HIGH FLOW OXYGEN THERAPY

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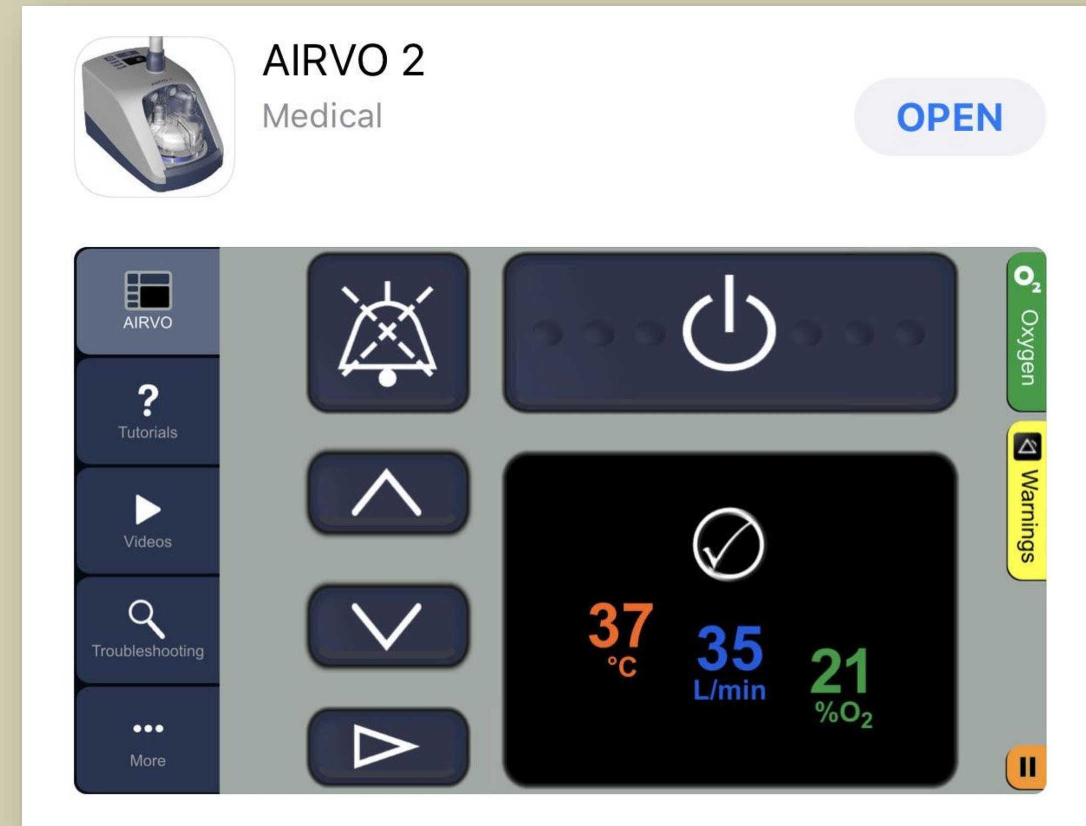

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OUTLINE

- Oxygen delivery system
- Physiologic effect of HFNC
- Current evidence for HFNC
- HFNC failure

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Oxygen delivery system

Low flow oxygen delivery system

- *Flow < inspiratory flow demand*
- Variable FIO2
- Nasal cannula, simple mask, partial rebreathing mask

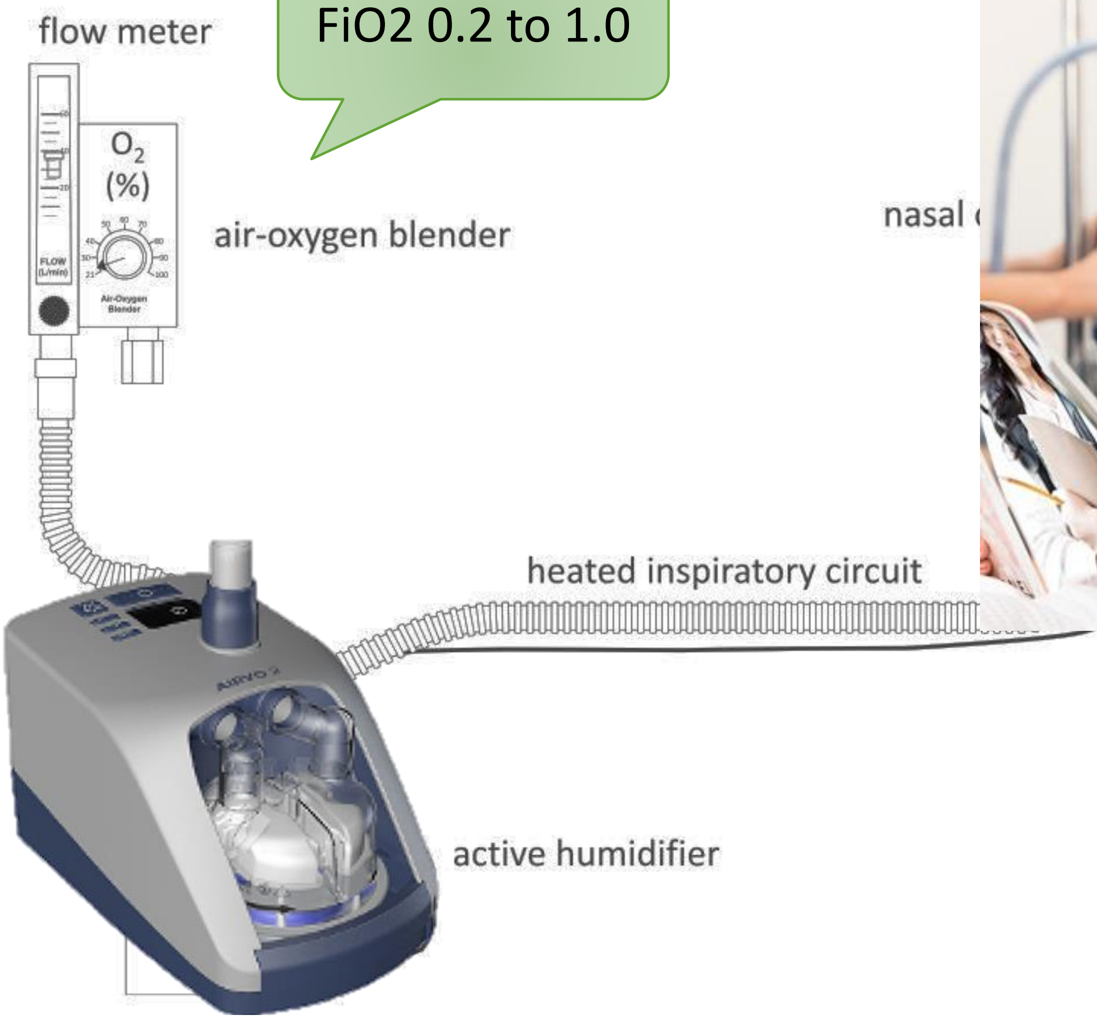
Oxygen delivery system

High flow oxygen delivery system

- *Flow > inspiratory flow demand*
- Constant F_IO_2
- Venturi mask,
  high flow nasal cannula,
  T-piece with reservoir,
  Non-invasive mechanical
  ventilator

