Oxygénothérapie

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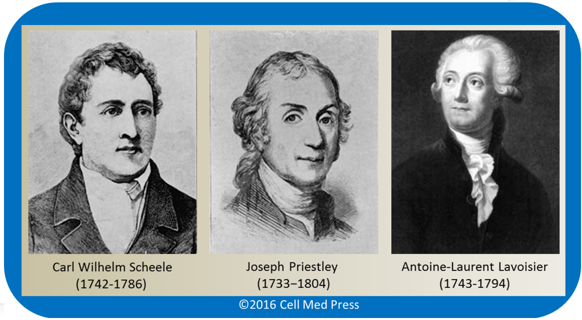
1. Introduction



- Découverte de l'oxygène en 1772 par Scheele
- Redécouvert par Priestley quelques années plus tard
- Lavoisier qui l'identifia dans l'air et décrivit son rôle capital dans la combustion
- L'oxygène est un élément très familier en réanimation et aux urgences

→13,7 % des patients hospitalisés (O'Driscoll, 2011)

→25 à 75% des patients aux urgences et en réanimation (Siemieniuk, 2018)

I. Introduction

18 JUIN 1990
(M.B. 26/7/90)

Arrêté royal portant fixation de la liste des prestations techniques de soins infirmiers et de la liste des actes pouvant être confiés par un médecin à des praticiens de l'art infirmier, ainsi que des modalités d'exécution relatives à ces prestations et à ces actes et des conditions de qualification auxquelles les praticiens de l'art infirmier doivent répondre, modifié par les arrêtés royaux des 04/09/1990, 25/11/1991, 27/12/1994, 06/06/1997, 02/07/1999, 07/10/2002, 13/07/2006 et 21/04/2007

18 JUNI 1990
(B.S. 26/7/90)

Koninklijk besluit houdende vaststelling van de lijst van de technische verpleegkundige verstrekkingen en de lijst van de handelingen die door een arts aan beoefenaars van de verpleegkunde kunnen worden toevertrouwd, alsmede de wijze van uitvoering van die verstrekkingen en handelingen en de kwalificatie-vereisten waaraan de beoefenaars van de verpleegkunde moeten voldoen, gewijzigd door de koninklijke besluiten van 04/09/1990, 25/11/1991, 27/12/1994, 06/06/1997, 02/07/1999, 07/10/2002, 13/07/2006 en 21/04/2007

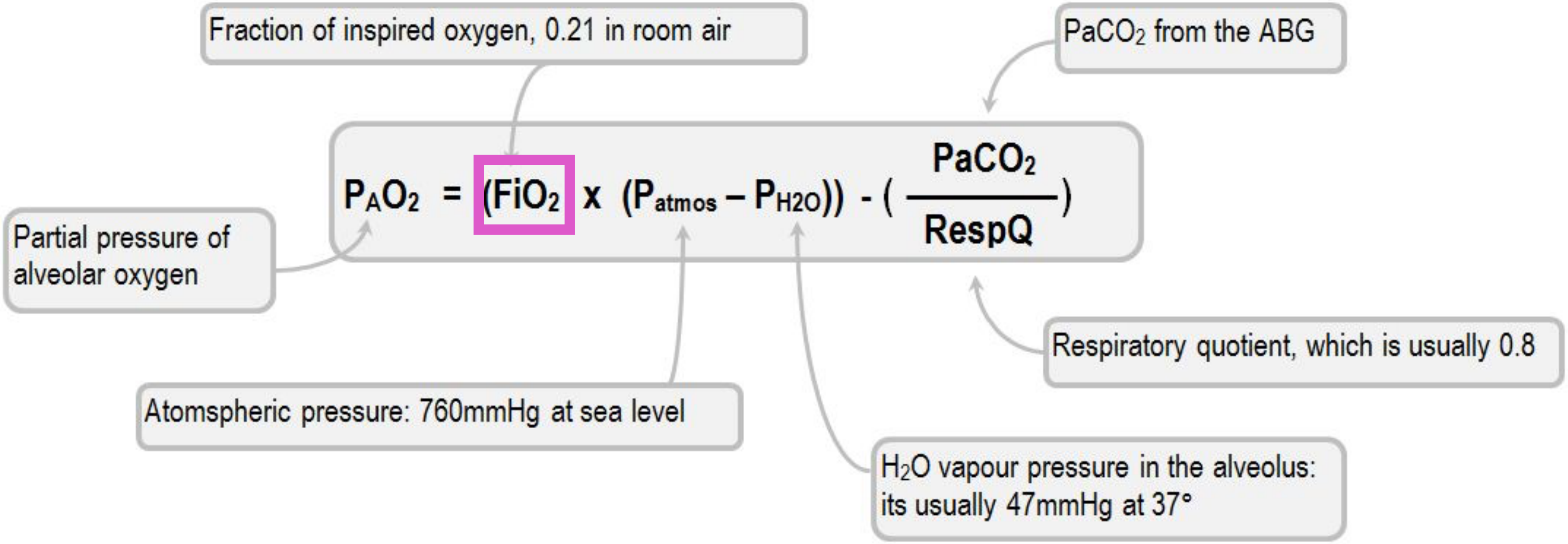
1.1 Système respiratoire.
B1.

- Aspiration et drainage des voies aériennes.
- Soins infirmiers et surveillance auprès des patients ayant une voie respiratoire artificielle.
- Manipulation et surveillance d'appareils de respiration contrôlée
- Réanimation cardio-pulmonaire avec des moyens non-invasifs
- Administration d'oxygène.

1.1 Ademhalingsstelsel
B1.

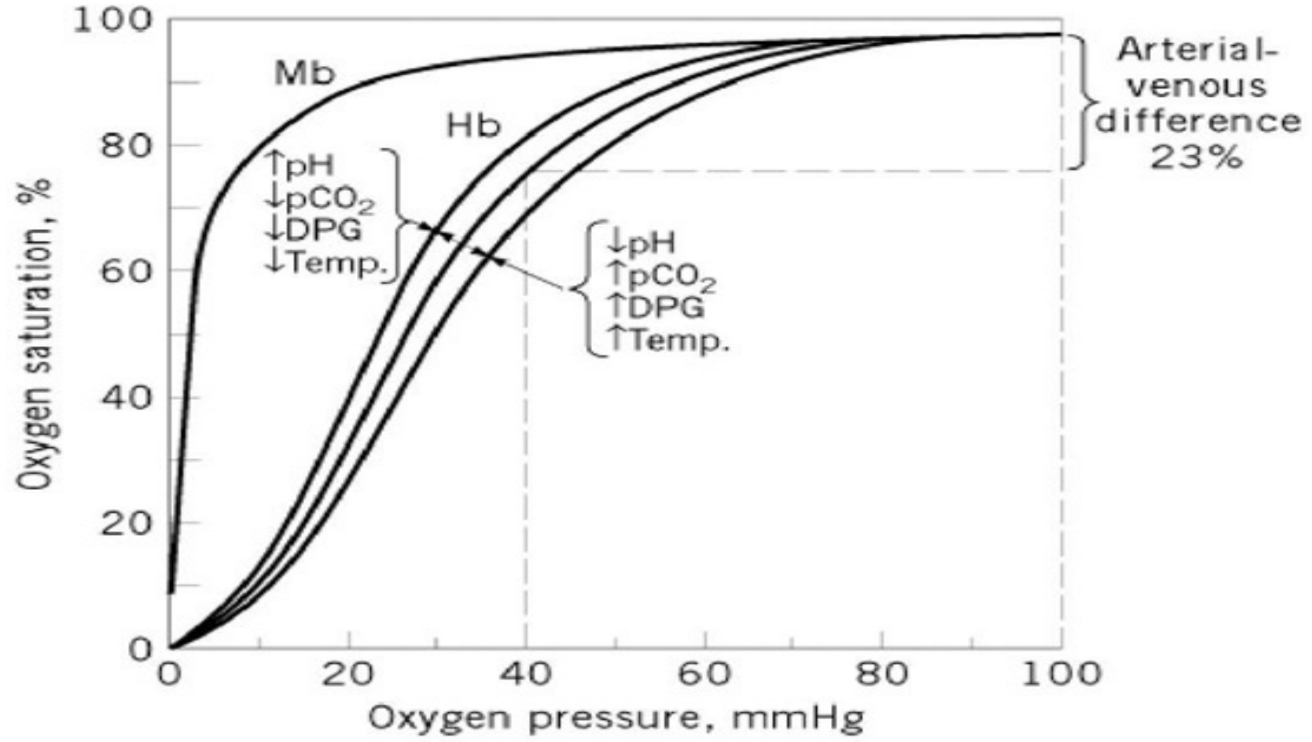
- Luchtwegenaspiratie en -drainage
- Verpleegkundige zorgen aan en toezicht op patiënten met een kunstmatige luchtweg
- Gebruik van en toezicht op toestellen voor gecontroleerde beademing
- Cardiopulmonaire resuscitatie met niet-invasieve middelen
- Zuurstoftoediening.

1. Introduction

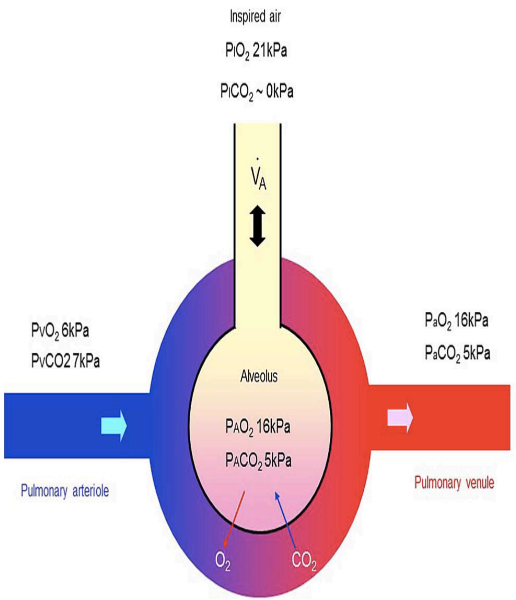


https://derangedphysiology.com/main/cicm-primary-exam/required-reading/respiratory-system/Chapter%20134/alveolar-gas-equation

1. Introduction



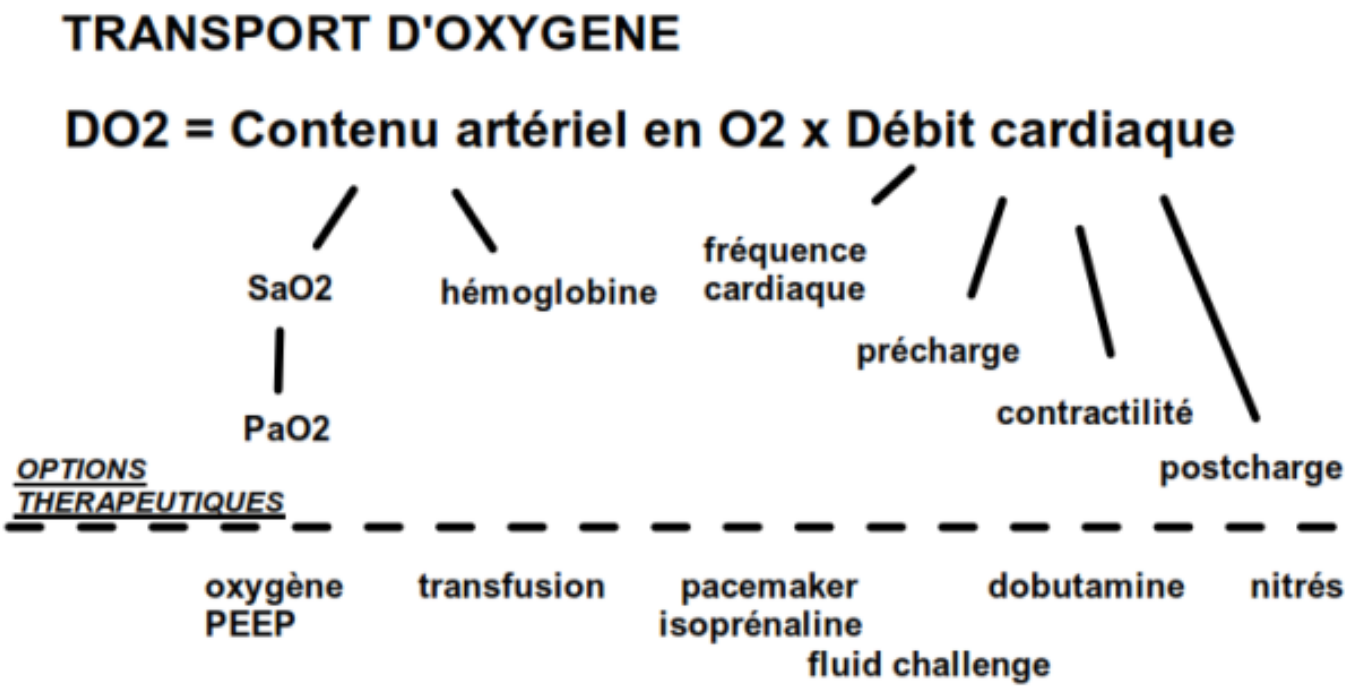
Déterminants of PaO2



- Diffusion
- Capillary permeability
- Exchange surfaces
- The shunt effect (VA/Q)

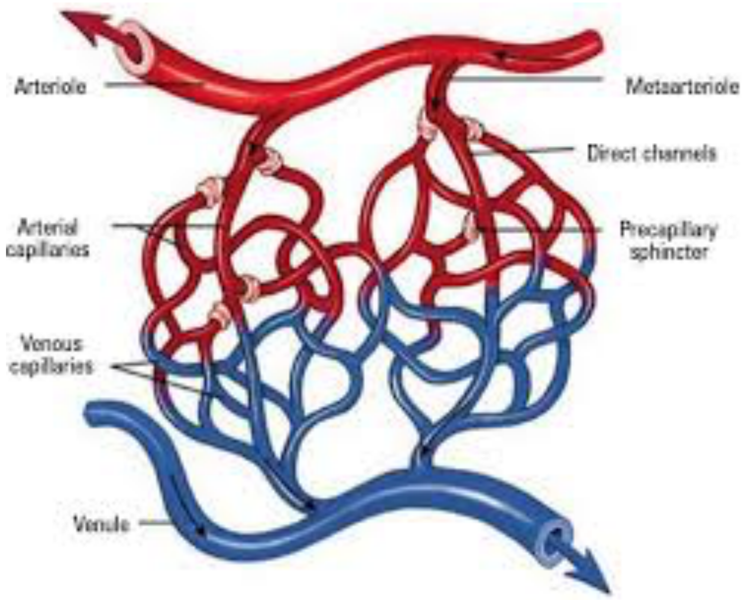
1. Introduction

$$CaO_2 = (Hb \times 1{,}34 \times SaO_2) + (0{,}003 \times PaO_2)$$

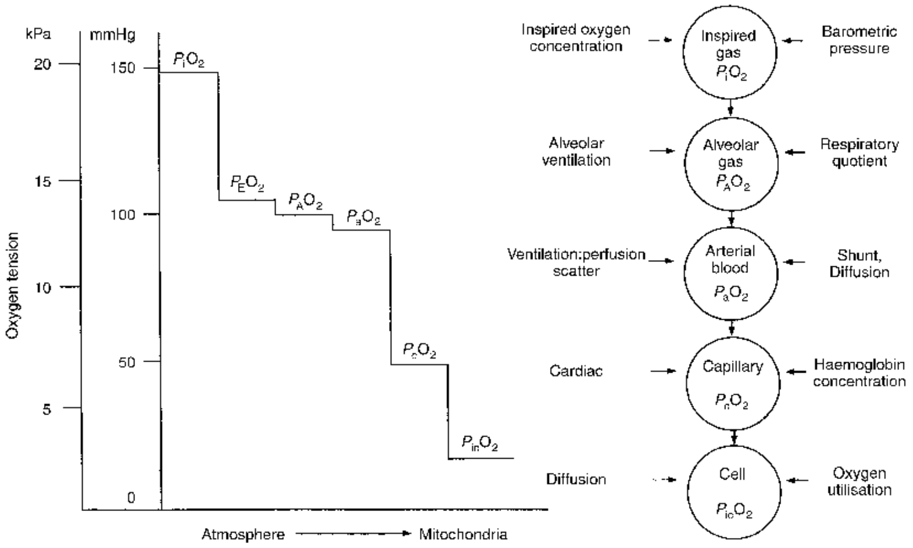


J-L VINCENT 2007

1. Introduction



http://dx.doi.org/10.5935/0103-507x.20170033



Nunn, 1987, p. 243

2. Modalités d'administration de l'O2

J. Messika, SRLF 2019

2. Modalités d'administration de l'O2

Pour les hypoxémies légères

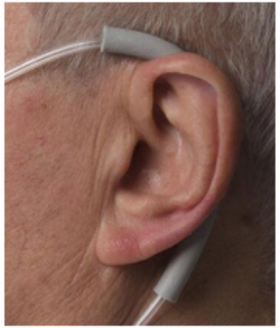
Débit de 0,25 à 6 L/min

+ confortable que Masque à O_2

Système d'oxygénation

majoritaire en Europe et aux EU

Incidence 37%, range of (28–47%)



Turjanica MA. Incidence, correlates, and interventions used for pressure ulcers of the ear. Medsurg Nurs Off J Acad Med-Surg Nurses. oct 2011;20(5):241–6; quiz 247.

Bouche ouverte ou fermée ?

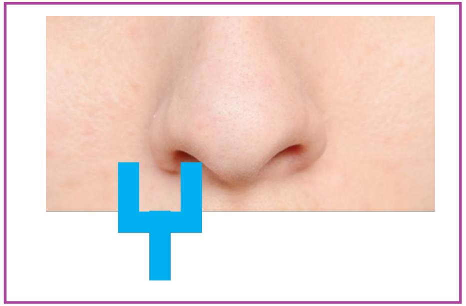
Résultats contradictoires:

- Pour Weinstein et al. si bouche ouverte, FiO_2 > bouche fermée
- Pour Bahar et al. si bouche ouverte, FiO_2 < bouche fermée

Wettstein, R. (2005). Delivered oxygen concentrations using low-flow and high-flow nasal cannulas. *Respiratory care*, *50*(5), 604-609.

Bahar N et al. What is the effect on FiO_2 of mouth closed breathing versus mouth open breathing with nasal cannula? *Annals of Intensive Care* 2018, 8(Suppl 1):P-70

Chevauchement LN sur aile du nez: Quel effet sur FiO_2 ?



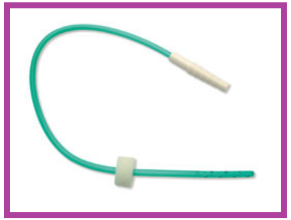
FiO_2 diminue mais effet limité → moins ± 4% (valeur absolue)

	O_2 : 4L/min			
	Closed mouth		Open mouth	
				
MV	FiO_2	FiO_2	FiO_2	FiO_2
7 L/min	(a) 44 % (+/- 0.9%)	(e) 40 % (+/- 0.8%)	(i) 37 % (+/- 0.5%)	(m) 31 % (+/- 0.9%)
10 L/min	(b) 41 % (+/- 0.7%)	(f) 35 % (+/- 0.7%)	(j) 35 % (+/- 0.8%)	(n) 30 % (+/- 0.4%)
14 L/min	(c) 37 % (+/- 0.6%)	(g) 28 % (+/- 0.9%)	(k) 31 % (+/- 0.6%)	(o) 27 % (+/- 0.3%)
17 L/min	(d) 33 % (+/- 0.5%)	(h) 26 % (+/- 1%)	(l) 29 % (+/- 0.8%)	(p) 26 % (+/- 0.2%)

Mandianga JM, Duprez F et al. What is the effect on FiO_2 when the prongs of the nasal cannula overlap a nostril and the cheek? *Annals of Intensive Care* 2018, **8(Suppl 1):**P-71

Systèmes d'administration de l'oxygène

2) Sonde à O_2:



Pour les hypoxémies légères

Débit MAX 5 L/min

FiO_2 supérieures à la CN

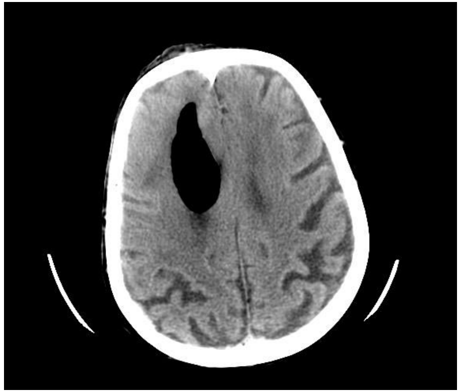
Inconvénients:

FiO_2 HAUTEMENT variable (en fonction du débit inspiratoire du patient)

Moins confortable que CN

Risques de pneumo-orbitus ou pneumo-encephalus (surtout en pédiatrie)

Post anesthésie ?



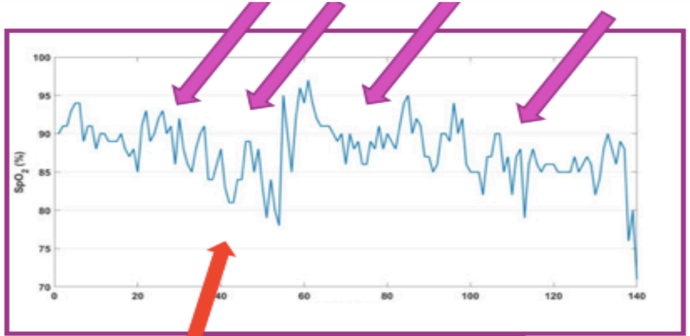
O'Brien BJ. Tension pneumo-orbitus and pneumocephalus induced by a nasal oxygen cannula: report on two paediatric cases. J Paediatr Child Health. oct 2000;36(5):511–4.

