulmonary edema	**+++**	*[9 ,13,14,15,16,17,18,19]*
Hypercapnic respiratory failure	**+– –**	*[5 ,20,21,22]*
Pediatric	**+++**	*[23,24,25,26,27,28,29,30,31]*
Trauma	**++–**	*[32 , 33]*
Immunocompromised	**+++**	*[13 , 34]*
Do-not-intubate patients	**+++**	*[35 , 36]*
Procedures - Rapid sequence intubation - Bronchoscopy	**++–**	*[38 , 39 , 42 , 43]*

- European Journal of Internal Medicine, 2019, Vol 64, P10-14

Application and settings

- No guideline
- But practically suggestion
  - patients in need of HFNC are at high risk of severe respiratory failure or mechanical ventilation
  - applied in a monitored setting such as the in ICU, ED or intermediate care floor.

Initial settings and adjustments

- **Flow**
  - **below 5 L/min and up to 60L/min**
  - **Initial set 25-35 LPM (**patient comfort and compliance are key factors)
- **Oxygen**
  - **FiO2 21%~100%,**
  - **Set target peripheral SpO2**
- **Heat and Humidity**
  - Heat to 37 º C and 100% relative humidity

Initial settings and adjustments

- titrate up
  - Flow rate increased 5-10L/min
  - Prefer FiO2 keep < 60% as possible
- Switch to conventional low-flow
  - once the flow ≤20 L/min and FiO_2 ≤50 %.
- Aerosolized medication
  - Not recommandation

Table 1 Typical starting flows for initiation of HFNC and clinical flow ranges according to age group and size.

Age	Weight (kg)	Cannula	Typical starting flow (L/min)	Typical flow range (L/min)
0–30 days	<4	Neonate	4–5	2–8
1 month to 1 year	4–10	Infant	4–10	2–20
1–6 year	10–20	Pediatric small	5–15	5–30
6–12 year	20–40	Pediatric	10–20	5–40
>12 year	>40	Pediatric large/adult	20–30	5–50

- J Pediatr (Rio J). 2017;93:36---45.

Table 2 Initial flow values used in high-flow oxygen therapy in different studies and disease conditions.

Disease process	Reference	Initial flow (l/min)								
		20	25	30	35	40	45	50	55	60
Acute respiratory failure	Parke et al.[29]				x	x				
	Roca et al.[5]	x	x	x						
	Sztrymf et al.[26]							x	x	
Postsurgery	Corley et al.[16]				x	x				
Heart failure	Roca et al.[20]					x				
Palliative care	Peters et al.[51]				x	x				

- Med Intensiva. 2015;**39(8):505---515**

	Fixed performance	Variable performance
Other Names	High flow-jet mixing	Low flow
FiO_2 Range	24 to 85	24 to 50
Characteristics	Provide a specified FiO_2 throughout the respiratory cycle	Provides an FiO_2 that depends on PIFR and how its used
Description	Flow rate ≥ PIFR[a]	Flow rate < PIFR
Rebreathing of CO_2	Avoided because mask is flushed by the high flow rates	Rebreathing may occur (for masks)
Indication	Controlled oxygen therapy required	Higher concentrations of oxygen required and controlled oxygen not necessary
Examples	Venturi	Hudson, MC, Nasal Cannulae

[a]PIFR, peak expiratory flow rate.

Table 2. Prospective trials evaluating high-flow nasal cannula oxygenation in medical patients

Study	Design/*N*	Patients	Comparison	Outcomes
Acute hypoxemic respiratory failure				
FLORALI Frat and colleagues, 2015 (18)	RCT 310	$Pa_{O_2}/Fi_{O_2} \leqslant 300$	HFNC 50 L/min vs. COT or NIV	Fewer intubations with HFNC (38%) than with COT (47%) and NIV (50%) Lower 90-d mortality with HFNC
HOT-ER Jones and colleagues, 2016 (19)	RCT 303	$Sp_{O_2} \leqslant 92\%$ and RR $\geqslant 22$ breaths/min Admitted to ED	HFNC 40 L/min vs. COT	5.5% of HFNC vs. 11.6% of COT intubated within 24 h ($P = 0.053$) No difference in 90-d mortality
Immunosuppressed				
Coudroy and colleagues, 2016 (36)	Observational cohort 115	$Pa_{O_2}/Fi_{O_2} \leqslant 300$ RR $\geqslant 25$ breaths/min	HFNC 50 L/min vs. NIV	Fewer intubations with HFNC than with NIV (35 vs. 55%) Lower 28-d mortality with HFNC (20 vs. 40%)
Frat and colleagues, 2016 (34)	*Post hoc* study of RCT 82	$Pa_{O_2}/Fi_{O_2} \leqslant 300$	HFNC 50 L/min vs. COT or NIV	31% of HFNC, 43% of COT, and 65% of NIV intubated by 28 d Age and NIV use as first-line therapy independently associated with need for intubation
Lemiale and colleagues, 2015 (80)	RCT 100	>6 L/min COT or symptoms of respiratory distress	HFNC 40–50 L/min vs. Venturi mask with 60% Fi_{O_2}	No difference in intubations or comfort HFNC applied for only 2 h
Lemiale and colleagues, 2017 (37)	*Post hoc* study of RCT 353	Pa_{O_2} <60 mm Hg RR >30 breaths/min or respiratory distress	Propensity-matched analysis of HFNC 40 L/min (10–50) vs. COT	No difference in intubations No difference in 28-d mortality
Prevention of reintubation				
Hernández and colleagues, 2016 (52)	RCT 527	Successfully passed SBT Low risk for reintubation	HFNC 30 L/min vs. COT	Fewer reintubations within 72 h with HFNC (4.9%) than with COT (12.2%) No difference in time to reintubation
Hernández and colleagues, 2016 (53)	RCT 604	Successfully passed SBT High risk for reintubation	HFNC 50 L/min vs. NIV	Similar reintubation rates (22.8% in HFNC vs. 19.1% in NIV) over 72 h Less respiratory failure overall in HFNC (26.9% vs. 39.8%) More adverse events with NIV
Maggiore and colleagues, 2014 (51)	RCT 105	$Pa_{O_2}/Fi_{O_2} \leqslant 300$ at time of extubation	HFNC 50 L/min vs. Venturi mask	HFNC reduced desaturations, reintubations, and NIV Improved comfort with HFNC
Tiruvoipati and colleagues, 2010 (12)	Randomized crossover 42	Successfully passed SBT	HFNC → HFFM or vice versa 30 L/min	No difference in RR or gas exchange Improved comfort with HFNC
Palliative				
Peters and colleagues, 2013 (43)	Prospective cohort 50	Do-not-intubate status, in respiratory distress	HFNC 30–60 L/min, no comparison	HFNC improved RR and oxygenation

Contraindication of HFNC

- No strong evidence, however be careful to apply it to patients to whom NPPV is contraindicated.

	Contraindication
1.	Consciousness disorder
	a. No response
	b. Agitated
	c. Uncooperative
2.	Claustrophobia
3.	Airway obstruction
4.	Facial injury, facial malformation
5.	A lot of sputum
6.	Risk of aspiration
7.	Unstable hemodynamics
	a. Shock
	b. Intractable arrhythmia
	c. Post-CPR
8.	Respiratory arrest

What’s new in HFNC application

High-flow nasal cannula for COVID-19 patients ?

Low risk of bio-aerosol dispersion

- European Respiratory Journal 2020

Why Did Outbreaks of Severe Acute Respiratory Syndrome Occur in Some Hospital Wards but Not in Others?

香港中文大學
The Chinese University of Hong Kong

- Clinical Infectious Diseases 2007; 44:1017–25

- A case-control study, 124 medical wards in 26 hospitals
- In Guangzhou and Hong Kong, China
- Experience from 2003 SARS

Table 5. Multivariate model for environmental or administrative factors.

