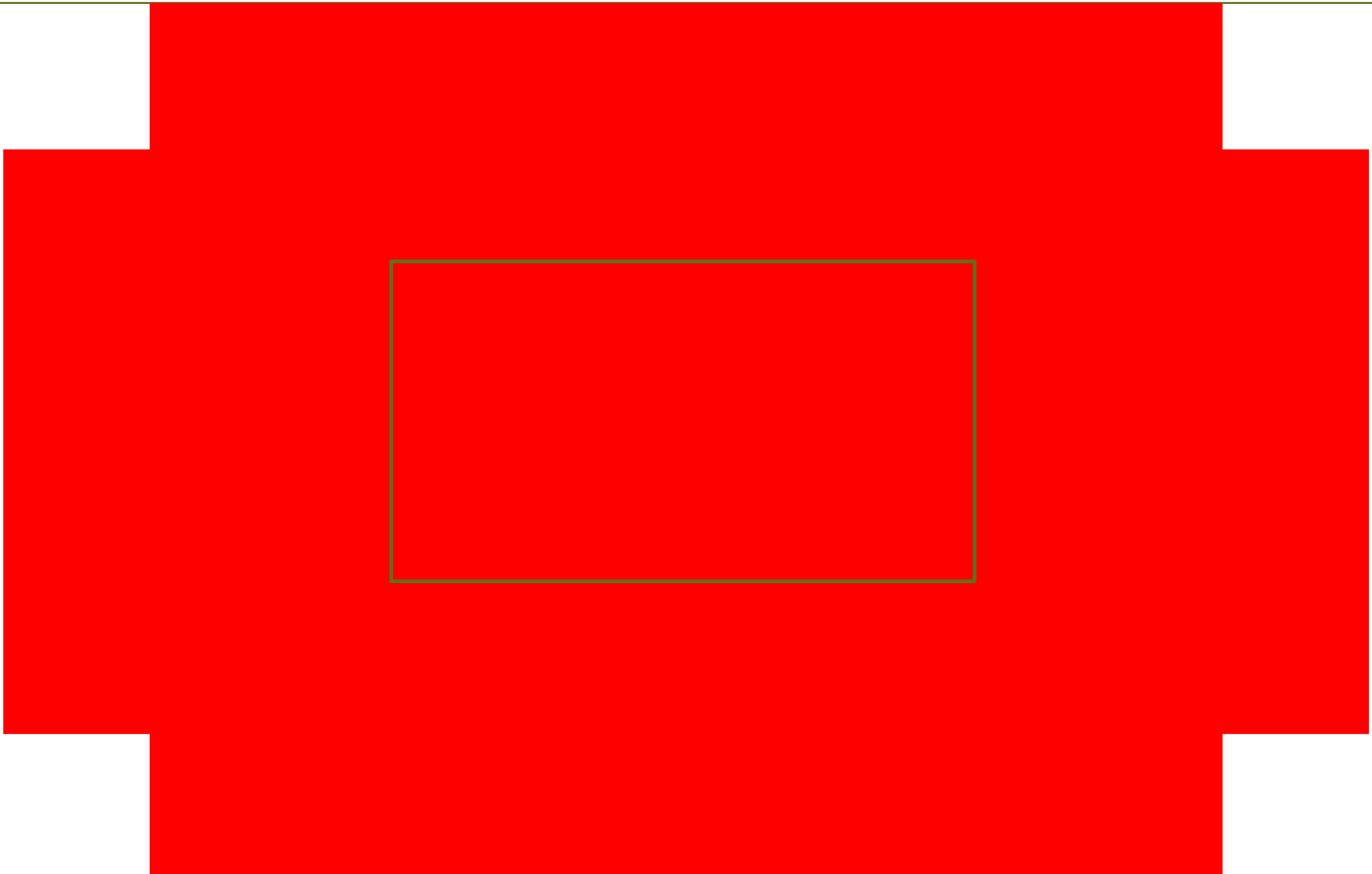


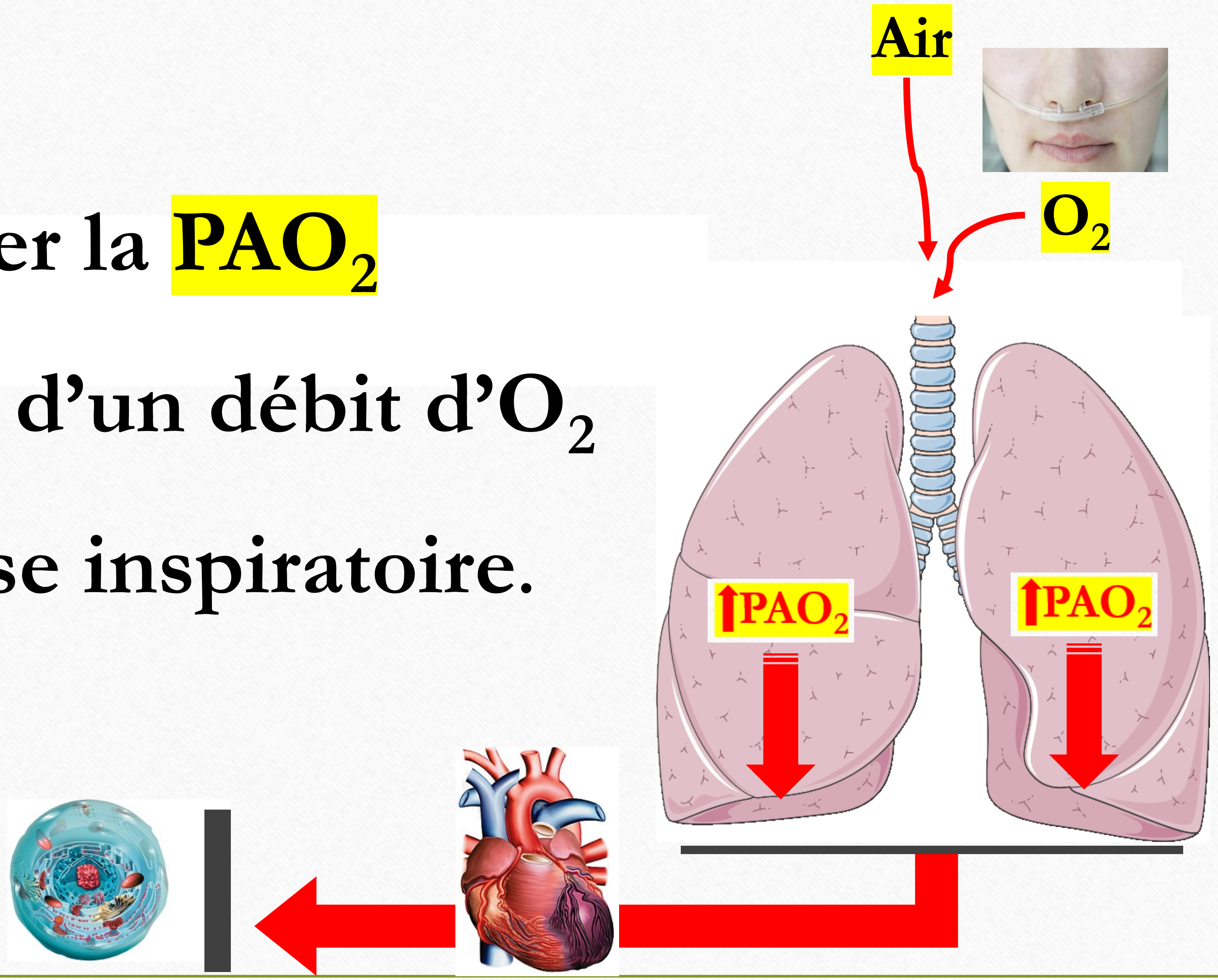
Que connaissons-nous ?

But de l’oxygénothérapie ?

Augmenter la PAO_2

par l'inhalation d'un débit d'O_2

durant la phase inspiratoire.



Indications

Hypoxémie

Mais aussi

- Choc hypovolémique (CaO$_2$…)
- Pneumothorax (réduction air cavitaire pleural)
- Intoxication CO = HYPOXIE
- Accident de décompression
- Cluster headache
- Plaies chroniques + fasciite nécrosante

Dyspnée non hypoxémiante = Pas d'~~O2~~





O'Driscoll BR,Howard LS, Earis J, et al. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax 2017;72:i1–i90.

HYPOXEMIE et HYPOXIE

Hypoxémie: diminution de la PaO_2

Hypoxie: diminution de l'apport en O_2 aux tissus

- PaO_2 <55 mmHg (hypoxie hypoxémique)
- Intox CO (diminution CaO_2)
- Demande métabolique cellulaire +++
- Ischémie relative ou absolue

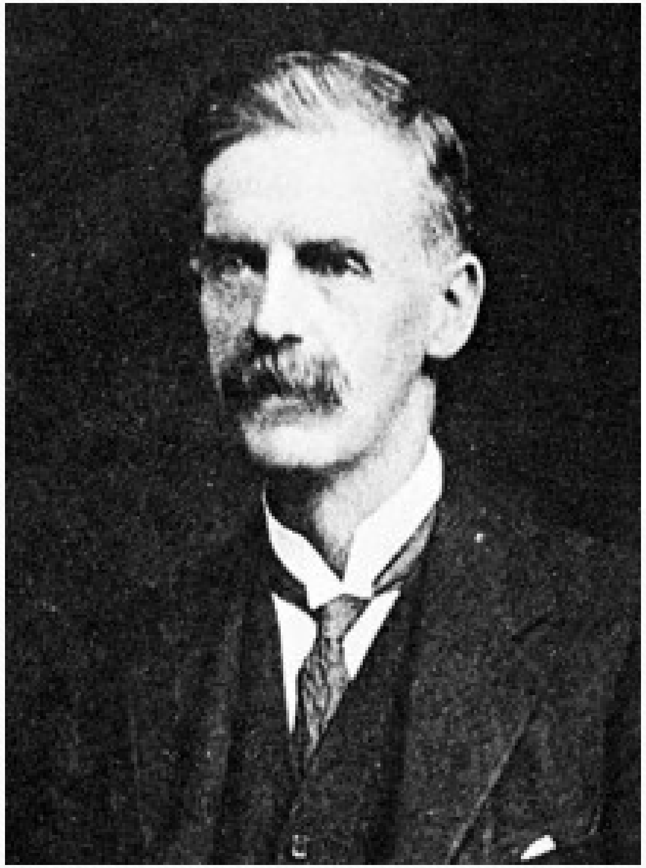
Hypoxémie: plusieurs définitions:

- $PaO_2 = 105 - (\text{âge}/2)$
- OMS: $PaO_2 < 60$ mm Hg
- Mayo clinic: $PaO_2 < 75$ mm Hg
- AARC: $PaO_2 < 80$ mm Hg
- PIF < 300 mm Hg ($PaO_2 < 63$ mm Hg)
- Définition Berlin (ARDS patient intubé)……
- Etc….

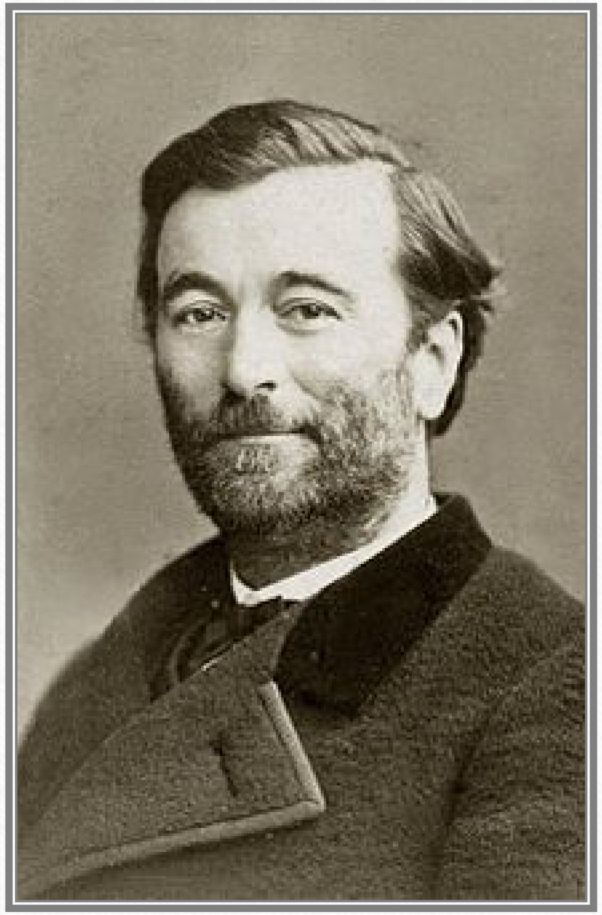
THE PATHOLOGICAL EFFECTS DUE TO INCREASE OF OXYGEN TENSION IN THE AIR BREATHED.
By J. LORRAIN SMITH, M.A., M.D.

RESPIRATION
PAUL BERT
Docteur en médecine et docteur ès sciences,
Chargé du Cours de physiologie comparée au Muséum.

HYPEROXEMIE



Lorrain Smith 1862-1931



Paul Bert 1833-1886

Hyperoxémie (mal définie, elle aussi…..)