2. Modalités d'administration de l'O2

<u>Masque à O_2:</u>

Pour les hypoxémies légères à modérées

Débit de 5 à 10 L/min (FiO_2 de 40 à 60 %)



<u>Inconvénients:</u>

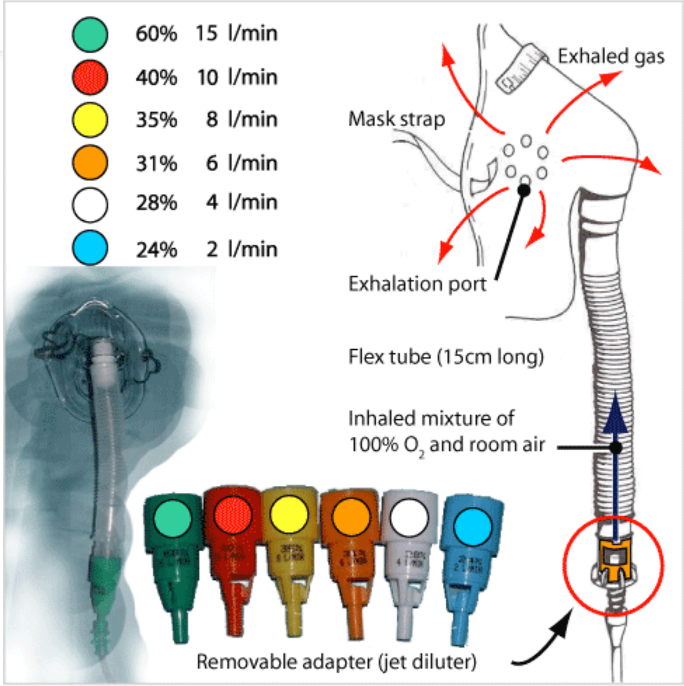
FiO_2 HAUTEMENT variable (en fonction du débit inspiratoire du patient)

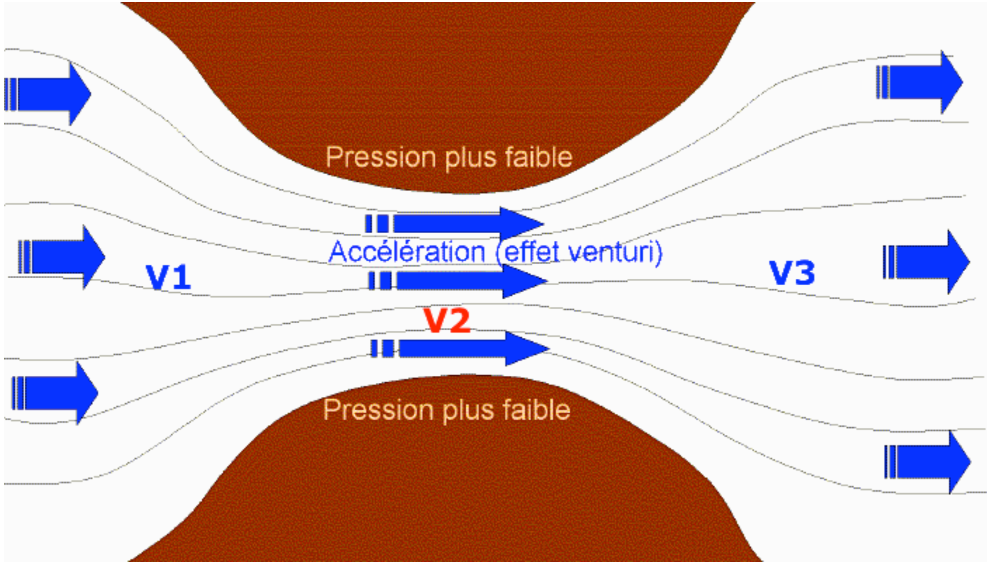
Pas plus efficace que Canule Nasale.

Sur 24 Heures masque est souvent retiré par le patient (chute SpO_2 récurrentes)

Nolan KM. Comparison of nasal cannulae with face mask for oxygen administration to postoperative patients. Br J Anaesth. avr 1993;70(4):440-2.

2. Modalités d'administration de l'O2





1) Beecroft JM. Venturi mask in the delivery of supplemental oxygen: pilot study in oxygen-dependent patients. Can Respir J. 2006 Jul-Aug;13(5):247-52

4) Masque Venturi:

Pour les hypoxémies légères à modérées (BPCO)

Pour obtenir FiO_2 fiables et fidèles

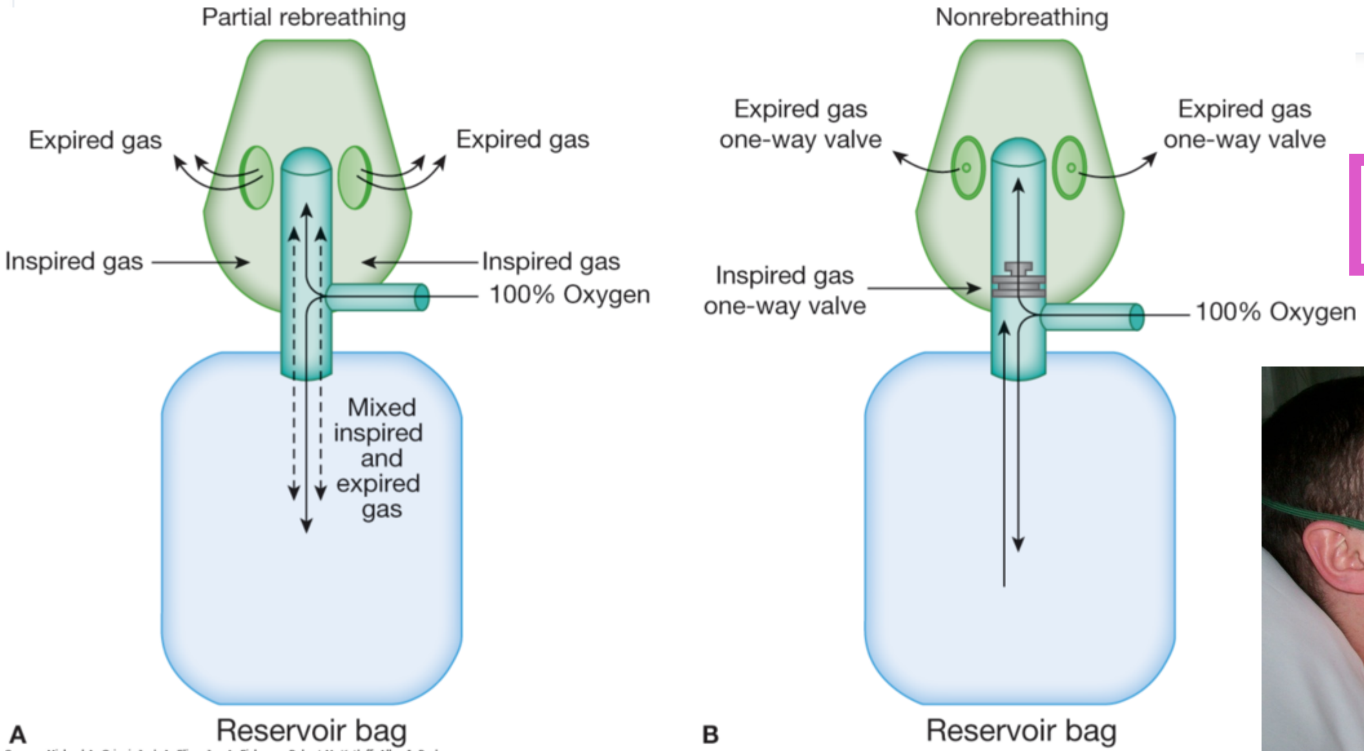
FiO_2 disponibles 24, 28, 31, 35, 40 or 50 %

Inconvénients:

Dès que $FiO_2 > 35\%$, si débit inspiratoire du patient est trop élevé, FiO_2 s'effondre

Beecroft JM. Comparison of the OxyMask and Venturi mask in the delivery of supplemental oxygen. Can Respir J. 2006 Jul-Aug;13(5):247-52

2. Modalités d'administration de l'O2



Source: Michael A. Grippi, Jack A. Elias, Jay A. Fishman, Robert M. Kotloff, Allan I. Pack, Robert M. Senior, Mark D. Siegel: *Fishman's Pulmonary Diseases and Disorders*: www.accessmedicine.com
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10 à 15 l/'

Systèmes d’administration de l’oxygène

5) Masque avec sac récupérateur:

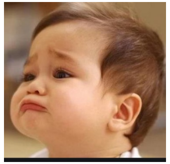
Pour les hypoxémies sévères (en théorie)

Inconvénients:

Débits O_2 élevés

FiO_2 pas si élevées qu’annoncées donc risque de SUR-DIAGNOSTIC

FiO_2: +/- 60%



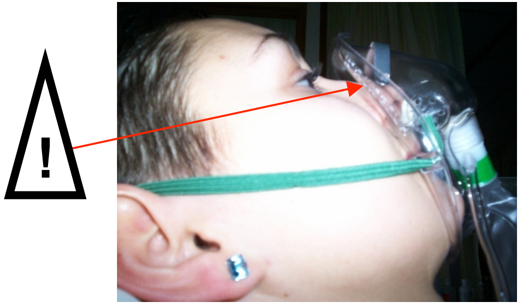
Bateman, N. T., & Leach, R. M. (1998). Acute oxygen therapy. BMJ : British Medical Journal, 317(7161), 798–801.
Martin M. Methods for evaluation of oxygen delivery through non-rebreather facemasks. Med Gas Res. 2012; 2: 31
Duprez F, et al. "Comparaison de la performance de trois masques à oxygène." Anesthésie & Réanimation 1 (2015): A314.

5) Masque avec sac récupérateur:

Inconvénients:

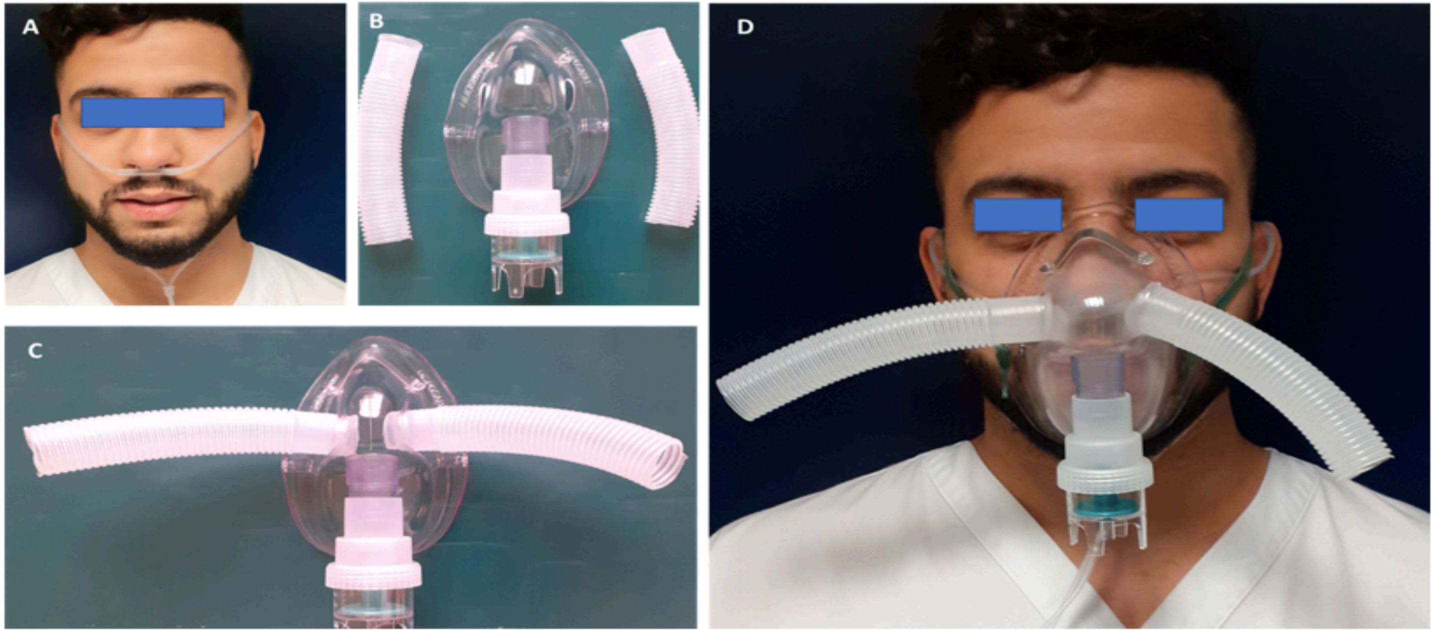
Si la ventilation minute du patient est > débit O_2 le sac réservoir se collabe

Si Fuites, si sac récupérateur plié: FiO_2 s'effondre +++++++++



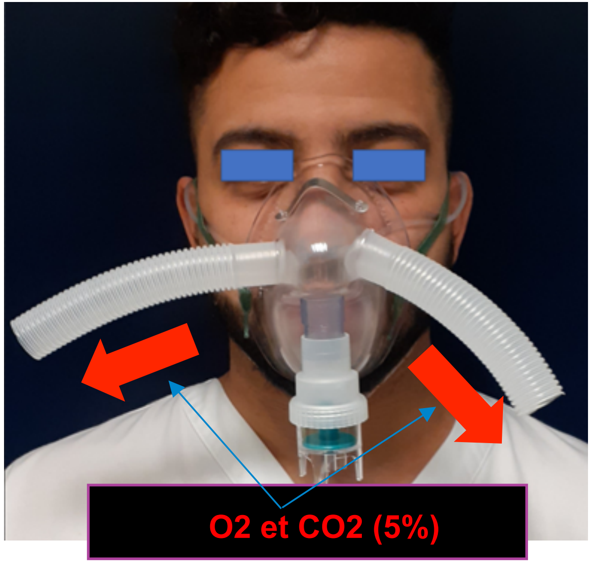
Bateman, N. T., & Leach, R. M. (1998). Acute oxygen therapy. BMJ : British Medical Journal, 317(7161), 798–801.
Martin M. Methods for evaluation of oxygen delivery through non-rebreather facemasks. Med Gas Res. 2012; 2: 31

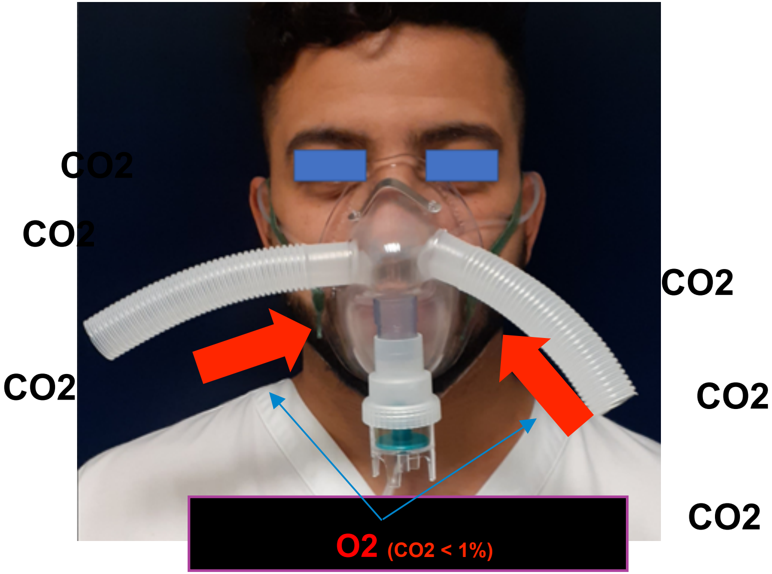
DTM = Double Trunk Mask



Hnatiuk W, Delivery of high concentrations of inspired oxygen via Tusk mask. Crit Care Med 1998;26(6):1032-1035.
Duprez F. A new adjunctive system to obtain higher PaO2 with nasal cannula double trunk mask. Crit Care 2001;5:

7) Double Trunk Mask





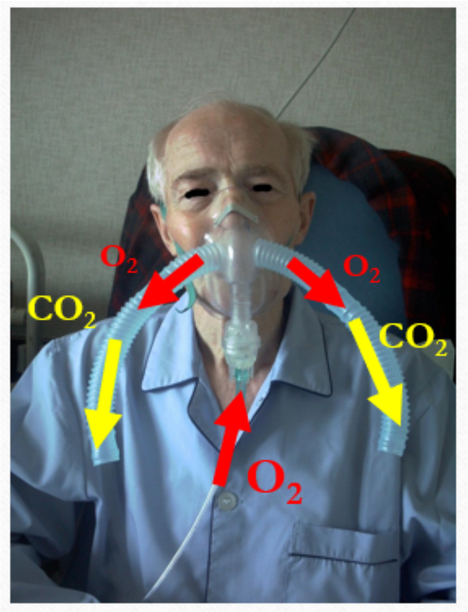
Expiration

$$FiO2 \cong \text{débit } O2 * \text{Temps expiratoire}$$

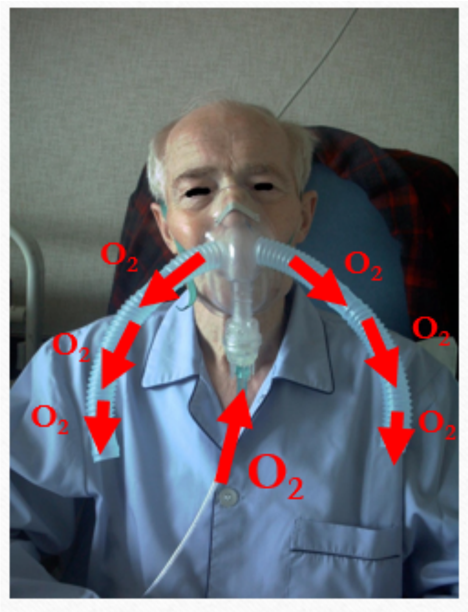
Inspiration

Hnatiuk W, Delivery of high concentrations of inspired oxygen via Tusk mask. Crit Care Med 1998;26(6):1032-1035.
Duprez F. A new adjunctive system to obtain higher PaO2 with nasal cannula double trunk mask. Crit Care 2001;5:

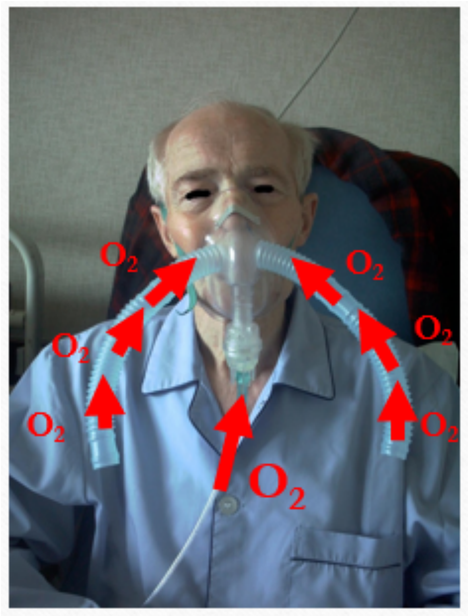
DTM = Double Trunk Mask



Début Expiration



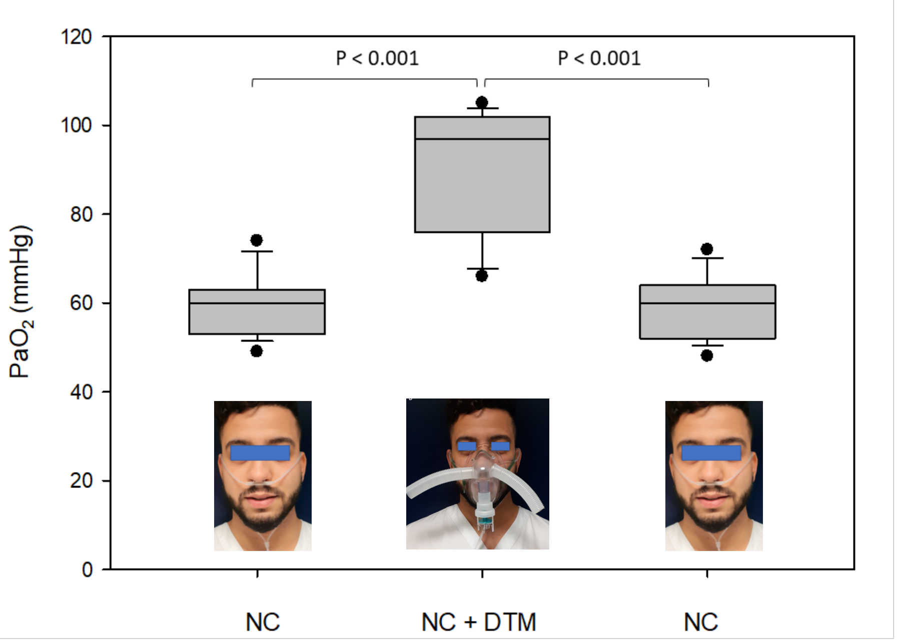
Fin Expiration

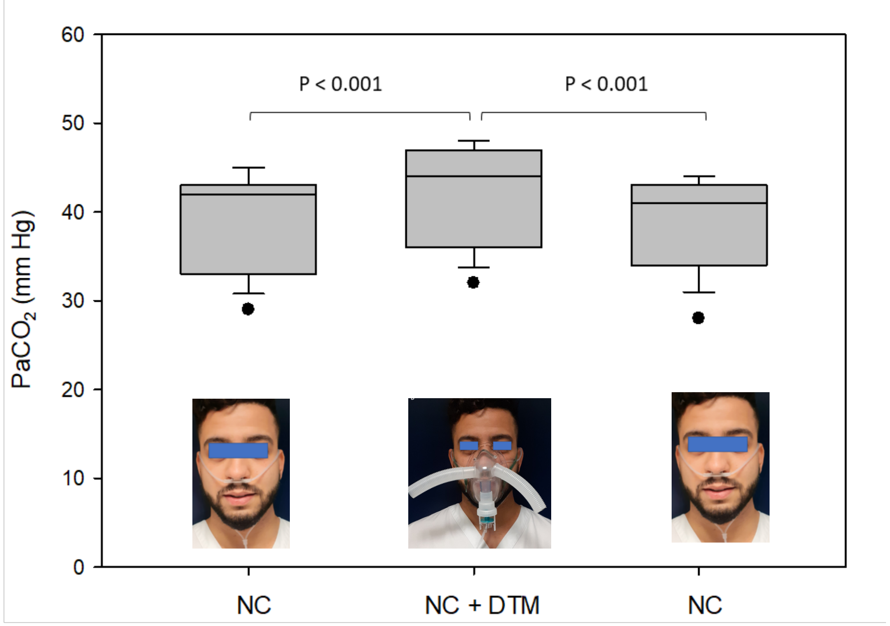


Début INSpiration

Hnatiuk W, Delivery of high concentrations of inspired oxygen via Tusk mask. Crit Care Med 1998;26(6):1032-1035.
Duprez F. A new adjunctive system to obtain higher PaO2 with nasal cannula double trunk mask. Crit Care 2001;5:

Improvement of Arterial Oxygenation Using the Double Trunk Mask Above Low Flow Nasal Cannula: A Pilot Study





Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
30’	30’	30’	30’	30’	30’²

Journal of Clinical Monitoring and Computing
ISSN: 1387-1307
2020
Minor revision
Awaiting editor decision

Oxygen flow rate : 5 ± 3 L/min

2. Modalités d'administration de l'O2

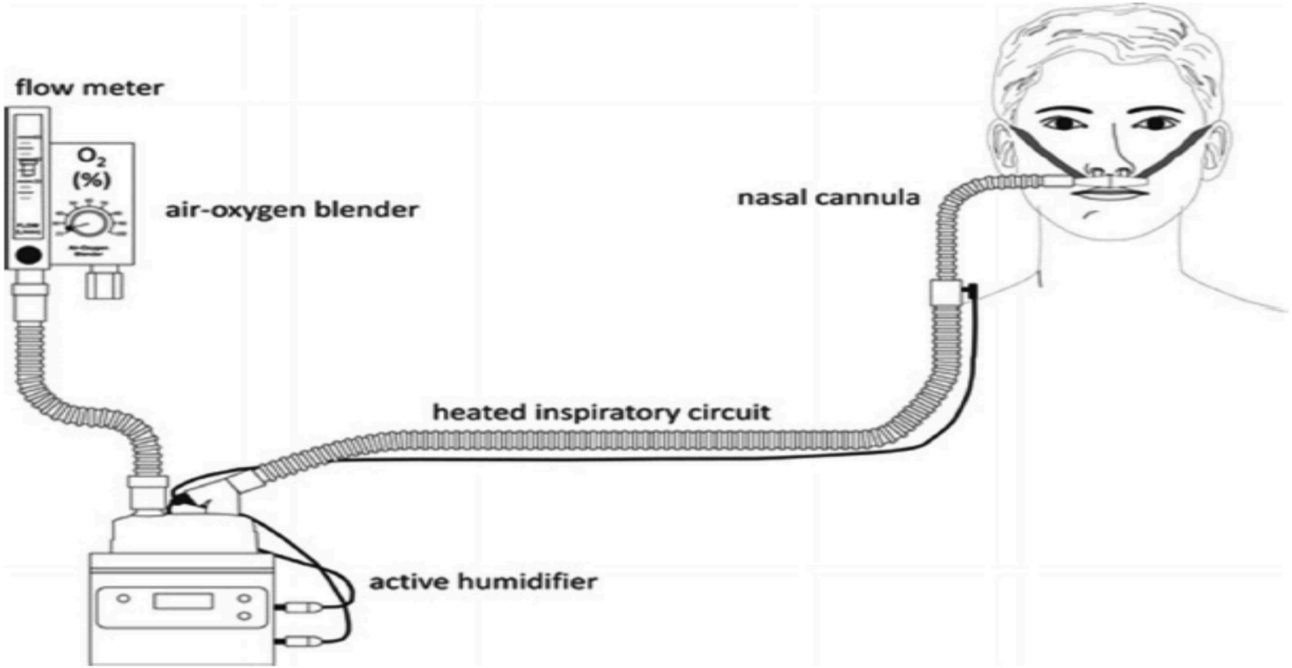
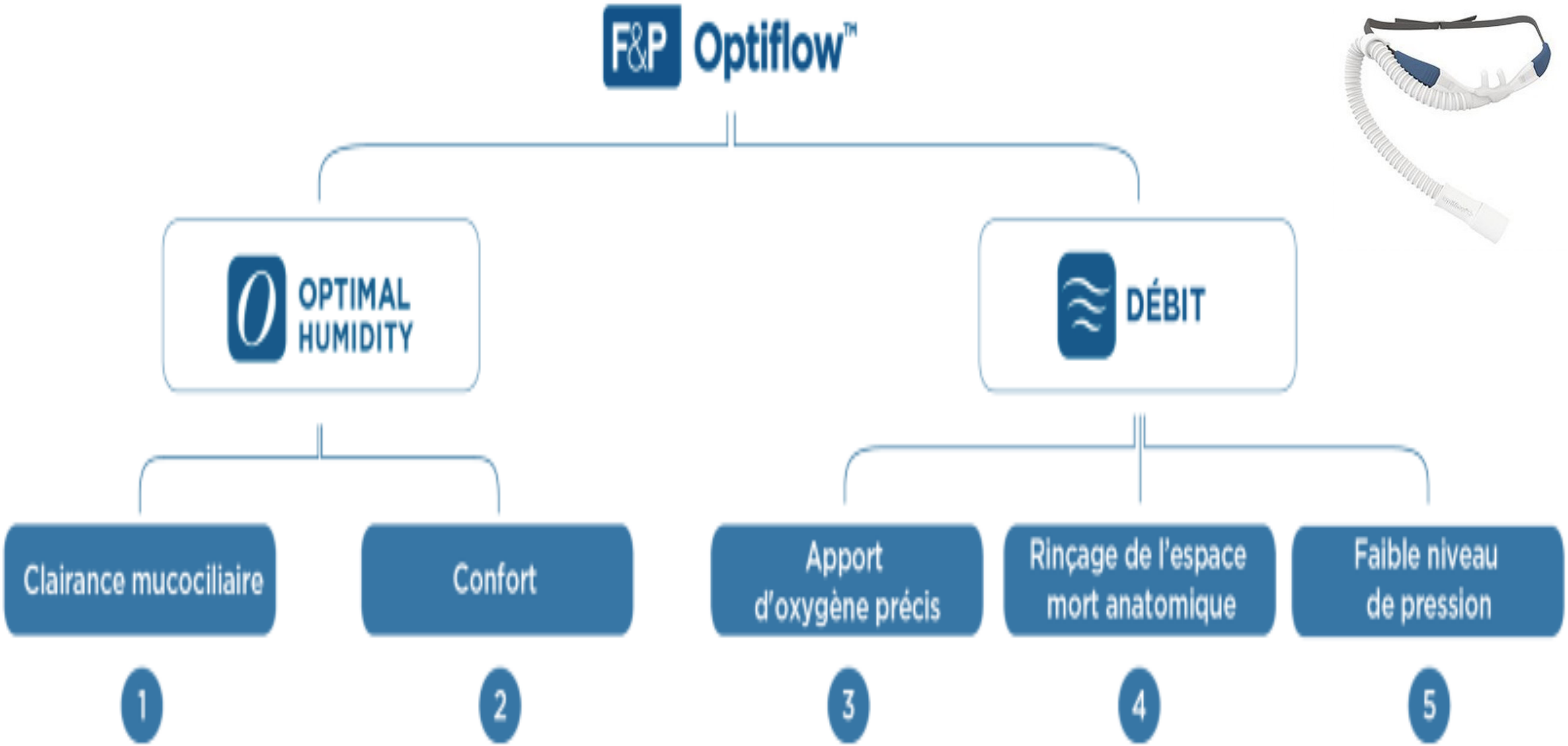
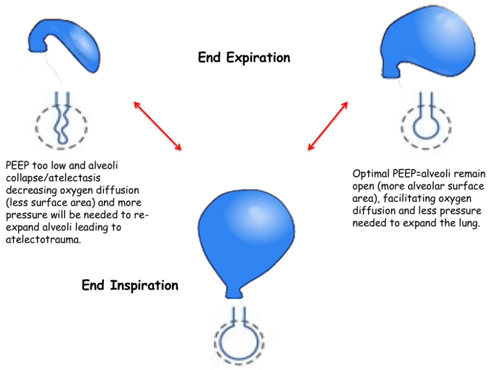


Fig. 1 High-flow nasal cannula oxygenation (HFNCO) device. An air/oxygen blender, allowing FiO_2 ranging from 0.21 to 1.0, generates flows of up to 60 L/min. The gas is heated and humidified by an active heated humidifier and delivered via a single limb

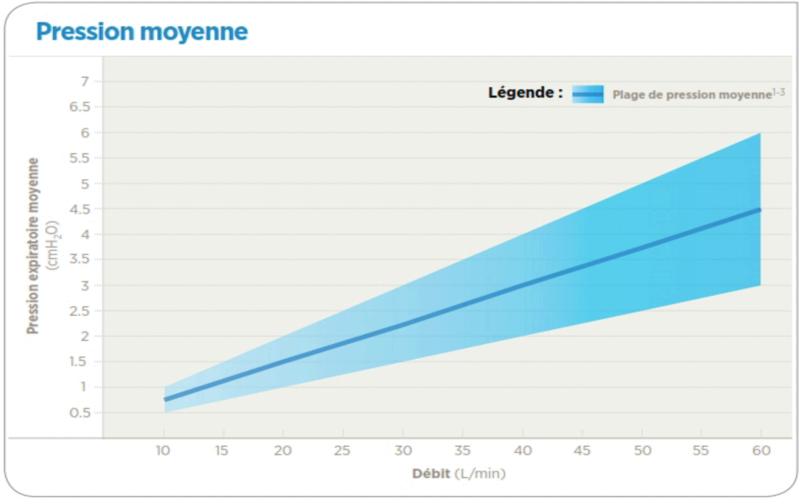
Intensive Care Med DOI 10.1007/s00134-016-4277-8


F&P Optiflow™
OPTIMAL HUMIDITY
DÉBIT
Clairance mucociliaire
Confort
Apport d'oxygène précis
Rinçage de l'espace mort anatomique
Faible niveau de pression
1
2
3
4
5

Effet Peep



Pression



Les preuves suggèrent une augmentation de 0,5-1 cmH_2O par 10 L/min[1-3]

Les mesures ont été prises au niveau du nasopharynx, bouche fermée.
NB : la pression est réduite quand la bouche est ouverte.

1. Parke R. et al. *Respir Care.* 2011. 2. Groves N. et al. *Aust Crit Care.* 2007. 3. Ritchie J. et al. *Anaesth Intensive Care.* 2011.
* *Studies used F&P Optiflow and F&P MR850/MR880.*

Effet Peep

12 patients, postop chir cardiaque

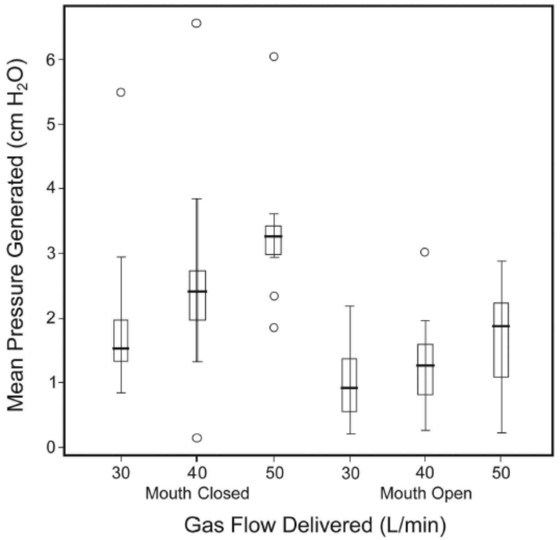


Fig. 2. Mean nasopharyngeal pressure during high-flow oxygen therapy, with mouth open or closed. The horizontal line in the middle of each box indicates the median, while the top and bottom

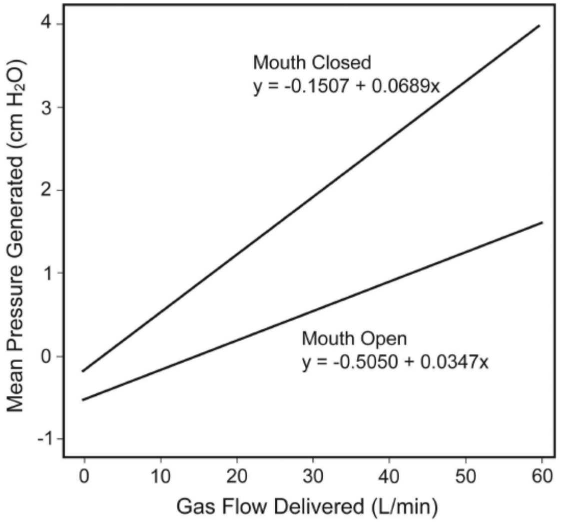


Fig. 3. Regression analysis of mean nasopharyngeal pressure during high-flow oxygen therapy, with mouth open or closed.

Effet Peep + confort

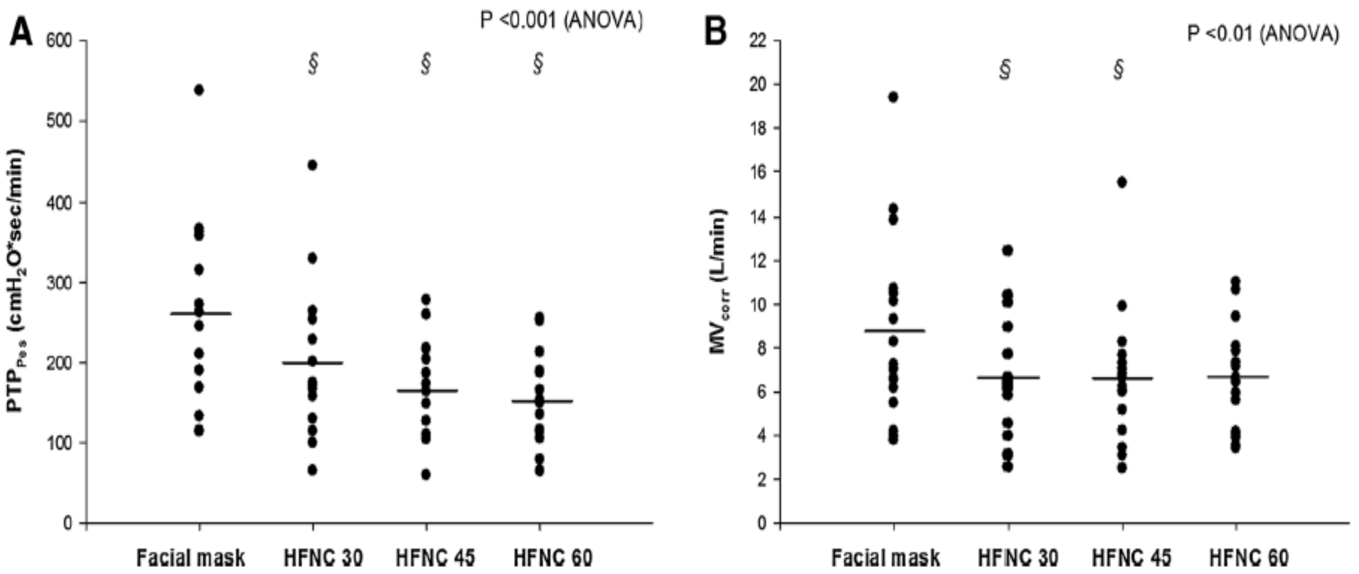


Fig. 1 Non-linear physiologic effects of high-flow nasal cannula (*HFNC*) delivered at increasing flow rates. **a**, **b** In patients with acute hypoxemic respiratory failure, HFNC delivered at increasing flow rate (30, 45 and 60 l/min) reduces the esophageal pressure–time product (PTP_{Pes}), which is a measure of patient effort (**a**) and corrected minute ventilation (*MV*), i.e. the MV needed to maintain a physiologic arterial carbon dioxide tension (MV_{corr}) (**b**) in an exponential decay manner in comparison to the standard facial mask. Filled circles represent individual patients' value at each flow rate while the horizontal line is the mean value. § indicates $p < 0.05$ by post-hoc Bonferroni test vs. Facial mask

Intensive Care Med, 2017 DOI 10.1007/s00134-017-4890-1

Rinçage espace mort (4)

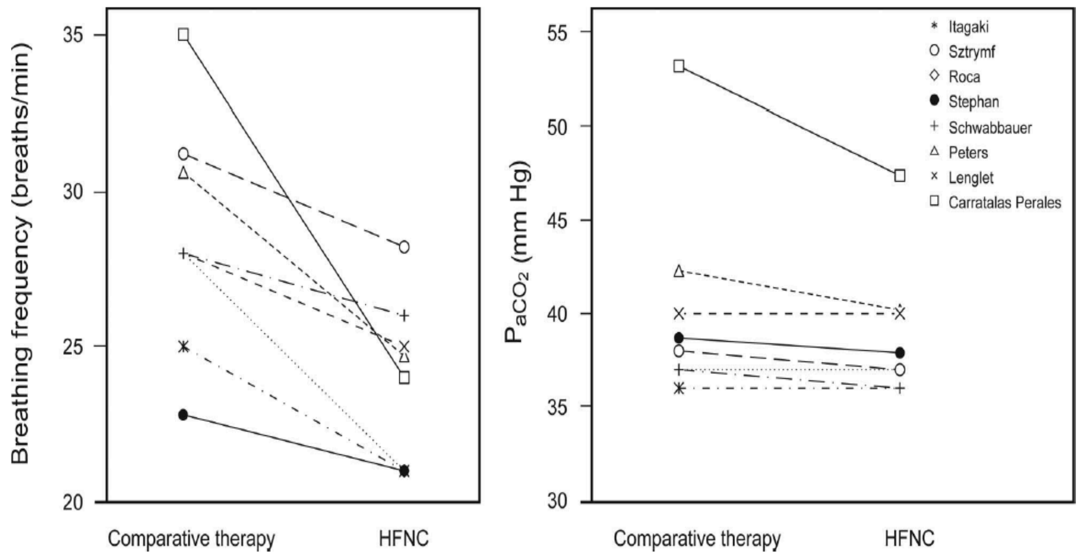
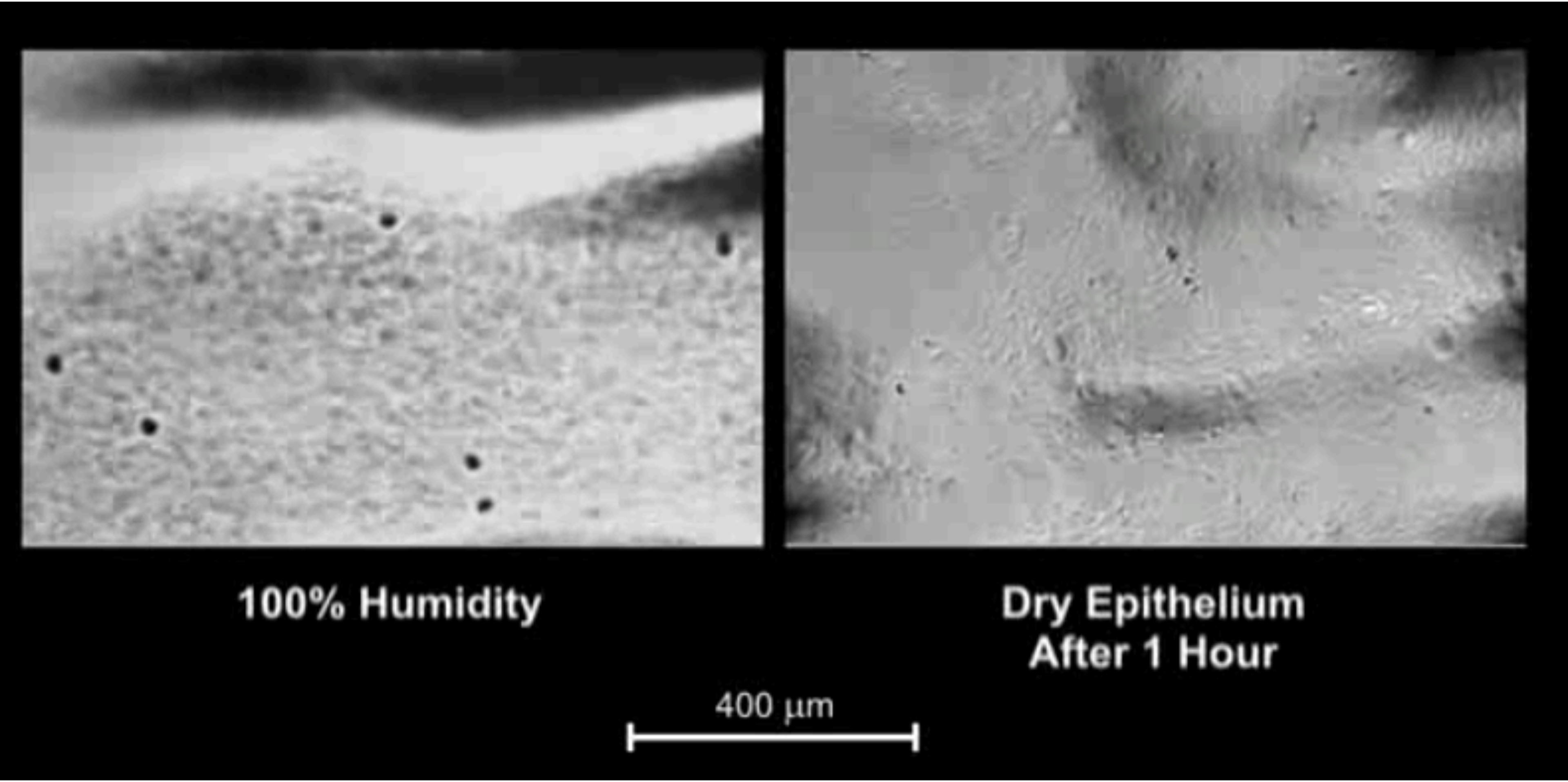


