Oxygénation apnéique

Congrès REAGSO
Gruissan
7 octobre 2023 11h45-12h05

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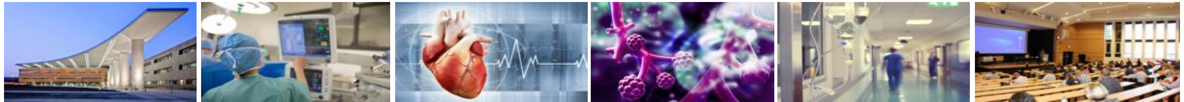

Liens d’intérêts

Dräger (Projets de Recherche, Simulation, Enseignement)
General Electrics (Projets de Recherche)
Fisher & Paykel (Enseignement, Symposium)

Fresenius Kabi (Conférence, Projets de Recherche)
LFB (Enseignement, Projets de Recherche)

MSD (Conférence)
AOP (Projets de Recherche, Conférence)

Edwards Lifescience (Projets de Recherche, Consulting)
Baxter (Conférence, Projets de Recherche)
Smith Medical (Enseignement)

Oxygénation apnéique

Un peu d'histoire…

passes through the respiratory capillaries. As this reduced hemoglobin is oxygenated, oxygen is removed from the respiratory spaces with the result that both the total barometric pressure and the oxygen partial pressure within the alveoli tend to fall below those of the atmosphere at the glottis. The above sequence of events is, of course, independent of the respiratory movements and continues during apnea as long as the

*Presented before the Twenty-Third Annual Congress of Anesthetists, Joint Session of the

A SCHEMATIC DIAGRAM of this physiologic mechanism is presented in figure 1. The manner of its action is as follows: As long as the blood is circulating, a constant stream of reduced hemoglobin passes through the respiratory capillaries. As this reduced hemoglobin is oxygenated, oxygen is removed from the respirator

Draper WB *et al*. *Curr Res Anesth Analg*. 1949; 28(6):307-18

Oxygénation apnéique

Définition

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*Presented before the Twenty-Third Annual Congress of Anesthetists, Joint Session of the

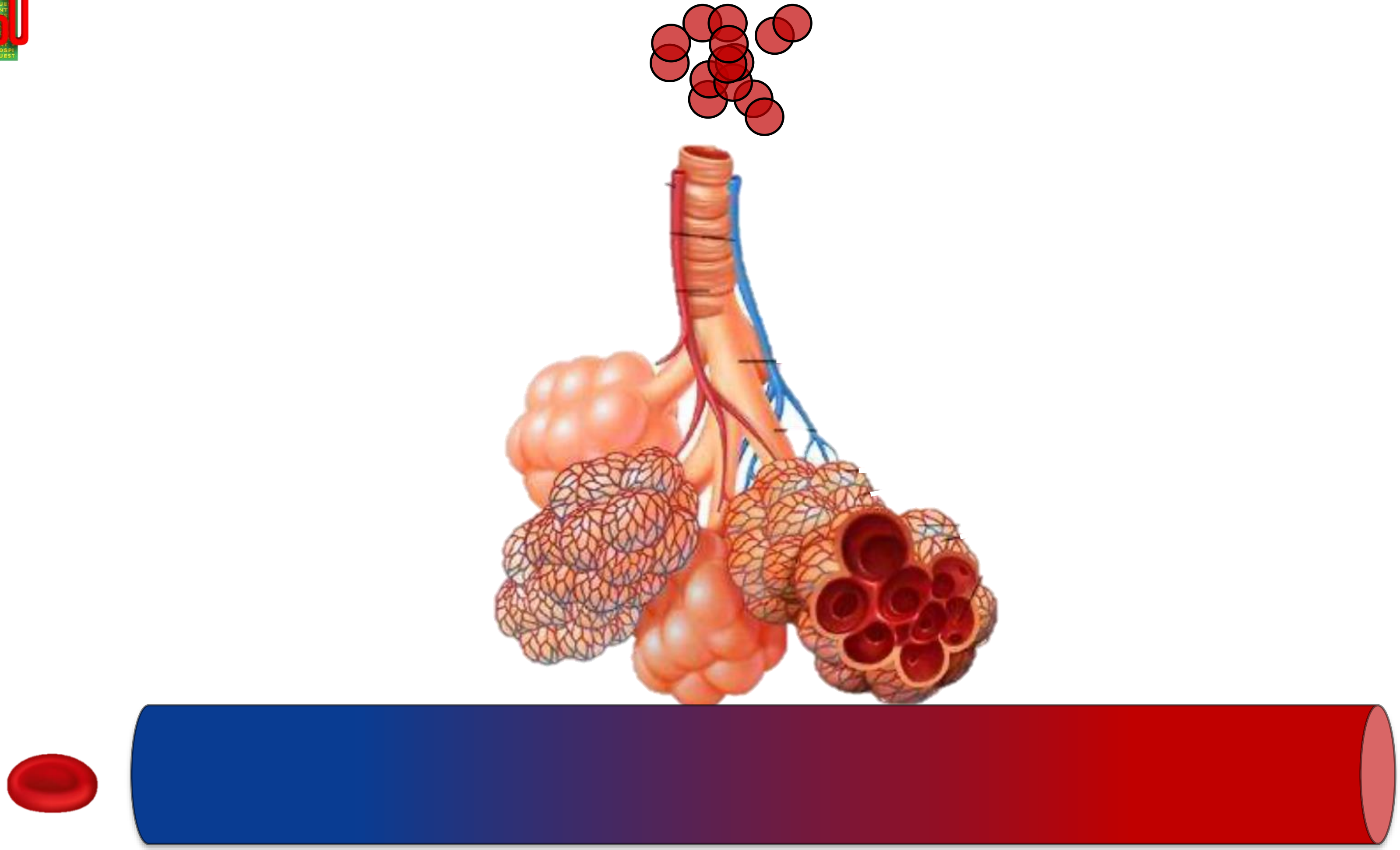
The Phenomenon of Diffusion Respiration.*

lliam B. Draper, M.Sc., M.D. and Richard W. Whitehead, M.A.,
Denver, Colo.
Department of Physiology and Pharmacology,
University of Colorado Medical Center

DIFFUSION RESPIRATION differs from the other forms of respiration in the fact that gas exchange b the atmosphere and the lung alveoli takes place in the a of respiratory movements of the chest and without in tion of any sort of artificial respiration. The phen been elaborated in several papers from this laboratory.[1 2] energy responsible for the flow of atmosphere inward tow during diffusion respiration is furnished by the body itself. fore, a form of natural respiration and should not be confus 'respiration without respiratory movements" described by