- **Pathologistes:**

PaO_2 > **à 90 , 120 voire même 150 mm Hg**

- **Plongeurs autonomes** (civils ou militaires)

PaO_2 > **1200** mm Hg (Effet Paul Bert)

- Eastwood GM. The impact of oxygen and carbon dioxide management on outcome after cardiac arrest. Curr Opin Crit Care 2014;20(3):266-27
- Sjoberg F. The medical use of oxygen: a time for critical reappraisal. J Intern Med 2013;274(6):505-528.2

Dangers: « Hyperoxémie »

-**Effet Euler Liljestrand** **(Hypercapnie: BPCO, OHV, opiacés)**

- Vasoconstriction hyperoxémique: **SCA, AVC**

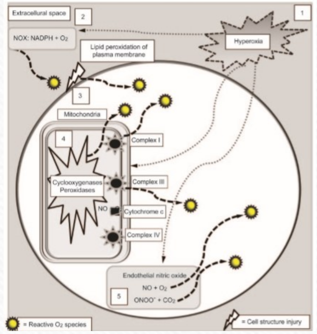
- **Diminution débit cardiaque**

- Atélectasie de dénitrogénation

- Rétinopathie des nouveaux nés prématurés (suspicion début 1950)

-Production R.O.S.= Anion superoxyde, peroxydes, hydroxyles…

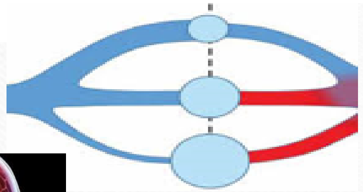
Cytotoxiques

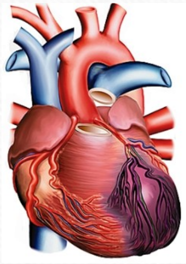


R.O.S.: Anion superoxyde O_2-, Oxygène singulet $O_2•$, Peroxyde d'hydrogène H_2O_2, Ozone O_3

Diminue NO disponible: vasoconstriction

Arythmies, mort cellulaire



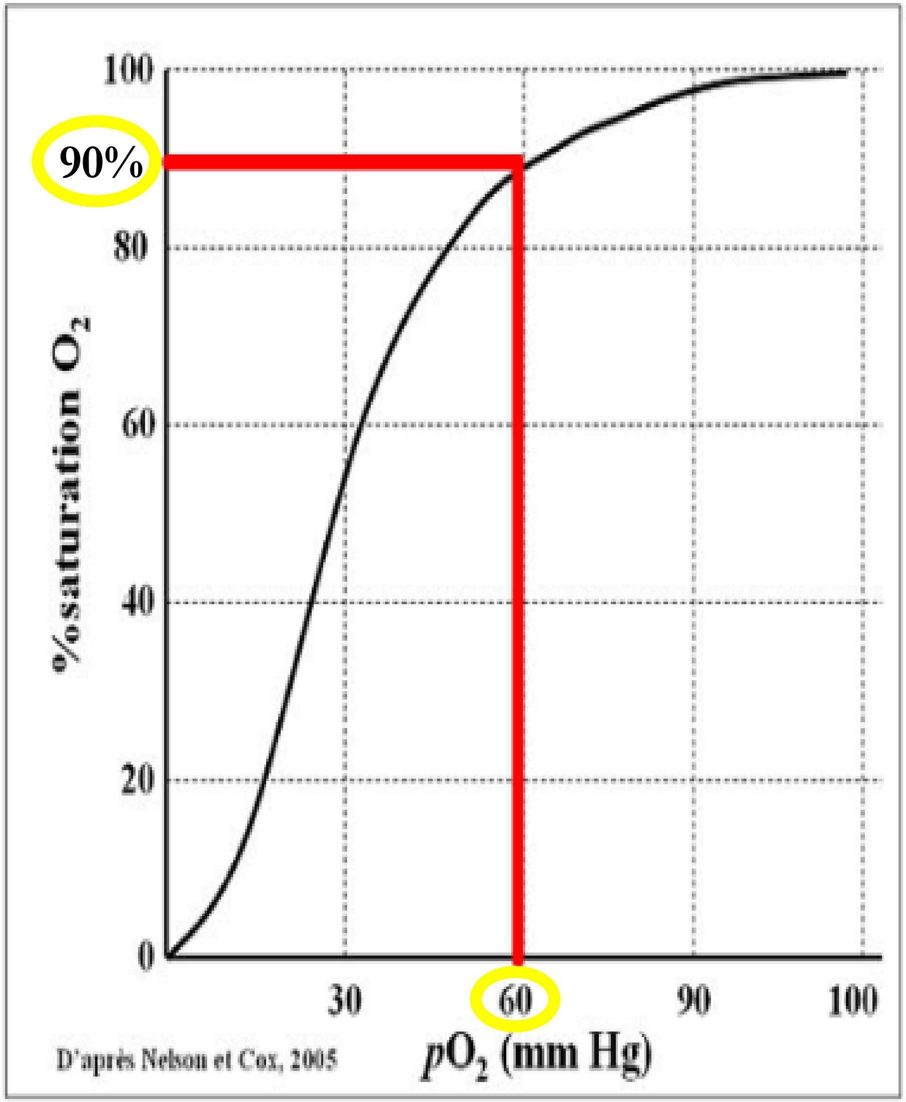


Thomson AJ, Webb DJ, Maxwell SR, Grant IS.Oxygen therapy in acute medical care. BMJ 2002;324:1406-7.
O'Driscoll BR,Howard LS, Earis J, et al. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax 2017;72:i1–i90.

Ciblage de la SpO_2 ?

BPCO: de 88 à 92 %

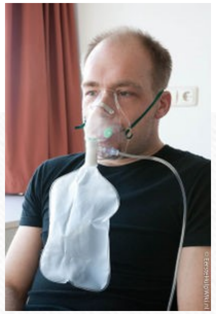
« Autres »: de 94 à 98%



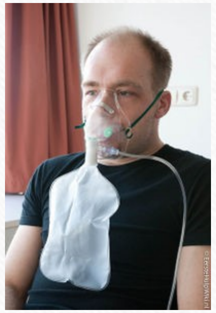
- O'Driscoll BR,Howard LS, Earis J, et al. BTS guideline for oxygen use in adults in healthcare and emergency settings. Thorax 2017;72:i1–i90.
- EPIC II conversion table 2007

Quels patients peuvent (malgré tout) recevoir massivement de l'O_2 ?

- Pneumothorax
- Choc hémorragique
- Intoxication CO + OPH….

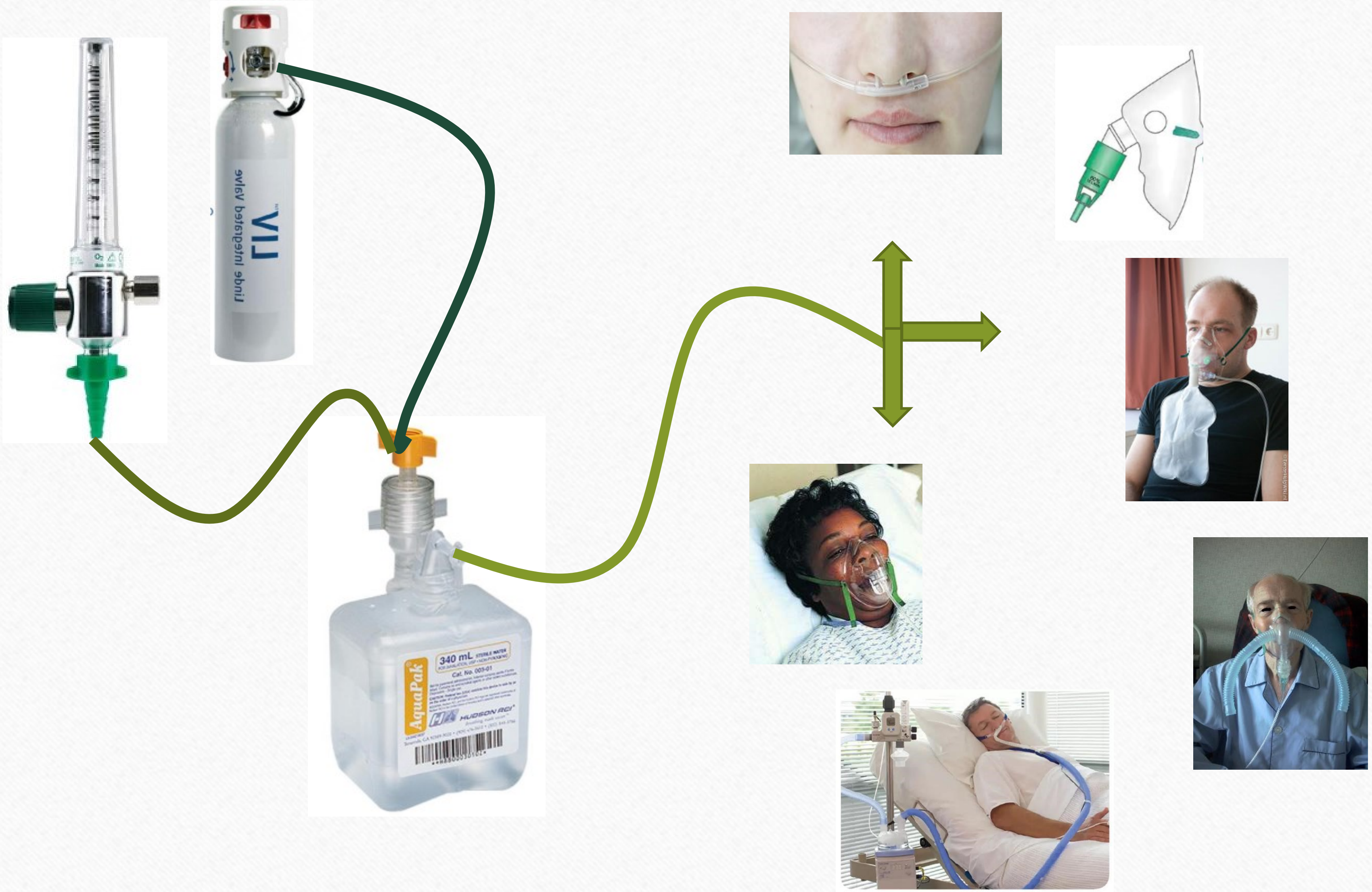


- Accident de décompression
- Embolies gazeuses
- Plaies à germes anaérobies

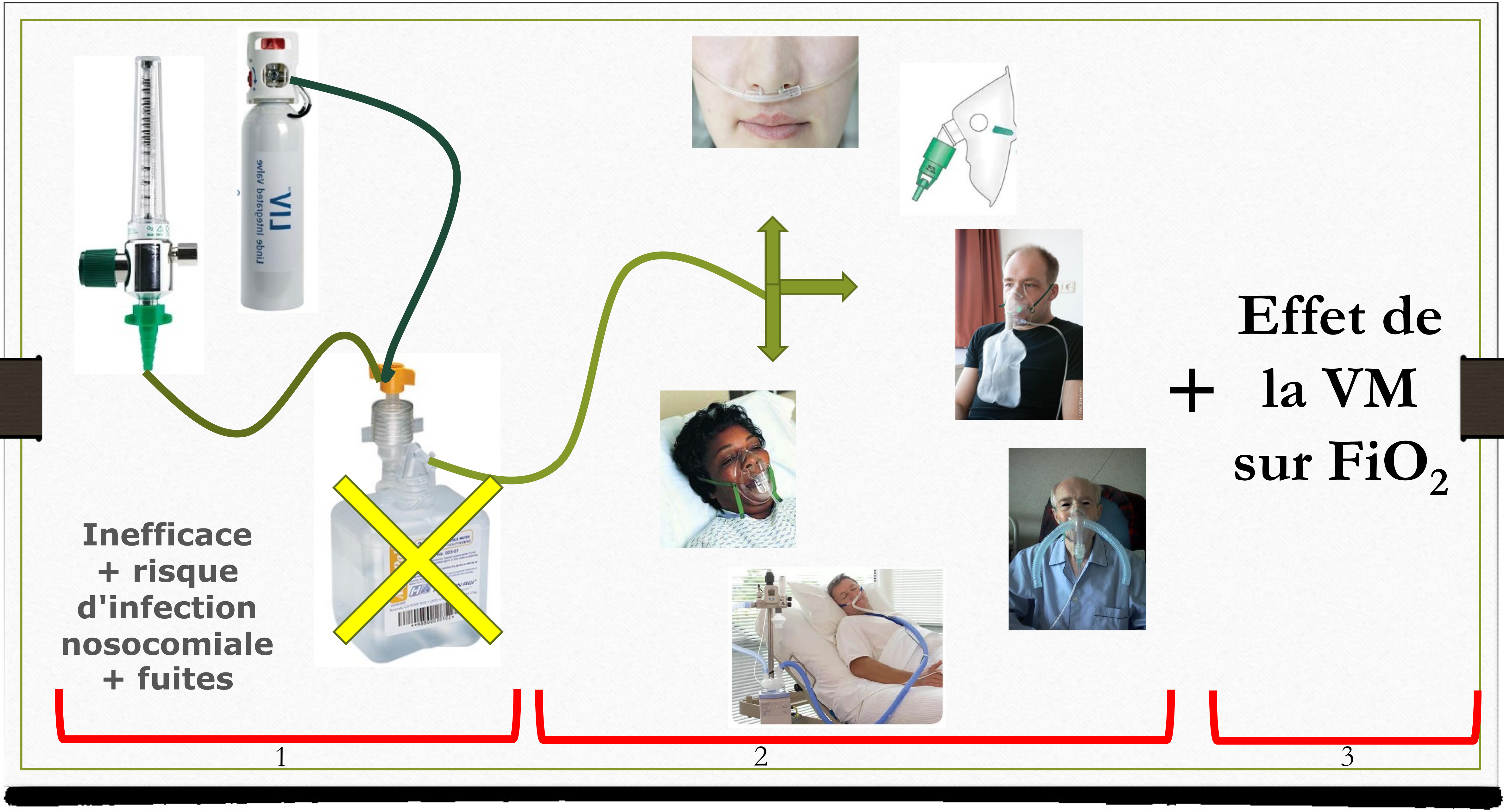


Prat D. Quelles méthodes d'oxygénation aux urgences ? Réanimation (2014) 23:483-489

Déterminants dans l'administration de l'oxygène ?