High flow nasal therapy

FiO2 0.2 to 1.0



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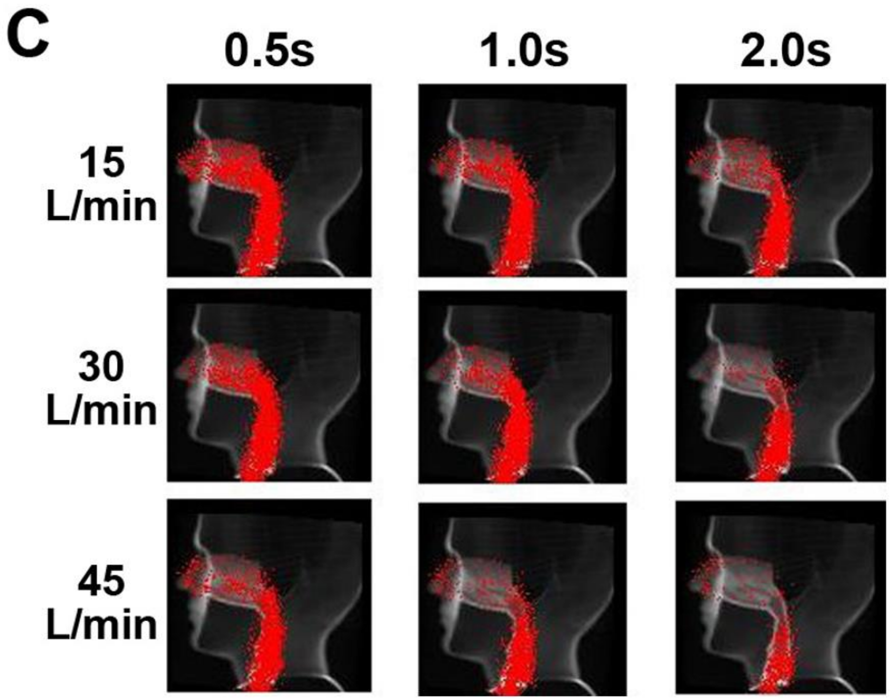
OUTLINE

- Physiologic effect of HFNC
  - Wash out CO2 in anatomical dead space
  - Creates positive nasopharyngeal pressure
  - Overcomes resistance against expiratory flow in nasopharynx
  - Increase respiratory lung volume
  - Humidification & Good mucociliary function
  - Constant F_IO_2

Wash out CO2 in anatomical dead space



- Upper airway model, constructed from segmented CT-scan images of a healthy volunteer
- Filling the models with tracer gases, ^{81m}Kr-gas radioactive
- NHF was delivered at rates of 15, 30, and 45 l/min
- Showed flow-dependent tracer-gas clearance in the models

Mündel T et,al. J Appl Physiol 2015; 18:1525-32

Creates positive nasopharyngeal pressure

Table 2 Expiratory pharyngeal pressure

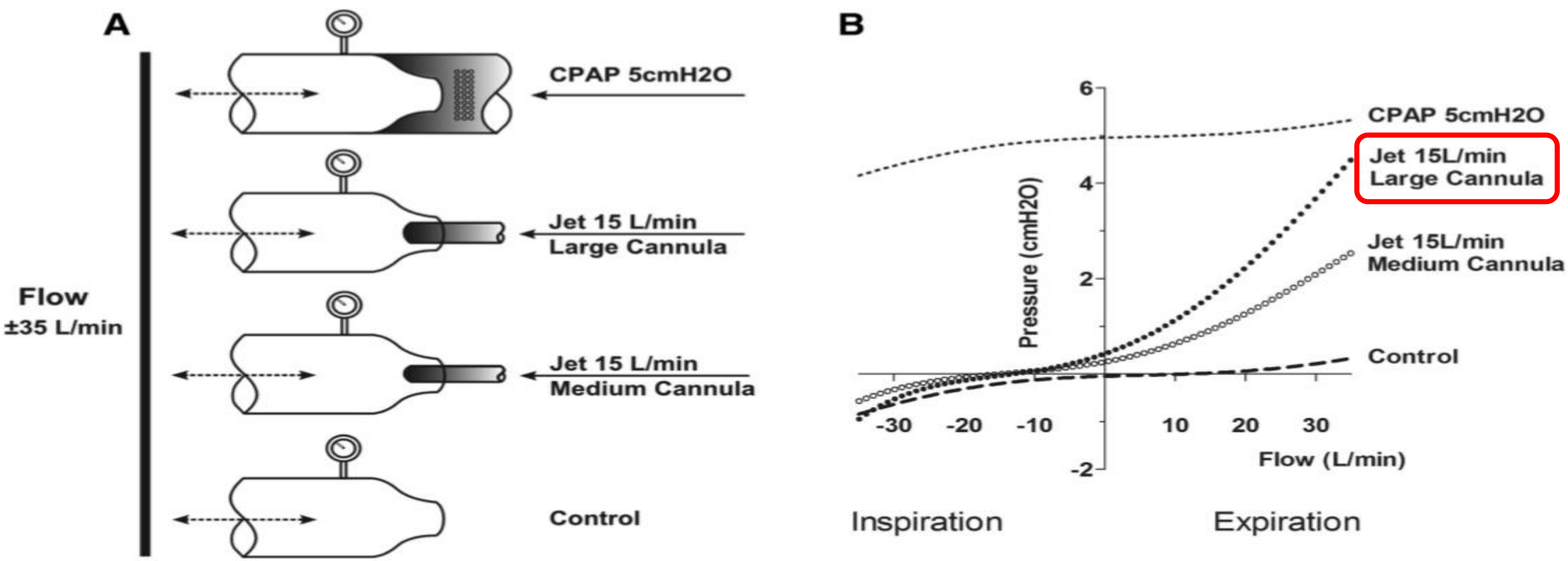
	Nasal flow (L/min)				
	0	10	20	40	60
Mouth open (cmH_2O)					
Group	0.3 (0.3–0.5)	0.7 (0.6–0.9)	1.4 (1.3–1.8)[a]	2.2 (2.0–2.5)[a,b]	2.7 (2.4–3.1)[a]
Male	0.4 (0.2–0.6)	0.7 (0.6–0.9)	1.4 (1.0–1.8)[a]	2.0 (1.9–2.3)[a]	2.6 (2.3–2.7)[a]
Female	0.3 (0.3–0.4)	0.7 (0.6–1.0)	1.4 (1.3–1.8)[a]	2.3 (2.1–2.7)[a]	3.1 (2.6–3.9)[a]
Mouth closed (cmH_2O)					
Group	0.8 (0.5–1.3)	1.7 (1.2–2.3)	2.9 (2.2–3.7)[a,b]	5.5 (4.1–7.2)[a,b]	7.4 (5.4–8.8)[a]
Male	0.7 (0.2–1.0)	1.2 (1.0–1.6)	2.2 (2.0–2.9)[a]	4.1 (3.2–5.2)[a]	5.4 (5.0–6.0)[a]
Female	1.2 (0.5–1.7)	2.3 (1.9–2.6)	3.7 (2.9–4.0)[a]	7.2 (5.9–7.7)[a]	8.7 (7.7–9.7)[a]

[a] Significant adjusted *p*-value for comparison with zero flow.
[b] Significant adjusted *p*-value for comparison with previous flow rate.