Factor	Guangzhou		Hong Kong		Overall	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Minimum distance between beds of ≤1 m	**5.41 (1.51–19.30)**	.009	5.13 (0.89–29.57)	.07	**3.36 (1.38–8.16)**	.008
Washing or changing facilities for staff	…	>.15	0.18 (0.02–1.58)	.12	**0.21 (0.05–0.88)**	.03
Never used exhaust fan	**3.96 (1.30–12.04)**	.02	…	>.15	…	>.15
Performance of resuscitation	2.86 (0.99–8.29)	.05	…	>.15	2.12 (0.87–5.12)	.10
Staff working while experiencing symptoms	**5.38 (1.39–20.77)**	.15	…	>.15	**5.50 (1.74–17.40)**	.004

Table 6. Multivariate model for host factors.

Factor	Guangzhou		Hong Kong		Overall	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Requiring oxygen therapy	**10.30 (2.57–41.34)**	.03	…	>.15	**3.59 (1.25–10.29)**	.02
Use of BIPAP ventilation	…	>.15	…	>.15	3.26 (0.93–11.41)	.06
Systemic symptoms	**13.35 (1.32–134.96)**	.001	…	>.15	…	>.15

Table 7. Multivariate model for all risk factors with $P < .15$ in the separate models for environmental or administrative factors and for host factors.

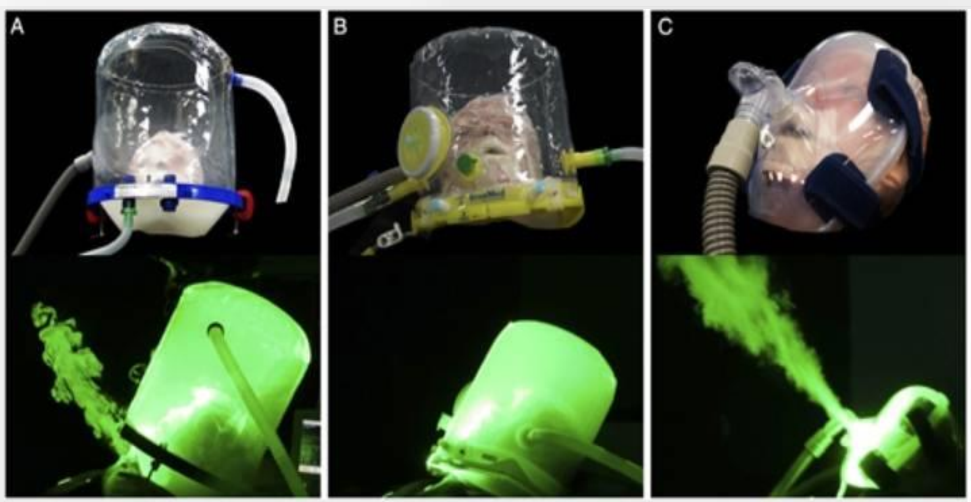
Type of factor, factor	Guangzhou		Hong Kong		Overall	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Environmental or administrative factors						
Minimum distance between beds of ≤1 m	**11.77 (1.54–90.13)**	.02	10.28 (0.58–182.10)	.11	**6.94 (1.68–28.75)**	.008
Washing or changing facilities for staff	…	>.15	…	>.15	0.12 (0.02–0.97)	.05
Never used exhaust fan	4.16 (0.98–17.72)	.05	…	>.15	…	>.15
Performance of resuscitation	…	>.15	…	>.15	**3.81 (1.04–13.87)**	.04
Staff working while experiencing symptoms	**11.18 (1.99–62.81)**	.006	**19.27 (1.12–332.48)**	.04	**10.55 (2.28–48.87)**	.003
Host factors						
Requiring oxygen therapy	**10.14 (1.70–60.37)**	.01	…	>.15	**4.30 (1.00–18.43)**	.05
Use of BIPAP ventilation	6.67 (0.90–49.23)	.06	…	>.15	**11.82 (1.97–70.80)**	.007
Systemic symptoms	12.71 (0.70–232.03)	.09	…	>.15	…	>.15

Risk factors of super-spreading nosocomial outbreaks of SARS:

6 independent risk factors
1. Minimum distance between beds <1m (OR 6.98, 95%CI 1.68-28.75, p=0.008)
2. Washing or changing facilities for staff (OR 0.12, 95%CI 0.02-0.97, p=0.05)
3. Performance of resuscitation (OR 3.81, 95%CI 1.04-13.87, p=0.04)
4. Staff working while experiencing symptoms (OR 10.55, 95%CI 2.28-48.87, p=0.003)
5. SARS pts requiring oxygen therapy >6L/min (OR 4.30, 95%CI 1.00-18.43, p=0.05)
6. SARS pts requiring non-invasive ventilation (OR 11.82, 95%CI 1.97-70.80, p=0.007)

Exhaled Air Dispersion During Noninvasive Ventilation via Helmets and a Total Facemask

David S. Hui, MD, FCCP; Benny K. Chow, PhD; Thomas Lo, MSc; Susanna S. Ng, MBChB; Fanny W. Ko, MD, FCCP; Tony Gin, MD; and Matthew T. V. Chan, MD



- **NIV via a helmet: leakage to 230mm if mask neck interface loose when IPAP ↑ from 12 to 20cmH20 while EPAP set at 10cmH20. No leakage with a good neck seal.**
- **NIV via a total face mask: leakage up to 812mm when IPAP ↑ from 10-18cmH20 while EPAP set at 5cmH20.**