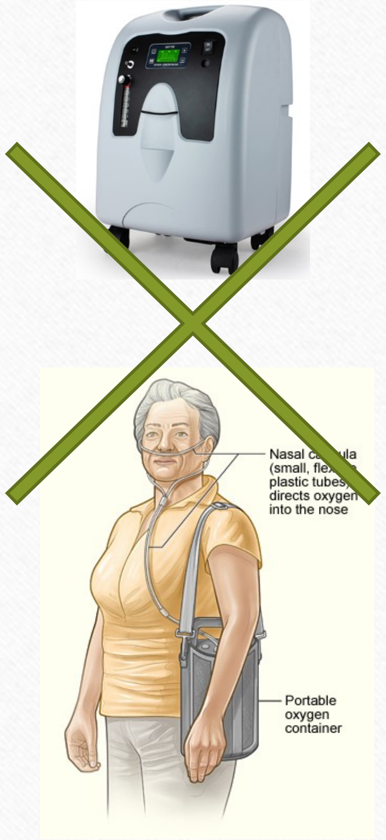


\+ Effet de la VM sur FiO_2

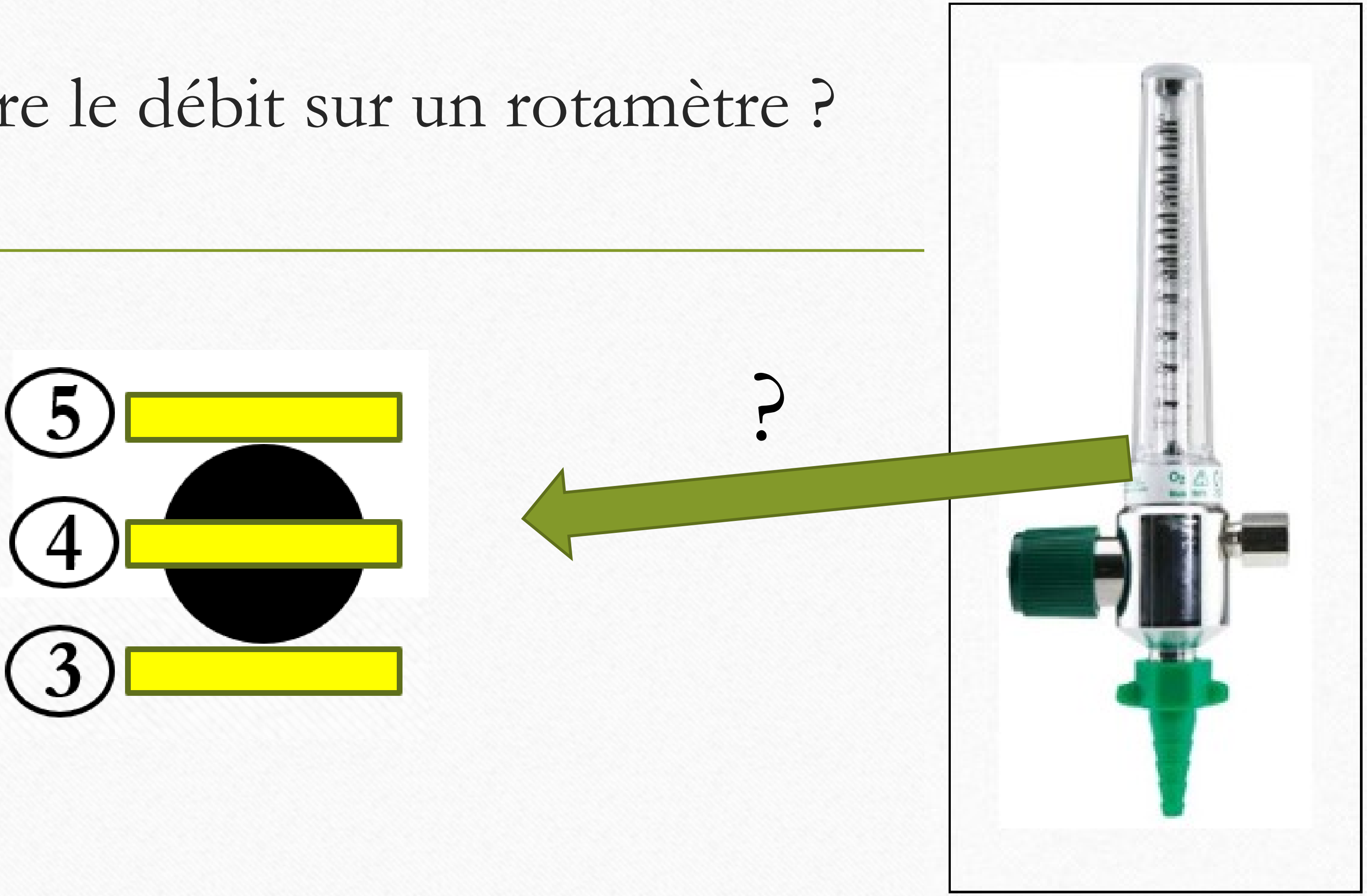


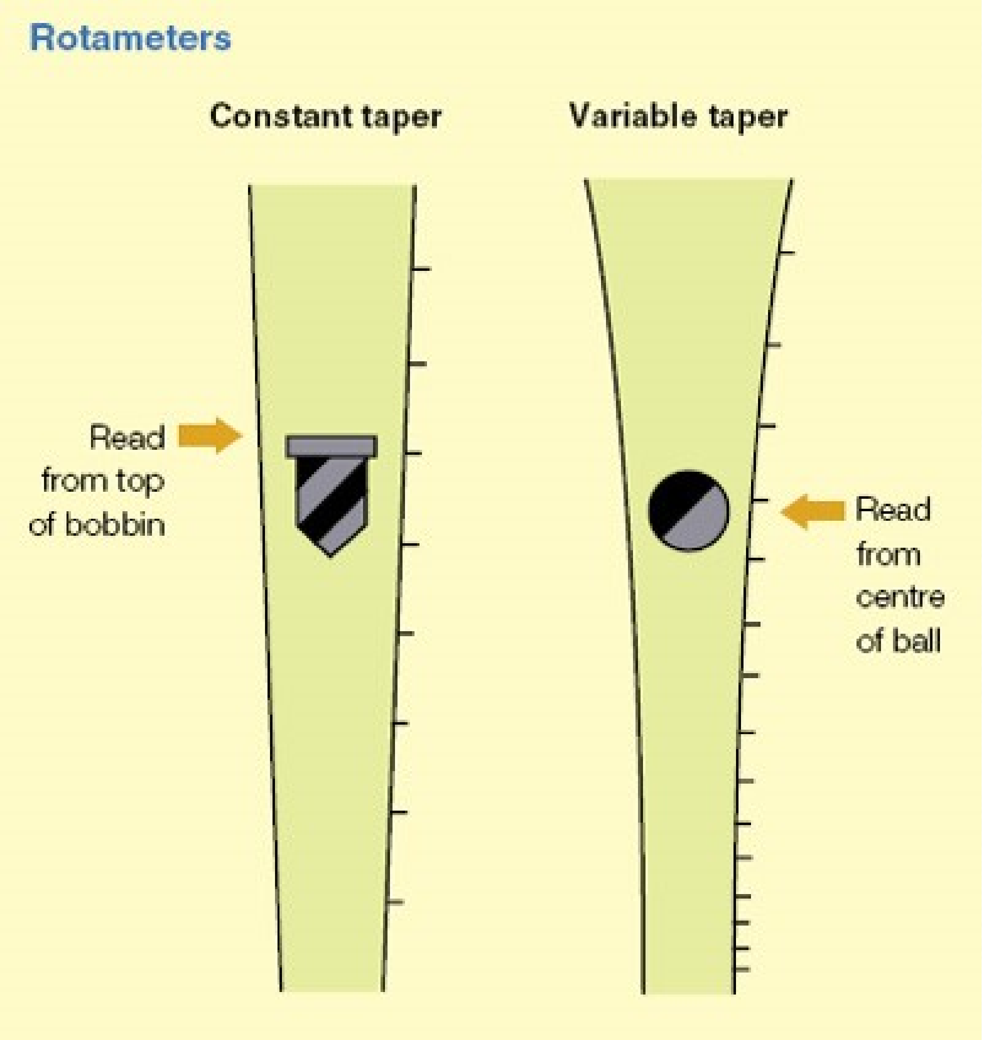
Gut-Gobert, C., & L'Her, E. (2006). Intérêts et modalités pratiques de mise en route d'une oxygénothérapie. *Revue des maladies respiratoires*, *23*(1), 13-23.

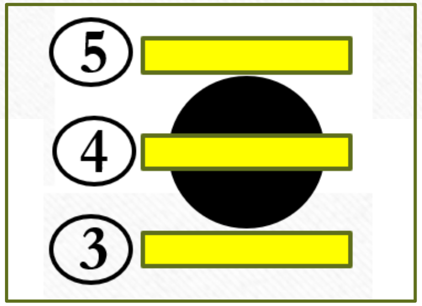
Délivrance de l’oxygène

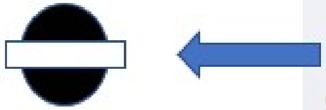


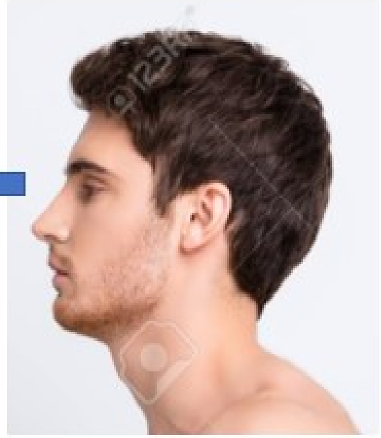
Comment lire le débit sur un rotamètre ?




Rotameters
Constant taper
Variable taper
Read from top of bobbin
Read from centre of ball


5
4
3

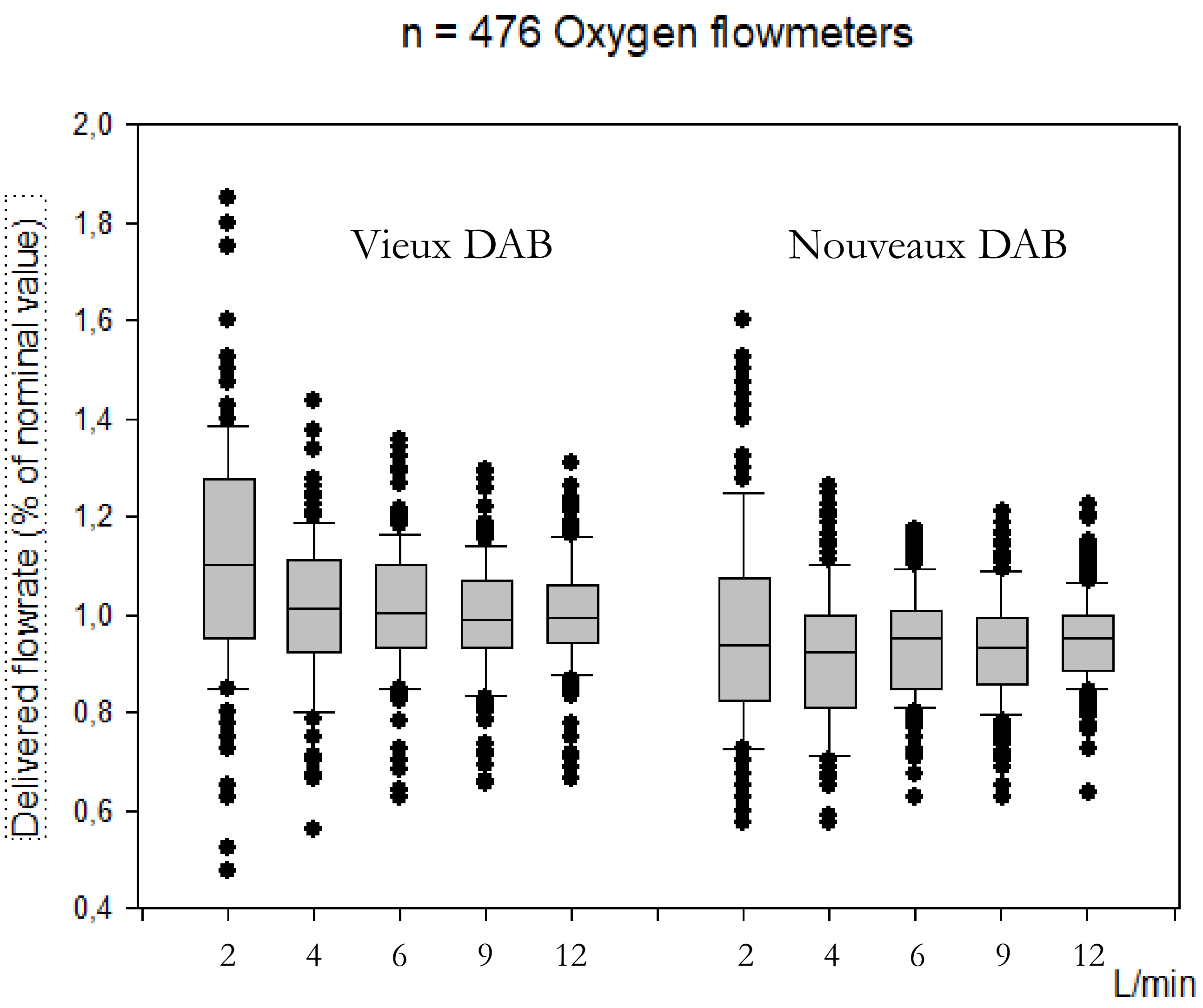




Scientific Research
An Academic Publisher

Quelle est l’exactitude des débits délivrés

par les rotamètres à bille ?