- HFNC : ↑ nasal flow → ↑ expiratory pharyngeal pressure

Groves et al. Aust Crit Care 2007; 20:126-31

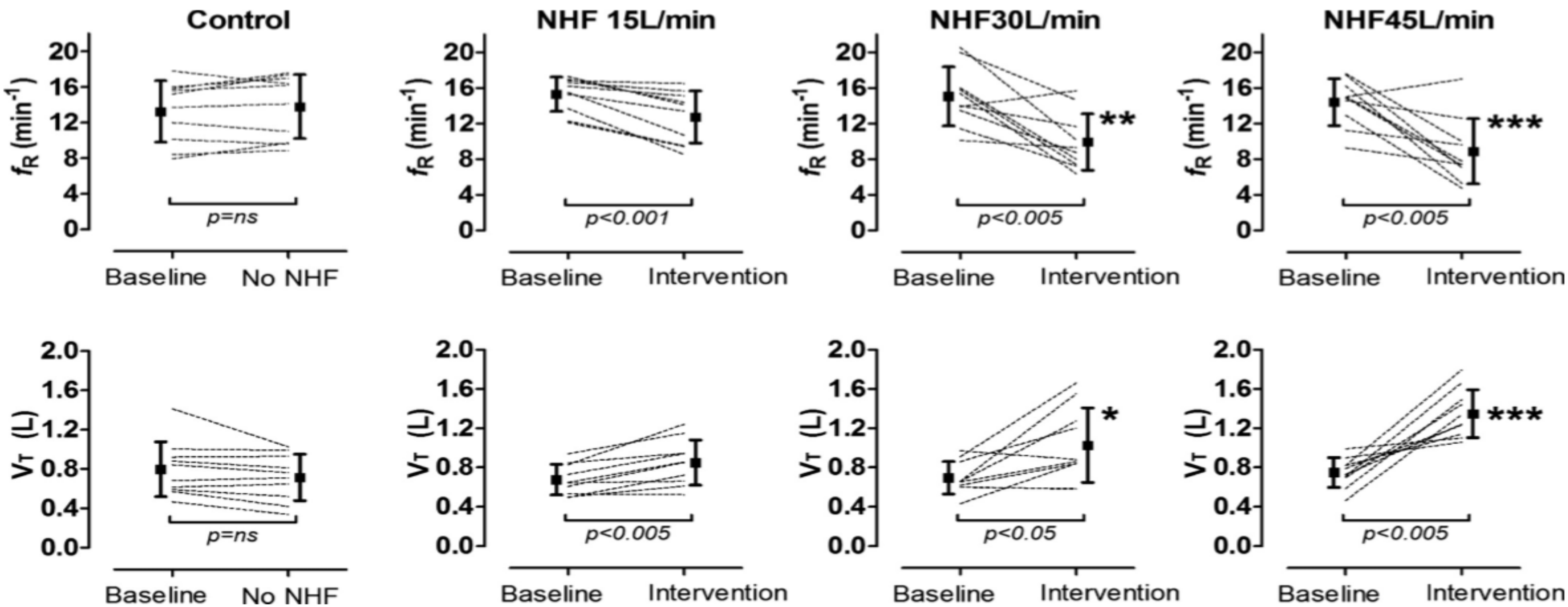
Overcomes resistance against expiratory flow in nasopharynx



- HFNC : ↑ expiratory resistance → ↑ expiratory flow

  ↓ inspiratory resistant

Increase respiratory lung volume



- HFNC: ↑ tidal volume (from 0.7 ± 0.1 L → 0.8 ± 0.2 L)

  ↓ respiratory rate (from 16 ± 2 → 13±3 bpm)

Increase respiratory lung volume

Table 2 Outcome variables. Low-flow oxygen compared with HFNCs

Variable	Low-flow oxygen [mean (SD)]	HFNC [mean (SD)]	Mean difference [mean (SD)]	95% confidence interval	*P*-value
End-expiratory lung impedance (units)	419 (212.5)	1936 (212.9)	1517 (46.6)	1425, 1608	<0.001
Mean airway pressure (cm H_2O)	−0.3 (0.9)	2.7 (1.2)	3.0 (1.3)	2.4, 3.7	<0.001
Respiratory rate (bpm)	20.9 (4.4)	17.5 (4.6)	−3.4 (2.8)	−2.0, −4.7	<0.001
Borg score					
0–10	2.7 (2.6)	1.9 (2.3)	−0.8 (1.2)	−0.1, −1.4	0.023
Tidal variation (units)	1512 (195.0)	1671 (195.1)	159 (21.6)	117, 201	<0.001
Pa_{O_2}/FI_{O_2} ratio (mm Hg)	160 (53.7)	190.6 (57.9)	30.6 (25.9)	17.9, 43.3	<0.001

- HFNC→ ↑ end-expiratory lung impedance

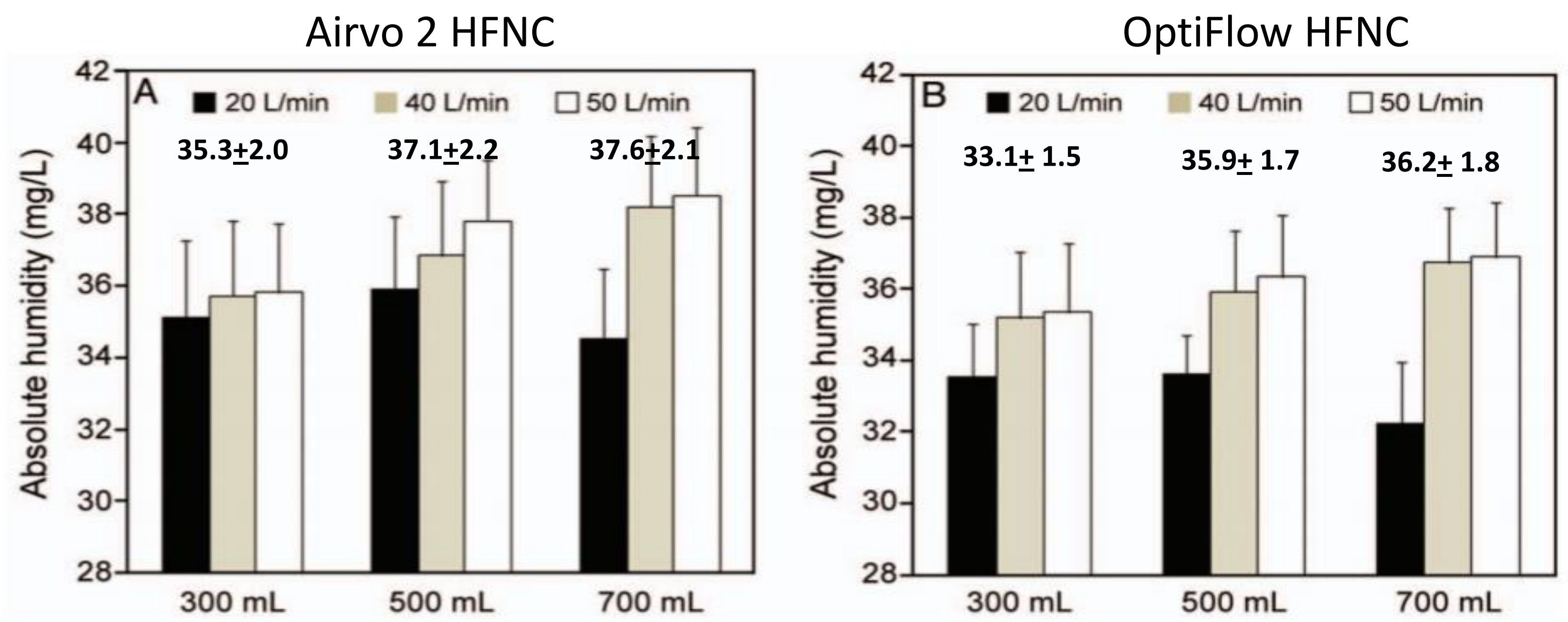
  ↑ mean airway pressure, ↑ tidal impedance variation

  improved PF ratio, dyspnea score

  → ↓ respiratory rate

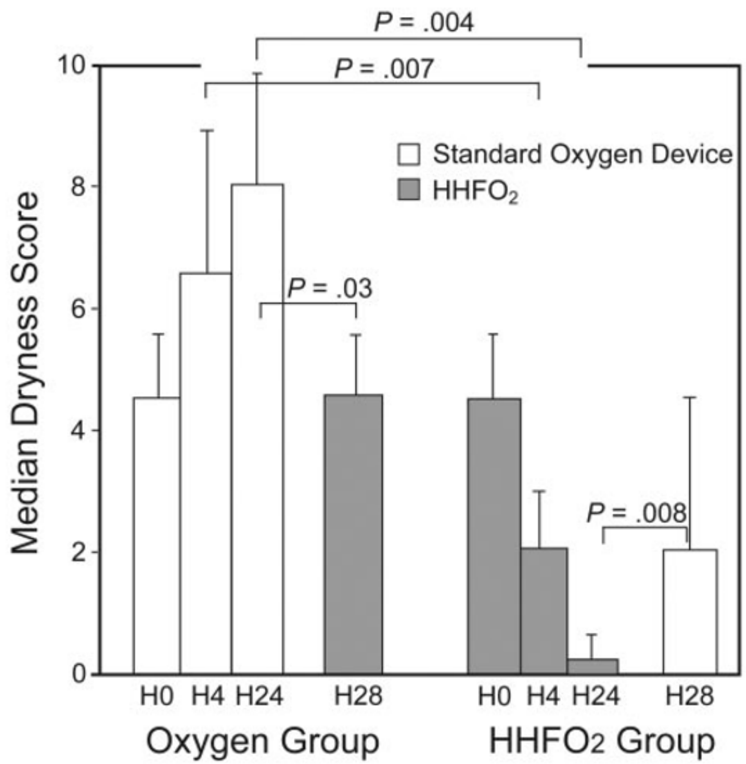
Corley A et,al. Br J Anaesth 2011; 107:998-1004