- CHEST 2015 May;147(5):1336-1343

Barrier Enclosure during Endotracheal Intubation

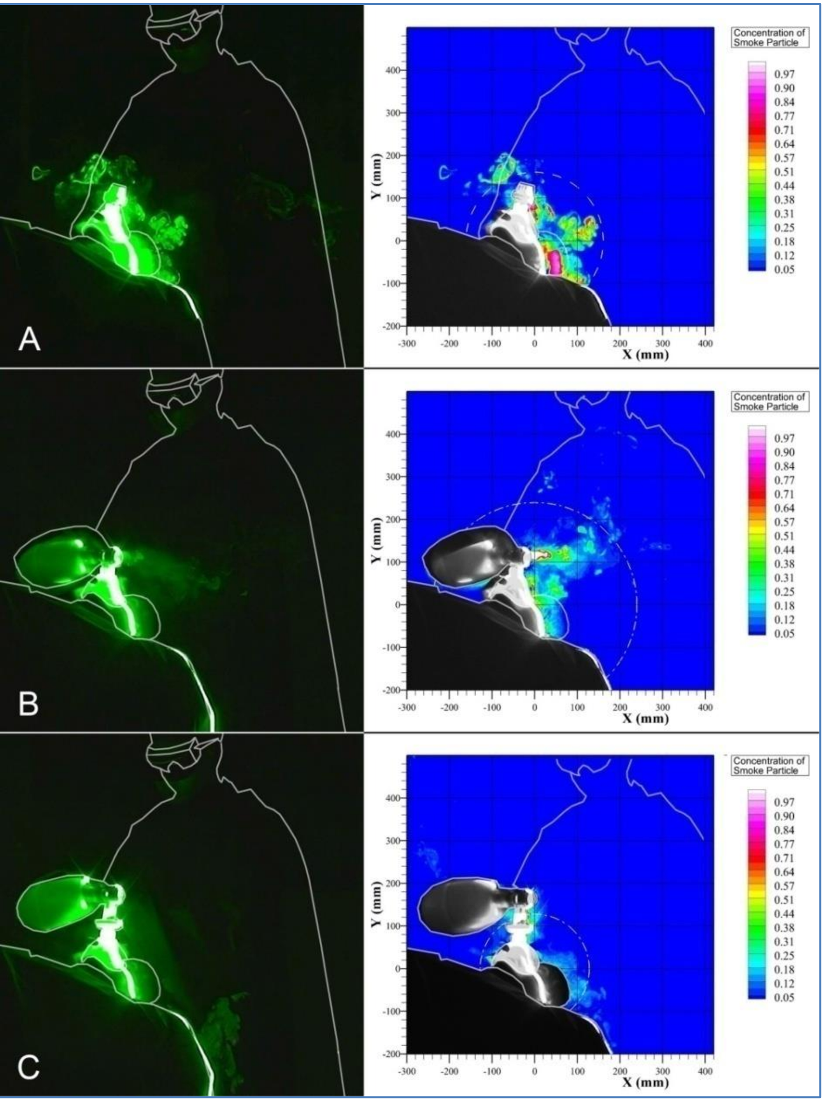
- N Engl J Med 2020; 382:1957-1958

Summary of exhaled smoke dispersion distances with different O2 devices

Oxygen device		Dispersion distance, cm
HFNC[3]	60 L/min	17.2 ± 3.3
	30 L/min	13.0 ± 1.1
	10 L/min	6.5 ± 1.5
Simple mask[4]	15 L/min	11.2 ± 0.7
	10 L/min	9.5 ± 0.6
Nonrebreather mask[4]	10 L/min	24.6 ± 2.2
Venturi mask at F_IO_2 0.4[4]	6 L/min	39.7 ± 1.6
Venturi mask at F_IO_2 0.35[4]	6 L/min	27.2 ± 1.1

- European Respiratory Journal 2020

NIV/HFNC in COVID 19 patient ?



- *Nature Scientific Reports* **volume 8**, 198 (2018)

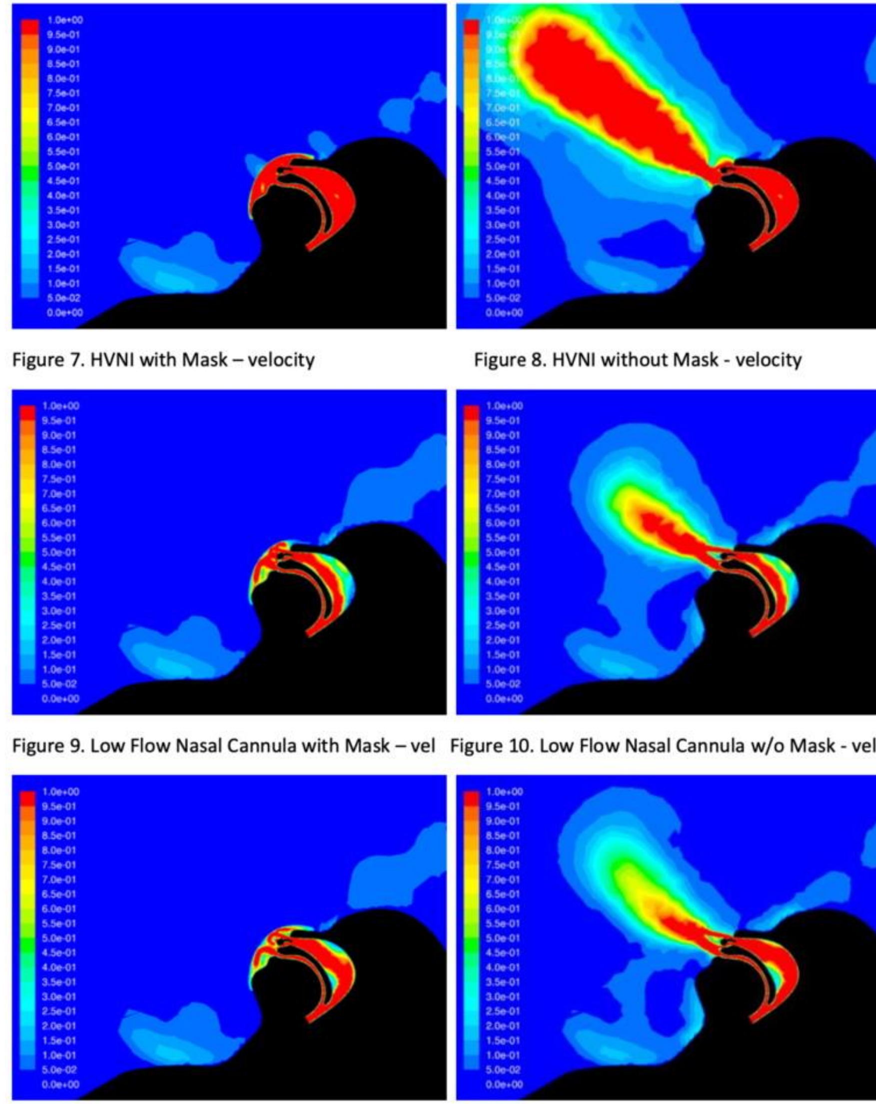


Figure 7. HVNI with Mask – velocity

Figure 8. HVNI without Mask - velocity

Figure 9. Low Flow Nasal Cannula with Mask – vel

Figure 10. Low Flow Nasal Cannula w/o Mask - vel

- Simple Surgical Mask during HFNC

- CHEST-2020-1164.

氧氣治療於新冠肺炎

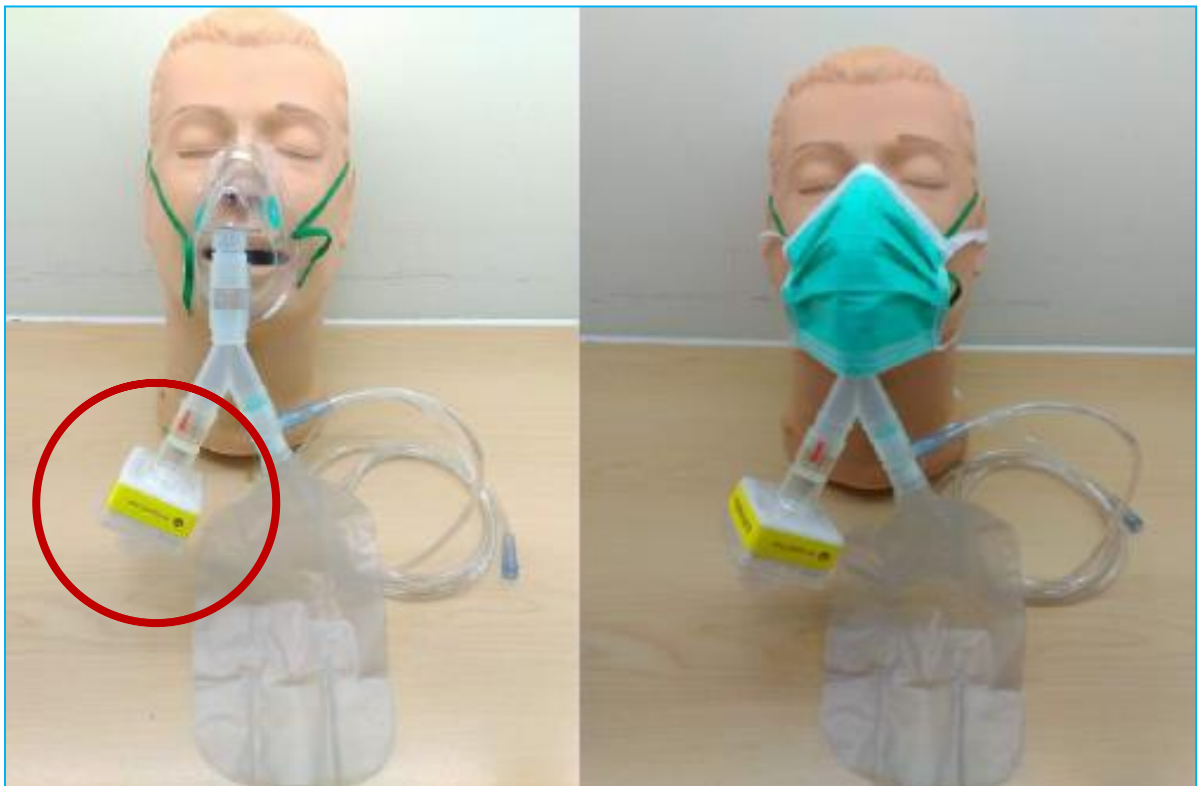
- 因新冠病毒的高傳染性，醫療人員應特別小心會增加病毒氣溶膠(aerosol)的醫療行為!
  - 使用每分鐘大於六升氣流速的氧氣患者均要小心。