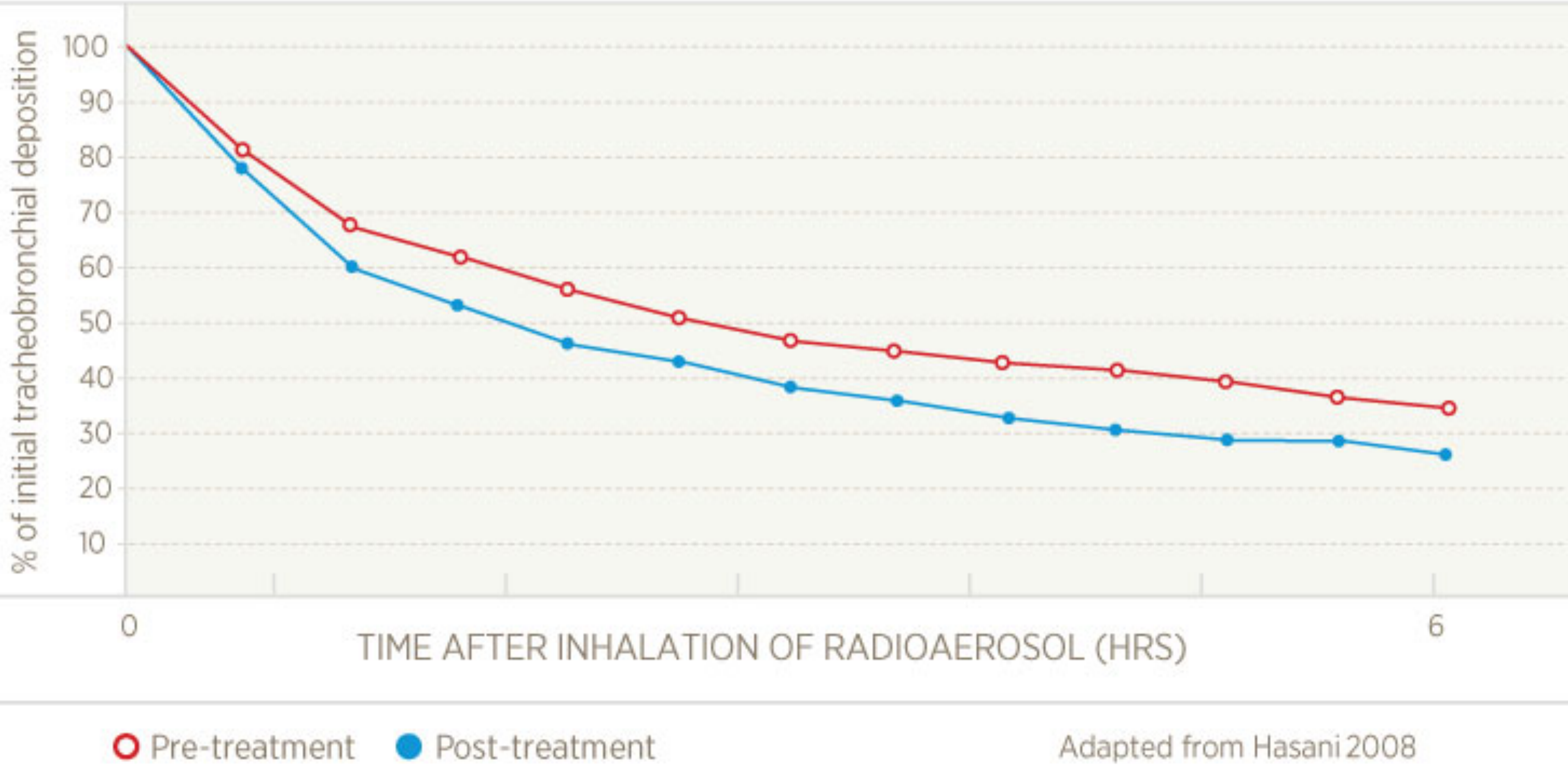
Fig. 3. Breathing frequency and P_{aCO_2}: comparison between high-flow nasal cannula oxygen therapy (HFNC) and comparative therapies in 8 studies. Left: Difference of breathing frequency between comparative therapy and HFNC. In all studies, breathing frequency with HFNC was lower. Right: Difference of P_{aCO_2}. Here, no statistically significant differences between the therapies are apparent.

RESPIRATORY CARE • APRIL 2016 VOL 61 NO 4

Nasal high flow clears anatomical dead space in upper airway models

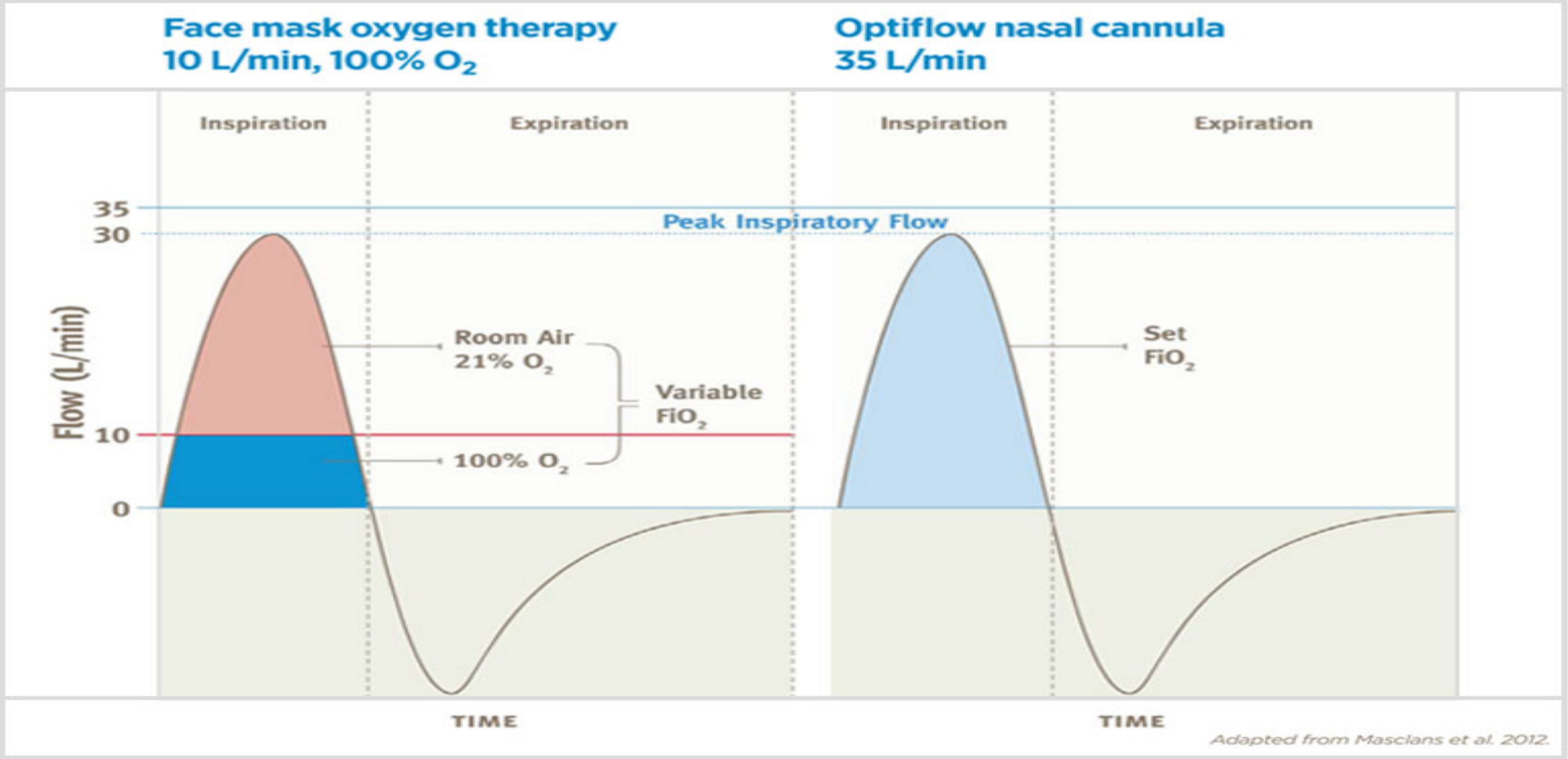

100% Humidity
Dry Epithelium
After 1 Hour
400 µm

Optiflow mucociliary clearance



Adapted from Hasani 2008

Dilution de la FiO2



Confort

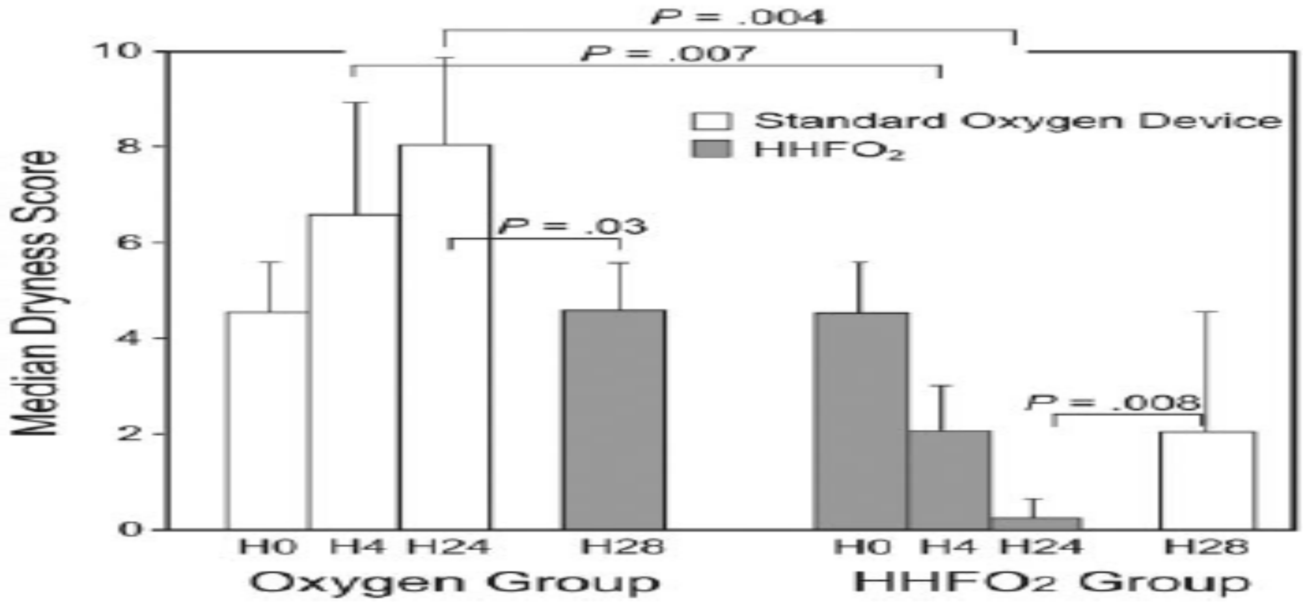
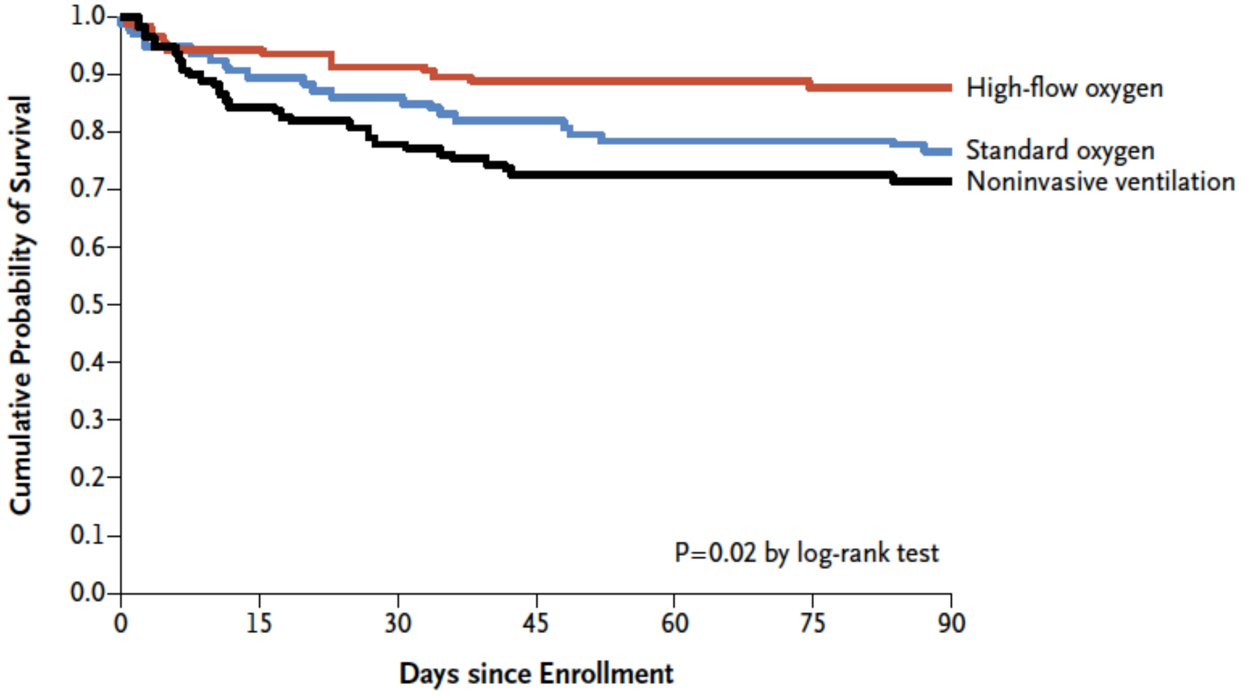


Fig. 3. Dryness score (nose) evaluated at hour 0 (H0), H4, H24, and H28, using a numerical rating scale. After 24 hours, the subjects were switched to the other device. The difference between the 2 groups was significant starting at H4 ($P = .007$). Median values and interquartile ranges are shown. $HHFO_2$ = heated humidified high-flow oxygen therapy.



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

Figure 3. Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.

Study florali, NEJM 2016

	Overall, % (*n*)	Seniors, % (*n*)	Juniors, % (*n*)	*p**
Hypoxemic ARF	100 (111/111)	100 (68/68)	100 (43/43)	1
Pneumonia	98 (109/111)	97 (66/68)	100 (43/43)	0.52
Thoracic trauma	91 (100/110)	90 (60/67)	93 (40/43)	0.74
Pulmonary embolism	85 (94/110)	87 (58/67)	84 (36/43)	0.78
ARDS	71 (78/110)	67 (45/67)	77 (33/43)	0.39
Acute pulmonary edema	57 (63/111)	74 (50/68)	30 (13/43)	< 0.000
Acute severe asthma	40 (44/109)	45 (30/67)	33 (14/42)	0.32
"Do not intubate" patients	92 (100/109)	90 (60/67)	95 (40/42)	0.48
Per bronchoscopy	92 (97/106)	91 (58/64)	93 (39/42)	1
Preoxygenation before ETI	84 (86/102)	81 (51/63)	90 (35/39)	0.28
Post-operative ARF	76 (80/105)	77 (50/65)	75 (30/40)	0.82
Post-extubation ARF treatment	70 (74/105)	70 (45/64)	71 (29/41)	1
Post-extubation ARF prevention	44 (39/89)	45 (25/56)	42 (14/33)	1
Hypercapnic ARF	33 (27/83)	29 (15/52)	39 (12/31)	0.47
Bronchial dilatation	32 (35/108)	27 (18/67)	41 (17/41)	0.14
Thoracic wall deformity	32 (35/111)	30 (19/68)	37 (16/43)	0.40
COPD exacerbation	28 (31/110)	22 (15/67)	37 (16/43)	0.13
Acute pulmonary edema	25 (28/111)	31 (21/68)	16 (7/43)	0.12
Neuromuscular disease	20 (22/111)	19 (13/68)	21 (9/43)	0.81
Obesity hypoventilation syndrome	19 (21/111)	16 (11/68)	23 (10/43)	0.46
Acute severe asthma	14 (15/111)	15 (10/68)	12 (5/43)	0.78
Obstructive sleep apnea syndrome	7 (8/110)	6 (4/67)	9 (4/43)	0.71

ARF: Acute respiratory failure; ARDS: Acute respiratory distress syndrome; COPD: chronic obstructive pulmonary disease; ETI: endotracheal intubation. HFNC: high-flow nasal cannula; ICU: intensive care unit

*Comparisons were performed between junior and senior ICU physicians

Besnier et al. Ann. Intensive Care (2019) https://doi.org/10.1186/s13613-019-0569-9

ROX Index = (SpO2/FiO2)/RR

ROX Index

$ROX = (SpO_2/FIO_2)/\text{respiratory rate}$

Success : ROX ≥ 4.88

SpO_2: 94%
FIO_2: 0.6
SpO_2/FIO_2: 157
Rate: 25

ROX: 6.27

Consider Intubation: < 3.85

SpO_2: 92%
FIO_2: 0.8
SpO_2/FIO_2: 115
Rate: 35

ROX: 3.29

Roca, Am J Respir Crit Care Med Epub 2018

$$\frac{SpO_2 / FiO_2}{\text{Respiratory Rate}} = \textbf{ROX index}$$

Example at 6 hours

SpO_2 = **88%**

FiO_2 = **.70**

RR = **28** breaths/minute

$$\frac{88 / .70}{28} = 4.48$$

In the example above, the resulting score of 4.48 is greater than the score for predicted failure at 6 hours (3.47 as shown in the ROX Score table right). Therefore, continued NHF treatment should be considered.

ROX score margin for failure over time

Time Point (Hours of NHF use)	**ROX Score**	**Positive Predictive Value %**
2 hours	< 2.85	98
6 hours	**< 3.47**	98–99
12 hours	< 3.85	99
> 12 hours	< 4.88	80

Insuffisance respiratoire aiguë hypoxémiante non hypercapnique

Critères d'inclusions : > 18 ans, FR > 20 cycles/', PaO2/FiO2 ≤ 300 mmHg, PaCO2 ≤ 45 mmHg

Critères d'exclusions : OPH, indications d'intubation, fibrose pulmonaire, obésité morbide, **instabilité HD et altération conscience (GCS ≤ 12)**

Ne pas retarder l'intubation !!!

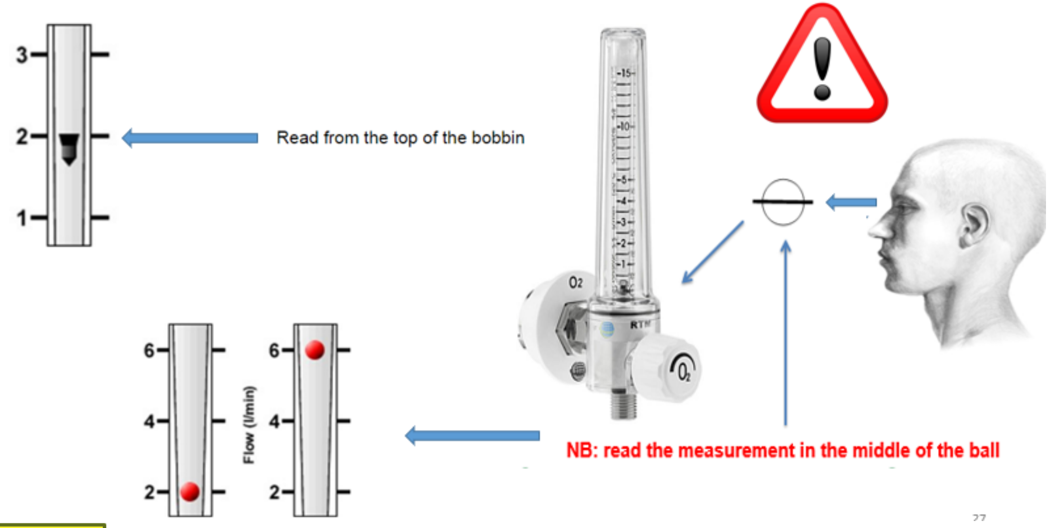
Frat et al

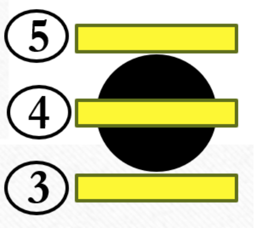
TABLE 3. Multivariate Logistic Regression Analyses of Factors Associated With Intubation

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
Pa_{O_2}/Fi_{O_2} ≤ 200 mm Hg at H1	4.26 (1.62–11.16)	0.003

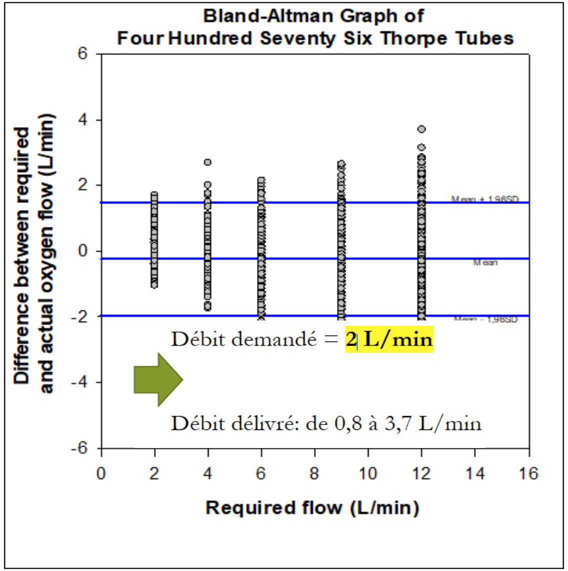
Crit Care Med. 2017 Nov 2

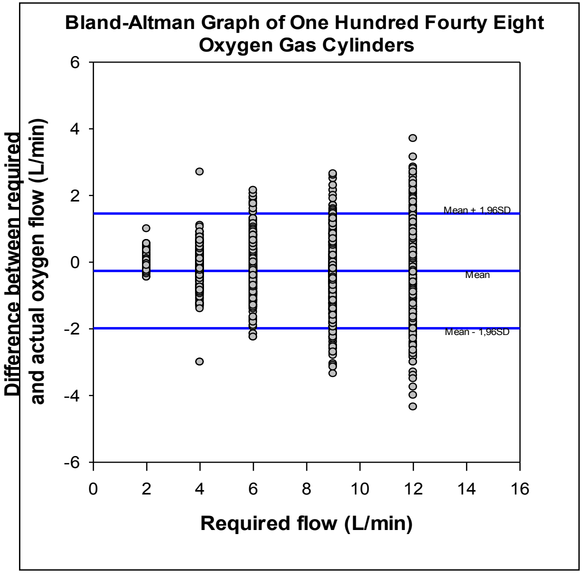
3. Précision de la FiO2

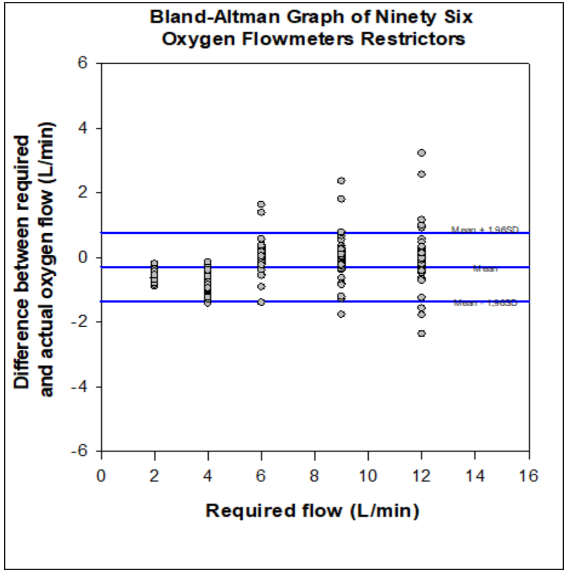




Lecture correcte de la valeur du débit d'O_2







Duprez F et al. (2014). Accuracy of medical oxygen flowmeters: A multicentric field study. *Health*, *6*(15), 1978.