Humidification & Good mucociliary function



- Absolute humidity was lower at 20 than 40 and 50 L/min of flow
- HFNC → AH increased with increasing HFNC flow

Humidification
& Good mucociliary function



9 L/min 12 L/min
Baseline median oxygen flow

- HFNC
  - → ↓ dryness of nasal mucosa
  - → ↓ discomfort
  - → improves clinical tolerance of oxygen therapy

Cuquemelle et,al. Respir Care 2017; 57:1571-7

Constant F_IO_2

Delivered flow rate	Nose breathing at rest			Mouth breathing at rest			Nose breathing with exercise		
	F_EO_2	F_ECO_2	FiO_2	F_EO_2	F_ECO_2	FiO_2	F_EO_2	F_ECO_2	FiO_2
50 l/min	0.511	0.052	0.568	0.484	0.046	0.535	0.328	0.071	0.408
40 l/min	0.488	0.059	0.550	0.448	0.048	0.502	0.289	0.070	0.370
30 l/min	0.458	0.055	0.519	0.431	0.049	0.486	0.242	0.068	0.321
20 l/min	0.404	0.054	0.465	0.361	0.048	0.416	0.235	0.066	0.313
10 l/min	0.309	0.053	0.369	0.284	0.051	0.342	0.188	0.064	0.263

F_EO_2=fraction of end-tidal O_2, F_ECO_2 =fraction of end-tidal CO_2, FiO_2=fraction of inspiratory O_2.

- FiO2 approached 0.60 as gas flow rates increased above 30 l/minute during nose breathing at rest

Ritchie et,al. Anaesth Intensive Care 2011; 39: 1103-1110

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- Oxygen delivery system
- Physiologic effect of HFNC
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Hypercapnic respiratory failure :HFNC effect in COPD &IPF

Effects of Nasal High Flow on Ventilation in Volunteers, COPD and Idiopathic Pulmonary Fibrosis Patients

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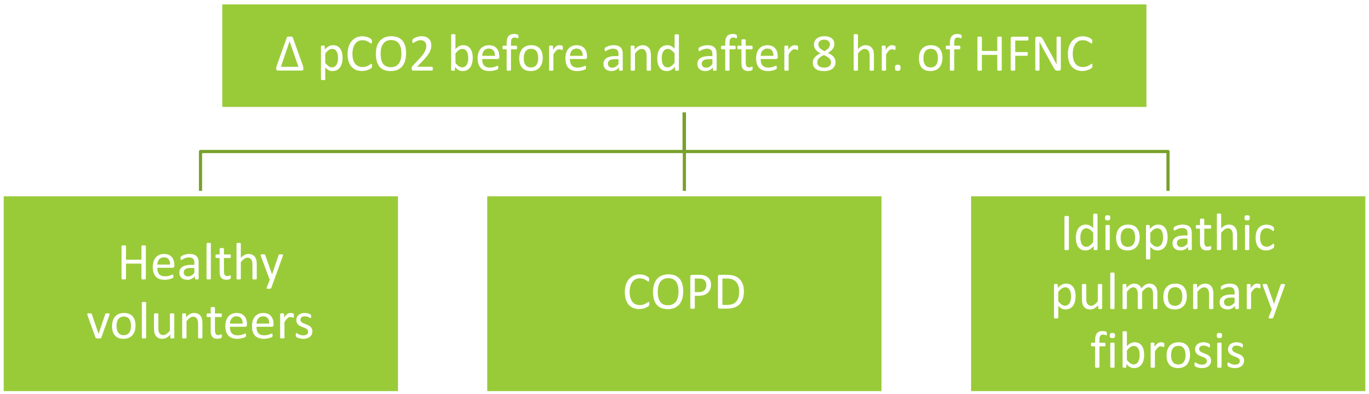
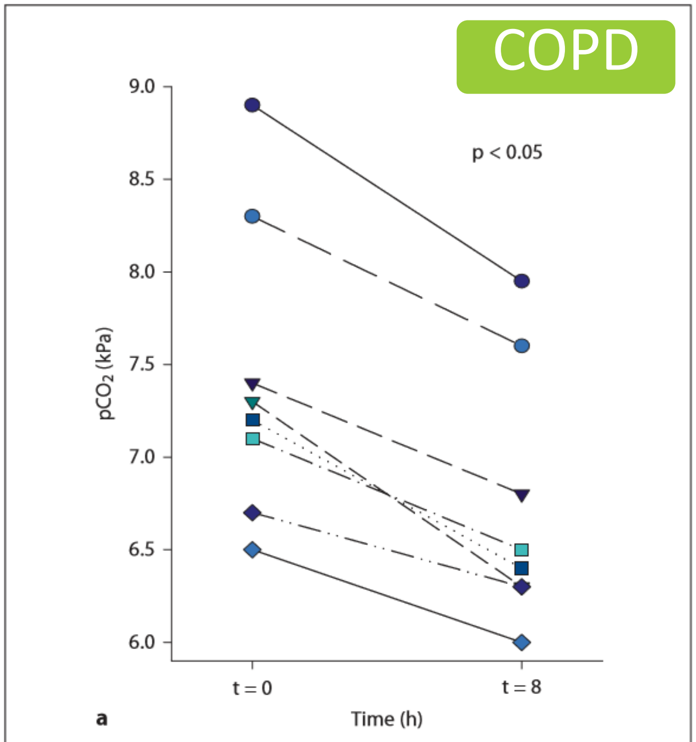
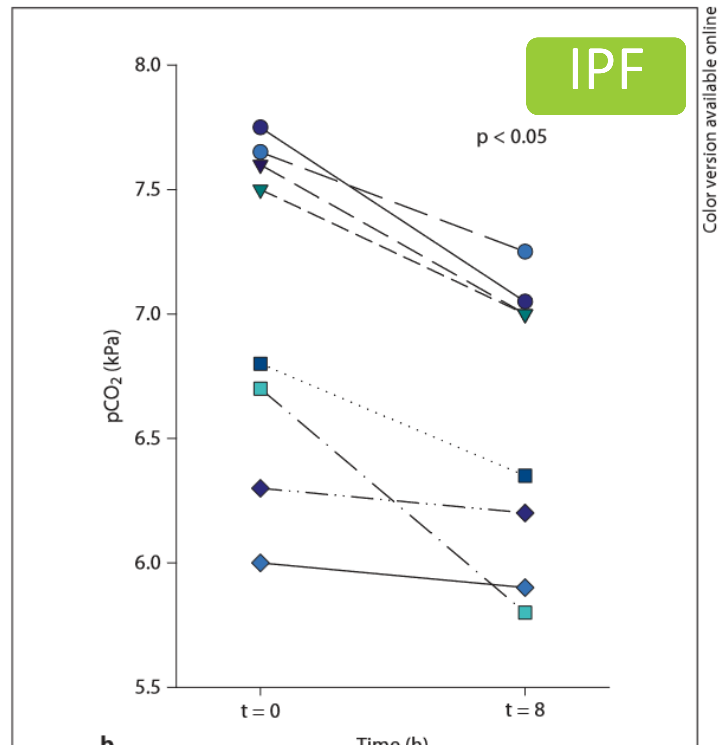