- 戴鼻導管或使用氧氣面罩時，建議病人加戴外科口罩!
  - 不建議使用可調式氧 氣面罩(Venturi mask)
  - 不 建議使用噴霧藥劑 ，若需要吸入藥物，建議使用吸藥輔助腔+定量氣霧劑 治療。

- 台灣胸腔暨重症加護醫學會 2020/05

氧氣治療於新冠肺炎

- 嚴重缺氧P/F<200時，使用Non rebreathing mask
  - 需加裝單向閥與高效濾網；也建議 病人加戴外科口罩。



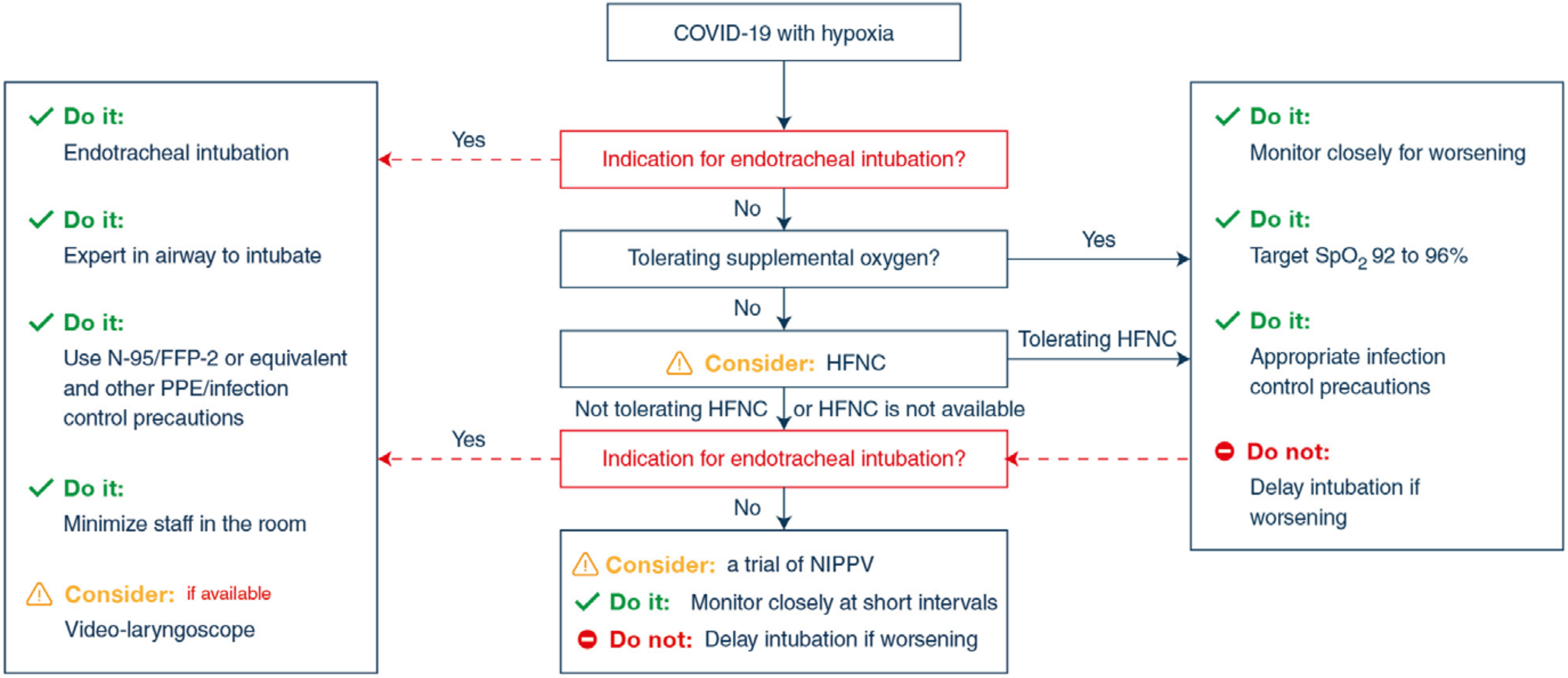
新冠肺炎病人非侵襲性呼吸器的使用

- NIV治療易有懸浮微粒，對醫護人員有威脅，故**不建議於該類病人**!
- 若考慮使用，應於負壓隔離室使用，醫護需穿著完整個人防護裝備；管路 應加裝高效濾網

高流量鼻導管的使用

- 有可能增加病毒氣溶膠 (aerosol) 產生，增加病毒傳播可能性!
  - 醫療人 員應穿戴N95 及全套防護裝備；
  - 且應在負壓病室或換氣良好獨立房間，來照顧 使用高流量鼻導管的病人。

Surviving Sepsis Campaign: guidelines on the management of critically ill adults with COVID-19



- CCM 2020/Jun • Vol 48 • No 6

Surviving Sepsis Campaign: guidelines on the management of critically ill adults with COVID-19

Recommendations and Statements of ventilation

25	For adults with COVID-19 and **acute hypoxemic respiratory failure** despite conventional oxygen therapy, we ***suggest*** using HFNC over conventional oxygen therapy.	Weak
26	In adults with COVID-19 and **acute hypoxemic respiratory failure**, we ***suggest*** using HFNC over NIPPV.	Weak
27	In adults with COVID-19 and **acute hypoxemic respiratory failure**, if HFNC is not available and there is no urgent indication for endotracheal intubation, we ***suggest*** a trial of NIPPV with close monitoring and short-interval assessment for worsening of respiratory failure.	Weak
28	**We were not able to make a recommendation** regarding the use of helmet NIPPV compared with mask NIPPV. It is an option, but we are not certain about its safety or efficacy in COVID-19.	No recommendation
29	In adults with COVID-19 receiving NIPPV or HFNC, we ***recommend*** close monitoring for worsening of respiratory status, and early intubation in a controlled setting if worsening occurs.	Best practice statement