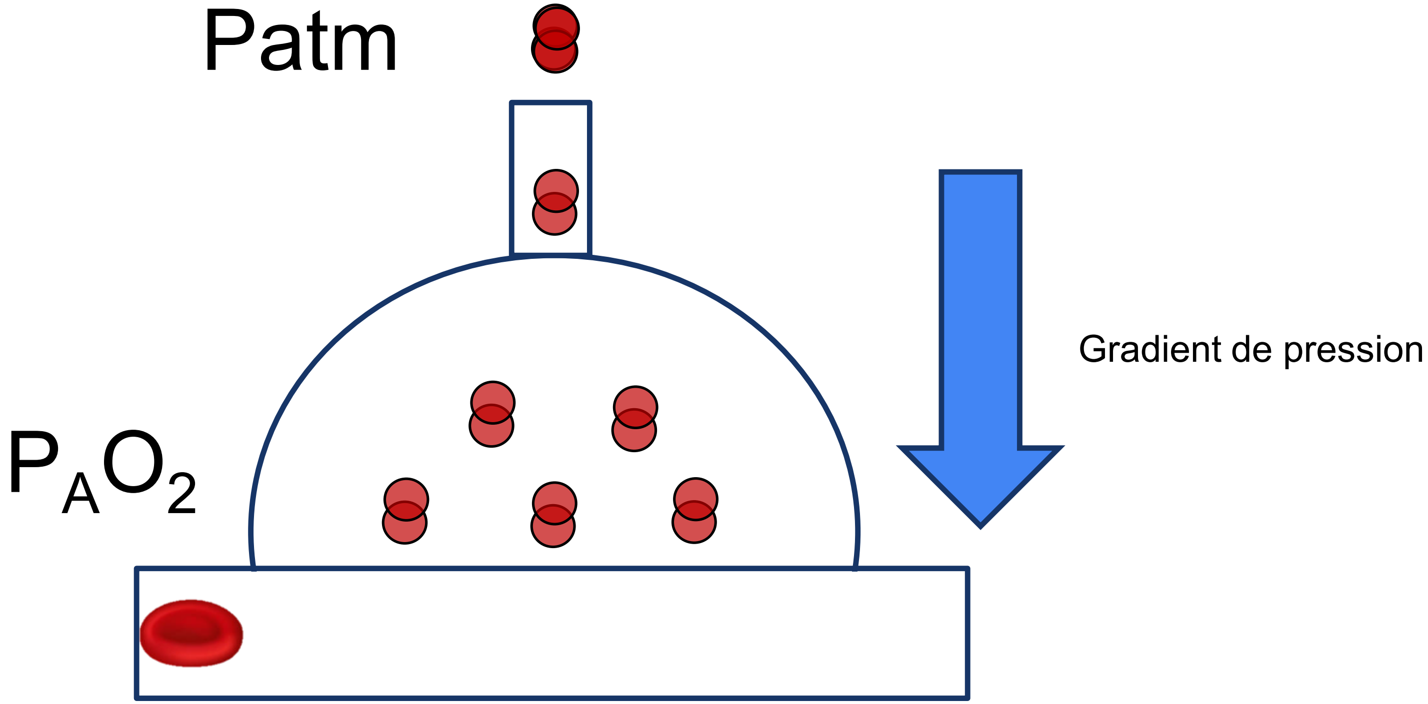
Draper WB *et al*. *Curr Res Anesth Analg*. 1949; 28(6):307-18