Scientific Research

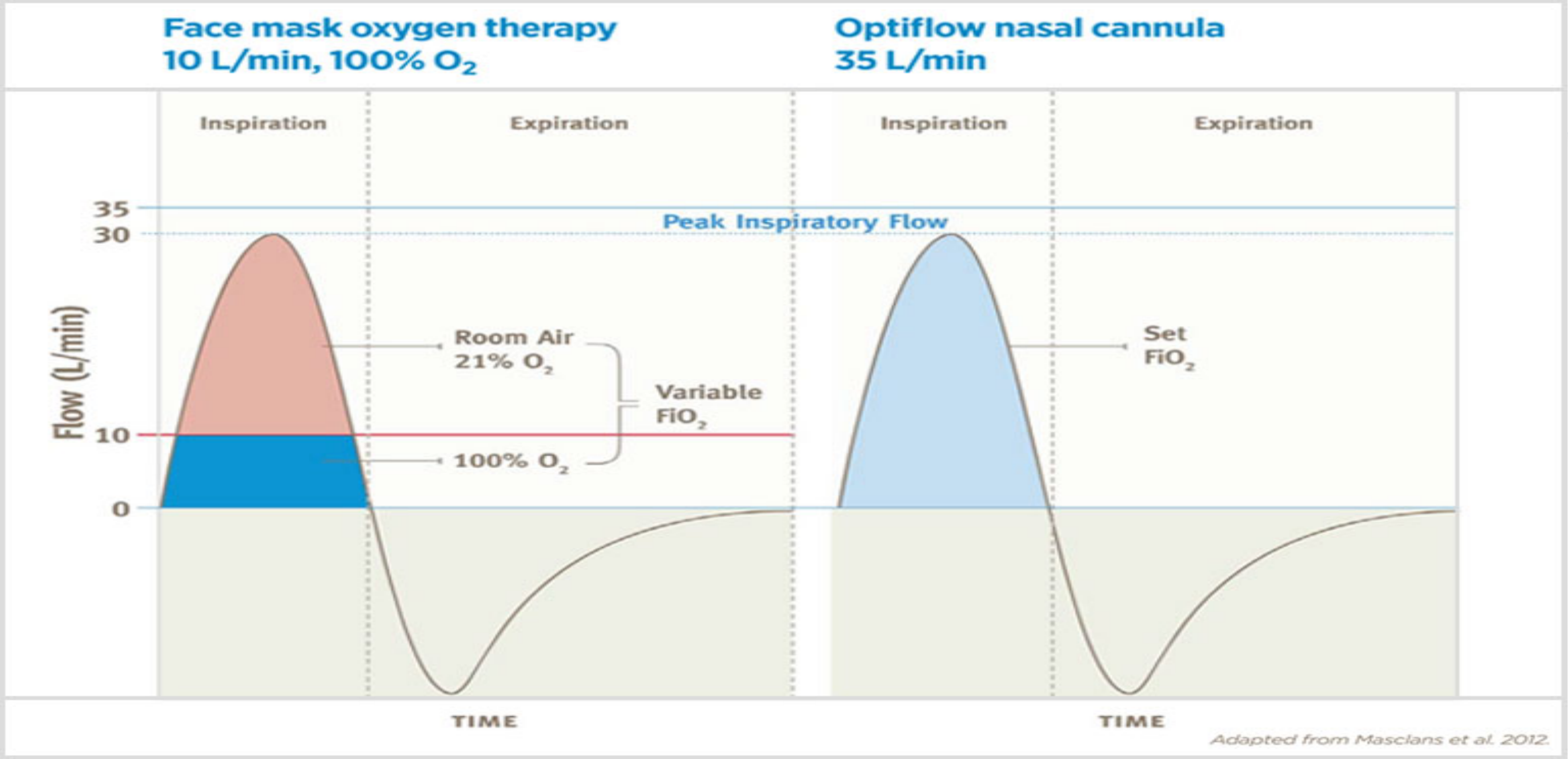
Duprez, F. et al (2018). Accuracy of oxygen flow delivered by compressed-gas cylinders in hospital and prehospital emergency care. *Respiratory care*, *63*(3), 332-338.

RESPIRATORY CARE

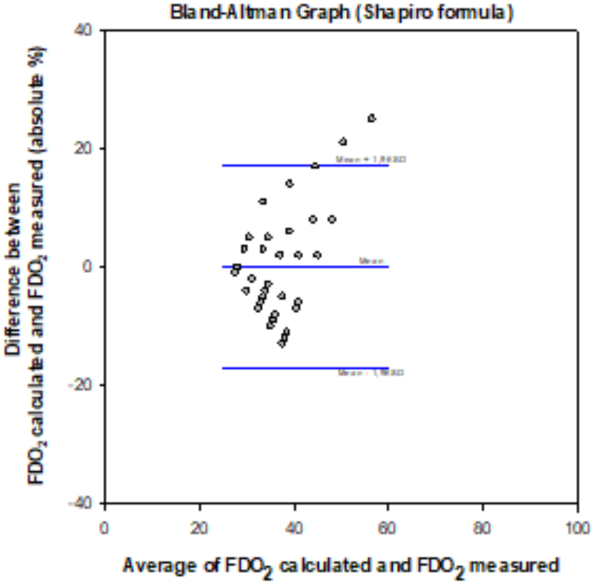
Duprez, F. et al (2019). Thorpe Tube and oxygen flow restrictors, what's accuracy ?

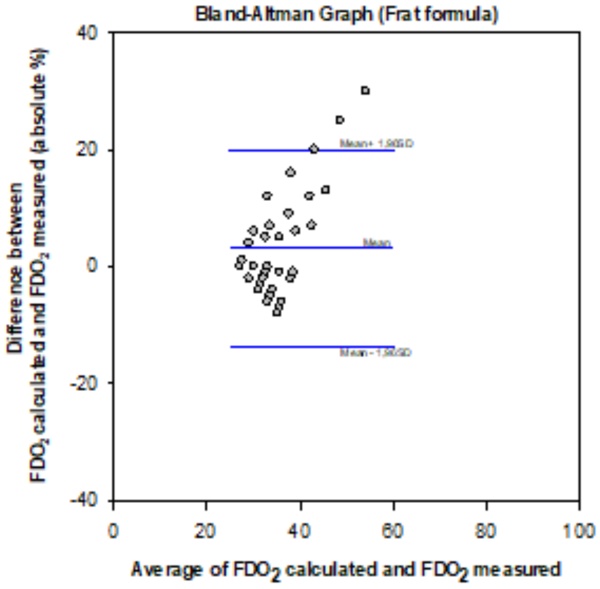
Journal of Clinical Monitoring and Computing

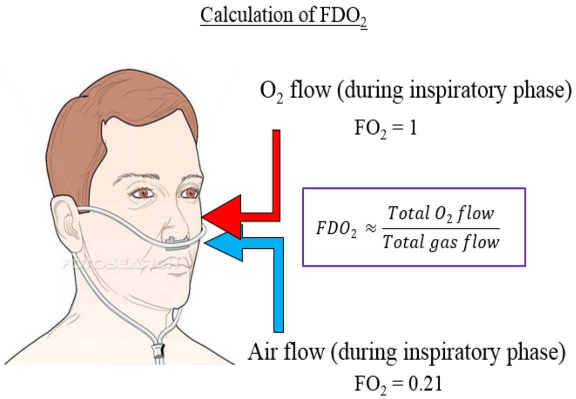
Dilution de la FiO2



$$FDO2=21\%+(3\%*LPM\ O2)$$







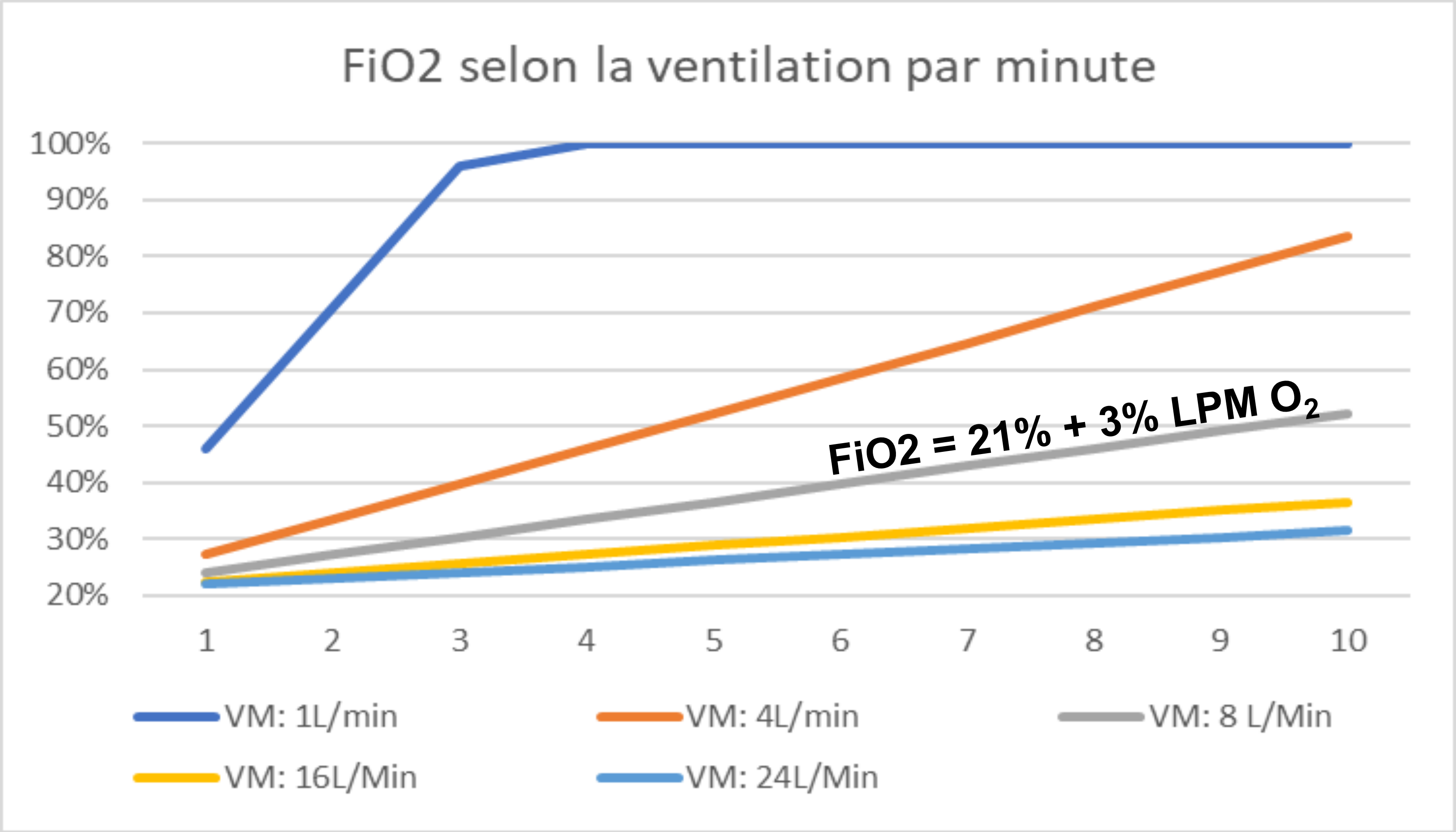
$$FDO2=21\%+(O2\ flow/4*VM)$$

F. Duprez et al. Respiratory care, 2018

$$FiO2 = 21\% + (\ ?\ \% * débit\ O2)$$

VM 1 L/min	25%
VM 2 L/min	13%
VM 3 L/min	8%
VM 4 L/min	6%
Adulte de petite taille au repos (VM 5 L/min)	5%
Adulte de taille normale au repos (VM 6 à 7 L/min)	4%
Adulte de grande taille au repos (VM 8 à 10 L/min)	3%
Adulte effort léger (VM 11 à 16 L/min)	2%
Adulte effort modéré (VM 17 à 20 L/min)	1%

?


FiO2 selon la ventilation par minute
100%
90%
80%
70%
60%
50%
40%
30%
20%
FiO2 = 21% + 3% LPM O2
1
2
3
4
5
6
7
8
9
10
VM: 1L/min
VM: 4L/min
VM: 8 L/Min
VM: 16L/Min
VM: 24L/Min

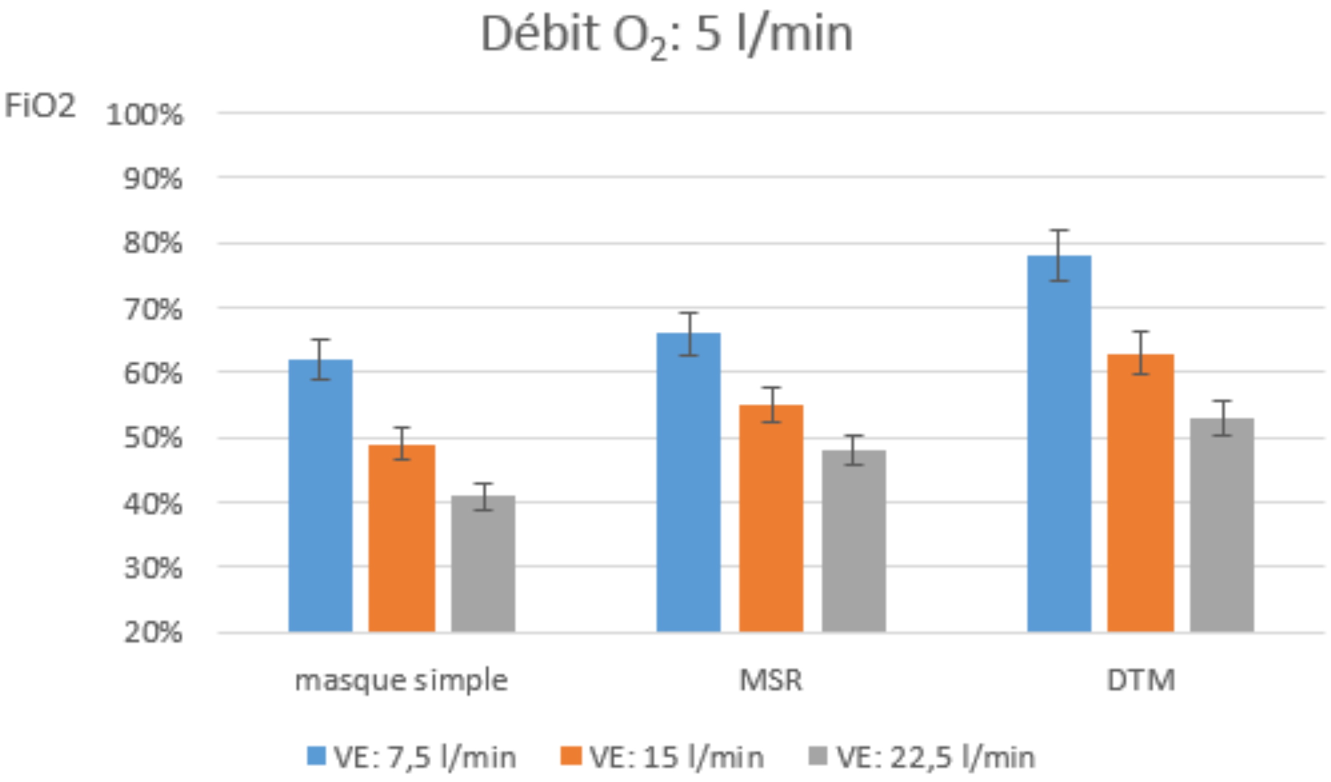
Device characteristics

Device	Mask	Reservoir	Total storage
Nasal prongs	No	50 ml (DS)	50 ml
Simple mask	100 – 200 ml	50 ml (DS)	150 – 250 ml
Mask reservoir	100 – 200 ml	650 – 1050 ml	750 – 1250 ml
Venturi mask	100 – 200 ml	50 ml (DS)	150 – 250 ml

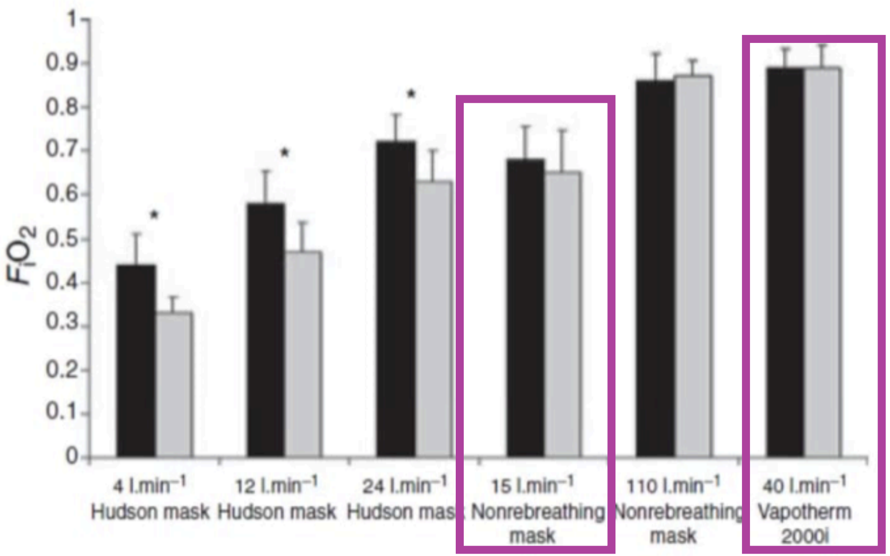
DS = dead space = air in the hypopharynx.
Mask reservoir = partial rebreathing & non-rebreathing masks.