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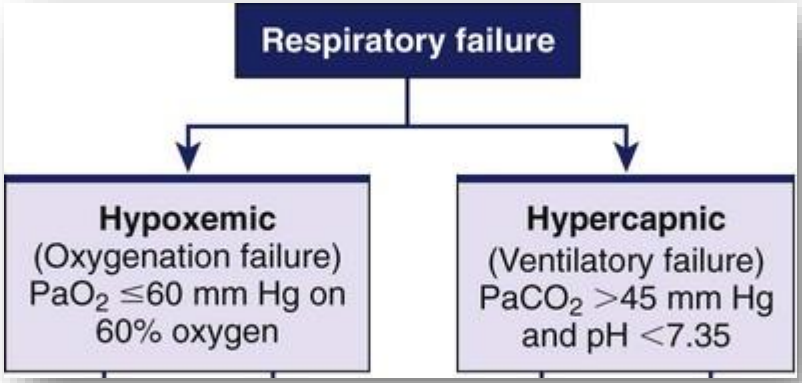
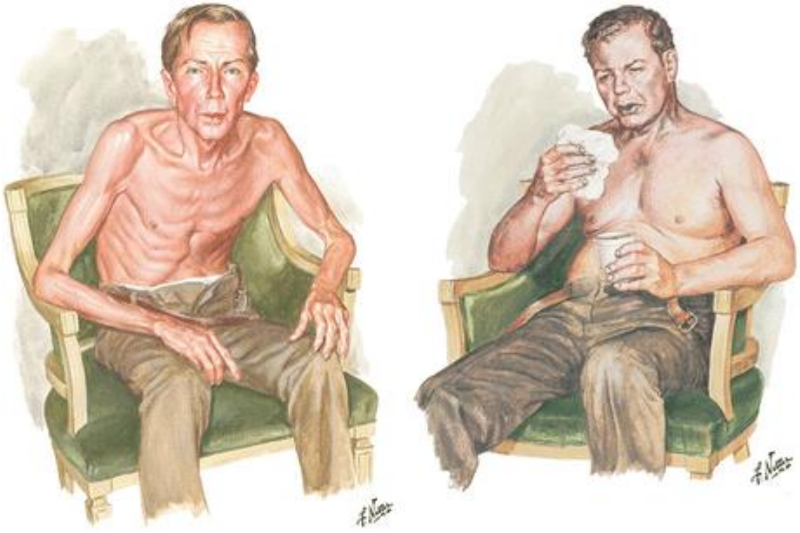
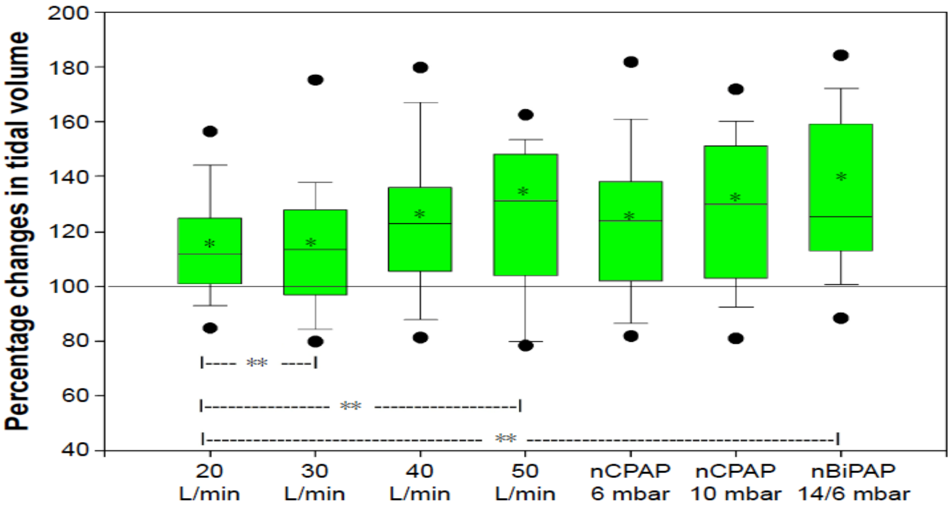
SEA-LONG

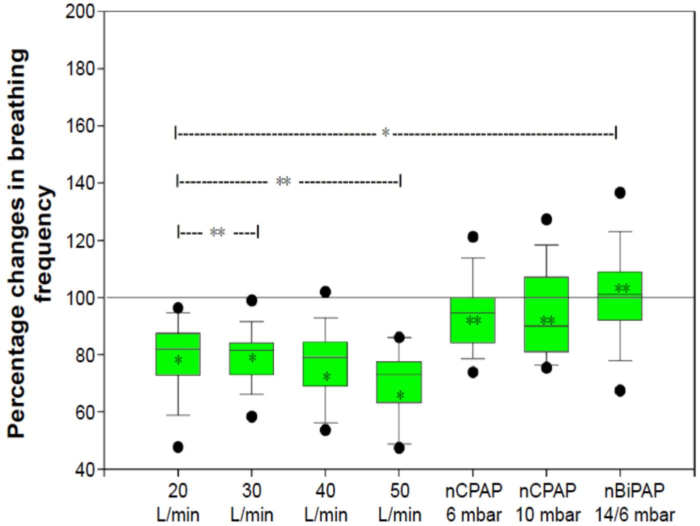
High Flow Nasal Cannula, Is There a Role in COPD?





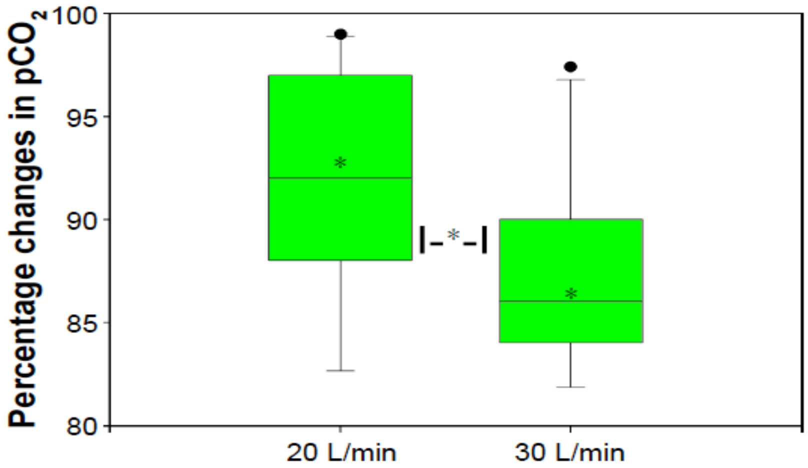
HFNC effects on breathing pattern in stable hypercapnic COPD

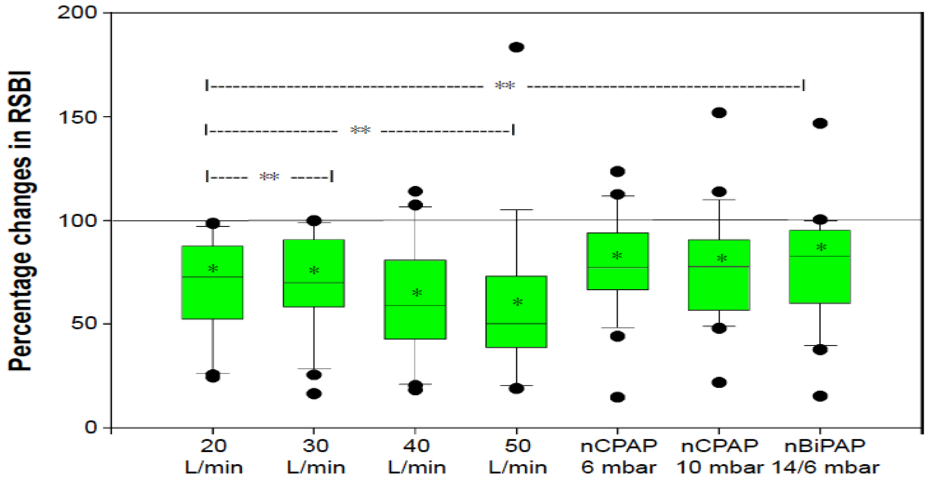




Braunlich J et al Int J COPD 2016: 11

Impact on PCO2 and comfort





N=54 ABG change after 2 hours

- Braunlich J et al Int J COPD 2016: 11

Nasal highflow improves ventilation in patients with severe COPD

Table 3 Changes in ventilatory parameters

	Spontaneous breathing	20 L/min	30 L/min	40 L/min	50 L/min	nCPAP (6 mbar)	nCPAP (10 mbar)	nBiPAP (14/6 mbar)
VT								
Mean (mL) ± SD;	441.2±146.2	534.2±215.2;	523.7±228.5;	561.7±248.8;	558.8±260.0;	562.6±215.7;	579.3±262.6;	606.9±249.5;
mean (%) ± SD		104.9±21.4	113.3±27.6	123.2±27.7	123.8±27.2	125.3±29.4	126.8±28.8	133.6±30.1
P-value from mean (%)		<0.01	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01
BR								
Mean (bpm) ± SD;	15.7±4.1	11.6±3.6;	11.1±3.6;	10.3±3.3;	9.9±2.7;	14.3±3.8;	14.3±4.3;	15.4±4.3;
mean (%) ± SD		76.6±17.0	73.8±18.1	71.0±19.1	67.9±14.8	94.6±14.0	94.2±16.3	101.6±18.4
P-value from mean (%)		<0.01	<0.01	<0.01	<0.01	>0.05	>0.05	>0.05
MV								
Mean L/min ± SD;	7.1±2.9	6.0±2.8;	5.6±2.6;	5.5±2.5;	5.4±2.5;	7.8±3.2;	8.2±3.8;	8.9±3.5;
mean (%) ± SD		86.6±14.2	83.3±21.1	85.3±24.0	83.7±24.7	117.7±32.2	119.9±28.6	133.7±36.2
P-value from mean (%)		<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01

Note: *P*-values in comparison to spontaneous breathing.
Abbreviations: BR, breathing rate; MV, minute volume–medium prong size; nCPAP, (nasal) continuous positive airway pressure; nBiPAP, (nasal) bilevel positive airway pressure; VT, tidal volume; SD, standard deviation.