Résultats principaux

476 Débitmètres à bille (DAB) analysés

8 hôpitaux (France, Belgique)

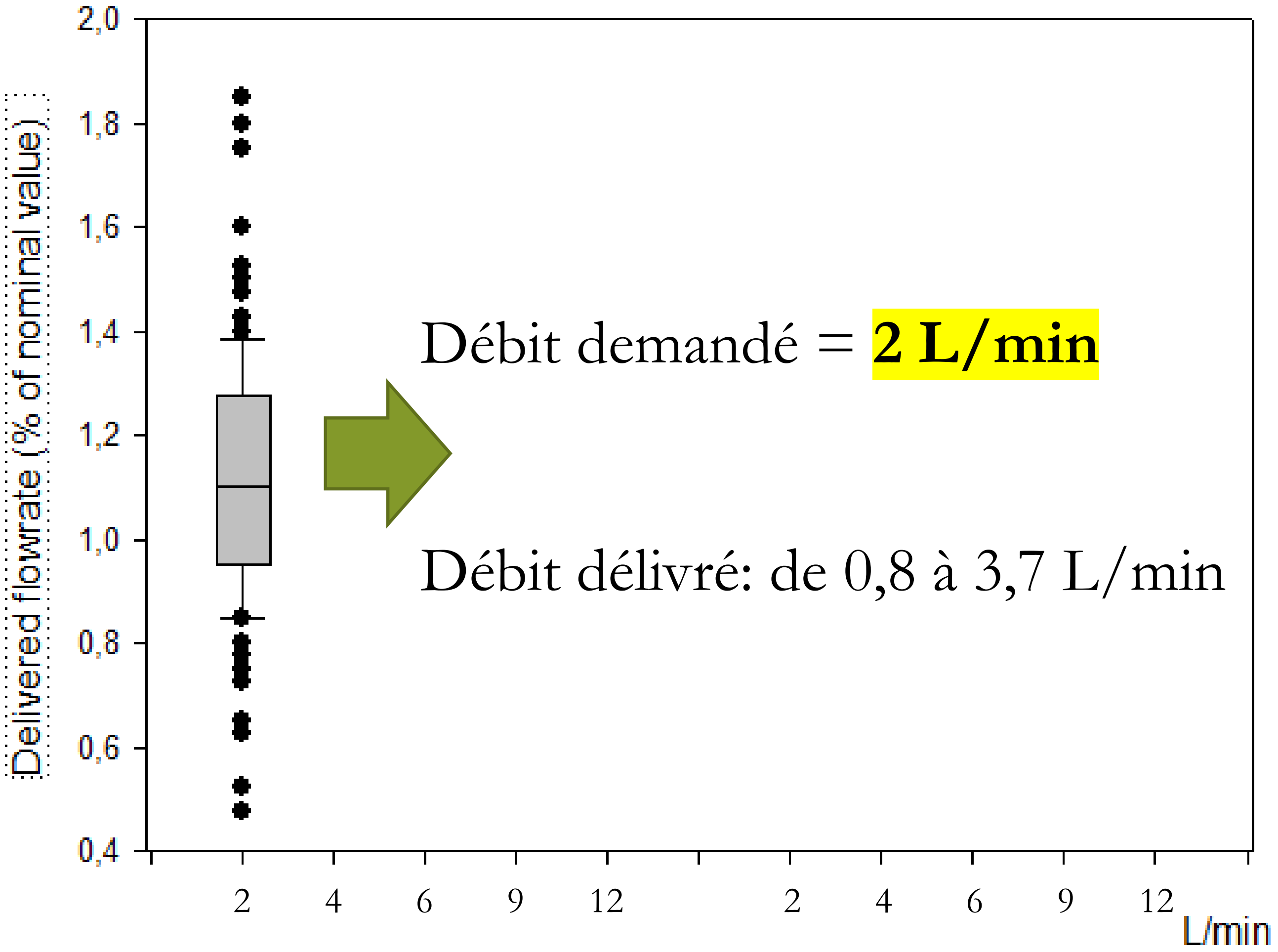
2 types de DAB identifiés (old and new)

Débits analysés: 2, 4, 6, 9, 12 L/min

Scientific Research
An Academic Publisher

Duprez F, Barile M, Bonus T, *et al.* Accuracy of medical oxygen flowmeters: a multicentric field study. *Health*, **2014**, vol. 6, no 15, p. 1978.

n = 476 Oxygen flowmeters



Débit demandé = **2 L/min**

Débit délivré: de 0,8 à 3,7 L/min

<u>Résultats principaux</u>

476 Débitmètres à bille (DAB) analysés

8 hôpitaux (France, Belgique)

2 types de DAB identifiés (old and new)

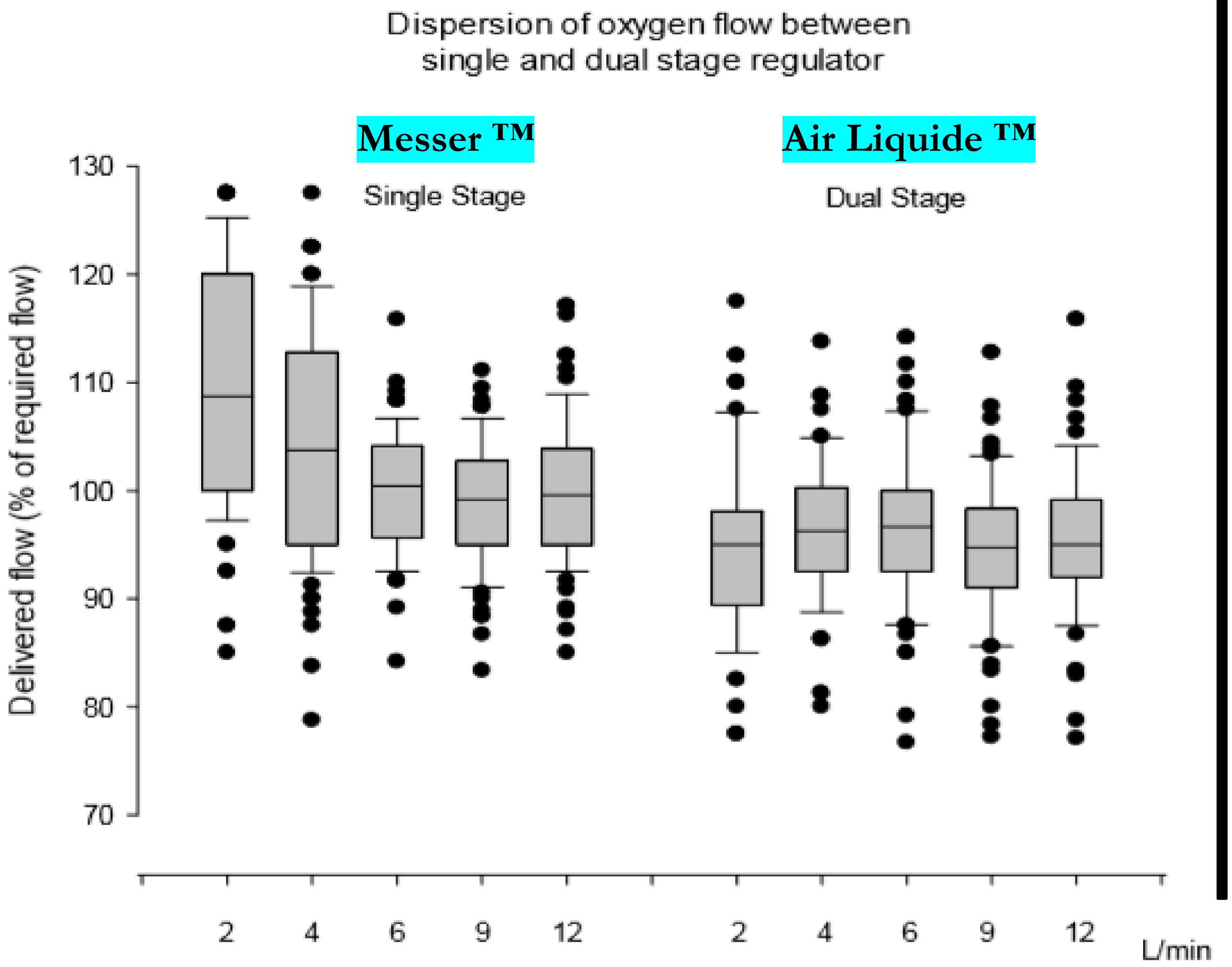
Débits analysés: 2, 4, 6, 9, 12 L/min

Scientific Research
An Academic Publisher

Duprez F, Barile M, Bonus T, *et al.* Accuracy of medical oxygen flowmeters: a multicentric field study. *Health*, **2014**, vol. 6, no 15, p. 1978.

Quelle est l’exactitude des débits délivrés

par les obus à oxygène ?



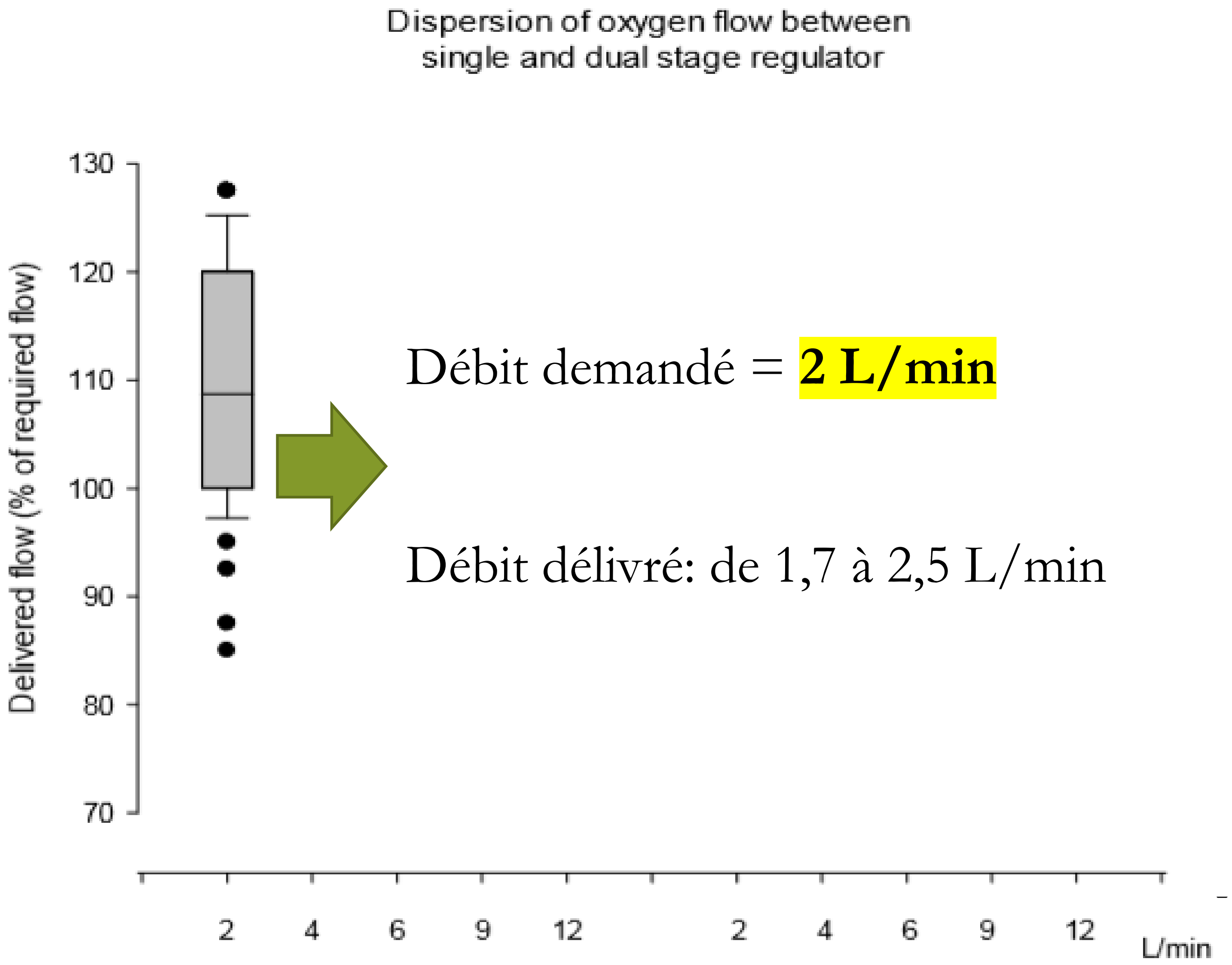
- N= 148 Oxygen flowmeters
- 2 hospital emergency units
- 2 ambulance services
- 1 firefighting brigade
- 2 types de DAB identifiés

(Simple étage, double étage)

- Débits: 2, 4, 6, 9, 12 L/min

RESPIRATORY CARE

Duprez F. Accuracy of Oxygen Flow Delivered by Compressed-Gas Cylinders in Hospital and Prehospital Emergency Care. Respir Care. 2018 Mar;63(3):332-338..