By Dr. Fekri Eltahir Abdalla

DTM = Double Trunk Mask



3. Précision de la FiO2



- *Vmin = 20 l/min*
  - O_2 = 15 l/min
  - FiO_2 ≈ 60 %
- *Vmin = 30 l/min*
  - O_2 = 15 l/min
  - FiO_2 ≈ 46 %
- O_2 = 50 l/min
  - FiO_2 ≈ 100 %

Sim et al. Anesthesia 2008

Mauri et al. Am J Resp Crit Care Med 2017

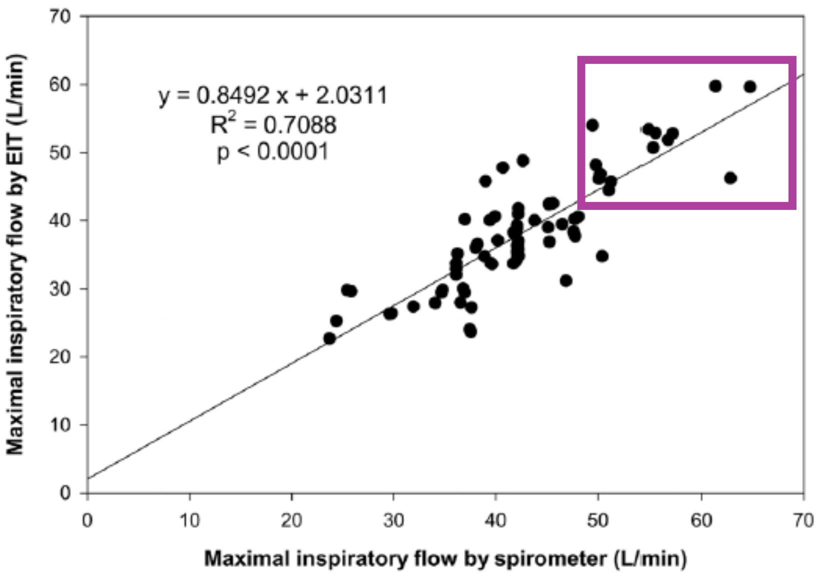
Mauri *et al. Ann. Intensive Care* (2019) 9:83
https://doi.org/10.1186/s13613-019-0560-5

Annals of Intensive Care

RESEARCH **Open Access**

Noninvasive assessment of airflows by electrical impedance tomography in intubated hypoxemic patients: an exploratory study

Tommaso Mauri[1,2*], Elena Spinelli[1], Francesca Dalla Corte[3], Eleonora Scotti[2], Cecilia Turrini[3], Marta Lazzeri[3], Laura Alban[3], Marco Albanese[3], Donatella Tortolani[3], Yu-Mei Wang[1,4], Savino Spadaro[3], Jian-Xin Zhou[4], Antonio Pesenti[1,2] and Giacomo Grasselli[1,2]

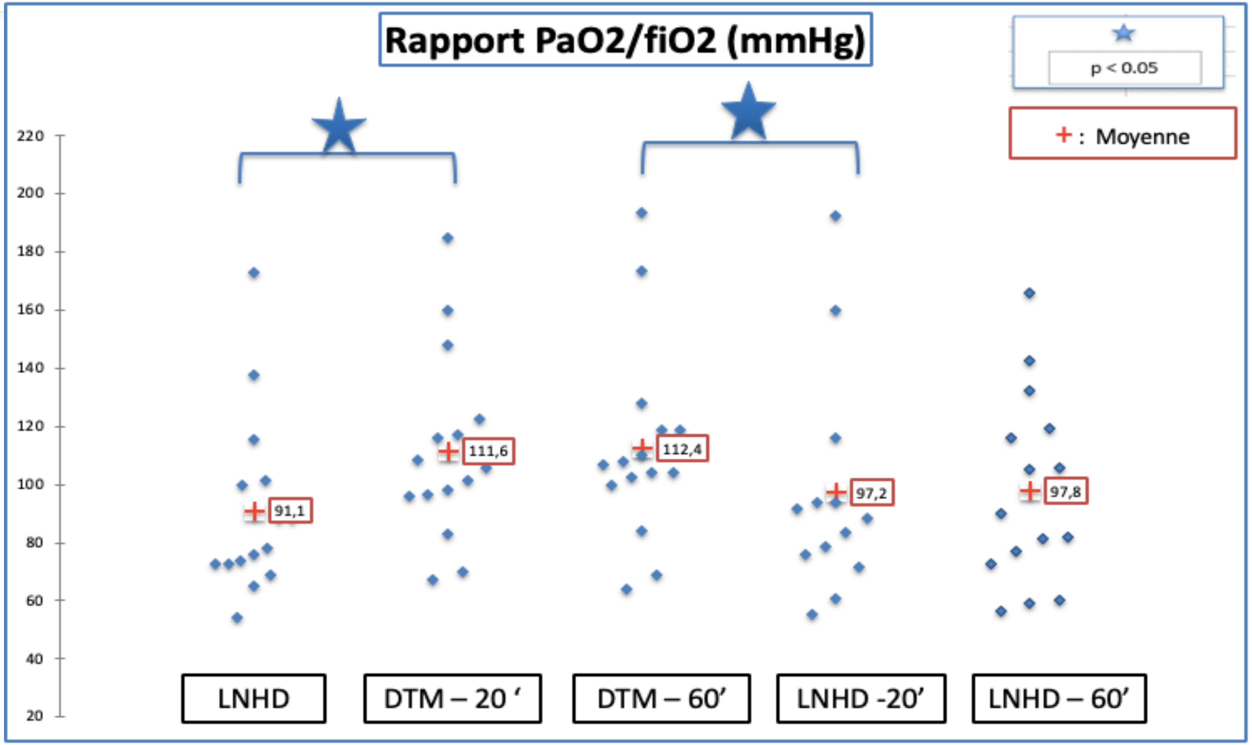


The Double-Trunk Mask Improves Oxygenation During High-Flow Nasal Cannula Therapy for Acute Hypoxemic Respiratory Failure

Respiratory Care April 2019

Frédéric Duprez, Arnaud Bruyneel, Shahram Machayekhi, Marie Droguet, Yves Bouckaert, Serge Brimioulle, Gregory Cuvelier, and Gregory Reychler

Fig. 1. Subject receiving classic high-flow nasal cannula (HFNC) therapy with a double-trunk mask (DTM). The DTM is composed of a normal aerosol mask (nebulizer and mouth piece) with 2 lateral holes (22 mm in diameter) and 15 cm of corrugated tubing inserted in the holes. The DTM was only applied to the face of subjects breathing spontaneously without obstructed airways. Subjects were already receiving O_2 via a nasal cannula. 1: trunk; 2: HFNC; 3: nebulizer; 4: aerosol mask. The nasal cannula is positioned according to the manufacturer's recommendation.



4. Normes SpO2

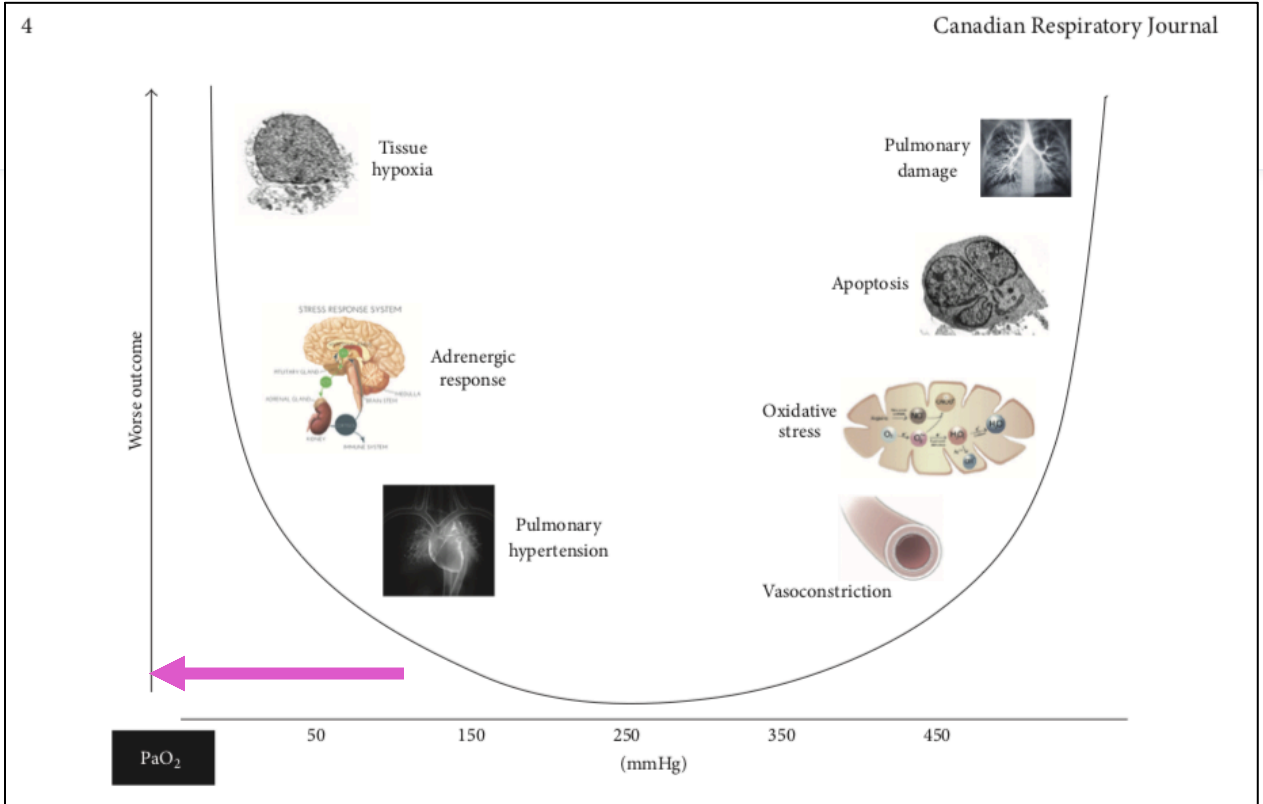


FIGURE 1: Schematic showing U-shaped association of PaO$_2$ with outcome.

Jean-Louis Vincent, 2017

4. Normes SpO2

14,441 eligible ICU patients
Three tertiary care ICUs in dutch

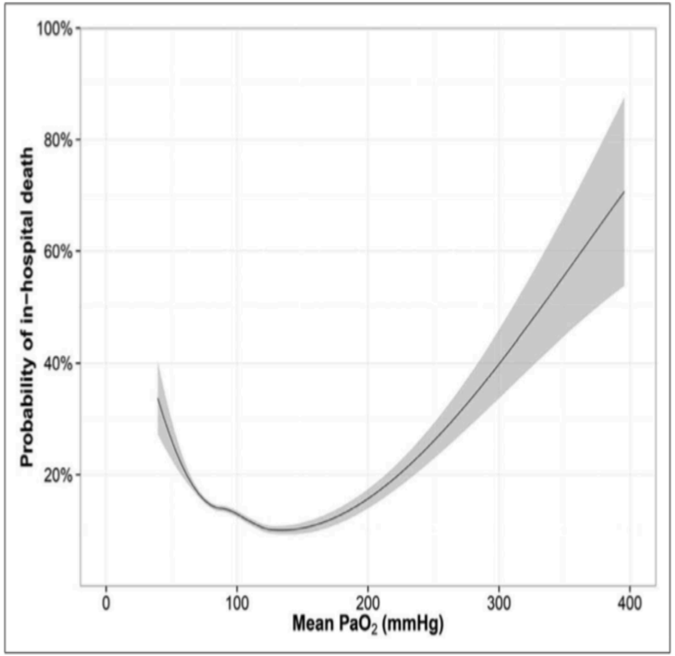


Figure 1. Adjusted probability of in-hospital death by mean Pao_2. Loess smoothing curve predicted from logistic regression model adjusted for age, Acute Physiology and Chronic Health Evaluation IV score, and ICU length of stay (LOS). *Solid line* represents oxygenation by mean Pao_2 over the total ICU LOS. *Gray zones* represent 95% CIs.

CCM fev 2017

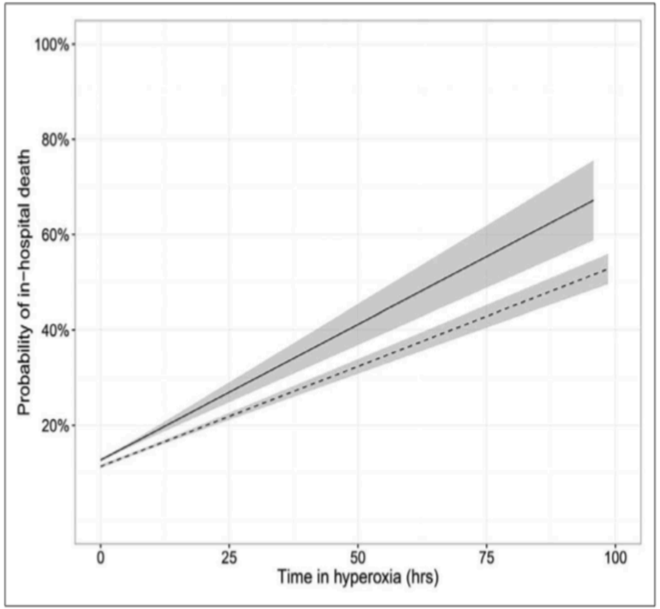
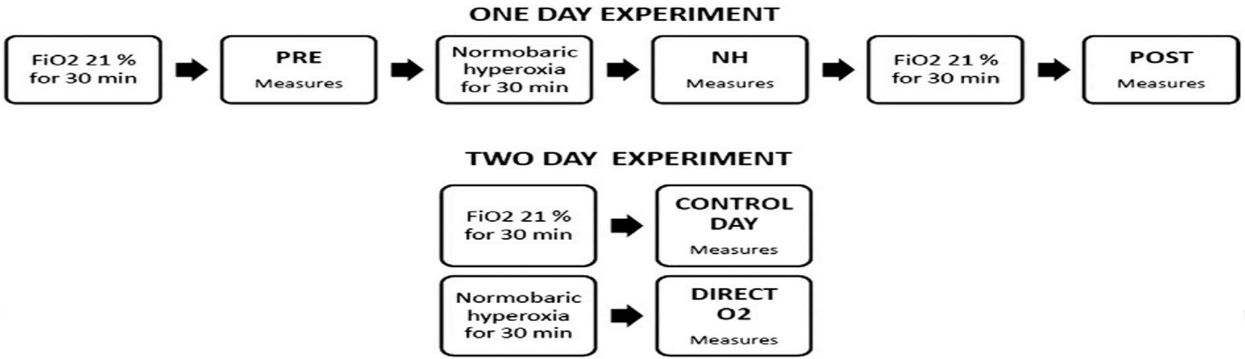
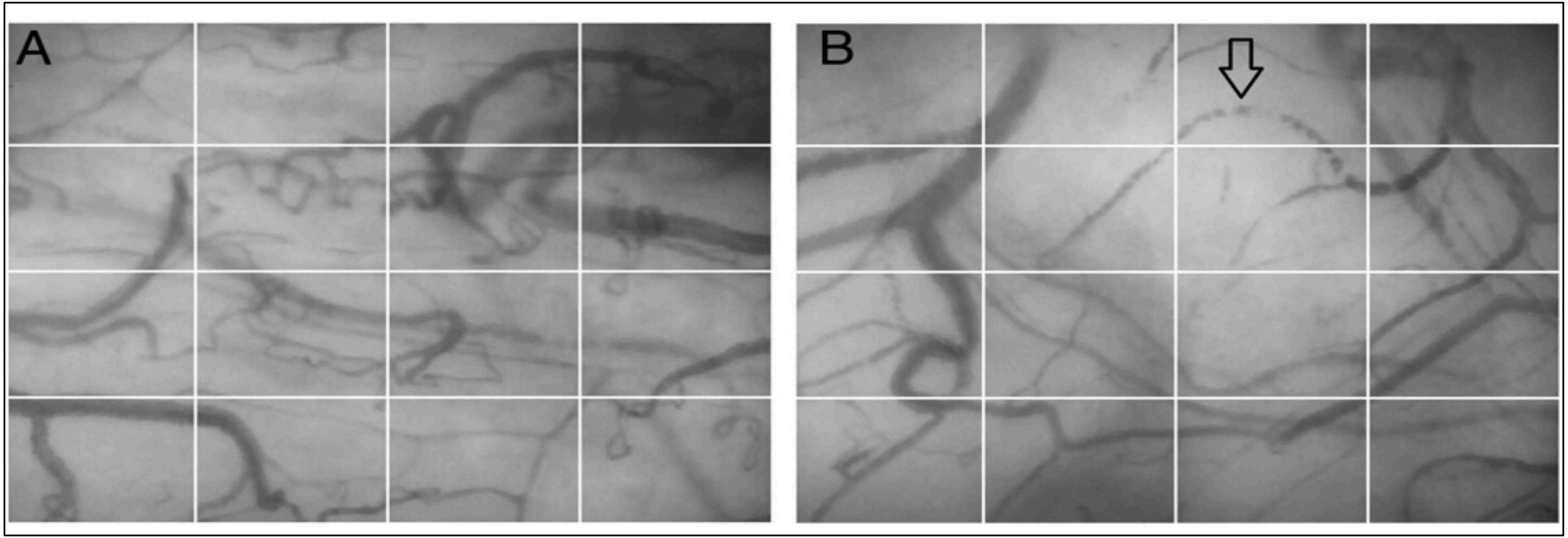


Figure 2. Adjusted probability of in-hospital death by time in hyperoxia. Probability of death predicted from logistic regression model adjusted for age, Acute Physiology and Chronic Health Evaluation IV score, and ICU length of stay. *Lines* represent estimated time in mild (*dashed*) and severe (*solid*) hyperoxia. *Gray zones* represent 95% CIs. A linear model was presented, because the smoothing curve for both metrics showed a clear linear relationship between the predicted outcome and time in hyperoxia.





D. Orbegozo Cortés et al. / Microvascular Research 98 (2015) 23–28

- Of all PaO2 values, **73%** were higher than the upper limit of the commonly self-reported acceptable range
- **58%** of cases, not respirator parameter adjustment

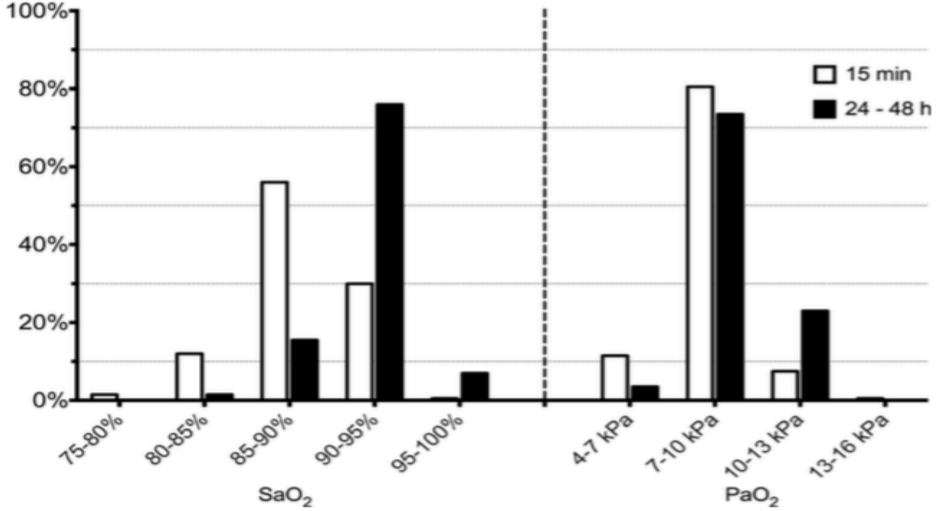
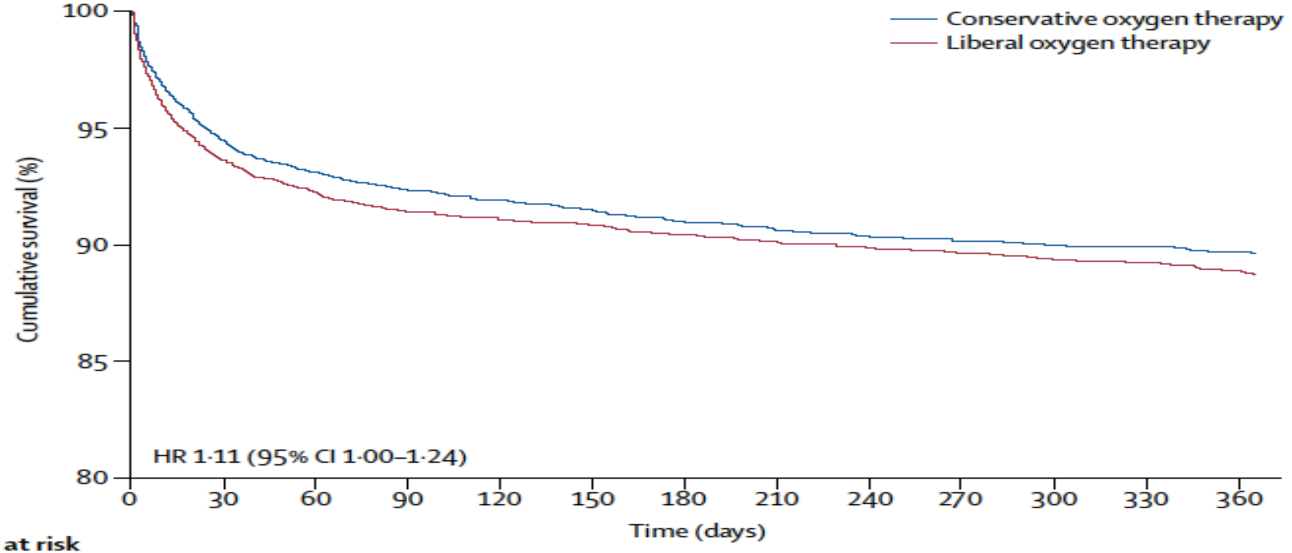


Figure 1 Self-reported tolerance limits for short-term (15 min, open bars) and longer term (24 to 48 h, closed bars) oxygenation. Bars represent percentage of respondents ($n = 200$). The presented case is a young to middle-aged ARDS patient in the ICU requiring mechanical ventilation. Ventilator settings (e.g., PEEP, airway pressures, I/E ratio, flow ratio) are optimized with respect to the PaO_2/FiO_2 ratio and hemodynamic indices. Lung injury due to high FiO_2 and/or ventilator settings is minimized. There is no evidence to indicate end-organ ischemia, and hemodynamics are stable.

Helmerhorst et al. Annals of Intensive Care 2014, 4:23

Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis

Derek K Chu†, Lisa H-Y Kim*†, Paul J Young, Nima Zamiri, Saleh A Almenawer, Roman Jaeschke, Wojciech Szczeklik, Holger J Schünemann, John D Neary, Waleed Alhazzani*



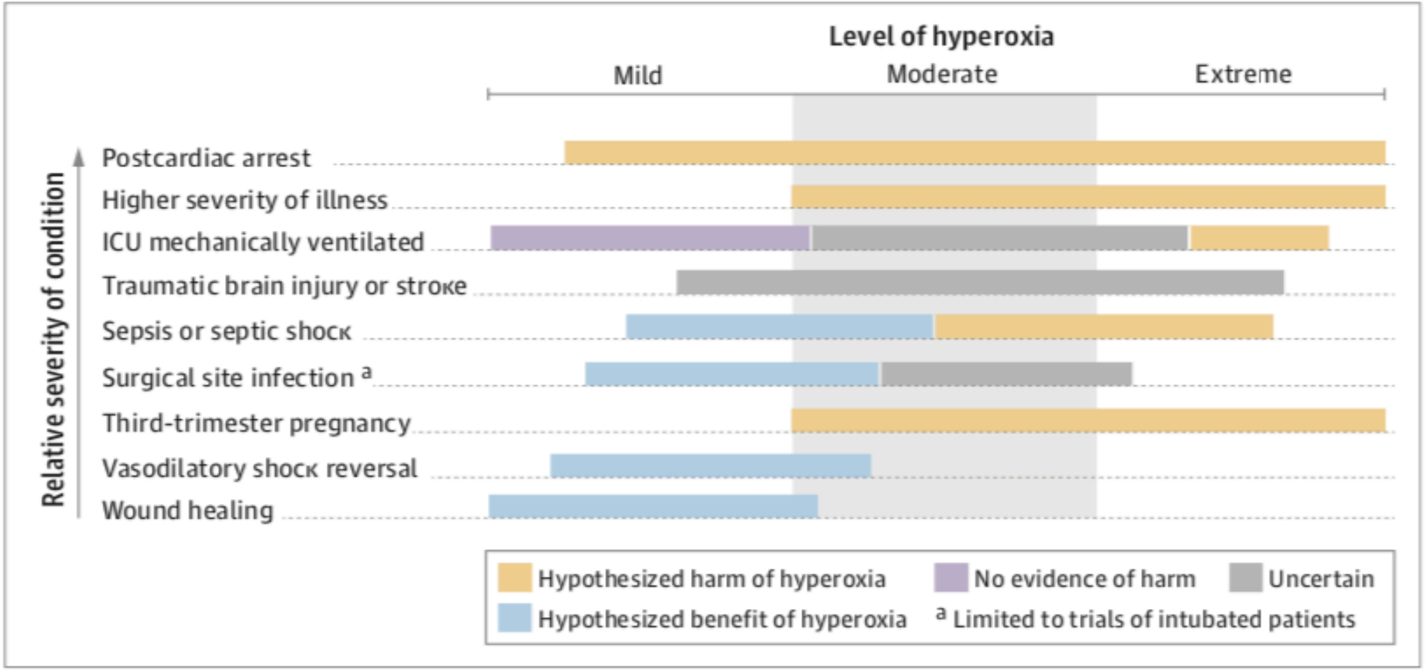
Number at risk

	0	30	60	90	120	150	180	210	240	270	300	330	360
Conservative	6900	6484	6372	6130	3542	3527	3507	3372	3361	3352	3345	3344	3334
Liberal	6943	6450	6345	6119	3564	3554	3539	3402	3390	3381	3370	3365	3351

Figure 5: **Kaplan-Meier analysis of cumulative survival for liberal versus conservative oxygen therapy**

The Lancet - Vol 391 April 28, 2018

Figure. Hypothesized Benefits or Harm of Oxygen Therapy Across Clinical Conditions



Hypothesized clinical conditions across which oxygen may induce benefit or harm. The hypothesis is that no specific threshold of oxygen induces harm, but the effect of hyperoxia is specific to the underlying condition and changes with the severity of illness or an exogenous stimulus.