Oxygénation apnéique



Oxygénation apnéique

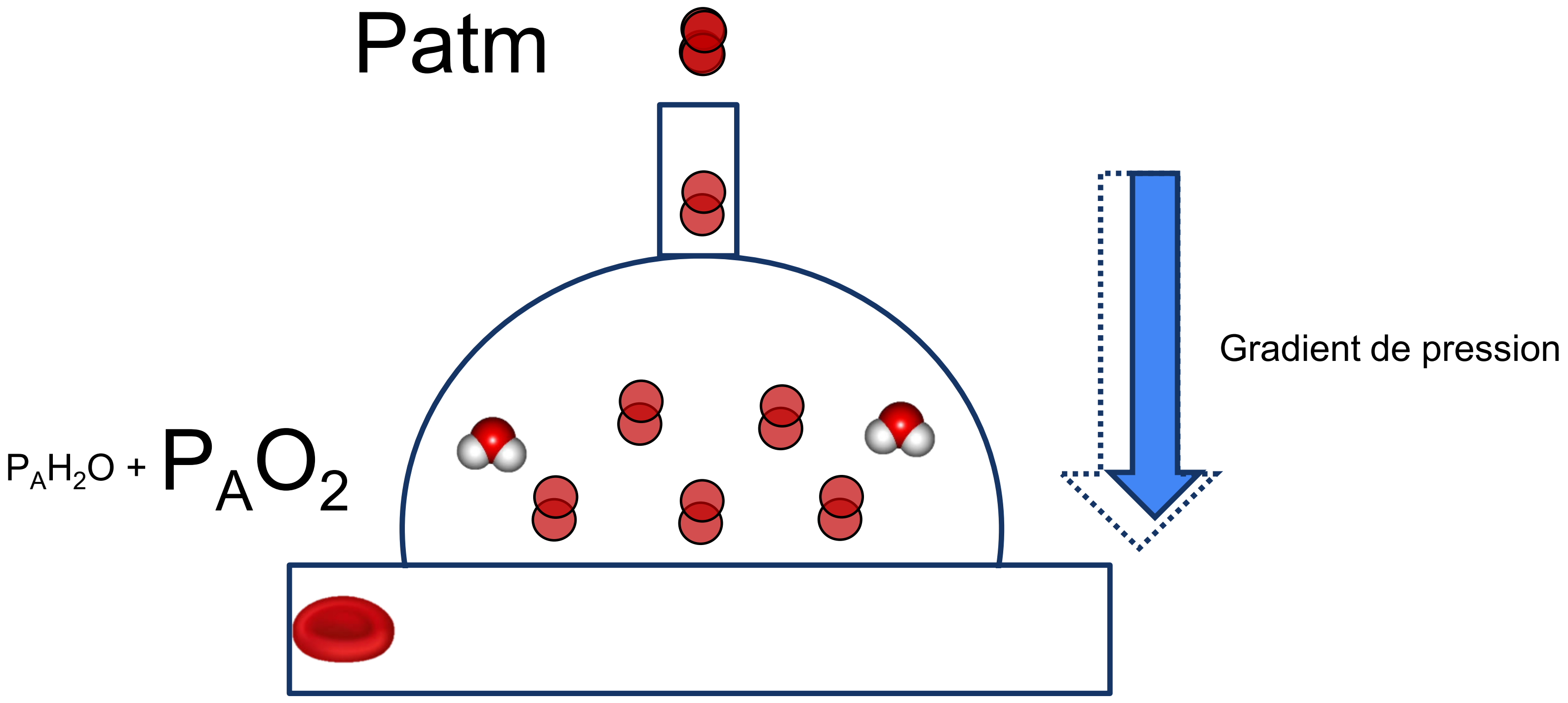
Mécanisme



Consommation en O_2

VO_2 = 200-250 mL.min^{-1}

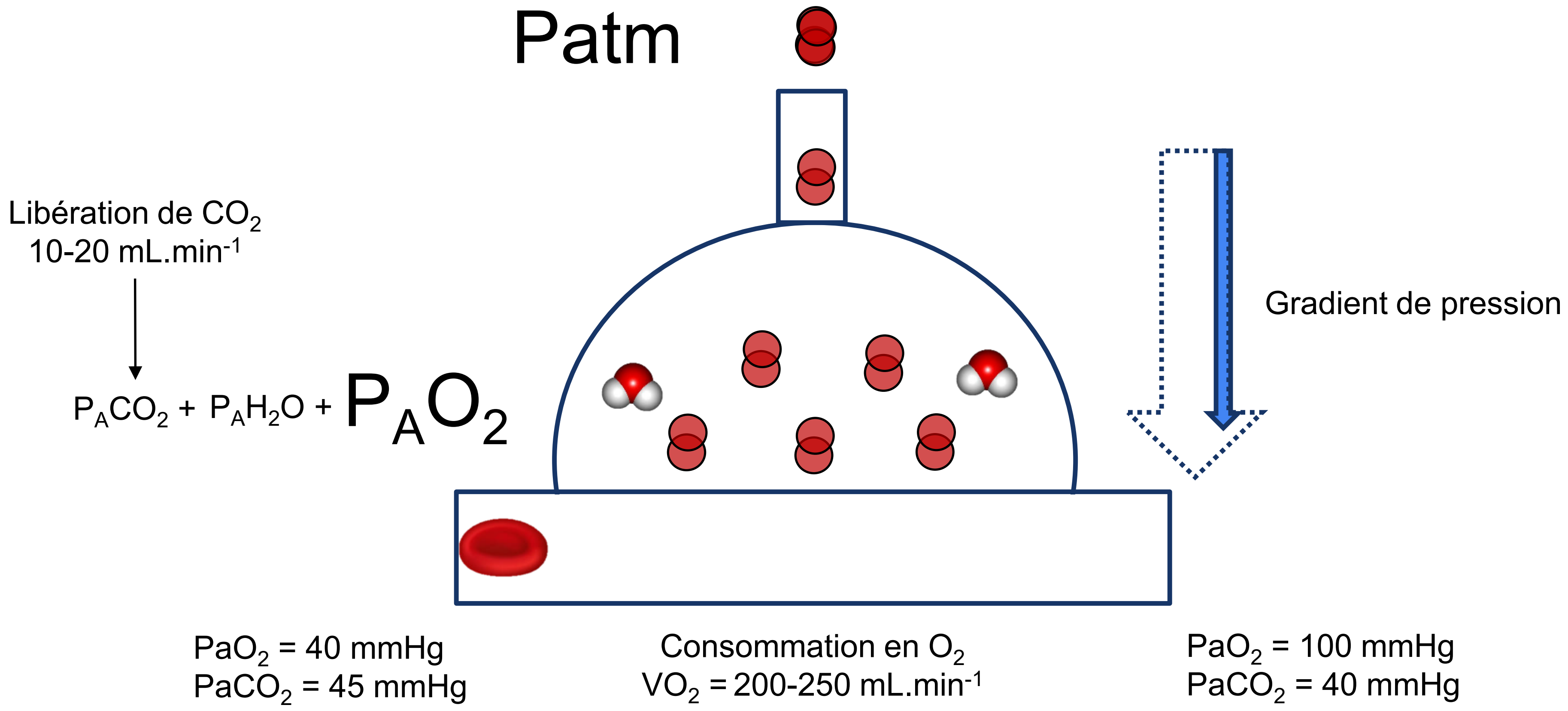
Oxygénation apnéique
Mécanisme



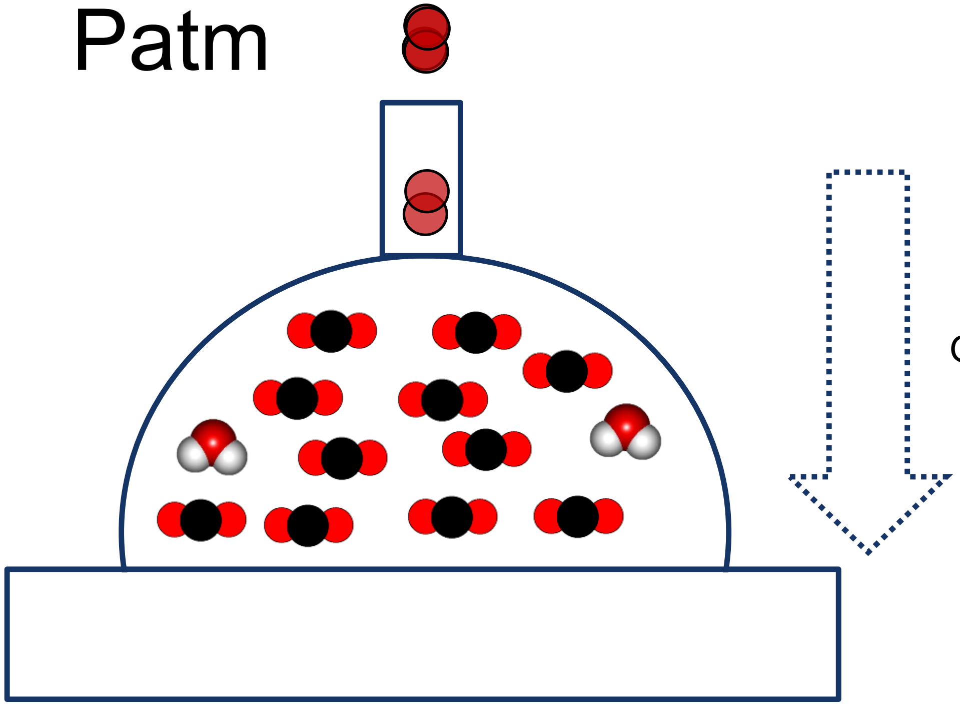
Consommation en O_2
VO_2 = 200-250 mL.min^{-1}