Débit demandé = **2 L/min**

Débit délivré: de 1,7 à 2,5 L/min

RESPIRATORY CARE

Duprez F. Accuracy of Oxygen Flow Delivered by Compressed-Gas Cylinders in Hospital and Prehospital Emergency Care. Respir Care. 2018 Mar;63(3):332-338..

Comparaison résultats entre obus et rotamètres

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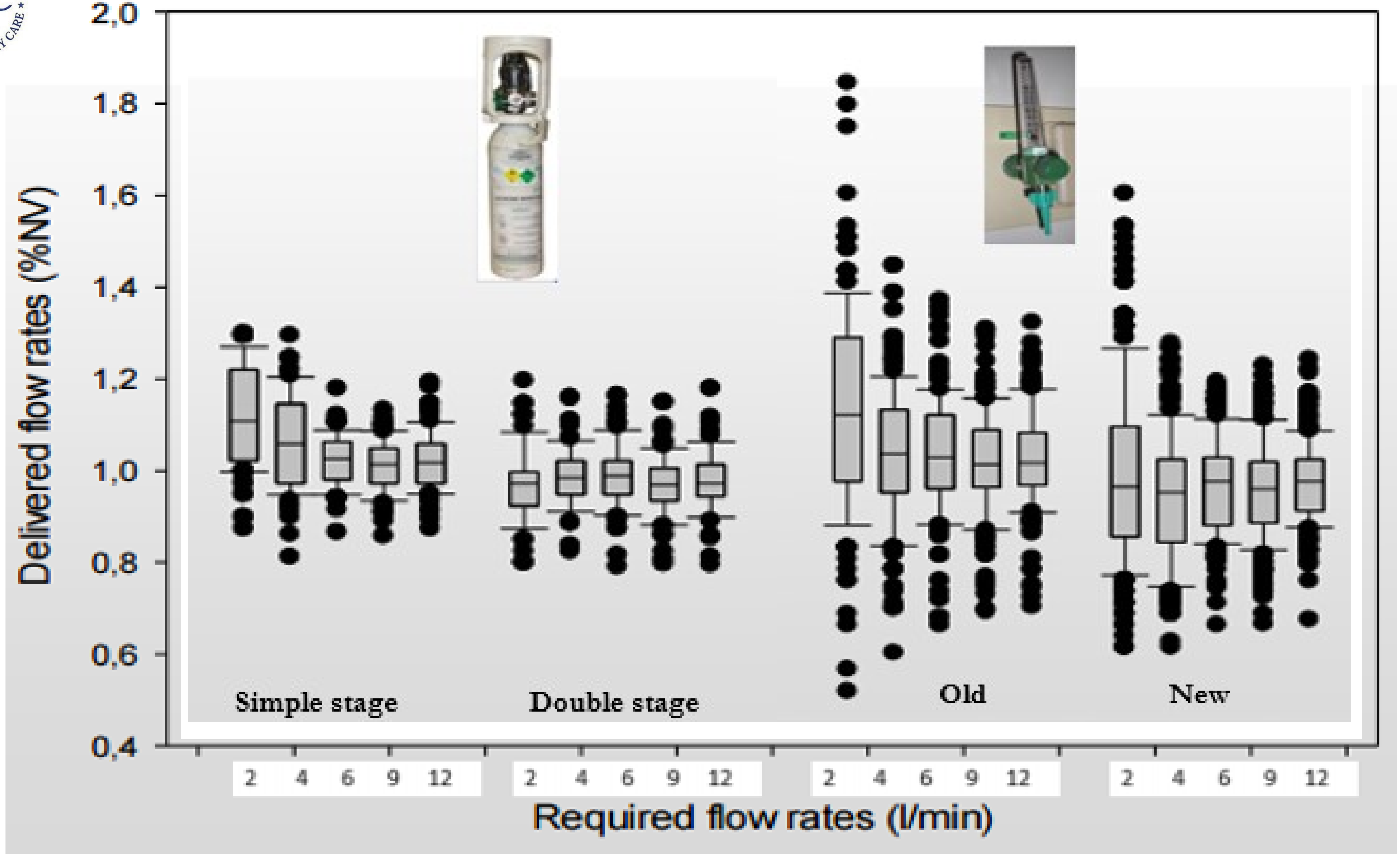
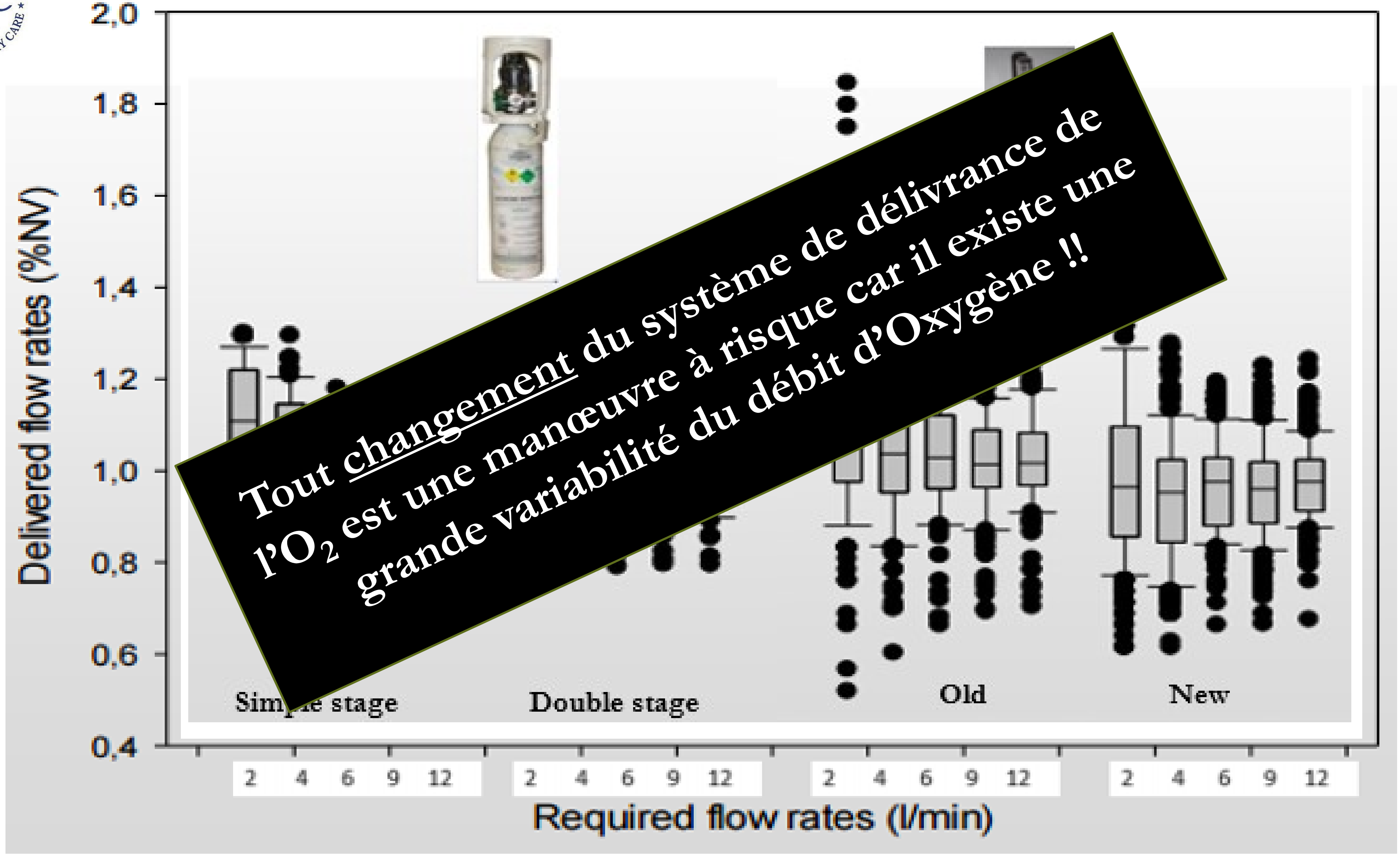
RESPIRATORY CARE



2,0
1,8
1,6
1,4
1,2
1,0
0,8
0,6
0,4
Delivered flow rates (%NV)
Simple stage
Double stage
Old
New
2 4 6 9 12
2 4 6 9 12
2 4 6 9 12
2 4 6 9 12
Required flow rates (l/min)



Tout <u>changement</u> du système de délivrance de l'O_2 est une manœuvre à risque car il existe une grande variabilité du débit d'Oxygène !!

Systèmes d'administration de l'oxygène

Lunettes à O_2

Masque à O_2

Venturi

NRM

DTM

HFO

Hypoxémie

Hypoxémie

Hypoxémie

Etude de prévalence dans l'administration de l'O_2

Nasal Cannula

"In **ICU**, most patients received oxygen by **simple nasal cannula** and patients also received oxygen via **open face mask**" *

Oxygen Mask

Pourtant, d'après [1,2,3]

Canule nasale vs Masque à O_2 ➡ pas de ≠ entre les deux systèmes (PaO_2)

1) Stausholm K. Comparison of three devices for oxygen administration in the late postoperative period. Br J Anaesth. 1995 May;74(5):607-9.
2) Baser S. Binasal cannula versus face mask for oxygen therapy in patients with chronic pulmonary disease. Adv Ther. 2006;23(6):1068-74
3) Eastwood G. Nasopharyngeal oxygen as a safe and comfortable alternative to face mask oxygen therapy. Aust Crit Care. 2006 Feb;19(1):22

To fight against acute **hypoxemia** we can also use

Venturi Mask

Commonly available Venturi Mask

deliver 24, 28, 31, 35, 40 or 50 % oxygen.

"Not always able to guarantee the total flow with oxygen percentages above 35% in patients with high inspiratory flow demands" [1]

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

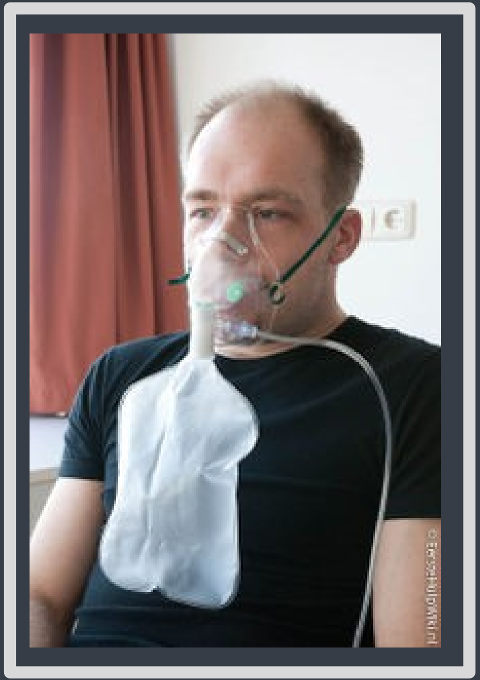
In Patients breathing spontaneously

To fight against acute **hypoxemia** we can also use

Non-rebreathing reservoir mask

NRM, delivers oxygen concentration between 60–80% or above.

It is effective for **short term** [1] treatment in critical illness, trauma patients, post cardiac, or respiratory arrest.



Non-rebreathing mask

1) Bateman, N. T., & Leach, R. M. (1998). Acute oxygen therapy. BMJ : British Medical Journal, 317(7161), 798–801.

In Patients breathing spontaneously

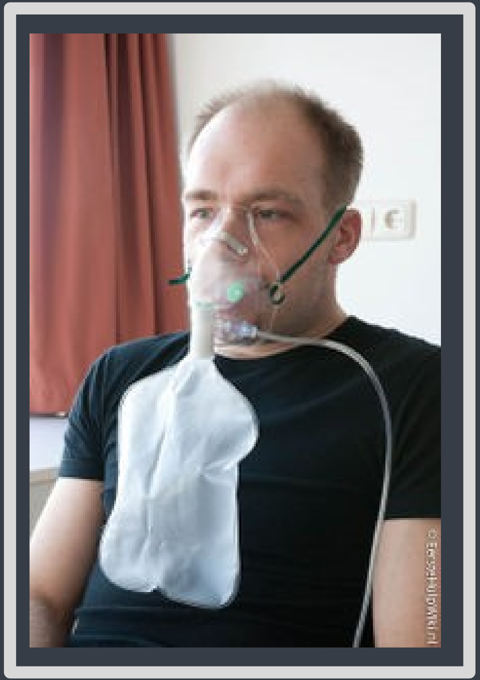
To fight against acute **hypoxemia** we can also use

Non-rebreathing reservoir mask

NRM, delivers oxygen concentration between 60–80% or above.

It is effective for **short term** [1] treatment in critical illness, trauma patients, post cardiac, or respiratory arrest.

However, recent clinical investigations have highlighted the potential for entrainment of room **air to dilute air/oxygen mixtures** delivered through non-rebreather facemasks [2]



Non-rebreathing mask

1) Bateman, N. T., & Leach, R. M. (1998). Acute oxygen therapy. BMJ : British Medical Journal, 317(7161), 798–801.