Hypercapnic respiratory failure :HFNC effect in COPD &IPF





CO_2↓ 55.6±6.5 → 50.5±5.2 mmHg

CO_2↓ 51.5±6 → 47.9±4 mmHg

➢ HFNC : ↑ CO_2 wash out

Bräunlich et,al. Respiration 2013;85:319–325

Hypoxemic respiratory failure : FLORALI trial

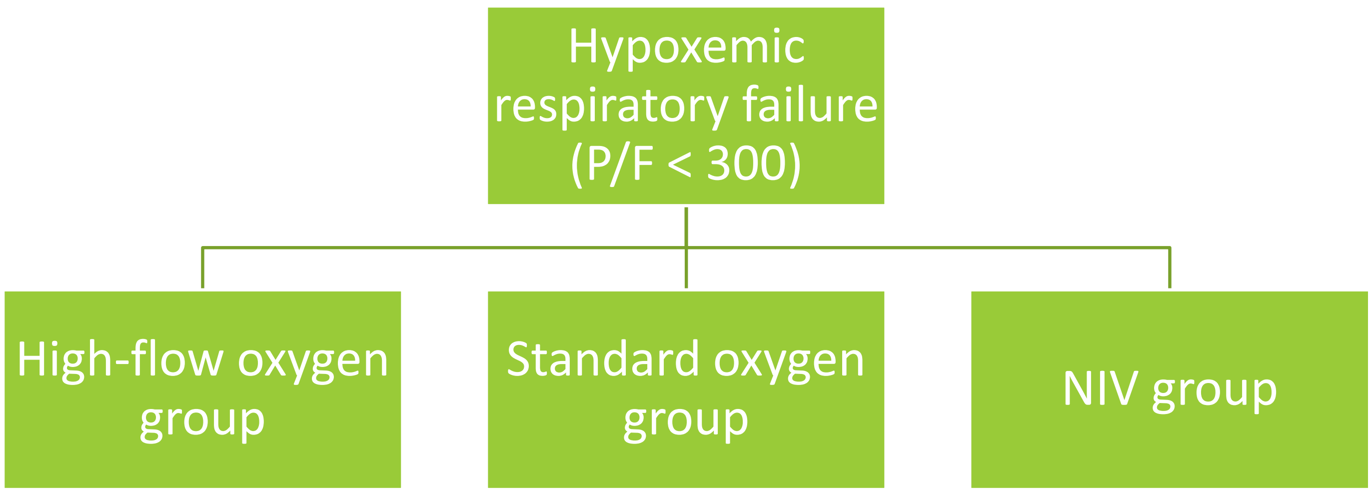
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 4, 2015 VOL. 372 NO. 23

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

Jean-Pierre Frat, M.D., Arnaud W. Thille, M.D., Ph.D., Alain Mercat, M.D., Ph.D., Christophe Girault, M.D., Ph.D., Stéphanie Ragot, Pharm.D., Ph.D., Sébastien Perbet, M.D., Gwénael Prat, M.D., Thierry Boulain, M.D., Elise Morawiec, M.D., Alice Cottereau, M.D., Jérôme Devaquet, M.D., Saad Nseir, M.D., Ph.D., Keyvan Razazi, M.D., Jean-Paul Mira, M.D., Ph.D., Laurent Argaud, M.D., Ph.D., Jean-Charles Chakarian, M.D., Jean-Damien Ricard, M.D., Ph.D., Xavier Wittebole, M.D., Stéphanie Chevalier, M.D., Alexandre Herbland, M.D., Muriel Fartoukh, M.D., Ph.D., Jean-Michel Constantin, M.D., Ph.D., Jean-Marie Tonnelier, M.D., Marc Pierrot, M.D., Armelle Mathonnet, M.D., Gaëtan Béduneau, M.D., Céline Delétage-Métreau, Ph.D., Jean-Christophe M. Richard, M.D., Ph.D., Laurent Brochard, M.D., and René Robert, M.D., Ph.D., for the FLORALI Study Group and the REVA Network*

Hypoxemic respiratory failure : FLORALI trial

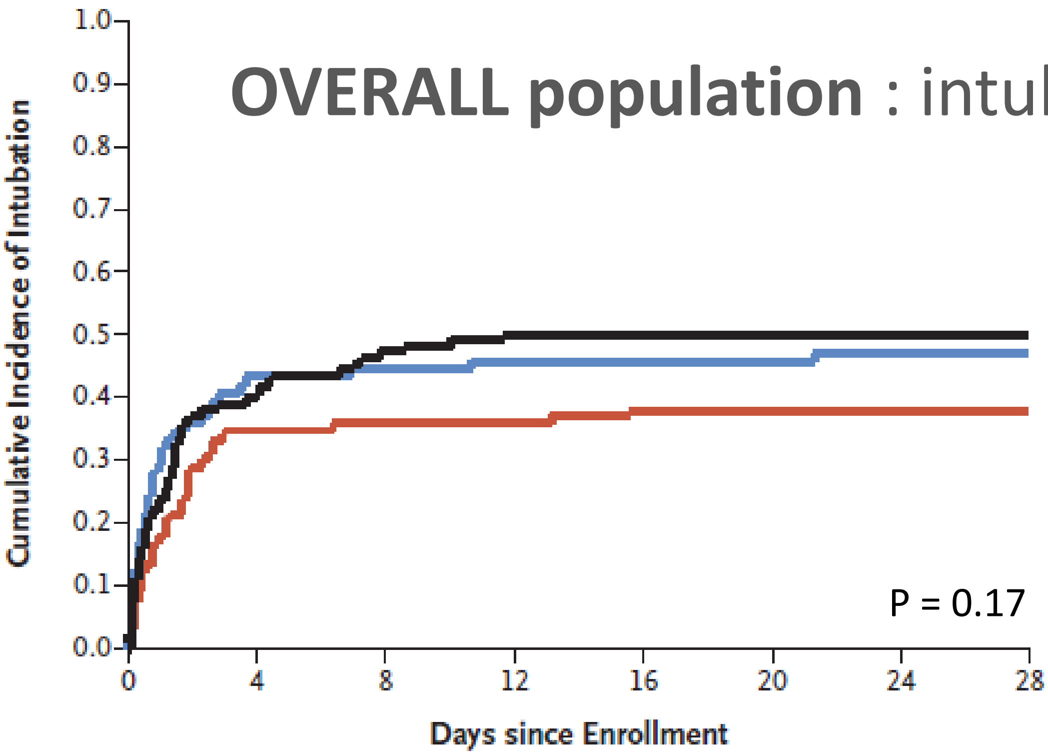


Primary outcome : intubation rate at day 28

Secondary outcomes : mortality in the ICU at 90 days

Frat et,al. N Engl J Med 2015;372:2185-96.

Hypoxemic respiratory failure : FLORALI trial



OVERALL population : intubation rate at day 28

NIV : 50%

Standard O_2: 47%

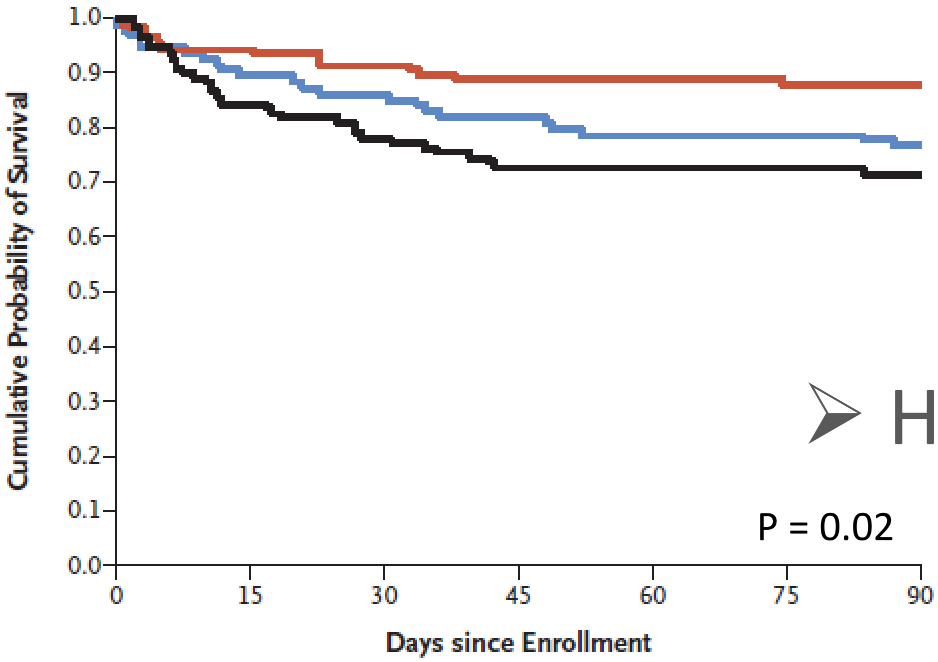
HFNC : 38%

- HFNC : ↓ intubation rate

Frat et,al. N Engl J Med 2015;372:2185-96.