Munshi L, Ferguson ND. Evolving Issues in Oxygen Therapy in Acute Care Medicine. *JAMA*. doi:10.1001/jama.2019.22029

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

CRITICAL CARE

VIEWPOINT

Oxygen-induced hypercapnia in COPD: myths and facts

Wilson F Abdo* and Leo MA Heunks

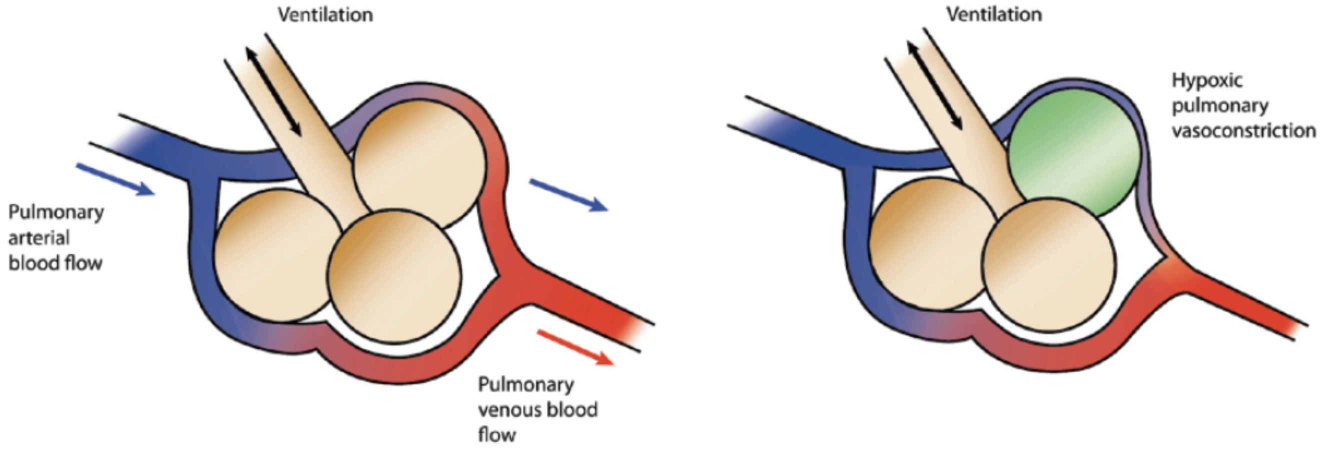
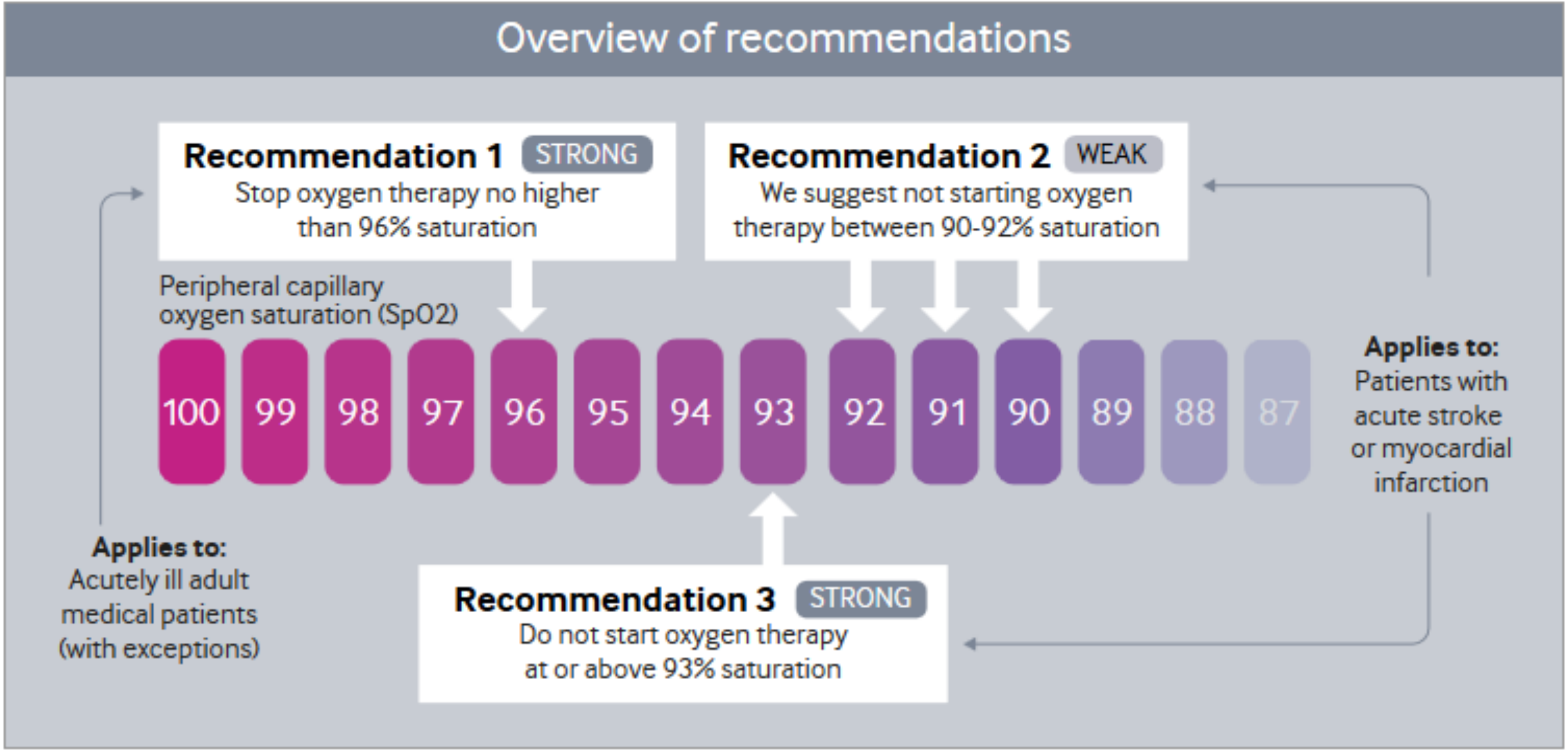
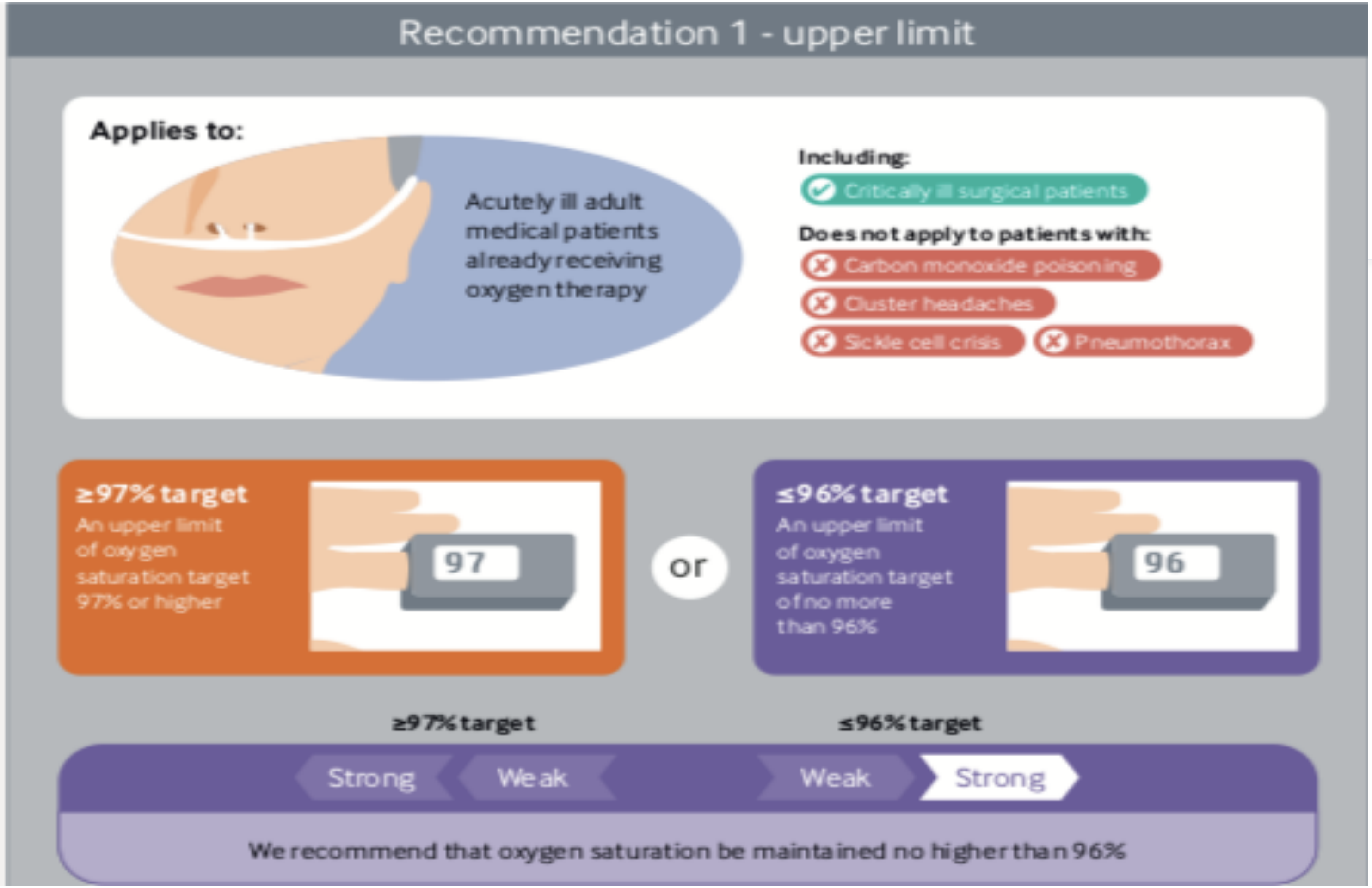


Figure 2. Hypoxic pulmonary vasoconstriction. The left frame shows normal alveolar ventilation and perfusion. In the right frame, reduced ventilation (thus O_2 tension) in the alveolus (green) leads to a reduced perfusion because of the hypoxic pulmonary vasoconstriction mechanism. Reprinted with permission from BMJ Publishing Group Ltd and Royal College of Paediatrics and Child Health [13].

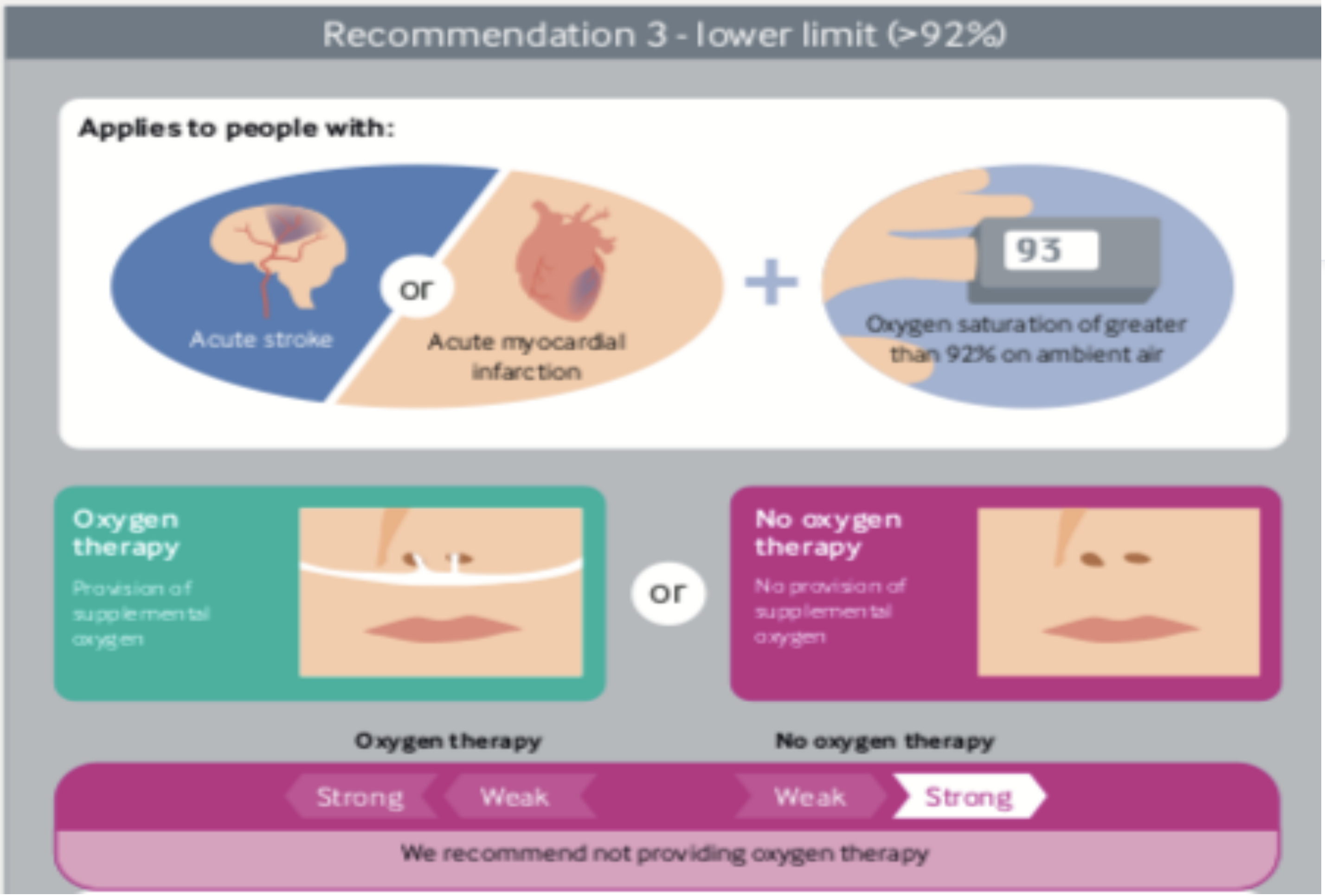
Oxygen therapy for acutely ill medical patients: a clinical practice guideline

BMJ 2018 ; 363 doi: https://doi.org/10.1136/bmj.k4169 (Published 24 October 2018)
Cite this as: *BMJ* 2018;363:k4169





BMJ 2018;363:k4169



BMJ 2018;363:k4169

Table 8 Mean (SD) PaO_2 (kPa and mm Hg) and SaO_2 (%) values (with range)

Mean (SD) PaO_2 and SaO_2 values (with range) in kPa and mm Hg				
Age	Mean (SD) PaO_2 (kPa and mm Hg)	Range±2SD PaO_2 (kPa and mm Hg)	Mean (SD) SaO_2 (%)	SaO_2±2SD
18–24	13.4 (0.71) 99.9 (5.3)	11.98–14.82 89.3–110.5	96.9 (0.40	96.1–97.7
25–34	13.4 (0.66) 99.8 (4.9)	12.08–14.72 90–109.6	96.7 (0.7)	95.3–98.1
35–44	13.18 (1.02) 98.3 (7.6)	11.14–15.22 83.1–113.5	96.7 (0.6)	95.5–97.9
45–54	13.0 (1.07) 97 (8)	10.86–15.14 81–113	96.5 (1)	94.4–98.5
55–64	12.09 (0.60) 90.2 (4.5)	10.89–13.29 81.2–99.2	95.1 (0.7)	94.5–97.3
>64	11.89 (1.43) 88.7 (10.7)	9.02–14.76 67.3–110.1	95.5 (1.4)	92.7–98.3

Adapted from Crapo *et al.*[17]
Values shown for seated healthy men and women non-smoking volunteers at sea level (adapted from Crapo *et al*).
PaO_2, arterial oxygen tension; SaO_2, arterial oxygen saturation.

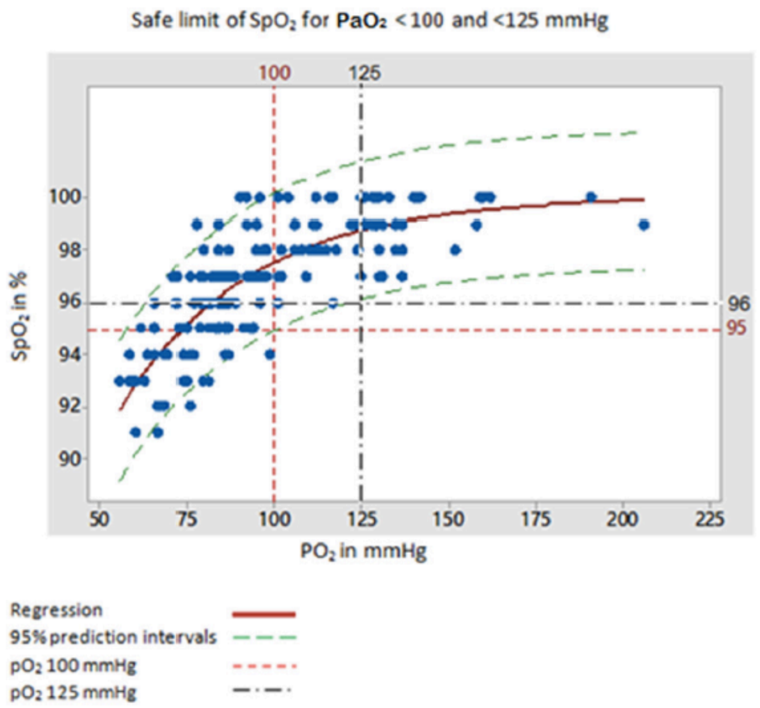
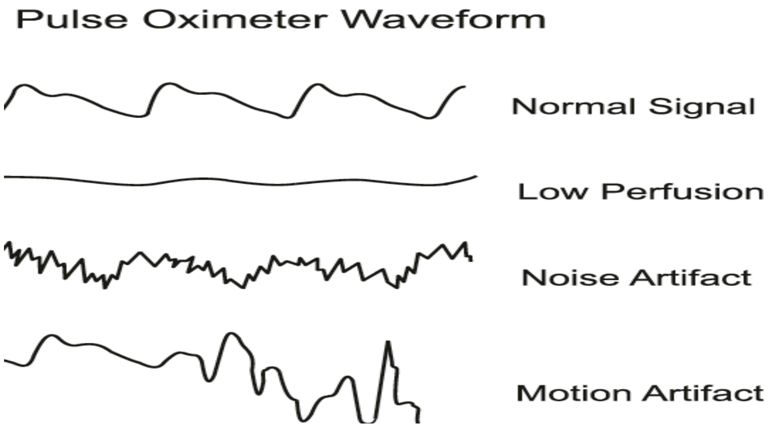


Fig. 2. Safe limit of SpO_2 for PaO_2 < 100 mm Hg (red dots) and < 125 mm Hg (black dots) in the exponential model.