Oxygénation apnéique

Mécanisme



Oxygénation apnéique
Mécanisme



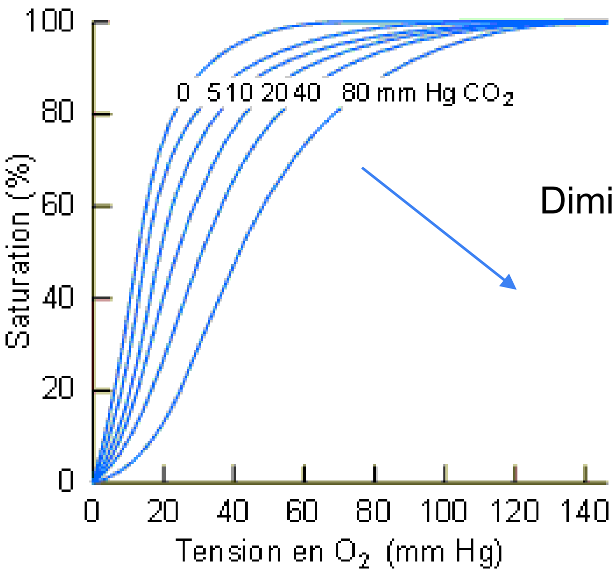
Libération de CO_2
10-20 $mL.min^{-1}$

$P_ACO_2 + P_AH_2O + P_AO_2$

Consommation en O_2
VO_2 = 200-250 $mL.min^{-1}$

Oxygénation apnéique
Définition

Effet BOHR



Diminution de l'affinité de l'Hgb pour l'O_2

=

Moins de captation

⇓

Hypoxémie

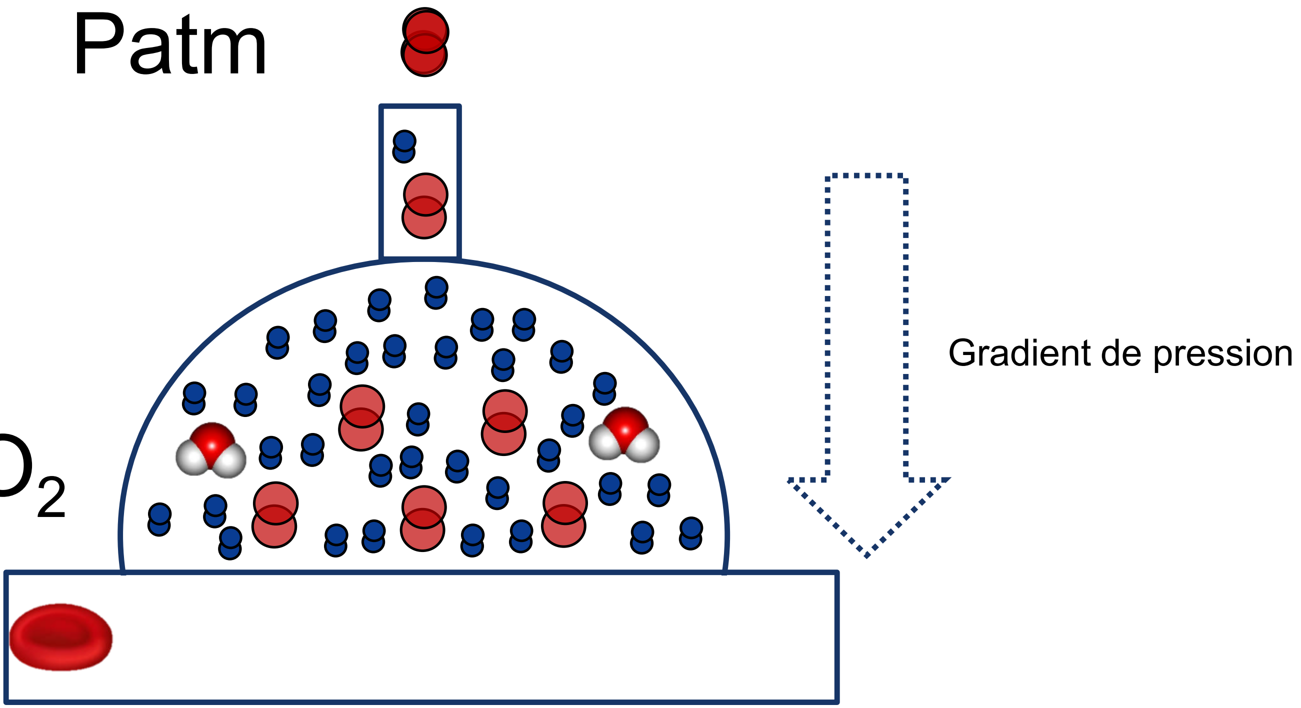
Désaturation

Oxygénation apnéique

Mécanisme

Libération de CO_2
10-20 $mL.min^{-1}$

$P_ACO_2 + P_AH_2O + P_AO_2$
+
P_AN_2



Consommation en O_2
$VO_2 = 200\text{-}250\ mL.min^{-1}$

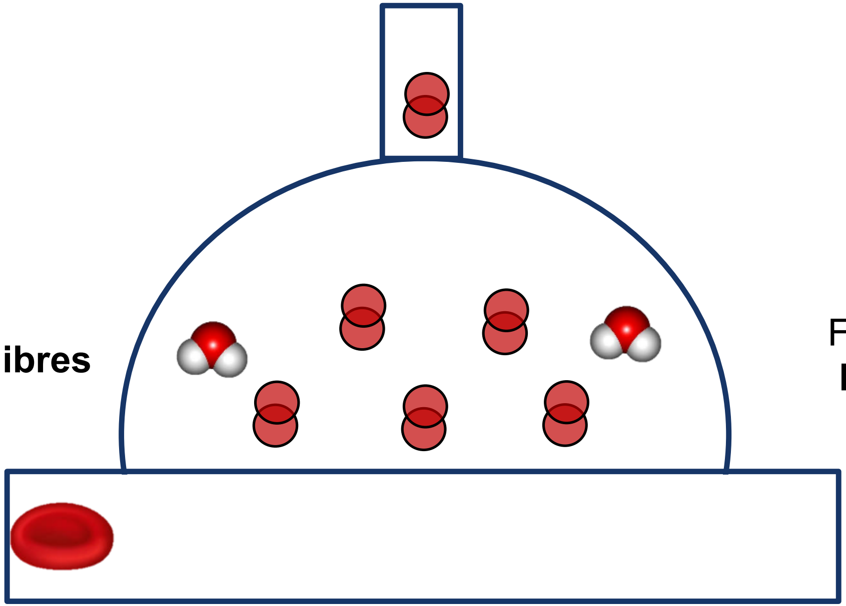
Oxygénation apnéique

Mécanisme

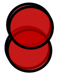
Voies aériennes supérieures libres

Voies aériennes inférieures libres
Alvéoles non collabées

Perfusion capillaire pulmonaire efficace



FiO_2 = 100%
Apport constant



Patm ↑

~~P_AN_2~~

FeO_2 élevée (> 80-90%)
Post pré-oxygénation

Oxygénation apnéique

Mécanisme

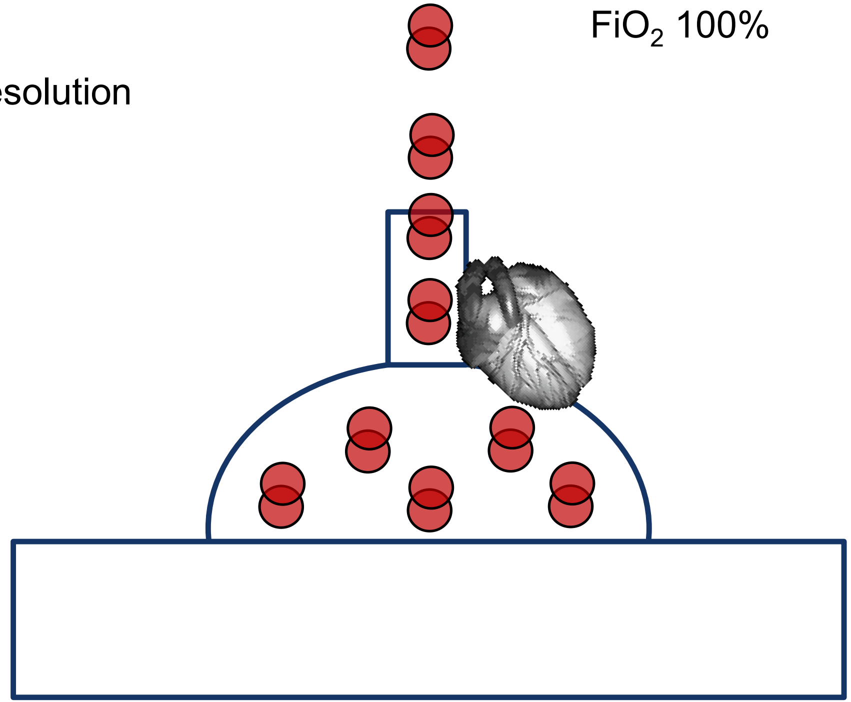
Traceur radioactif
Gamma caméra

Möller *et al.* J Appl Phys 2015 118(12):1525-32

Oxygénation apnéique
Mécanisme

200 patients intubés
Apnée au réveil
Analyseur de débit à haute résolution
Aventilatory mass flow
23 signaux exploitables

FiO_2 100%



FeO_2 élevée
> 80-90%

135 +/- 32 $mL.min^{-1}$
Oscillations rapides = FC

Rudlof B *et al.* Anaesthesist. 2010;59(5):401-9

Oxygénation apnéique

Est-ce que ça marche?

stances such as in bronchoscopy, result in

Accepted for publication June 25, 1959; presented at the Annual Meeting of the American

pression of the reservoir
apparatus. In the first pa
30 minute exposure to 100

8 patients intubés
Dénitrogénés
Apnée sous AG
O_2 sur sonde

Apnea was allowed to persist for the desired period, usually between 30–55 minutes. The bag was observed visually or manually for any sign of spontaneous respiration. When movement was observed, more muscle relaxant was given intravenously. The usual fractional dose

mined by the technique of Cohen and Golde berg.[13, 14] The arterial plasma sodium an potassium levels were obtained by flame pho tometry using an internal standard Baird ap paratus. The arterial pressure was determine by auscultation and the mean arterial pressur

$PaCO_2$
$+ 3$ mmHg.min^{-1}

18-55 min

pH

$PaCO_2$

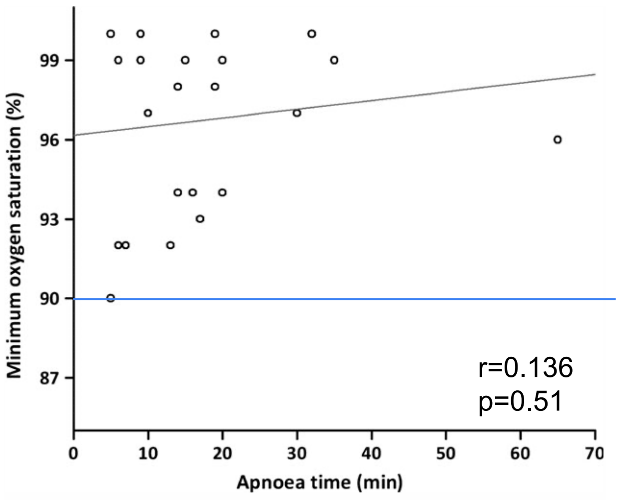
Frumin MJ *et al.* Anesthesiology 1959;20:789-98

Oxygénation apnéique
Est-ce que ça marche?

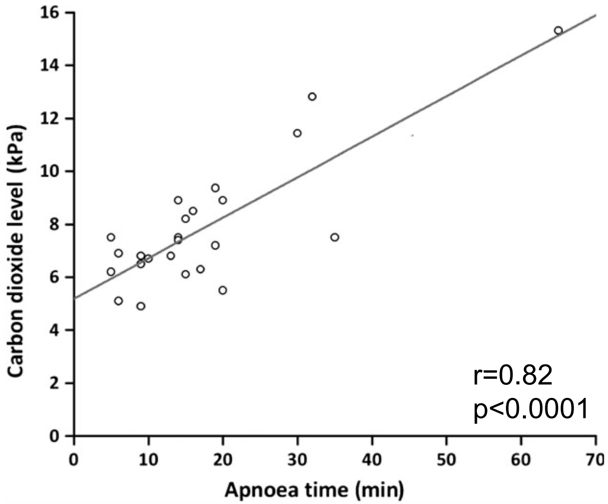
Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways

A. Patel[1,2] and S. A. R. Nouraei[3]

25 patients
Pré-oxygénation
Intubation difficile
ONHD humidifié et réchauffé
Maintien pendant la laryngoscopie
Subluxation mandibulaire
12 BMI > 30 $kg.m^{-2}$



$$CO_2 = (5.2 \pm 0.5) + (0.15 \pm 0.02) \times \text{apnoea time.}$$



Patel A *et al.* Anaesthesia 2015;70:323-329

Oxygénation apnéique

Indications

Pendant la laryngoscopie

Intubation difficile prévue (ou non?)