*** In summary:**
- NHF leads to a flow-dependent reduction in pCO_2.
- NHF enhances effectiveness of breathing in patients with COPD : educes pCO^2, the work of breathing, and respiratory work load.

HFNC oxygen therapy versus NIV for COPD with acute-moderate hypercapnic respiratory failure: an observational cohort study

- COPD AR, $PaCO_2 > 50$ mmHg, received HFNC or NIV

- 39 in the HFNC group and 43 in the NIV group

- Endpoint was treatment failure :
  - invasive ventilation, or a switch to the other study treatment, 28-day mortality.

- Int J COPD 2019:14 1229–1237

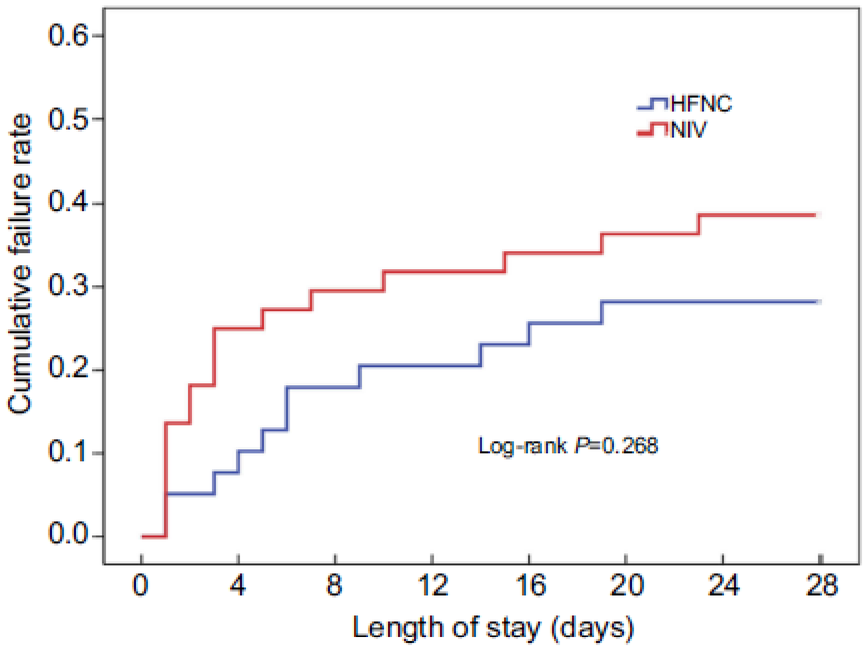


Figure 2 Kaplan-Meier curve analysis for cumulative failure rate.
Abbreviations: HFNC, High flow nasal cannula oxygen therapy; NIV, Non-invasive ventilation.

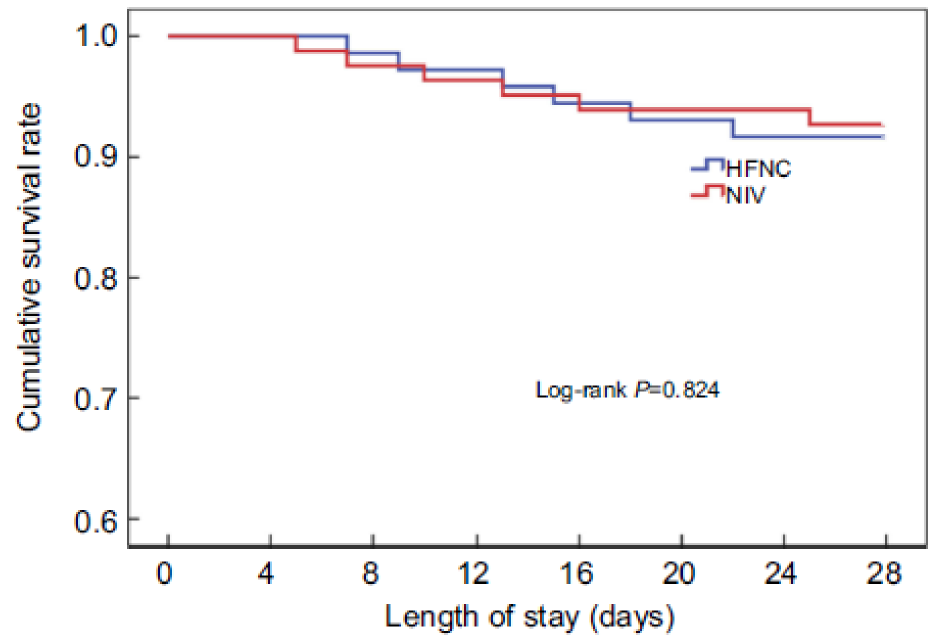


Figure 3 Kaplan-Meier curve analysis for cumulative survival rate.
Abbreviations: HFNC, High flow nasal cannula oxygen therapy; NIV, Non-invasive ventilation.

Outcomes between the HFNC and NIV groups

Outcomes	HFNC (n=39)	NIV (n=43)	P-value
Treatment failure, n(%)	11(28.2)	17(39.5)	0.268
Invasive ventilation, n(%)	8(20.5)	9(20.9)	1.0
Treatment switch, n(%)	3(7.7)	8(18.6)	0.148
28-day mortality, n(%)	6(15.4)	6(14.0)	0.824
Airway care interventions,/day*	5(4–7)	8(7–10)	<0.001
Duration of device application, hours*	16.0±3.9	11.7±3.1	<0.001
Respiratory frequency,/min #	22.3±3.1	23.5±2.9	0.064
$PaCO_2$, mm Hg#	51(48–56)	49(46–52)	0.078
PaO_2/FiO_2, mm Hg #	179 (172–192)	187 (174–207)	0.083
Respiratory support duration, days	5(4–7)	6(5–8)	0.148
Nasal facial skin breakdown after treatment, n(%)	2(5.1)	9(20.9)	0.036
Length of stay in ICU, days	7(6–8)	8(6–10)	0.149
Length of stay in hospital, days	9(7–11)	10(7–12)	0.207

Effects of HFNC in patients with persistent hypercapnia after an COPD AE: a prospective pilot study

Background: Persistent hypercapnia after COPD exacerbation is associated with excess mortality and early rehospitalization. High Flow Nasal cannula (HFNC), may be theoretically an alternative to long-term noninvasive ventilation (NIV), since physiological studies have shown a reduction in PaCO2 level after few hours of treatment. In this clinical study we assessed the acceptability of HFNC and its effectiveness in reducing the level of $PaCO_2$ in patients recovering from an Acute Hypercapnic Respiratory Failure (AHRF) episode. We also hypothesized that the respon

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response in terms of $PaCO_2$ decrease ($p = 0.044$). In addition, the subset of patients with a lower pH at enrolment were those who responded best in terms of CO_2 clearance (score test for trend of odds, $p = 0.0038$).

Conclusions: HFNC is able to significantly decrease the level of $PaCO_2$ after 72 h only in "pure" COPD patients, recovering from AHRF. No effects in terms of CO2 reduction were found in those with overlap syndrome. The present findings will help guide selection of the best target population and allow a sample size calculation for future long-term randomized control trials of HFNC vs NIV.