Hypoxemic respiratory failure : FLORALI trial

Cumulative probability of survival at 90 days



HFNC

Standard O_2

NIV

- HFNC : ↑ survival rate

Post-extubation : OPERA trial

Intensive Care Med (2016) 42:1888–1898
DOI 10.1007/s00134-016-4594-y

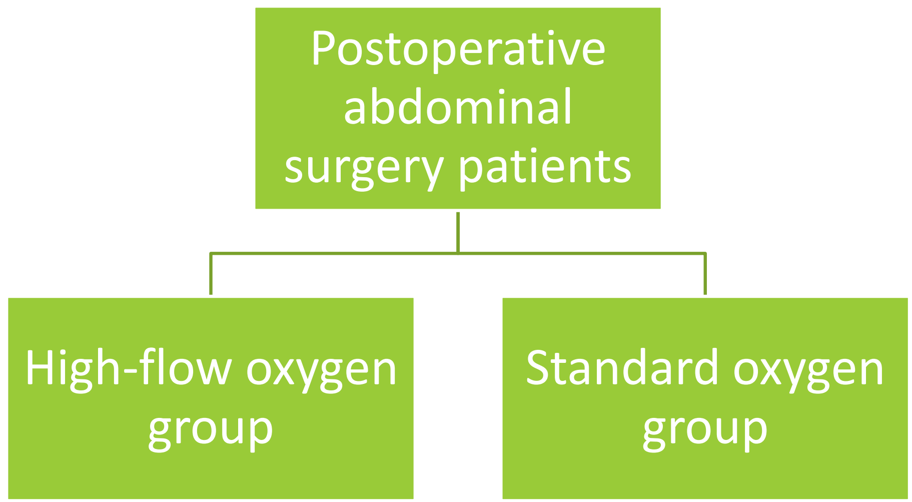
ORIGINAL

CrossMark

Effect of early postextubation high-flow nasal cannula vs conventional oxygen therapy on hypoxaemia in patients after major abdominal surgery: a French multicentre randomised controlled trial (OPERA)

Emmanuel Futier[1,2], Catherine Paugam-Burtz[3], Thomas Godet[1], Linda Khoy-Ear[3], Sacha Rozencwajg[3], Jean-Marc Delay[4], Daniel Verzilli[4], Jeremie Dupuis[1], Gerald Chanques[4,6], Jean-Etienne Bazin[1], Jean-Michel Constantin[1,2], Bruno Pereira[5], Samir Jaber[4,6*] and OPERA study investigators

Post-extubation
: OPERA trial

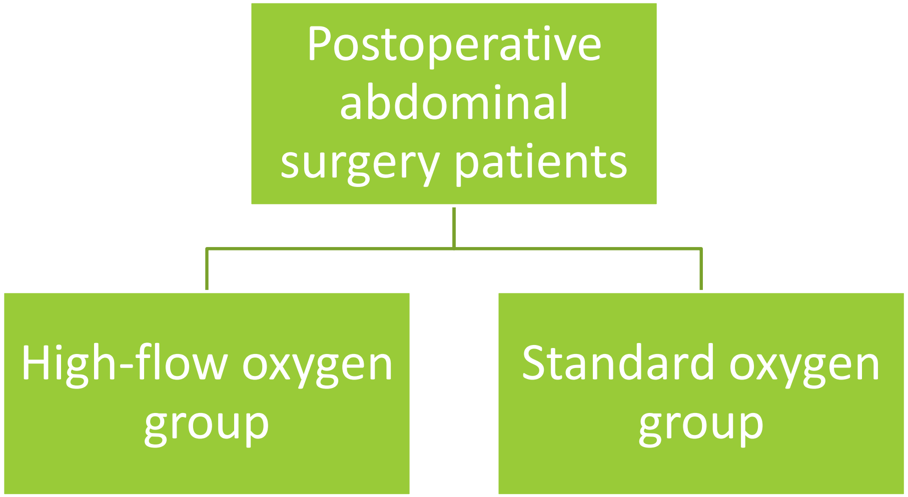


Primary outcome:

hypoxemia (P/F ratio < 300)

- 1 hr after extubation
- after O_2 treatment discontinuation

Post-extubation
: OPERA trial



Secondary outcome:
- postoperative pulmonary complications
- duration of hospital stay
- mortality rate

Post-extubation
: OPERA trial

Primary outcome: hypoxemia (P/F ratio < 300)

Outcomes	No./total no. (%)		ARR or between-group difference (95 % CI)	*p* value
	Usual care	HFNC oxygen therapy		
Primary outcomes				
Postoperative hypoxaemia[a,b]				
1 h after extubation	27/112 (24)	23/108 (21)	−3 (−14 to 8)	0.62
After discontinuation of the study treatment	34/112 (30)	29/108 (27)	−4 (−15 to 8)	0.57

- HFNC : does not ↓ postop hypoxemia

Futier et,al. Intensive Care Med (2016) 42:1888–1898

Post-extubation : OPERA trial

Secondary outcome:

Outcomes	No./total no. (%)		ARR or between-group difference (95 % CI)	p value
	Usual care	HFNC oxygen therapy		
Secondary outcomes				
Need for supplemental oxygen therapy after treatment discontinuation	92/112 (82)	79/108 (73)	−9 (−20 to 2)	0.11
Pulmonary complications[c] within 7 days	19/112 (17)	21/108 (20)	2 (−8 to 13)	0.63
ICU length of stay (days)	5 (3–13)	6 (4–16)	3 (−5 to 12)	0.53
Hospital length of stay (days)	11 (7–18)	12 (7–20)	0.5 (−3.5 to 4.5	0.58
In-hospital mortality	3/112 (3)	2/108 (2)	−1 (−5 to 3)	0.68

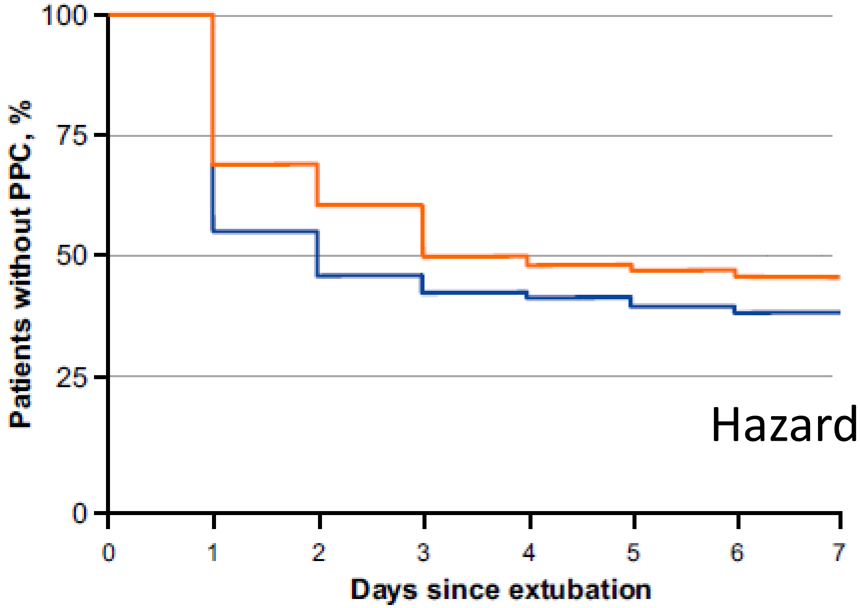
- HFNC : does not ↓

postop pulmonary complication , length of hospital stays , mortality

Futier et,al. Intensive Care Med (2016) 42:1888–1898

Post-extubation : OPERA trial

Secondary outcome: postop pulmonary complication



Hazard ratio 0.81 (95% CI : 0.57-11.5)