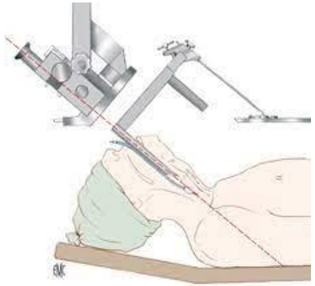
Haut risque de désaturation

Pendant les sédations procédurales

ORL - CMF

Endoscopies digestives

Fibroscopie pulmonaires



Oxygénation apnéique

Laryngoscopie

High-Flow Nasal Cannula for Apneic Oxygenation in Obese Patients for Elective Surgery: A Systematic Review and Meta-Analysis

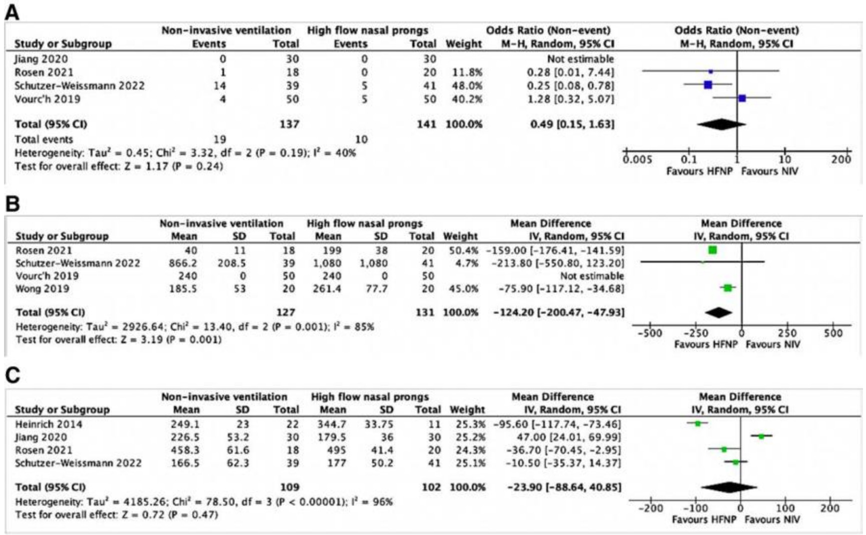
Matthew R. Bright, MD,*† William A. Harley, MD,†‡ Gina Velli, MInfoMgt,§
Syeda Farah Zahir, PhD,‖ and Victoria Eley, PhD*†

6 RCT
351 patients
BMI > 30 kg.m^{-2}

SpO_2 < 92%

Temps apnée sans désaturation

PaO_2



Bright MR *et al.* Anesth Analg. 2023 1;136(3):483-493

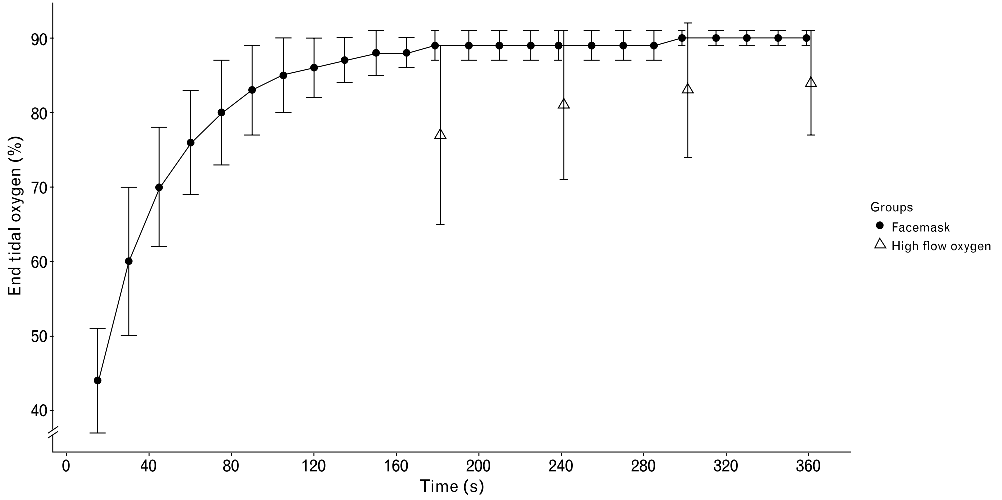
Oxygénation apnéique
Pré-oxygénation

Comparison of pre-oxygenation using spontaneous breathing through face mask and high-flow nasal oxygen

A randomised controlled crossover study in healthy volunteers

Jean-Luc Hanouz, David Lhermitte, Jean-Louis Gérard and Marc Olivier Fischer

50 volontaires sains
Cross-over



	Face mask group ($n = 50$)	High-flow nasal oxygen group ($n = 50$)	*P*
ETO_2 at 3 min	89 (2)	77 (12)	<0.001
ETO_2 at 4 min	89 (2)	81 (10)	<0.001
ETO_2 at 5 min	90 (1)	83 (9)*	<0.001
ETO_2 at 6 min	90 (1)	84 (7)*	<0.001

Hanouz JL *et al.* Eur J Anaesthesiol. 2019 36(5):335-34

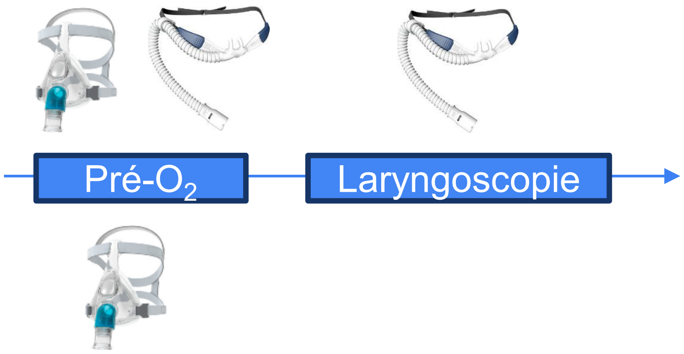
Oxygénation apnéique

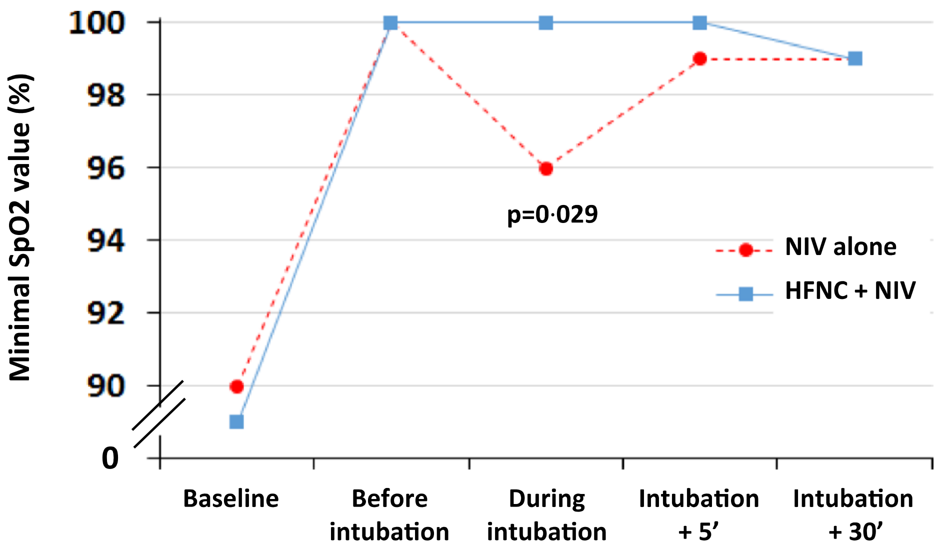
« Pré-oxygénation »