2) Martin M. Methods for evaluation of oxygen delivery through non-rebreather facemasks. Med Gas Res. 2012; 2: 31

In Patients breathing spontaneously

To fight against acute **hypoxemia** we can also use

High Flow Oxygenation

High Flow Oxygenation

High-flow nasal cannula (HFNC) oxygen therapy is carried out using an air/oxygen blender, active humidifier, single heated tube, and nasal cannula. Able to deliver adequately heated and humidified medical gas at flows up to 60 L/min, it is considered to have a number of physiological advantages compared with other standard oxygen therapies[1,2,3,4]

1) Chanques G. Discomfort associated with underhumidified high-flow oxygen therapy in critically ill patients. Intensive Care Med 2009;35(6):996–1003
2) Nishimura M. High-flow nasal cannula oxygen therapy in adults. J Intensive Care 2015;3(1):15
3) Frat JP. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. N Engl J Med 2015;372(23):2185–2196
4) Peters SG. High-flow nasal cannula therapy in do-not-intubate patients with hypoxemic respiratory distress. Respir Care 2013;58(4):597–600

In Patients breathing spontaneously

To fight against acute **hypoxemi**... we can also use

High Flow ...

Pas toujours évident à mettre en œuvre en situation d'urgence

(mais pas impossible)

High-flow nasal cannula (HFNC) o...

using an air/oxygen blende... ...ted

tube, and nasal can... ...y heated and

humidified medica... ...min, it is considered

to have a number of ... ...vantages compared with

other standard oxygen t... ...pies[1,2,3,4]

High Flow Oxygenation

1) Chanques G. Discomfort associated with underhumidified high-flow oxygen therapy in critically ill patients. Intensive Care Med 2009;35(6):996–1003
2) Nishimura M. High-flow nasal cannula oxygen therapy in adults. J Intensive Care 2015;3(1):15
3) Frat JP. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. N Engl J Med 2015;372(23):2185–2196
4) Peters SG. High-flow nasal cannula therapy in do-not-intubate patients with hypoxemic respiratory distress. Respir Care 2013;58(4):597–600

COMMENT OPTIMISER LA DÉLIVRANCE DE L'OXYGÈNE ?

(1)

Formules de prédiction de la FDO_2

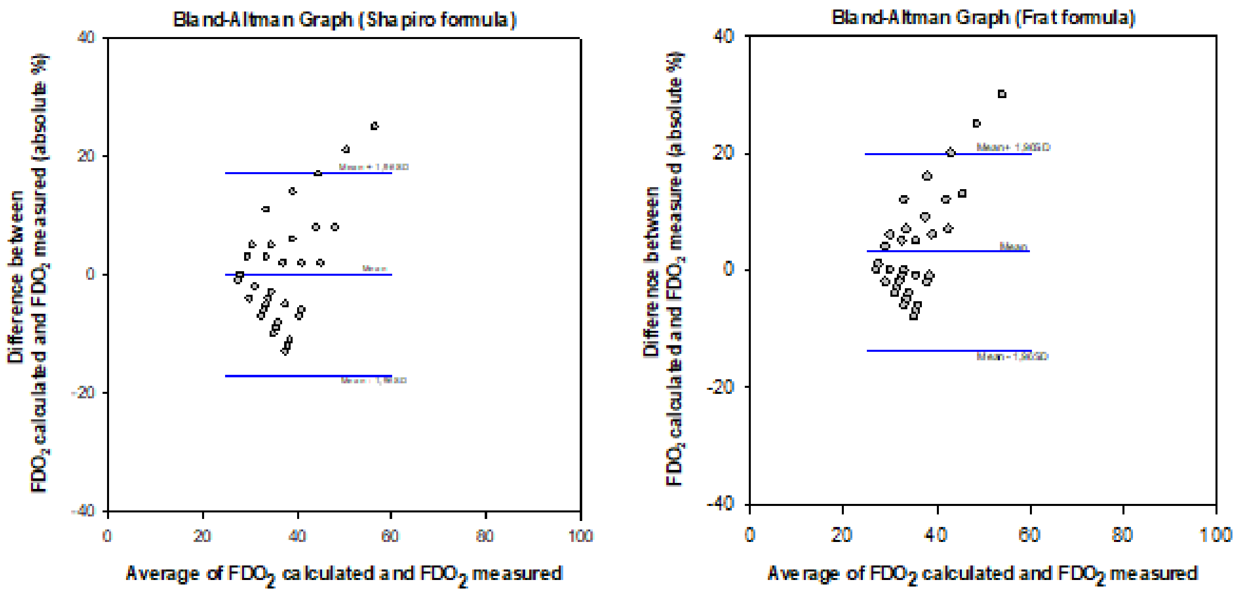
$$FiO_2 = 21\% + (3\% * LPM\ O_2)$$

JL Vincent formula

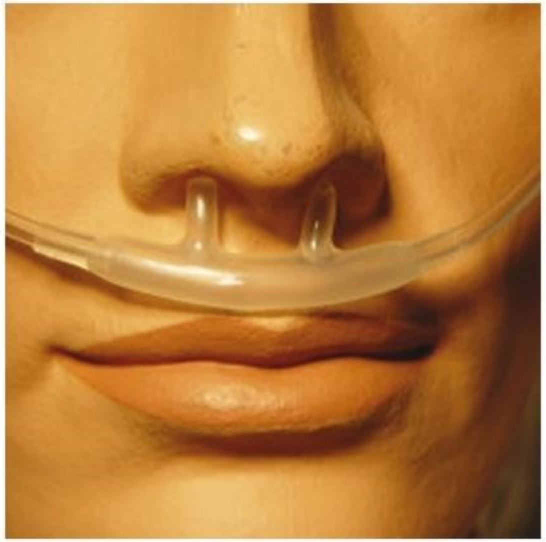
$$FiO_2 = 20\% + (4\% * LPM\ O_2)$$

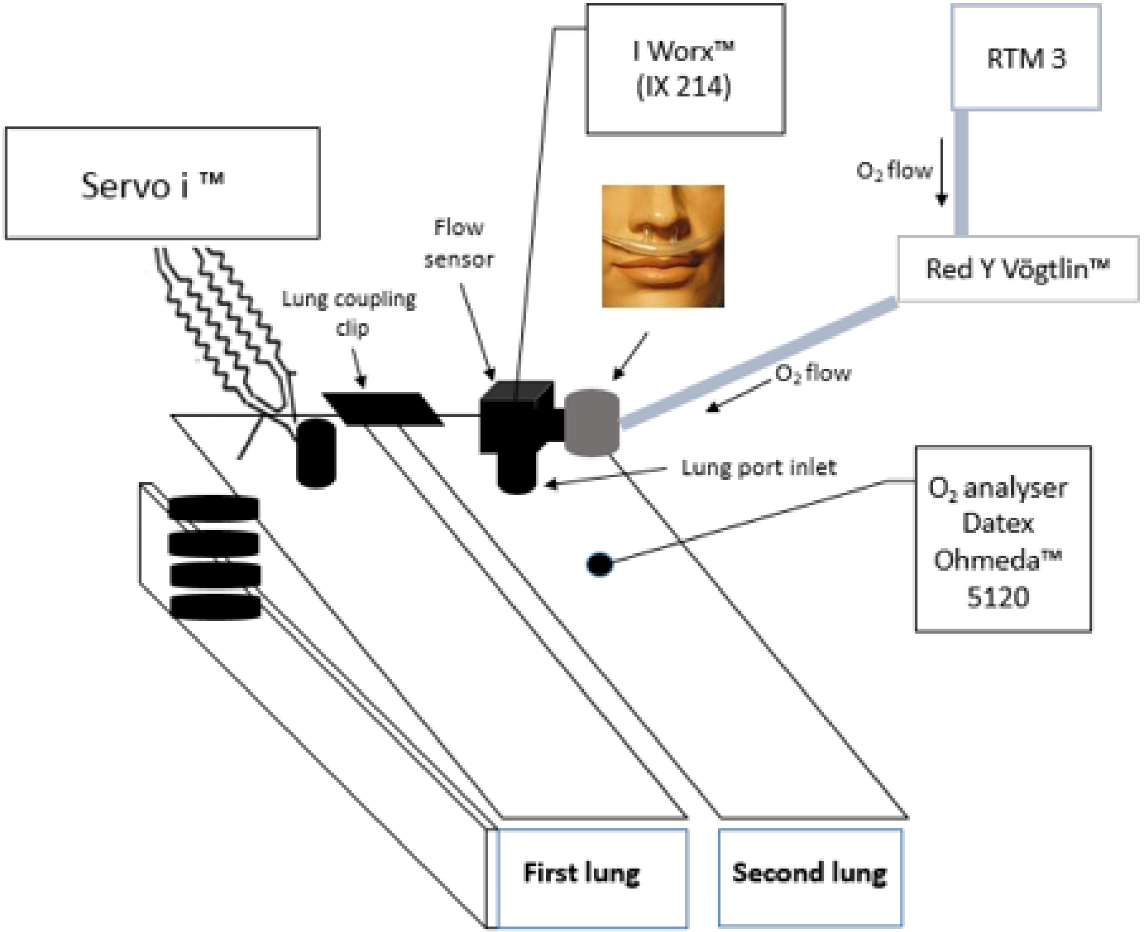
Shapiro formula (USA 1982)

$$\boldsymbol{FiO_2 = 21\% + (3\% * LPM\ O_2)}$$



Bland-Altman Graph (Shapiro formula)
Difference between FDO2 calculated and FDO2 measured (absolute %)
Average of FDO2 calculated and FDO2 measured
Bland-Altman Graph (Frat formula)
Difference between FDO2 calculated and FDO2 measured (absolute %)
Average of FDO2 calculated and FDO2 measured





Servo i ™
I Worx™ (IX 214)
RTM 3
O2 flow
Red Y Vögtlin™
Flow sensor
Lung coupling clip
O2 flow
Lung port inlet
O2 analyser Datex Ohmeda™ 5120
First lung
Second lung

Formules de prédiction de la FDO_2

$$FiO_2 = 21\% + (3\% * LPM\ O_2)$$

Vincent formula

$$FiO2 = 21\% + \left(\frac{LPM\ O2}{4 * VM}\right)$$

Duprez formula

$$FiO_2 = 21\% + (3\% * LPM\ O_2)$$

$$FiO2 = 21\% + \left(\frac{LPM\ O2}{4 * VM}\right)$$

Patient adulte au repos 80 kg pci soit

VM = 8 L/min

$$FiO_2 = 21\% + (3\% * LPM\ O_2)$$

$$FiO2 = 21\% + (\frac{LPM\ O2}{4 * VM})$$

Patient adulte au repos 80 kg pci soit

VM = 8 L/min

Donc 4 * VM = 4 * 8 = 32

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$$FiO2 = 21\% + \left(\frac{LPM\ O2}{4 * VM}\right)$$

Patient adulte au repos 80 kg pci soit

VM = 8 L/min

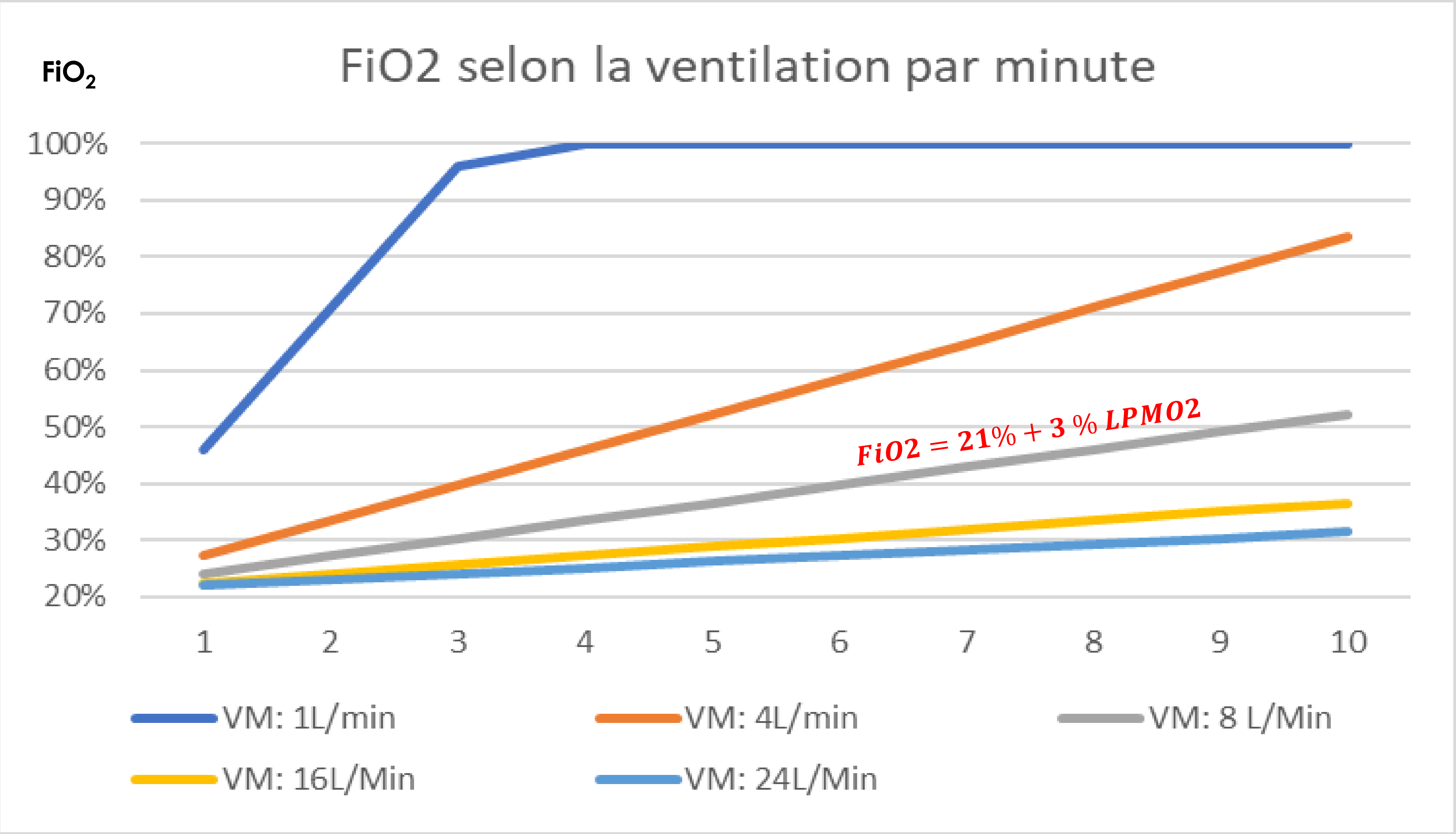
Donc (4 * VM) = (4 * 8) = 32 or $\frac{\mathbf{1\ LPM\ O2}}{\mathbf{32}}$ **= 0,03 = 3 %**