➢ HFNC : does not improve pulmonary outcomes in postoperative patients compared w/ standard O_2 therapy

Post-extubation : BiPOP study

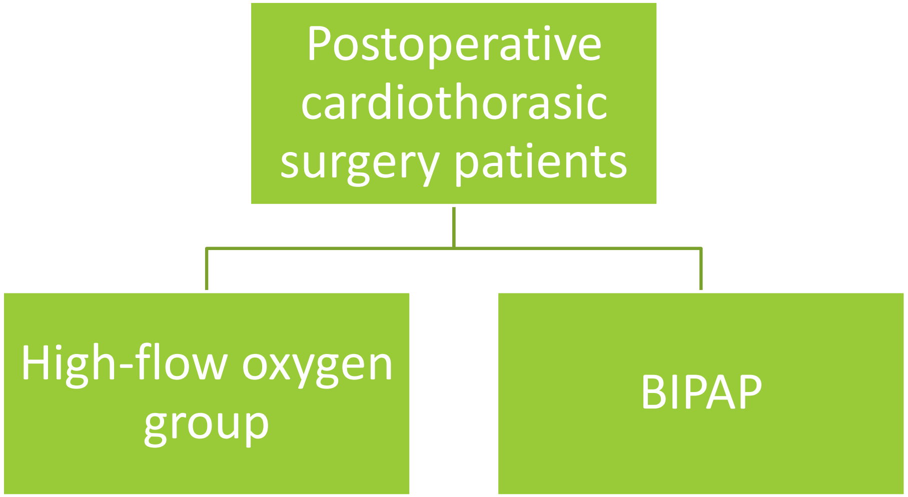
Research

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in Hypoxemic Patients After Cardiothoracic Surgery
A Randomized Clinical Trial

François Stéphan, MD, PhD; Benoit Barrucand, MD; Pascal Petit, MD; Saida Rézaiguia-Delclaux, MD; Anne Médard, MD; Bertrand Delannoy, MD; Bernard Cosserant, MD; Guillaume Flicoteaux, MD; Audrey Imbert, MD; Catherine Pilorge, MD; Laurence Bérard, MD; for the BiPOP Study Group

Post-extubation : BiPOP study



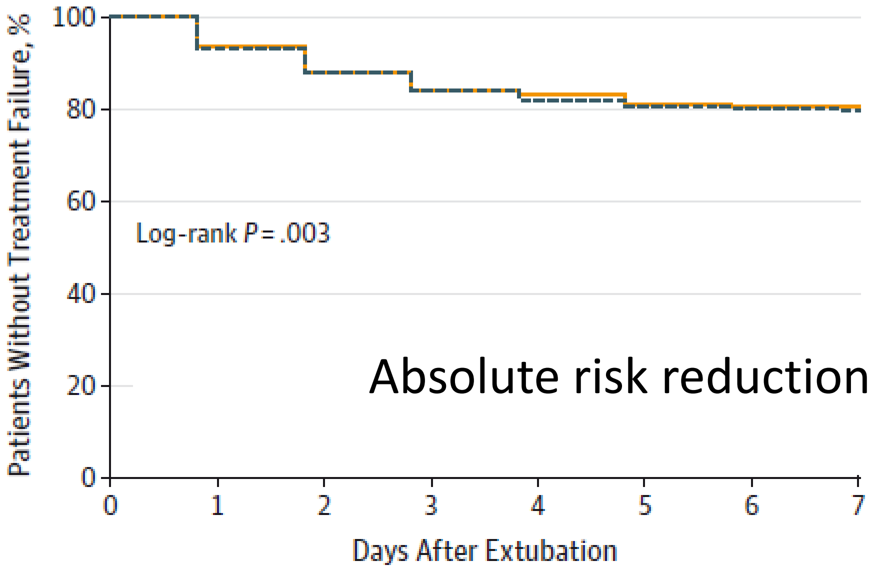
Primary outcome: treatment failure

- Reintubation
- Premature Rx discontinuation:

  patient request, adverse effects ie. gastric distention

Post-extubation : BiPOP study

Patients w/o treatment failure (%)



BiPAP: 78.1 %

HFNC : 79 %

Absolute risk reduction 0.9 (95% CI : - 4.9 % to 6.6 %)

- HFNC : is not inferior to BiPAP in postoperative patients.

HFNC and ARDS

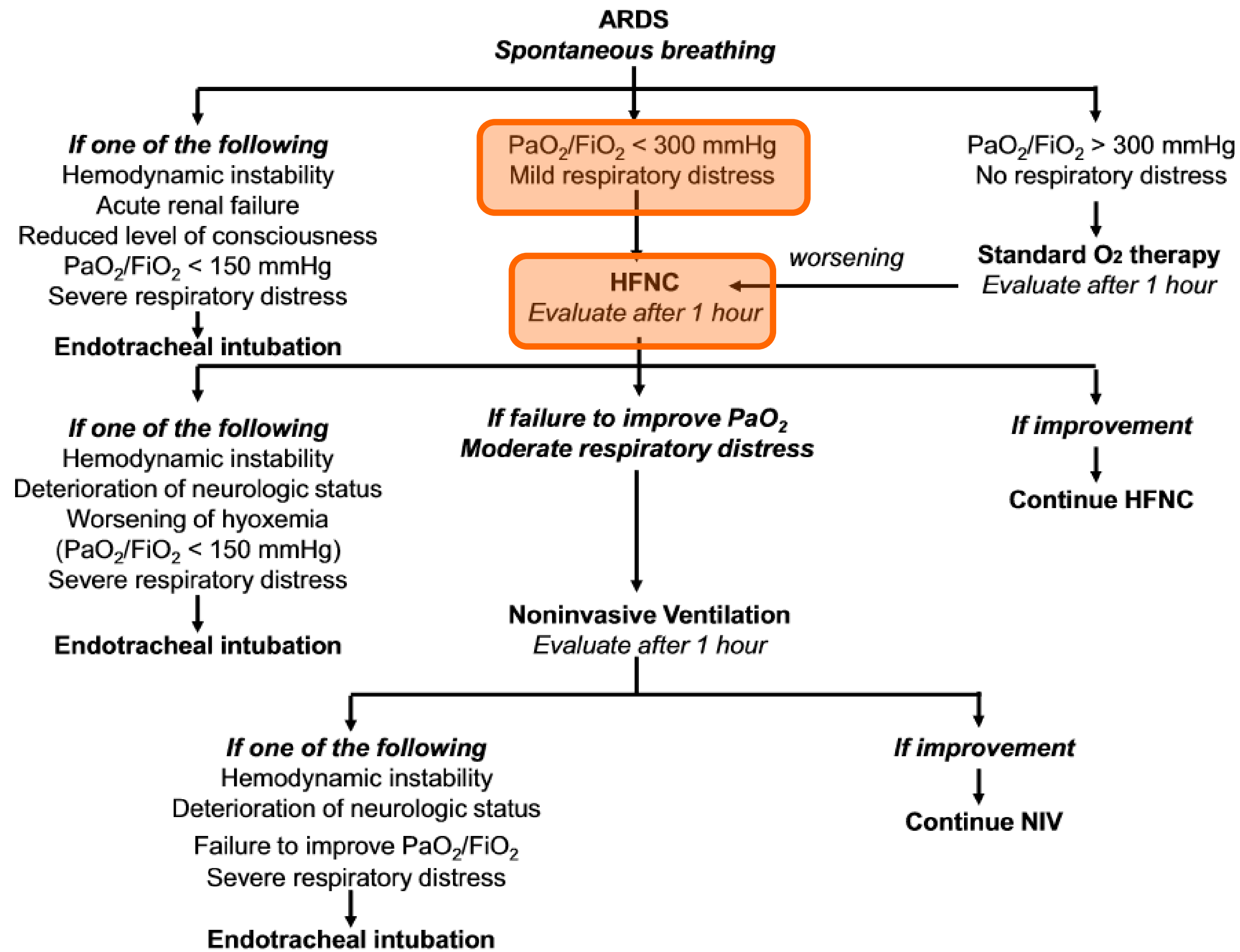


Fig. 1 Algorithm for practical use of high-flow nasal cannula (HFNC) and non-invasive mechanical ventilation (NIV) in acute respiratory distress syndrome (ARDS)