Apnoeic oxygenation via high-flow nasal cannula oxygen combined with non-invasive ventilation preoxygenation for intubation in hypoxaemic patients in the intensive care unit: the single-centre, blinded, randomised controlled OPTINIV trial

Samir Jaber[1,2*], Marion Monnin[1], Mehdi Girard[1], Matthieu Conseil[1], Moussa Cisse[1], Julie Carr[1], Martin Mahul[1], Jean Marc Delay[1], Fouad Belafia[1], Gérald Chanques[1,2], Nicolas Molinari[3] and Audrey De Jong[1,2]

RCT
49 patients hypoxémiques
ICU

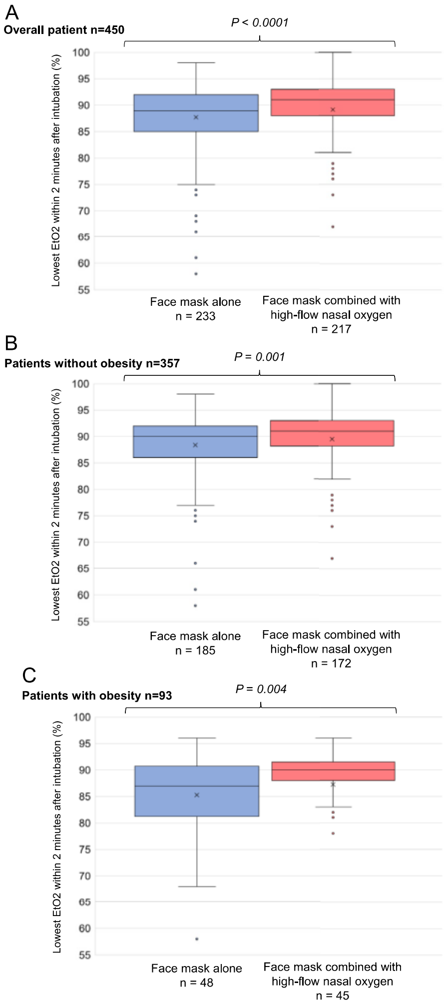




Jaber S *et al.* Intensive Care Med. 2016 42:1877-1887

Oxygénation apnéique

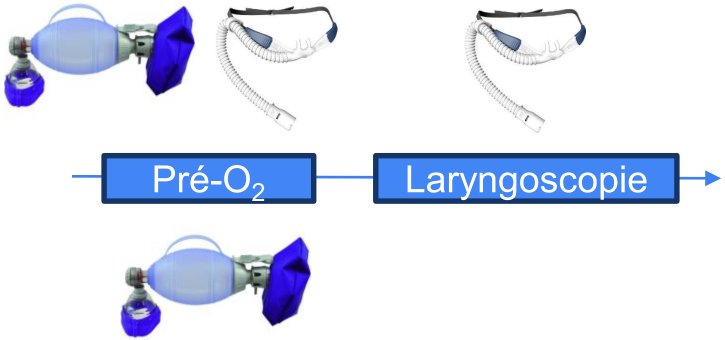
« Pré-oxygénation »

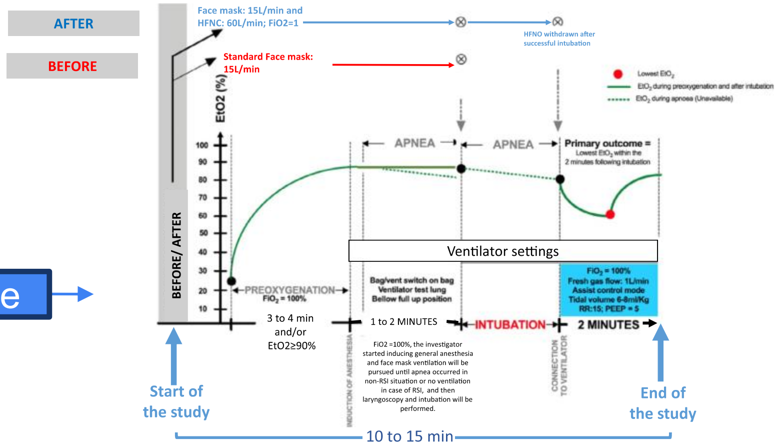


Preoxygenation with standard facemask combining apnoeic oxygenation using high flow nasal cannula versuss standard facemask alone in patients with and without obesity: the OPTIMASK international study

Samir Jaber[1,2*], Audrey De Jong[1,2], Maximilian S. Schaefer[3], Jiaqiang Zhang[4], Xiaowen Ma[5], Xinrui Hao[4], Shujing Zhou[5], Shang Lv[4], Valerie Banner-Goodspeed[3], Xiuhua Niu[6], Thomas Sfara[1,2] and Daniel Talmor[3]

Avant-après
450 patients
OR



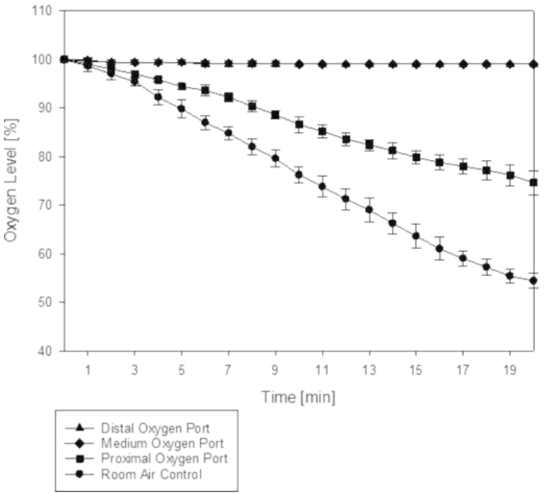


Jaber S *et al.* Annals of Intensive Care. 2023 13:26

Oxygénation apnéique
Laryngoscopie

The efficacy of apneic oxygenation during intubation using a prototype of an oxygenation laryngoscope - a technical simulation

Wolfgang A Wetsch[1,2*], Daniel C Schroeder[1,3], Susanne J Herff[1], Bernd W Böttiger[1,2], Volker Wenzel[4,5] and Holger Herff[1,2,6]



Wetsch WA, *et al.* BMC Anesthesiol. 2023 14;23(1):273

Oxygénation apnéique
Sédations procédurales

Acute sedation-associated complications in GI endoscopy (ProSed 2 Study): results from the prospective multicentre electronic registry of sedation-associated complications

Etude prospective (registre)
39 centres allemands
2011-2014
369206 endoscopies

Table 2 Type and frequency of minor complications

Type of minor complication	n	% relative to all minor complications (1.019)
Respiratory depression	338	33.17
Restlessness/difficult sedation	95	9.32
Aspiration event	71	6.97
Cardiac dysrhythmia (except bradycardia)	101	9.91
Hypotension	127	12.46
Vomiting	54	5.30
Laryngospasm	24	2.35
Sedation hangover	12	1.18
Bradycardia	20	1.96
Cramping	17	1.67
Extravasation	17	1.67
Paradoxical reaction	9	0.88
Allergic reactions	8	0.79
Nosebleed	5	0.49
Fall after mobilisation following endoscopy	1	0.10
Not specified	120	11.78
Total	1019	100

Behrens A, *et al.* Gut 2019 68;445-452

Oxygénation apnéique

Sédations procédurales

High-flow nasal oxygenation during gastrointestinal endoscopy. Systematic review and meta-analysis

Michele Carron[1,*], Enrico Tamburini[1], Bijan Safaee Fakhr[1], Alessandro De Cassai[2], Federico Linassi[3] and Paolo Navalesi[1]

Table 1 Characteristics of studies considered for review and meta-analysis. Data and P-values are from recent studies.[9–14]