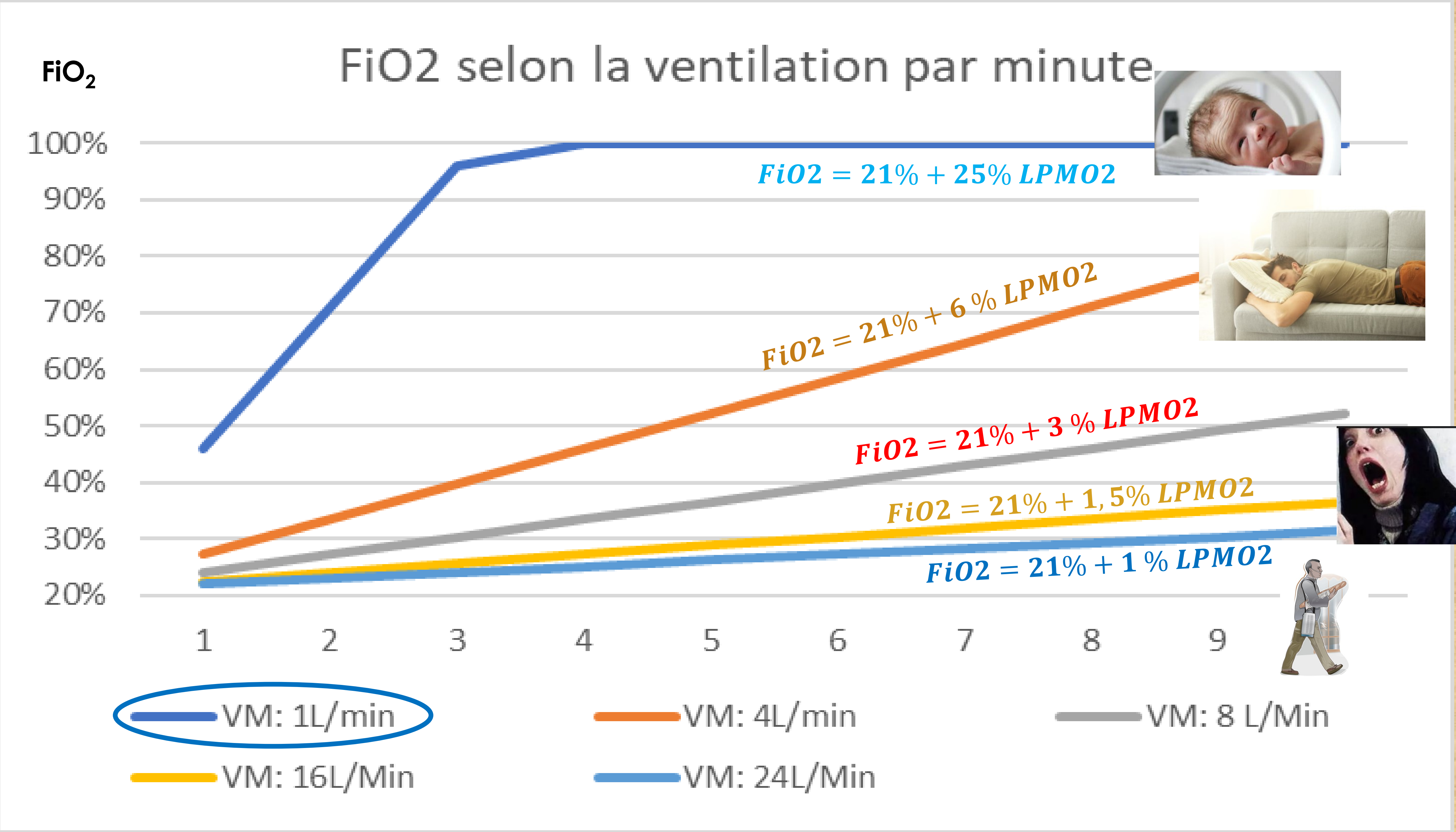
$$FiO_2 = 21\% + (3\% * LPM\ O_2)$$

Take home message

$$FiO_2 \cong \frac{LPM\ O_2}{VM}$$

Duprez F. A new formula for predicting the Fractional Delivered Oxygen (FDO2) during oxygen therapy at low flow. Respiratory Care december 2018


FiO2 selon la ventilation par minute
FiO_2
100%
90%
80%
70%
60%
50%
40%
30%
20%
1
2
3
4
5
6
7
8
9
10
$FiO2 = 21\% + 3\ \%\ LPMO2$
VM: 1L/min
VM: 4L/min
VM: 8 L/Min
VM: 16L/Min
VM: 24L/Min


FiO2 selon la ventilation par minute
FiO2
100%
90%
80%
70%
60%
50%
40%
30%
20%
1
2
3
4
5
6
7
8
9
FiO2 = 21% + 25% LPMO2
FiO2 = 21% + 6 % LPMO2
FiO2 = 21% + 3 % LPMO2
FiO2 = 21% + 1,5% LPMO2
FiO2 = 21% + 1 % LPMO2
VM: 1L/min
VM: 4L/min
VM: 8 L/Min
VM: 16L/Min
VM: 24L/Min

COMMENT OPTIMISER

LA DÉLIVRANCE DE

L'OXYGÈNE ?

(2)

Double Trunk Mask (DTM)

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:

Double Trunk Mask (DTM)

Corrugated Tubing
15 cm +/-

Masque aérosol classique

Lunettes nasales du HFNC

1)

The DTM improves oxygenation during high flow nasal cannula therapy for hypoxemic acute respiratory failure.

Duprez F, Bruyneel A, Droguet M, Bouckaert Y, Machayekhi M, Brimioulle S, Cuvelier G and Reychler G.
2018, **Respiratory Care journal**

RESPIRATORY CARE

Etude prospective multi-centrique en cross over (évaluation aveugle)

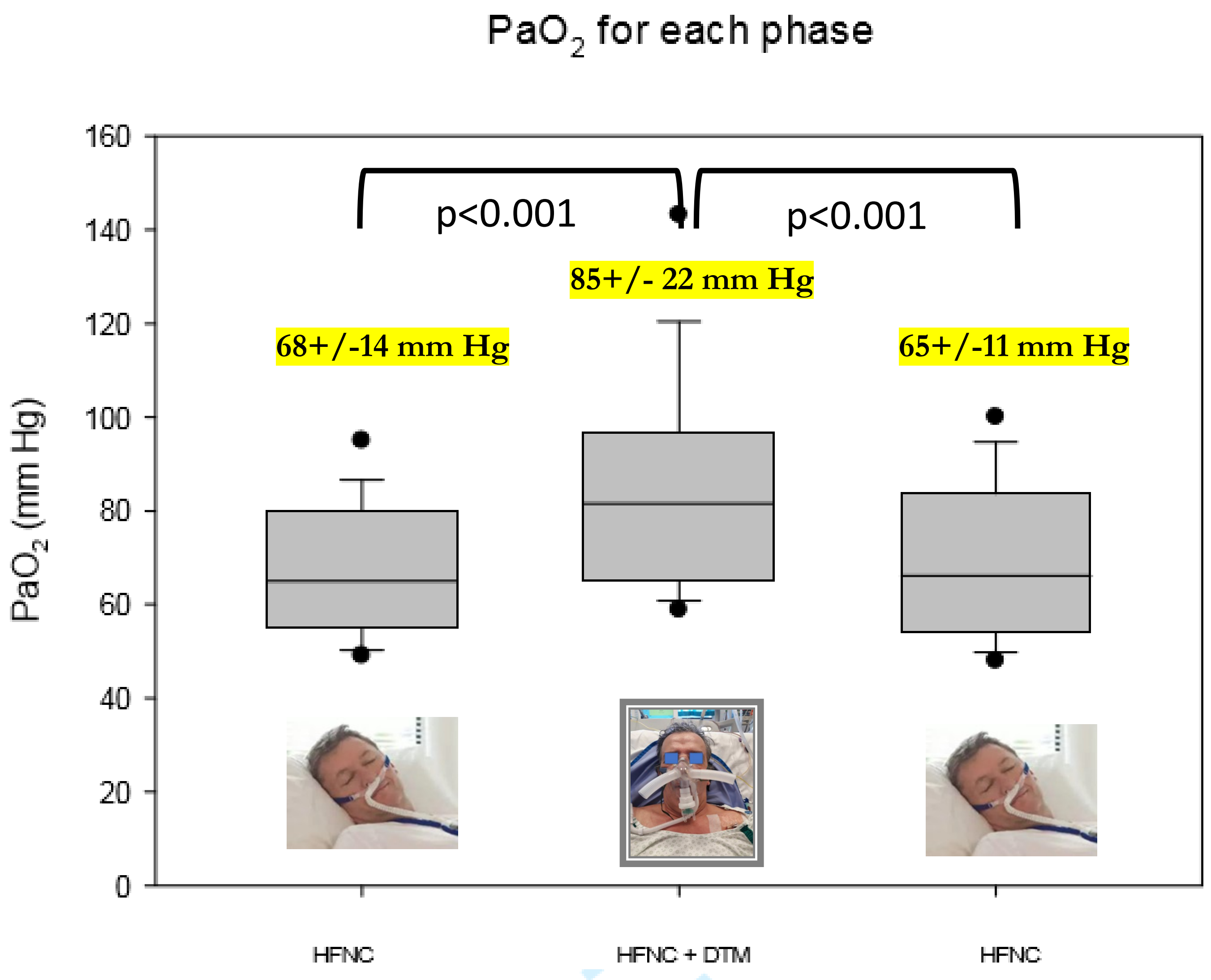
N = 15 patients (hypoxémie aigue et traités par HFNC (PaO2/FiO2 < 300 mmHg).

Intervention: > période de 30 minutes de HFNC, placement du DTM sur les canules nasales du HFNC, puis “retour” avec HFNC seul

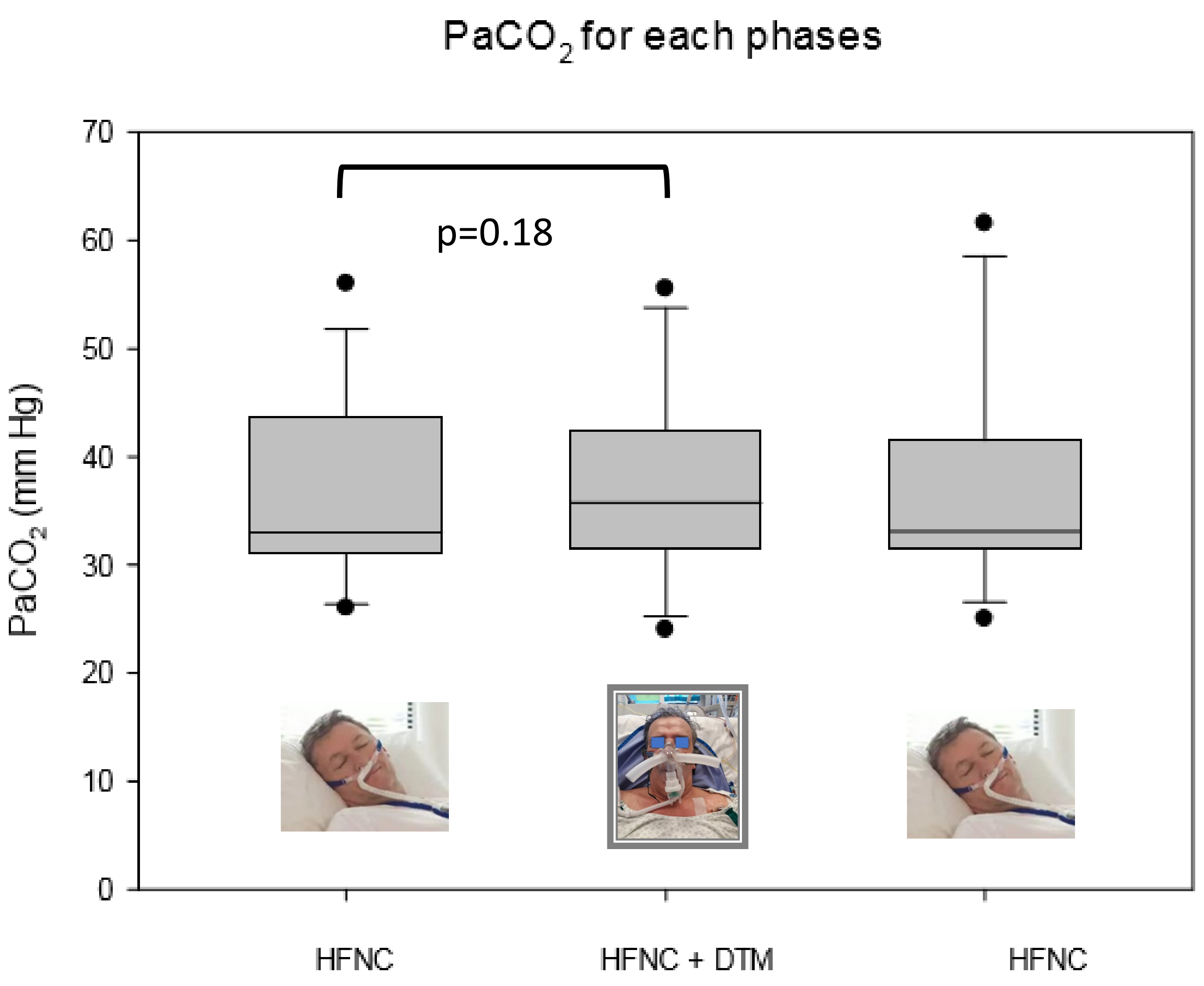
ClinicalTrials.gov (NCT03319602)