Durlinger et al. J Crit Care. 2017

Table 1 Limitations of pulse oximetry
Shape of oxygen dissociation curve
Dyshemoglobins
- Carboxyhemoglobin
- Methemoglobin
Dyes
Low perfusion state
Skin pigmentation
Anemia
Nail polish
Motion artifact
Limited knowledge of the technique



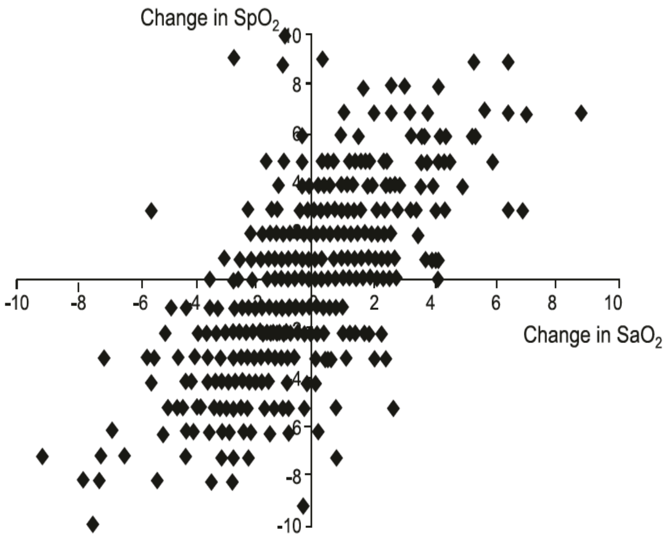


Fig. 3 Changes in oxygen saturation measured by pulse oximetry (SpO_2) compared with arterial oxygen saturation measured by a CO-oximeter (SaO_2) in critically ill patients. The pulse oximeter consistently overestimated the actual changes of SaO_2. Reprinted with permission from BioMed Central Ltd [8]

Seifi et al. BMC Nursing (2018) 17:15
https://doi.org/10.1186/s12912-018-0283-1

BMC Nursing

RESEARCH ARTICLE Open Access

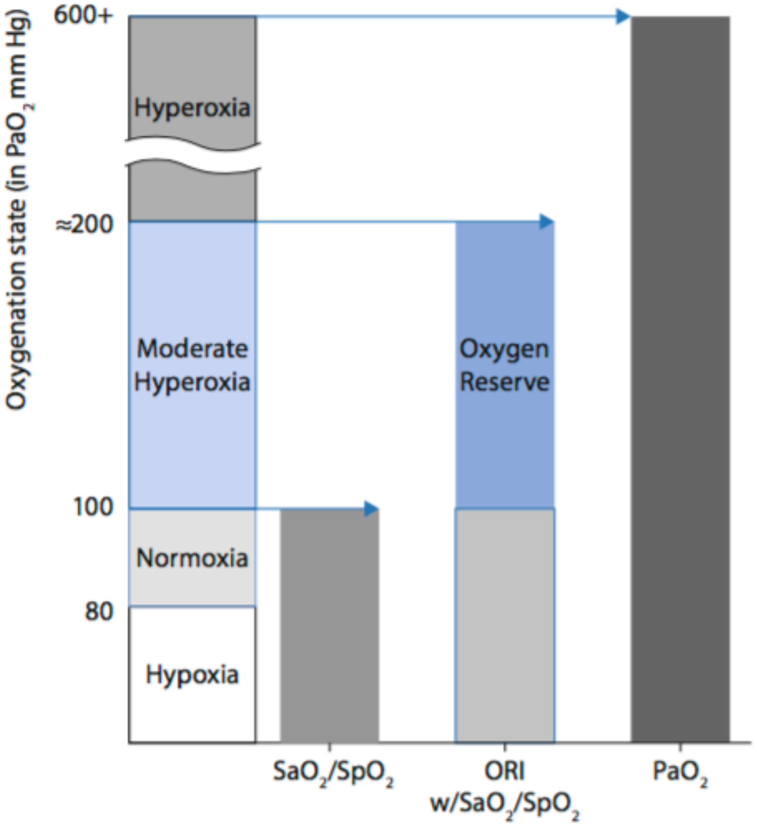
Accuracy of pulse oximetry in detection of oxygen saturation in patients admitted to the intensive care unit of heart surgery: comparison of finger, toe, forehead and earlobe probes

Sohila Seifi[1], Alireza Khatony[2*], Gholamreza Moradi[3], Alireza Abdi[2] and Farid Najafi[4]

Table 2 agreement and mean difference of Finger, Toe, Earlobe and Forehead pulse oximeters comparing to Standard SaO2

Statistical index SpO2 probe		Mean	SD	Mean difference SaO2-SpO2	*p*-Value for t-test of mean difference	CI 95% for agreement
Forehead	Front	95.55	1.75	1.25 ± 1.18	< 0.001	0.38–0.62
Earlobe	Oreille	96.67	1.34	0.14 ± 0.86	0.019	0.67–0.87
Finger	Doigt	96.28	1.06	0.53 ± 0.79	< 0.001	0.57–0.80
Toe	Orteil	96.52	1.06	0.29 ± 1.01	0.22	0.43–0.74

Fig. 1 The oxygen reserve index (ORI) reflects the moderate hyperoxic range ($PaO_2 > 100$ and $< \approx 200$ mmHg) which is defined as the patient's 'oxygen reserve'. Figure kindly provided by Masimo Corp., Irvine, CA, USA



LETTER

ORI monitoring allows a reduction of time with hyperoxia in critically ill patients: the randomized control ORI² study

Sigismond Lasocki*, Antoine Brochant, Maxime Leger, Thomas Gaillard, Pierre Lemarié, Soizic Gergaud and Pauline Dupré

Table 1 Main outcomes

	ORI ($n=75$)	Control ($n=71$)	p
Primary outcomes			
Percentage of days with hyperoxia, %	14 (0–29)	28 (9–50)	0.003*
Number of days with hyperoxia	1 (0–2)	2 (1–3)	0.023
Percentage of time (hours) with PaO2 ≥ 100 mmHg, %	7.4 (0–24.8)	17.3 (3.8–43.1)	0.0069
Percentage of time (hours) with PaO2 ≥ 120 mmHg, %	0 (0–7.2)	5.6 (0–18.1)	0.0037

Published online: 13 August 2019

Alarm levels	Examples	Alarm tone
1, Crisis	Asystole Ventricular tachycardia Ventricular fibrillation Ventricular bradycardia	Triple beep
2, Warning	Tachycardia Bradycardia Ventricular tachycardia > 2	Double beep
3, Advisory	Pulse oximetry Premature ventricular contractions	Single beep
4, Message	Irregular couplet	None
5, System warning	Lead failure Arrhythmia suspend	Fog horn

Critical Care Medicine
Society of Critical Care Medicine

Oxygen exposure resulting in arterial oxygen tensions above the protocol goal was associated with worse clinical outcomes in Acute Respiratory Distress Syndrome

L'oxygène dans le SDRA : avec modération ?

Publié le 01/08/2019 Réactu Bibliographie

https://www.srlf.org 30/07/19

Article commenté par le Dr Hadrien Winiszewski et le Pr Gilles Capellier, Service de réanimation médicale, CHU de Besançon

International Journal of COPD

Dovepress
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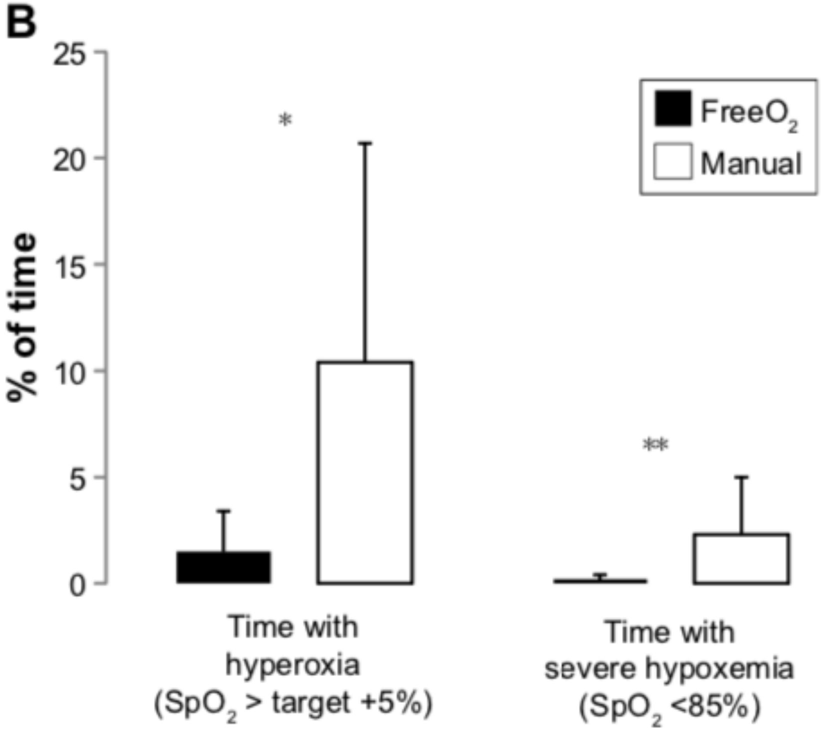
ORIGINAL RESEARCH

Automated oxygen titration and weaning with $FreeO_2$ in patients with acute exacerbation of COPD: a pilot randomized trial

This article was published in the following Dove Press journal:
International Journal of COPD
24 August 2016
Number of times this article has been viewed



International Journal of COPD

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ORIGINAL RESEARCH

Automated oxygen control with O2matic® during admission with exacerbation of COPD

This article was published in the following Dove Press journal:
International Journal of COPD

Ejvind Frausing Hansen[1]
Jens Dahlgaard Hove[1]
Charlotte Sandau Bech[1]
Jens-Ulrik Stæhr Jensen[2]
Thomas Kallemose[3]
Jørgen Vestbo[4]

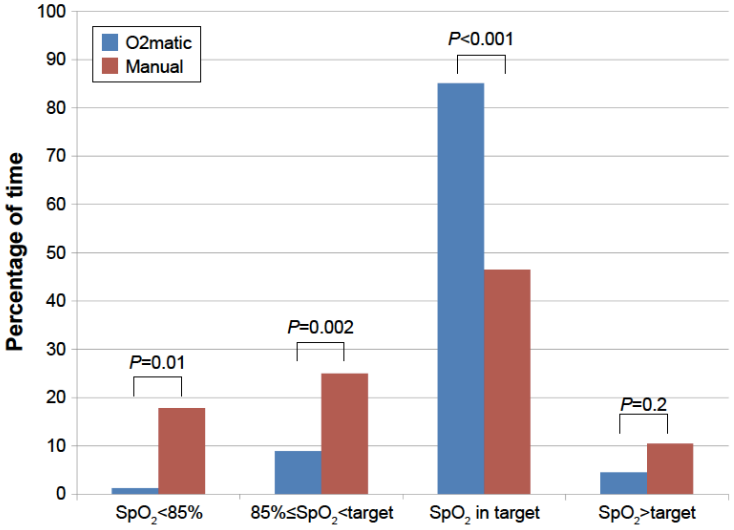


Figure 3 Fraction of time with different levels of SpO_2 for O2matic® (blue bars) and manual control (red bars).
Abbreviation: SpO_2, oxygen saturation.

International Journal of COPD 2018:13 3997–4003

Poiroux *et al. Ann. Intensive Care* (2018) 8:126
https://doi.org/10.1186/s13613-018-0472-9

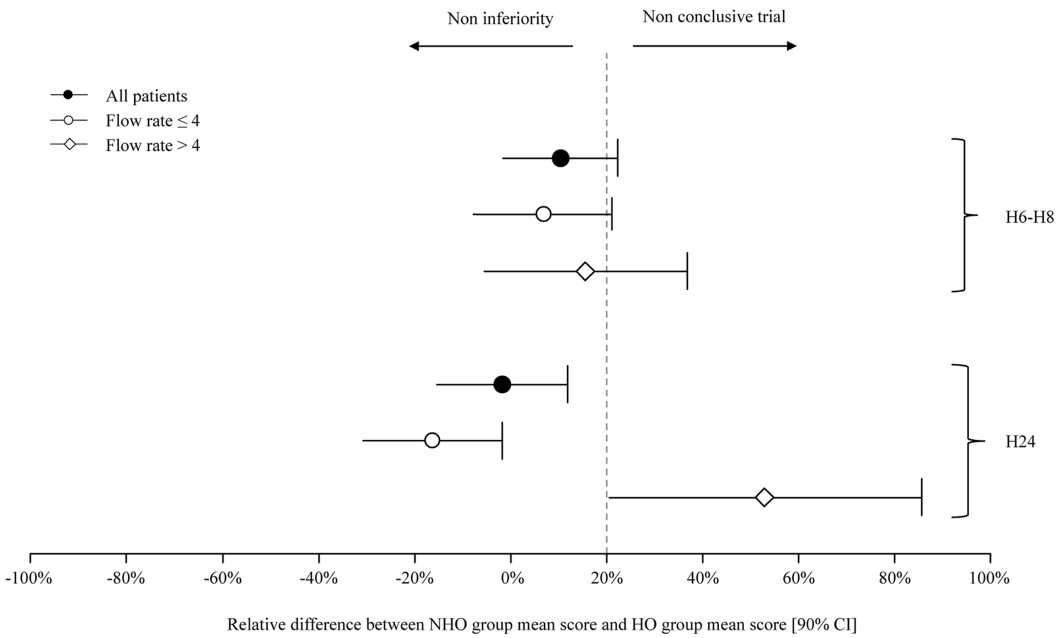
Annals of Intensive Care

RESEARCH

Open Access

Effect on comfort of administering bubble-humidified or dry oxygen: the Oxyrea non-inferiority randomized study

Laurent Poiroux[1*†], Lise Piquilloud[2†], Valérie Seegers[3], Cyril Le Roy[1], Karine Colonval[4], Carole Agasse[5], Vanessa Zinzoni[6], Vanessa Hodebert[7], Alexandre Cambonie[8], Josselin Saletes[9], Irma Bourgeon[10], François Beloncle[1], Alain Mercat[1] and for the REVA Network



JAN
Leading Global Nursing Research

REVIEW

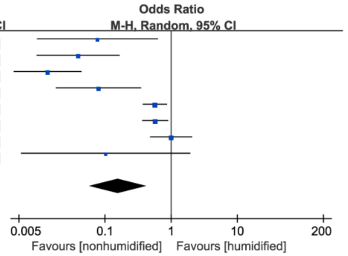
Is humidified better than non-humidified low-flow oxygen therapy? A systematic review and meta-analysis

Zunjia Wen, Wenting Wang, Haiying Zhang, Chao Wu, Jianping Ding, Meifen Shen

First published: 25 April 2017 | https://doi.org/10.1111/jan.13323 | Cited by: 3

Study or Subgroup	Nonhumidified oxygen Events	Total	Humidified oxygen Events	Total	Weight	Odds Ratio M-H, Random, 95% CI
Huang J 2014	1	40	10	40	9.4%	0.08 [0.01, 0.63]
Li 2011	2	130	37	130	12.1%	0.04 [0.01, 0.17]
Li 2015	3	173	95	168	13.3%	0.01 [0.00, 0.04]
Lou 2016	2	101	20	99	12.0%	0.08 [0.02, 0.35]
Ning 2014	53	201	77	199	15.8%	0.57 [0.37, 0.87]
Yang B 2015	41	184	67	201	15.8%	0.57 [0.36, 0.90]
Yang T 2015	20	70	20	70	15.0%	1.00 [0.48, 2.08]
Zhou 2015	0	50	4	50	6.7%	0.10 [0.01, 1.95]
Total (95% CI)		**949**		**957**	**100.0%**	**0.16 [0.06, 0.43]**
Total events	122		330			

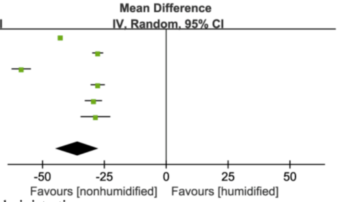
Heterogeneity: Tau² = 1.58; Chi² = 68.44, df = 7 (P < 0.00001); I² = 90%
Test for overall effect: Z = 3.62 (P = 0.0003)



A The forest plot for bacteria contaminations of humidifier bottles

Study or Subgroup	Nonhumidified oxygen Mean	SD	Total	Humidified oxygen Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Chen 2015	15.64	3.32	328	58.47	8.11	352	17.1%	-42.83 [-43.75, -41.91]
Huang S 2014	49.5	18.02	507	77.19	17.48	490	17.0%	-27.69 [-29.89, -25.49]
Lou 2016	47.2	13.06	101	105.8	15.01	99	16.6%	-58.60 [-62.50, -54.70]
Tian 2012	49.5	18.02	316	77.19	17.48	281	16.8%	-27.69 [-30.54, -24.84]
Yang B 2015	48.76	17	184	78.18	17.84	201	16.7%	-29.42 [-32.90, -25.94]
Zheng 2015	49.32	16.42	60	77.94	17.08	60	15.8%	-28.62 [-34.61, -22.63]
Total (95% CI)			**1496**			**1483**	**100.0%**	**-35.84 [-44.51, -27.17]**

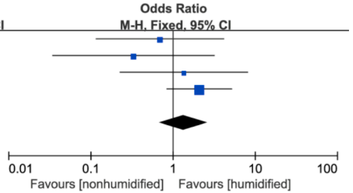
Heterogeneity: Tau² = 114.12; Chi² = 363.41, df = 5 (P < 0.00001); I² = 99%
Test for overall effect: Z = 8.10 (P < 0.00001)



B The forest plot for the mean operation time for oxygen administration

Study or Subgroup	Nonhumidified oxygen Events	Total	Humidified oxygen Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chen 2012	2	235	3	245	19.8%	0.69 [0.11, 4.18]
Liu 2015	1	174	3	174	20.3%	0.33 [0.03, 3.20]
Yuan 2013	3	256	2	230	14.1%	1.35 [0.22, 8.16]
Yue 2015	15	224	7	210	45.8%	2.08 [0.83, 5.21]
Total (95% CI)		**889**		**859**	**100.0%**	**1.35 [0.69, 2.65]**
Total events	21		15			

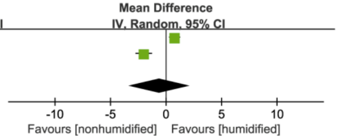
Heterogeneity: Chi² = 2.86, df = 3 (P = 0.41); I² = 0%
Test for overall effect: Z = 0.87 (P = 0.39)



C The forest plot for the smell of oxygen

Study or Subgroup	Nonhumidified oxygen Mean	SD	Total	Humidified oxygen Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Cai 2013	98.06	1.03	51	97.29	1.15	29	50.5%	0.77 [0.26, 1.28]
Wu 2016	90	3	90	92	2	90	49.5%	-2.00 [-2.74, -1.26]
Total (95% CI)			**141**			**119**	**100.0%**	**-0.60 [-3.32, 2.11]**

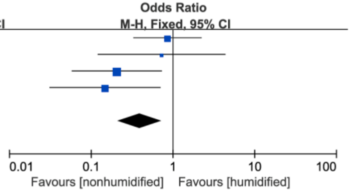
Heterogeneity: Tau² = 3.73; Chi² = 36.39, df = 1 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.43 (P = 0.66)



D The forest plot for the SpO_2

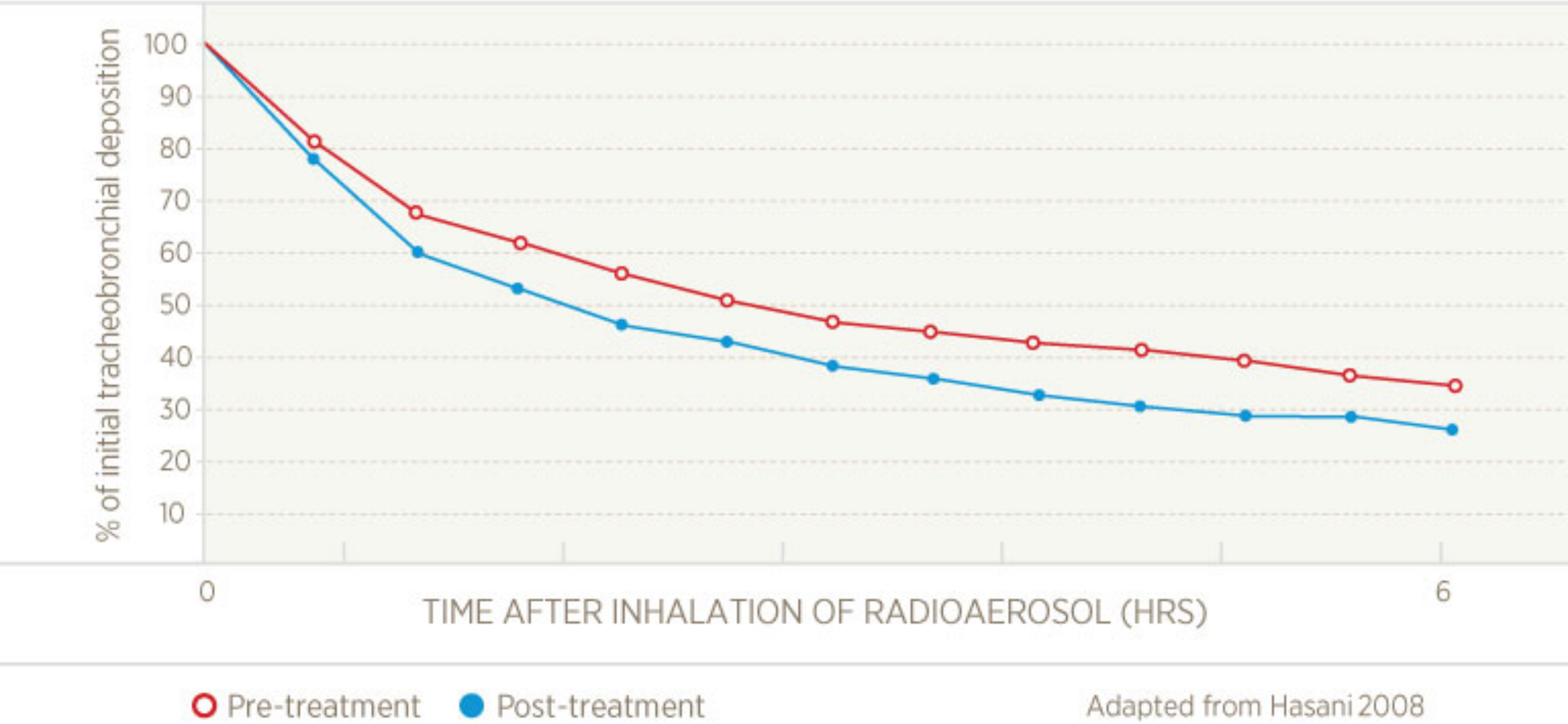
Study or Subgroup	Nonhumidified oxygen Events	Total	Humidified oxygen Events	Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Huang S 2014	8	507	9	490	25.3%	0.86 [0.33, 2.24]
Yang B 2015	2	184	3	201	8.0%	0.73 [0.12, 4.39]
Yue 2015	3	224	13	210	37.1%	0.21 [0.06, 0.73]
Zhou 2015	2	50	11	50	29.6%	0.15 [0.03, 0.71]
Total (95% CI)		**965**		**951**	**100.0%**	**0.39 [0.21, 0.73]**
Total events	15		36			

Heterogeneity: Chi² = 5.47, df = 3 (P = 0.14); I² = 45%
Test for overall effect: Z = 2.99 (P = 0.003)



E The forest plot for the incidence of respiratory infection

Optiflow mucociliary clearance



Adapted from Hasani 2008

Conclusions

- L'oxygène est un médicament !
- Il faut bien choisir la modalité d'administration selon le degré d'hypoxémie
- Attention à la précision et à la dilution de l'oxygène
- Normes SpO2 : 94-97% et 88-92% chez le BPCO
- Stop aux humidificateurs de type « Aquapacks »