在"純" COPD患者中，HFNC能夠在72小時後顯著降低$PaCO_2$，並且可以從急性高二氧化碳呼吸衰竭中恢復。

- *BMC Pulmonary Medicine*
volume 20, Article number: 12 (2020)

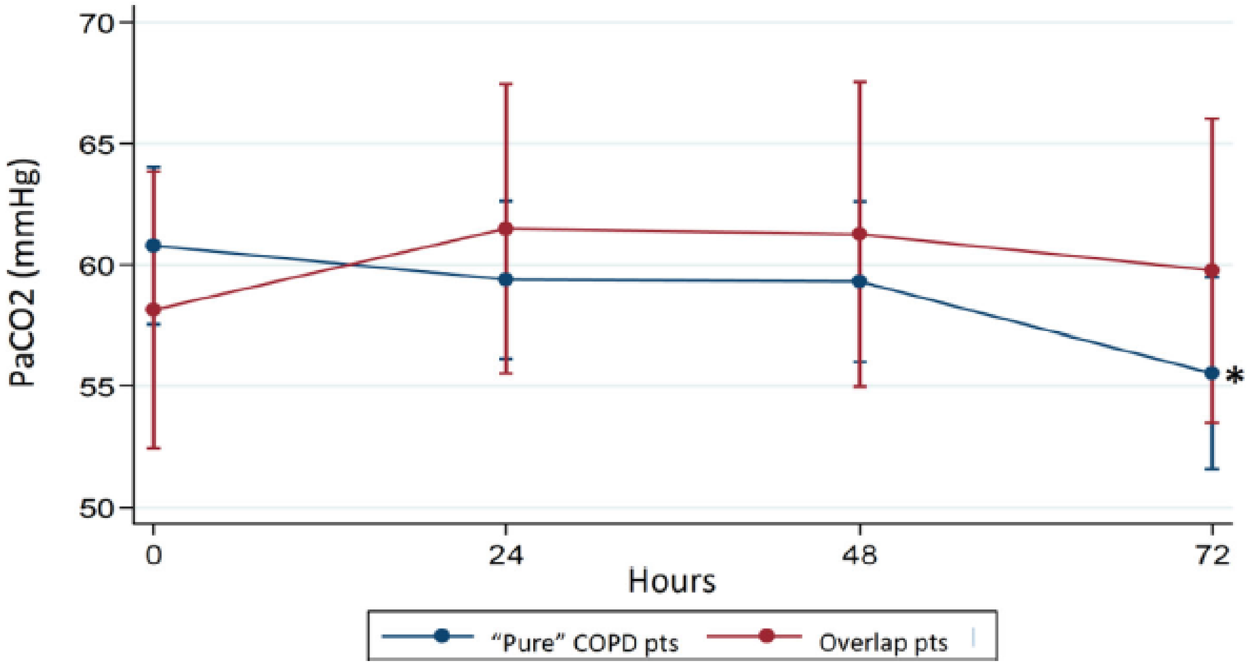
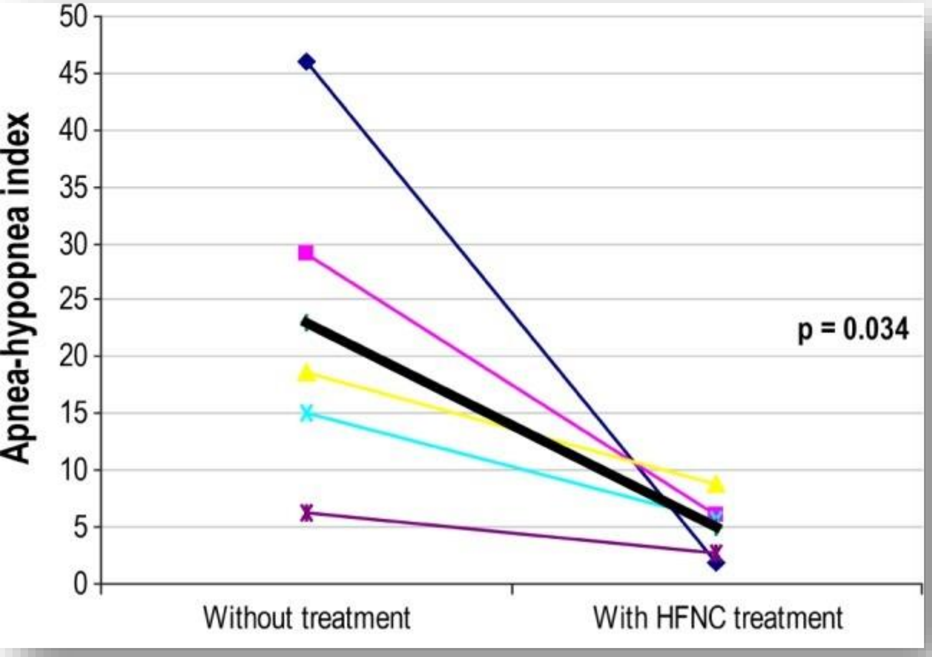
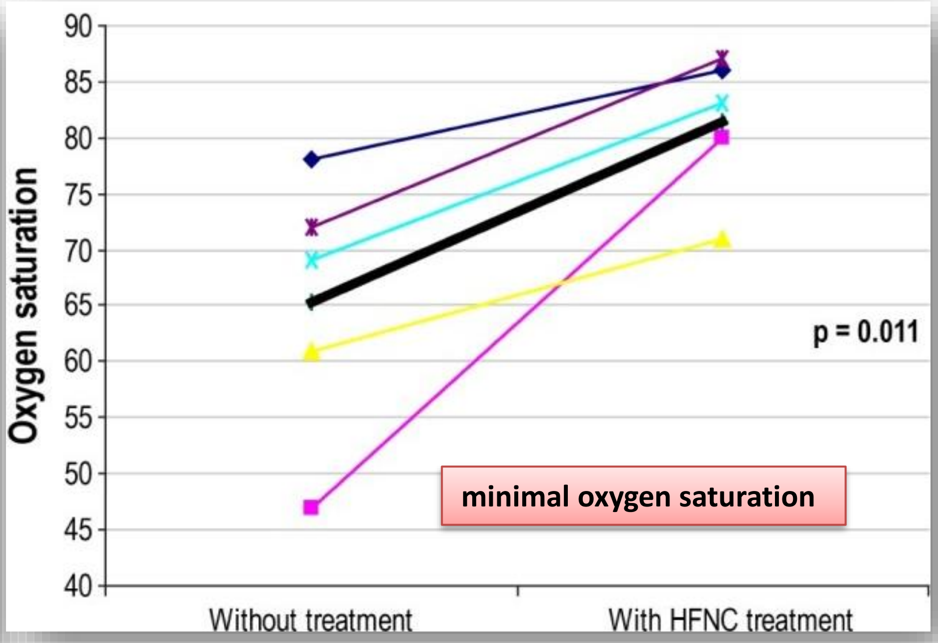


Fig. 3 Trend of PaCO2 values during the trial according the presence or not of COPD/OSA overlap syndrome. *72 h vs baseline: $p = 0.044$(Bonferroni-adjusted p-values)