Demoule et,al. Intensive Care Med 2016; 42:768–771

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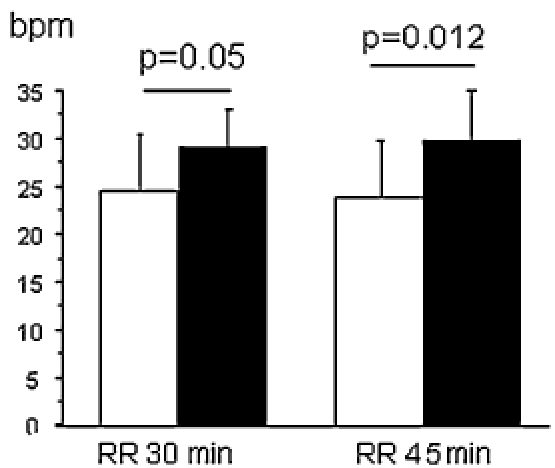
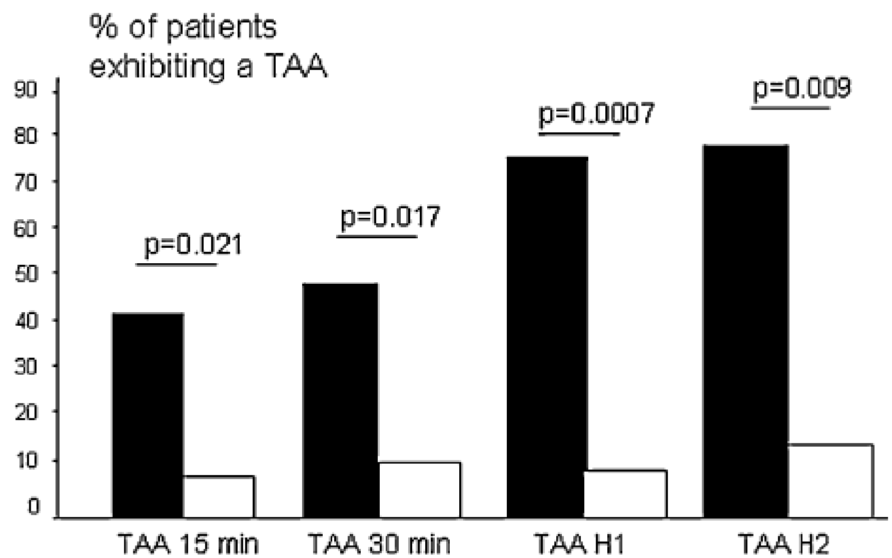
Signs of HFNC failure

Respiratory Rate



Time after HFNC started

Thoracoabdominal asynchrony



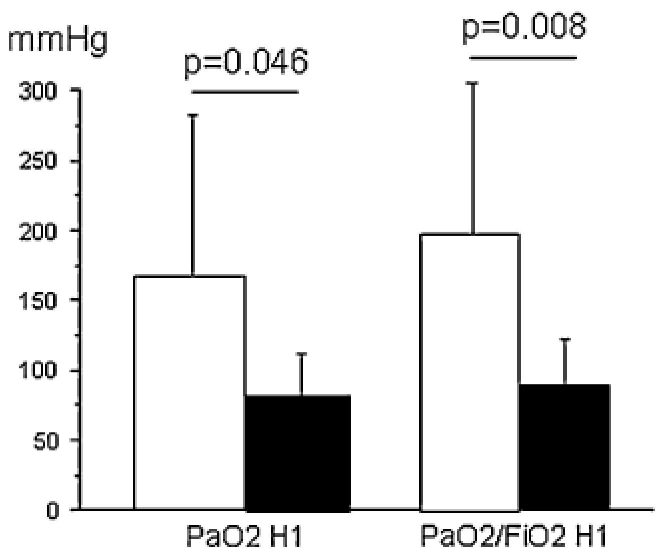
Time after HFNC started

HFNC success

HFNC failure

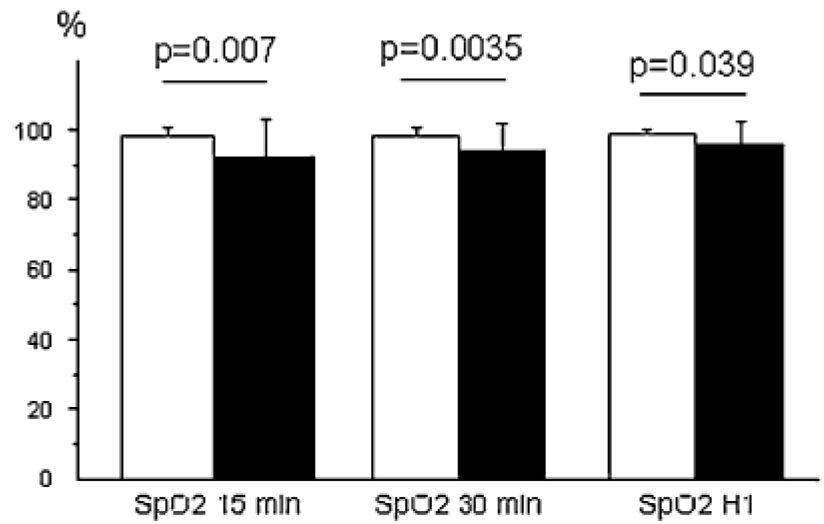
Signs of HFNC failure

ABG parameter



Time after HFNC started

SpO_2



Time after HFNC started

HFNC success

HFNC failure

Sztrymf et,al. Intensive Care Med 2011; 37:1780–1786

HFNC failure

Table 3 outcomes for the early HFNC failure group compared with the late HFNC failure group

Variables	Odds ratio (95 % CI)	*P* value[c]
Primary outcome		
Overall ICU mortality	0.323 (0.158–0.658)	0.002
Secondary outcomes		
Extubation success	3.284 (1.361–7.923)	0.008
Ventilator-weaning	3.056 (1.470–6.351)	0.003
Ventilator-free days to day 28	0.542 (0.383–0.768)[d]	0.001[e]
14-Day mortality from HFNC application	0.949 (0.455–1.977)	0.888
14-Day mortality from intubation	0.653 (0.325–1.311)	0.231
28-Day mortality from HFNC application	0.820 (0.416–1.616)	0.566
28-Day mortality from intubation	0.571 (0.287–1.138)	0.111
Length of ICU stay	0.827 (0.586–1.169)[f]	0.282[g]

The early intubated patients (<48 hr.)

↓ Overall ICU mortality

↑ Extubation success

↑ Ventilator weaning

Conclusion

- HFNC is an effective in treating
  - hypercapnic respiratory failure
  - hypoxemic respiratory failure
  - mild ARDS
- Role of HFNC in post operative patients is unclear
- Failure of HFNC might cause delayed intubation and worse clinical outcomes

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thank you!