Study (yr)	Procedure	Anaesthetic drugs	Population (COT/HFNO)	COT	HFNO
Teng and colleagues[9] (2019)	OGDS	Propofol (TCI), midazolam, alfentanil	General (51/50)	5 L min^{-1} NC	100% FiO_2 flow rate 30 L min^{-1}
Lin and colleagues[10] (2019)	Gastroscopy	Propofol (push strategy)	General (1000/994)	2 L min^{-1} NC	100% FiO_2 flow rate 60 L min^{-1}
Riccio and colleagues[11] (2019)	Elective colonoscopy	Propofol	Obese (31/28)	4 L min^{-1} NC	36–40% FiO_2 flow rate 60 L min^{-1}
Nay and colleagues[12] (2021)	Gastrointestinal endoscopy (upper, lower, both)	Propofol, midazolam, opioids, ketamine,	General (188/191)	0.50 FiO_2 NC or mask	50% FiO_2 flow rate 70 L min^{-1}
Kim and colleagues[13] (2021)	ERCP (prone position)	Propofol, midazolam	General (36/36)	5 L min^{-1} NC	100% FiO_2 flow rate 50 L min^{-1}
Mazzeffi and colleagues[14] (2021)	OGDS	Propofol, midazolam, fentanyl	General (130/132)	6 L min^{-1} NC	100% FiO_2 flow rate 20 L min^{-1}

Carron M,*et al.* BJA Open 2022 4(C);100098

Oxygénation apnéique
Sédations procédurales

High-flow nasal oxygenation during gastrointestinal endoscopy. Systematic review and meta-analysis

Michele Carron[1,*], Enrico Tamburini[1], Bijan Safaee Fakhr[1], Alessandro De Cassai[2], Federico Linassi[3] and Paolo Navalesi[1]

Table 3 Incidence of hypoxic events, rescue treatment, procedure interruption, and adverse events.

General population of patients*	**HFNO *n/N* (%)**	**COT n/N (%)**
Hypoxic events [9–14]	74/1431 (5.2)	391/1436 (27.2)
-hypoxic events (SpO_2 <90%) [9–13]	23/1299 (1.8)	165/1306 (12.6)
Hypoxic events with HFNO ≥40 L min^{-1} [10–13]	45/1249 (3.6)	337/1255 (26.9)
Hypoxic events with HFNO <40 L min^{-1} [9–14]	29/182 (15.9)	54/181(29.8)
Non-obese patients		
Hypoxic events [9,10,12,13]	27/1216 (2.2)	309/1226 (25.2)
-hypoxic events (SpO_2 <90%) [9,10,12,13]	5/1216 (0.4)	132/1226 (10.8)
Rescue treatment [9,10,13]	9/1080 (0.8)	358/1087 (32.9)
-minor rescue treatment [10,13]	8/1030 (0.8)	346/1036 (33.4)
-major rescue treatment [10,13]	0/1030 (0.0)	3/1036 (0.3)
Total adverse events [9,10]	101/1044 (9.7)	145/1051 (13.8)
-respiratory non-hypoxaemic events [9,10]	47/1044 (4.5)	48/1051 (4.6)
-cardiovascular events [9,10]	37/1044 (3.5)	48/1051 (4.6)
Obese patients		
Hypoxic events [11,12]	19/83 (22.9)	39/90 (43.3)
-hypoxic events (SpO_2 <90%) [11,12]	18/83 (21.7)	33/90 (36.7)

Carron M,*et al.* BJA Open 2022 4(C);100098

Oxygénation apnéique

Sédations procédurales

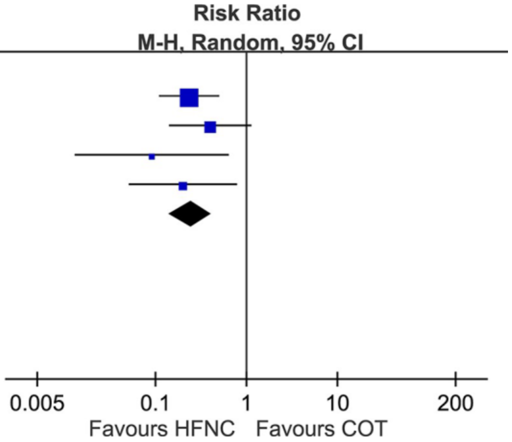
High-flow nasal cannula for reducing hypoxemic events in patients undergoing bronchoscopy: A systematic review and meta-analysis of randomized trials

Chien-Ling Su[1,2]☯, Ling-Ling Chiang[1]☯, Ka-Wai Tam[3,4,5]☯, Tzu-Tao Chen[1]*, Ming-Chi Hu[1]*

Study or Subgroup	HFNC Events	HFNC Total	COT Events	COT Total	Weight	Risk Ratio M-H, Random, 95% CI
2.1.1 Incidence of hypoxemic events during bronchoscopy						
Ben-Menachem 2020	6	37	27	39	50.1%	0.23 [0.11, 0.50]
Douglas 2018	4	30	10	30	26.7%	0.40 [0.14, 1.14]
Irfan 2020	1	20	11	20	7.6%	0.09 [0.01, 0.64]
Longhini 2021	2	18	10	18	15.5%	0.20 [0.05, 0.79]
Subtotal (95% CI)		**105**		**107**	**100.0%**	**0.25 [0.14, 0.42]**
Total events	13		58			

Heterogeneity: Tau² = 0.00; Chi² = 1.99, df = 3 (P = 0.57); I² = 0%

Test for overall effect: Z = 5.11 (P < 0.00001)



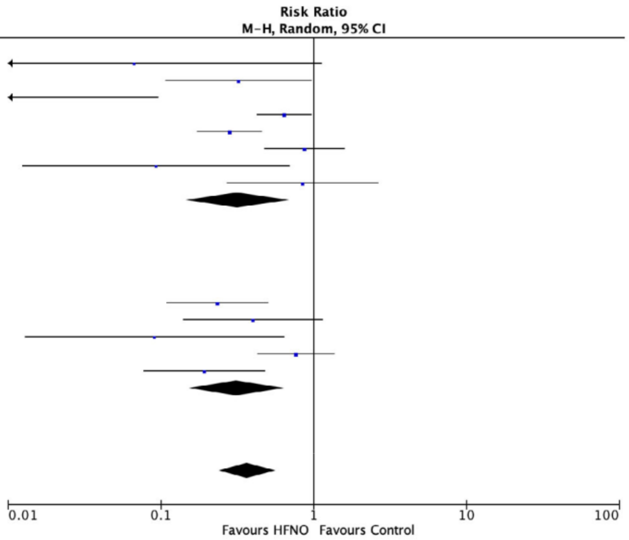
Su C-L, *et al.* PLOS One 2021 16(12); e0260716

Oxygénation apnéique
Sédations procédurales

Effect of high-flow nasal oxygen on hypoxaemia during procedural sedation: a systematic review and meta-analysis