High-Flow Nasal Cannula Therapy for Obstructive Sleep Apnea in Children



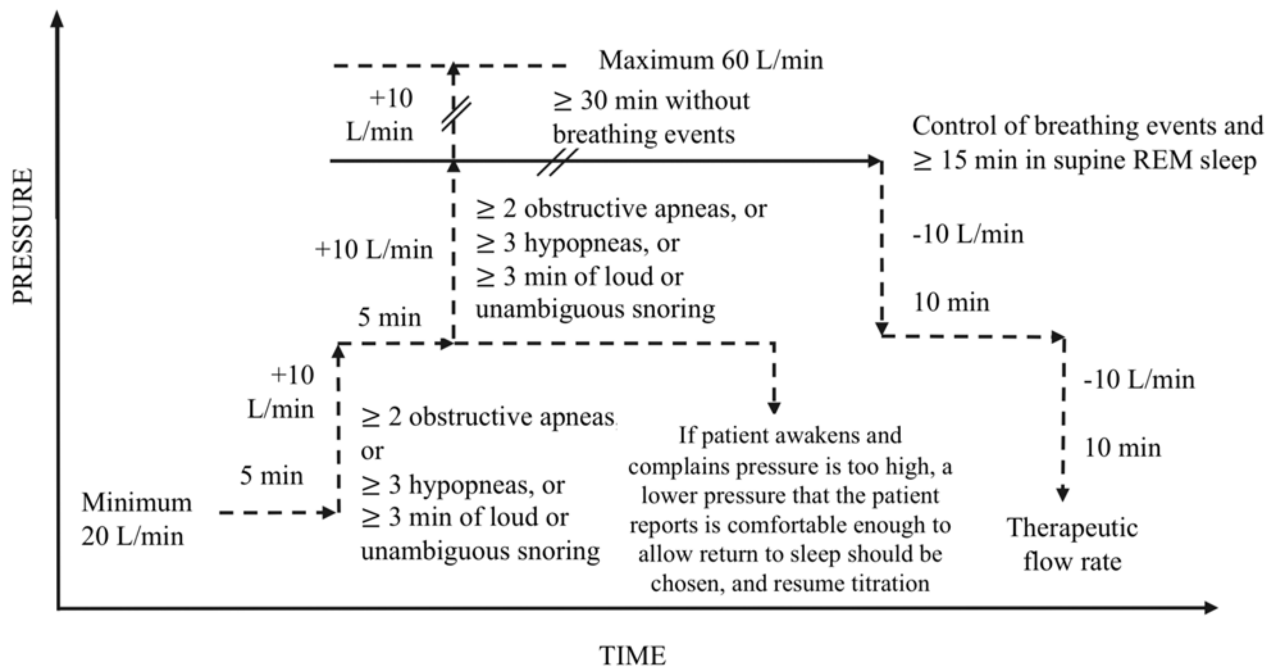


- *J Clin Sleep Med* 2015;11(9):1007–1010

HFNC ventilation therapy for OSA in ischemic stroke patients requiring nasogastric tube feeding: a preliminary study

- OSA, with acute stroke, need NG tube feeding
- One week after the stroke onset, N=11

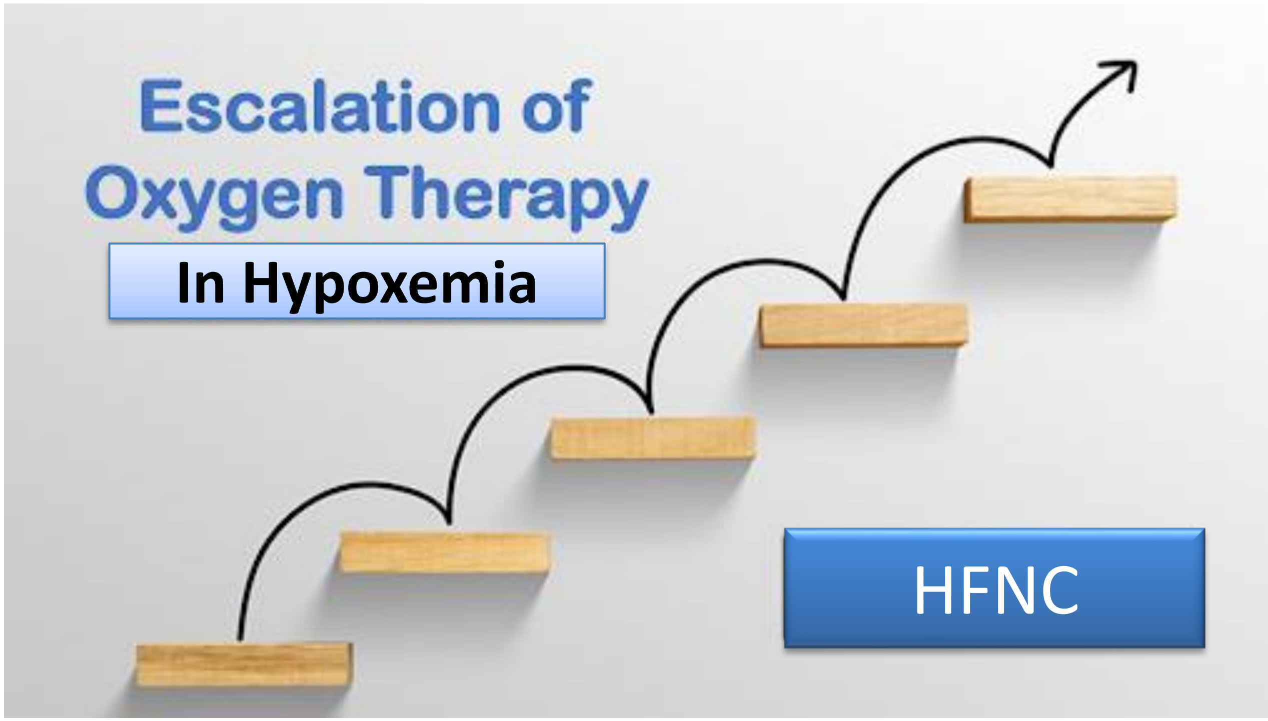
High-flow nasal cannula ventilation titration protocol

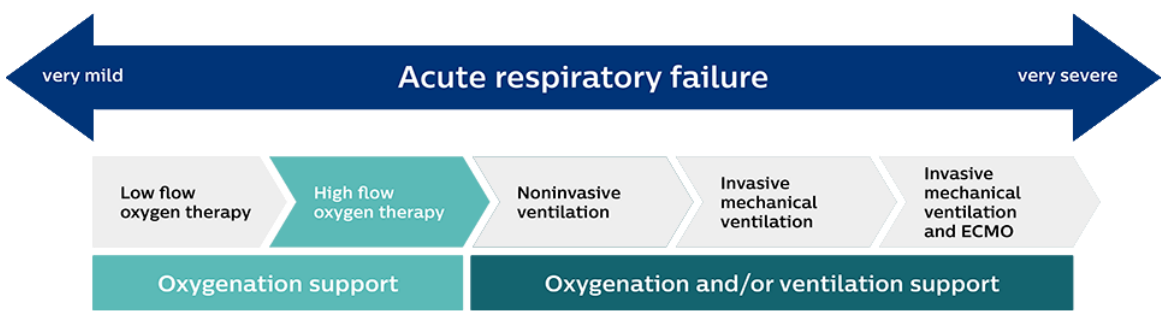


- Scientific Reports, (2020) 10:8524

The result of polysomnography in baseline and HFNC therapy

	Baseline	HFNC	*p value*
AHI	52.0 (29.9–61.9)	26.5 (3.3–34.6)	0.026*
Minimum SpO_2	78.0 (74.0–80.0)	88.0 (82.0–92.0)	0.009*
Mean SpO_2	94.0 (92.8–94.3)	95.0 (93.0–96.0)	0.106
ODI	53.0 (37.0–72.8)	16.2 (0.8–20.1)	0.007*
Sleep efficiency %	68.6 (39.7–76.2)	70.7 (43.1–82.2)	1
REM %	8.7 (3.5–9.0)	8.3 (0–35.5)	0.374
Deep sleep %	23.4 (14.4–31.1)	24.0 (10.1–35.7)	0.638
Spontaneous arousal index	6.3 (2.1–11.8)	8.7 (5.8–14.4)	0.386
Respiratory arousals index	28.1 (13.5–30.5)	4.1 (2.5–12.3)	0.005*
Total arousal index	34.6 (18.6–42.3)	15.0 (10.3–25.4)	0.022*


Escalation of
Oxygen Therapy
In Hypoxemia
HFNC


very mild
Acute respiratory failure
very severe
Low flow oxygen therapy
High flow oxygen therapy
Noninvasive ventilation
Invasive mechanical ventilation
Invasive mechanical ventilation and ECMO
Oxygenation support
Oxygenation and/or ventilation support

Right patient right time right dose