V. Thiruvenkatarajan,[1,2] V. Sekhar,[3] D. T. Wong,[4] J. Currie,[5] R. Van Wijk[2,6] and G. L. Ludbrook[7]

Study or Subgroup	HFNO Events	HFNO Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
1.1.1 Gastrointestinal						
Kim [34]	0	36	7	36	1.9%	0.07 [0.00, 1.13]
Lee [22]	4	95	12	92	6.0%	0.32 [0.11, 0.96]
Lin [12]	0	994	84	1000	1.9%	0.01 [0.00, 0.10]
Mazzeffi [8]	28	132	43	130	9.1%	0.64 [0.43, 0.97]
Nay [9]	18	191	63	188	8.8%	0.28 [0.17, 0.46]
Riccio [35]	11	28	14	31	8.3%	0.87 [0.48, 1.59]
Teng [36]	1	50	11	51	3.1%	0.09 [0.01, 0.69]
Thiruvenkatarajan [37]	5	65	6	66	5.8%	0.85 [0.27, 2.64]
Subtotal (95% CI)		**1591**		**1594**	**45.0%**	**0.32 [0.15, 0.70]**
Total events	67		240			
Heterogeneity: $Tau^2 = 0.83$; $Chi^2 = 41.90$, df = 7 (P < 0.00001); $I^2 = 83\%$						
Test for overall effect: Z = 2.87 (P = 0.004)						
1.1.2 Bronchoscopy						
Ben-Menachem [11]	6	37	27	39	7.6%	0.23 [0.11, 0.50]
Douglas [38]	4	30	10	30	6.2%	0.40 [0.14, 1.14]
Irfan [39]	1	20	11	20	3.2%	0.09 [0.01, 0.64]
Sharluyan [26]	14	51	19	53	8.5%	0.77 [0.43, 1.36]
Ucar [24]	5	85	26	85	6.9%	0.19 [0.08, 0.48]
Subtotal (95% CI)		**223**		**227**	**32.4%**	**0.31 [0.15, 0.64]**
Total events	30		93			
Heterogeneity: $Tau^2 = 0.42$; $Chi^2 = 12.19$, df = 4 (P = 0.02); $I^2 = 67\%$						
Test for overall effect: Z = 3.19 (P = 0.001)						
Total (95% CI)		**2024**		**2037**	**100.0%**	**0.37 [0.24, 0.56]**
Total events	115		371			
Heterogeneity: $Tau^2 = 0.48$; $Chi^2 = 58.05$, df = 16 (P < 0.00001); $I^2 = 72\%$						
Test for overall effect: Z = 4.62 (P < 0.00001)						
Test for subgroup differences: $Chi^2 = 0.70$, df = 3 (P = 0.87), $I^2 = 0\%$						



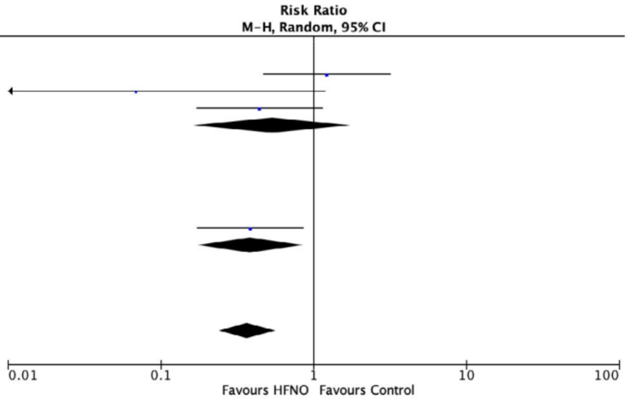
Thiruvenkatarajan V *et al.* Anaesthesia 2023 78; 81-92

Oxygénation apnéique
Sédations procédurales

Effect of high-flow nasal oxygen on hypoxaemia during procedural sedation: a systematic review and meta-analysis

V. Thiruvenkatarajan,[1,2] V. Sekhar,[3] D. T. Wong,[4] J. Currie,[5] R. Van Wijk[2,6] and G. L. Ludbrook[7]

Study or Subgroup	HFNO Events	HFNO Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
1.1.3 Cardiology						
Conway [27]	8	61	7	65	6.7%	1.22 [0.47, 3.16]
Duan [21]	0	96	7	99	1.8%	0.07 [0.00, 1.19]
Scheuermann-Jahn [Preprint]	5	35	11	34	6.7%	0.44 [0.17, 1.14]
Subtotal (95% CI)		**192**		**198**	**15.2%**	**0.53 [0.16, 1.74]**
Total events	13		25			
Heterogeneity: Tau² = 0.60; Chi² = 4.98, df = 2 (P = 0.08); I² = 60%						
Test for overall effect: Z = 1.04 (P = 0.30)						
1.1.4 Endovascular						
Vijitpavan [25]	5	18	13	18	7.4%	0.38 [0.17, 0.85]
Subtotal (95% CI)		**18**		**18**	**7.4%**	**0.38 [0.17, 0.85]**
Total events	5		13			
Heterogeneity: Not applicable						
Test for overall effect: Z = 2.35 (P = 0.02)						
Total (95% CI)		**2024**		**2037**	**100.0%**	**0.37 [0.24, 0.56]**
Total events	115		371			
Heterogeneity: Tau² = 0.48; Chi² = 58.05, df = 16 (P < 0.00001); I² = 72%						
Test for overall effect: Z = 4.62 (P < 0.00001)						
Test for subgroup differences: Chi² = 0.70, df = 3 (P = 0.87), I² = 0%						



Thiruvenkatarajan V *et al.* Anaesthesia 2023 78; 81-92

Oxygénation apnéique
Sédations procédurales

Effect of high-flow nasal oxygen on hypoxaemia during procedural sedation: a systematic review and meta-analysis

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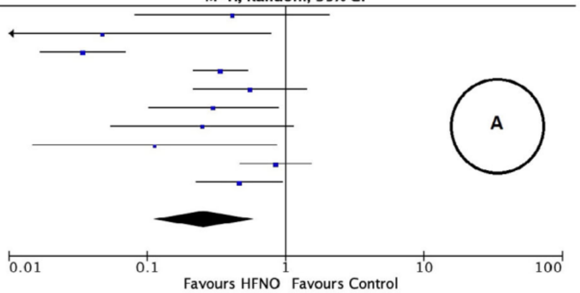
Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Duan [21]	2	96	5	99	8.7%	0.41 [0.08, 2.08]
Kim [34]	0	36	10	36	5.3%	0.05 [0.00, 0.78]
Lin [12]	8	994	235	1000	11.8%	0.03 [0.02, 0.07]
Nay [9]	21	191	61	188	12.4%	0.34 [0.22, 0.53]
Riccio [35]	5	28	10	31	11.0%	0.55 [0.22, 1.42]
Sago [23]	3	15	10	15	10.6%	0.30 [0.10, 0.88]
Sago [40]	2	20	4	10	9.0%	0.25 [0.05, 1.14]
Teng [36]	1	50	9	51	7.3%	0.11 [0.01, 0.86]
Thiruvenkatarajan [37]	15	65	18	66	12.1%	0.85 [0.47, 1.53]
Vijitpavan [25]	6	18	13	18	11.8%	0.46 [0.23, 0.94]
Total (95% CI)		**1513**		**1514**	**100.0%**	**0.26 [0.11, 0.59]**
Total events	63		375			

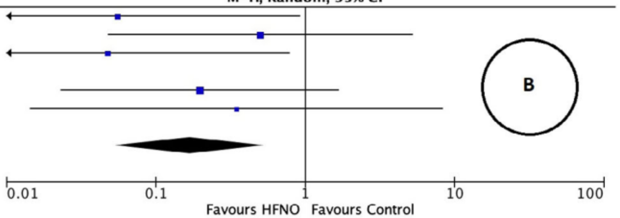
Heterogeneity: $Tau^2 = 1.42$; $Chi^2 = 74.96$, df = 9 ($P < 0.00001$); $I^2 = 88\%$
Test for overall effect: Z = 3.18 (P = 0.001)



Maneouvres de reventilation

Study or Subgroup	Experimental Events	Experimental Total	Control Events	Control Total	Weight	Risk Ratio M-H, Random, 95% CI
Ben-Menachem [11]	0	37	9	39	16.8%	0.06 [0.00, 0.92]
Douglas [38]	1	30	2	30	24.1%	0.50 [0.05, 5.22]
Kim [34]	0	36	10	36	16.9%	0.05 [0.00, 0.78]
Lee [22]	0	95	0	92		Not estimable
Nay [9]	1	191	5	188	29.0%	0.20 [0.02, 1.67]
Sharluyan [26]	0	51	1	53	13.1%	0.35 [0.01, 8.31]
Total (95% CI)		**440**		**438**	**100.0%**	**0.17 [0.05, 0.53]**
Total events	2		27			

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 2.70$, df = 4 ($P = 0.61$); $I^2 = 0\%$
Test for overall effect: Z = 3.03 (P = 0.002)



Interruption de la procédure

Thiruvenkatarajan V *et al.* Anaesthesia 2023 78; 81-92

Oxygénation apnéique

Conclusions

Mécanisme physiologique souvent méconnu

Conditions pratiques d'utilisation

FiO_2 100% - Haut-débit?
Post-pré-oxygénation
Précoce+++

Voies aériennes LIBRES+++

Indications

Laryngoscopie (difficile attendue, précarité du patient)
Sédation procédurale
Place en cas d'intubation difficile non-prévue?

MERCI POUR VOTRE ATTENTION

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