Accord CE Erasmes-Epicura N°034/008

Resultats:



PaO2 for each phase
PaO2 (mm Hg)
160
140
120
100
80
60
40
20
0
p<0.001
p<0.001
85+/- 22 mm Hg
68+/-14 mm Hg
65+/-11 mm Hg
HFNC
HFNC + DTM
HFNC


PaCO2 for each phases
p=0.18
PaCO2 (mm Hg)
70
60
50
40
30
20
10
0
HFNC
HFNC + DTM
HFNC

	PaO2/FiO2 (mm Hg)	
	HFNC	HFNC + DTM
Subject 1	78	100
Subject 2	172	176
Subject 3	100	179
Subject 4	138	125
Subject 5	74	65
Subject 6	101	100
Subject 7	115	128
Subject 8	73	102
Subject 9	89	117
Subject 10	65	103
Subject 11	89	109
Subject 12	76	118
Subject 13	73	84
Subject 14	54	69
Subject 15	69	102

GRADES D'HYPOXEMIE

Léger = PaO2/FIO2 entre 200 and 300 mm Hg
Modéré = PaO2/FIO2 entre 100 et 200 mm Hg
Sévère = PaO2/FIO2 en dessous de100 mm Hg

75% de répondants.

Peu d'impact sur la $PaCO_2$

2)

Association du DTM sur les canules nasales

(O_2 à bas débit: 3 – 6 L/min)

Duprez F, Bruyneel A,
Machayekhi M, Brimioulle S,
Cuvelier G and Reychler G.
2018, **Respiratory Care journal**
In process

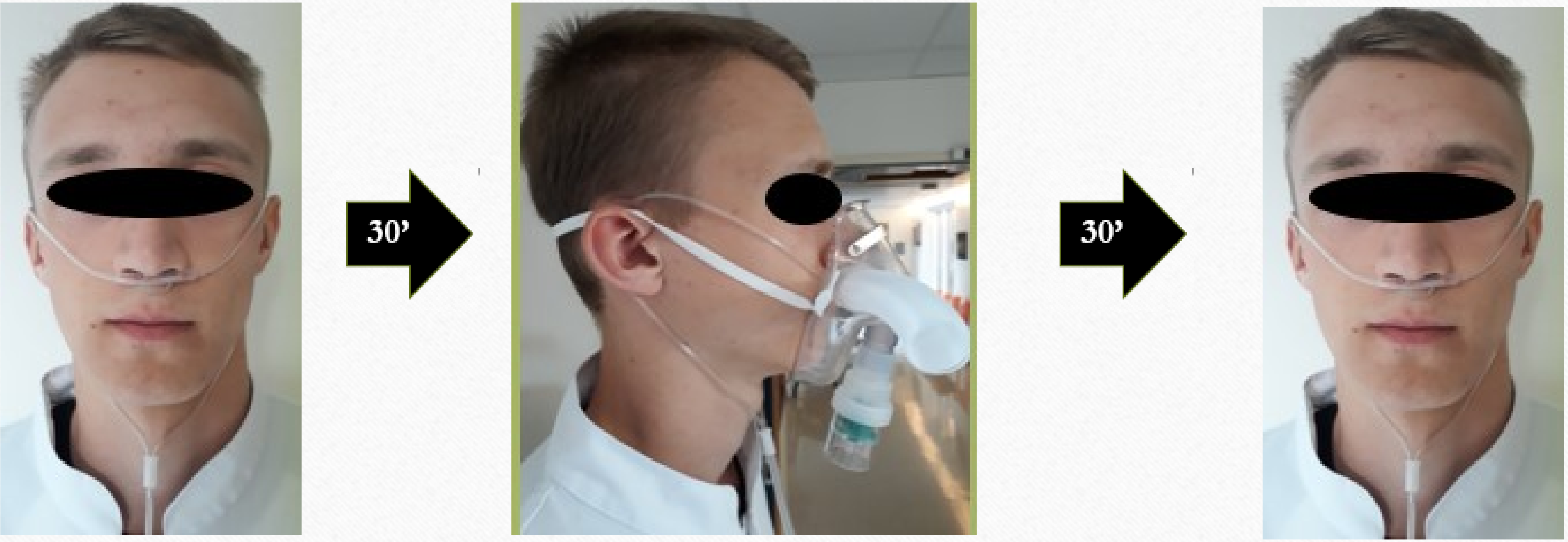
RESPIRATORY CARE

Association du DTM sur les canules nasales (O_2 à bas débit)

Etude prospective en cross over avec évaluation en aveugle

N = 17 patients (hypoxémie aigue oxygénés par canule nasale à bas debit.

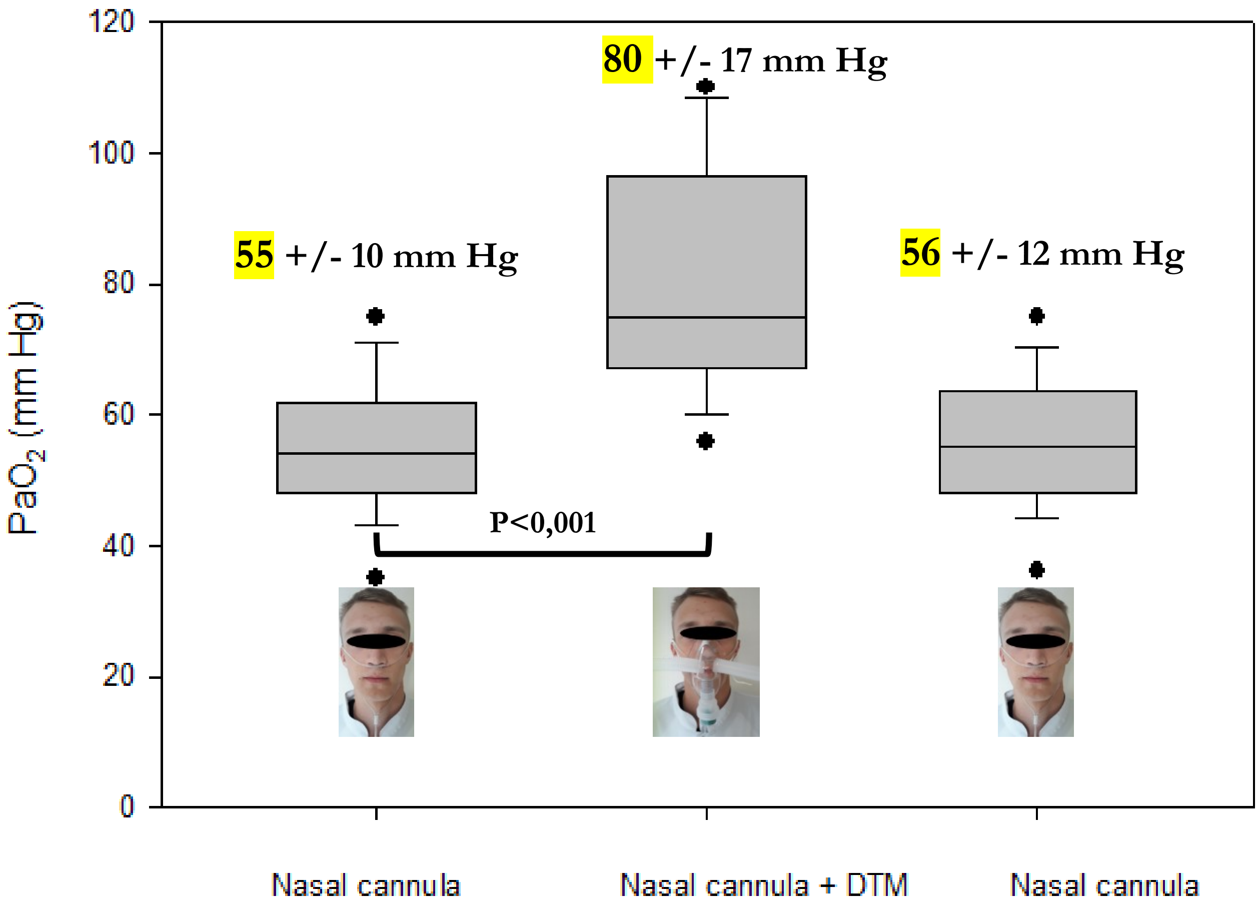
Intervention:> période de 30’ de CN, placement du DTM sur les canules nasales



ClinicalTrials.gov (NCT03457363) Accord CE Erasmes-Epicura N° B406201835593

PaO2 for each phases

Débit O_2 moyen 5 (+/- 3) L/min)

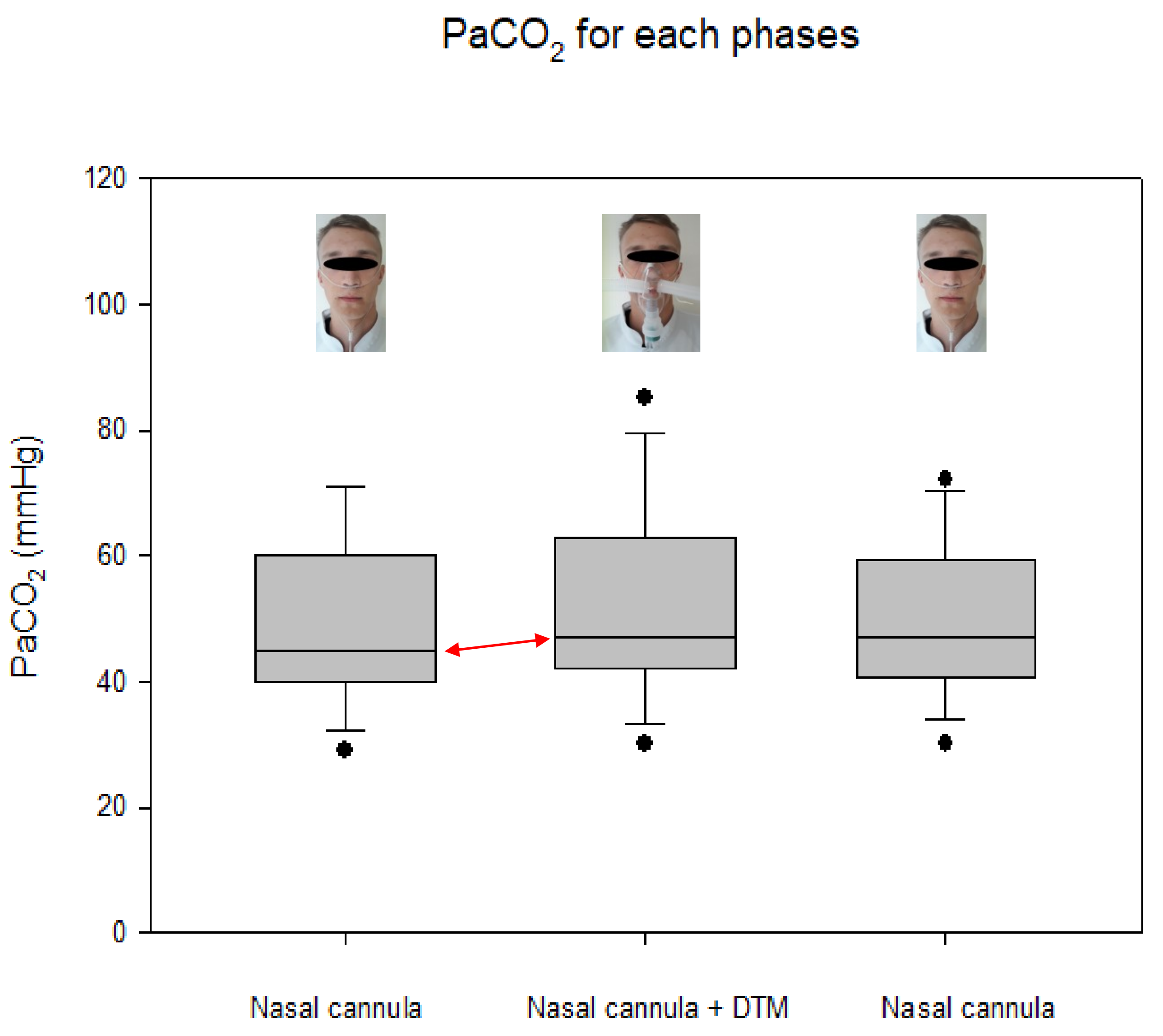


Augmentation de

47 % de la PaO2 !

Augmentation de la PaCO2 de 45 à 47 mm Hg !

P<0,05



Conclusion étude DTM à bas débit

- Augmentation de la PaO_2 de façon extrêmement significative
- **Augmentation de la $PaCO_2$** faible SAUF chez les BPCO, mais pas d'impact majeur sur le pH !!!!!!

DTM permet d'augmenter transitoirement la PaO_2 dans certaines situations:

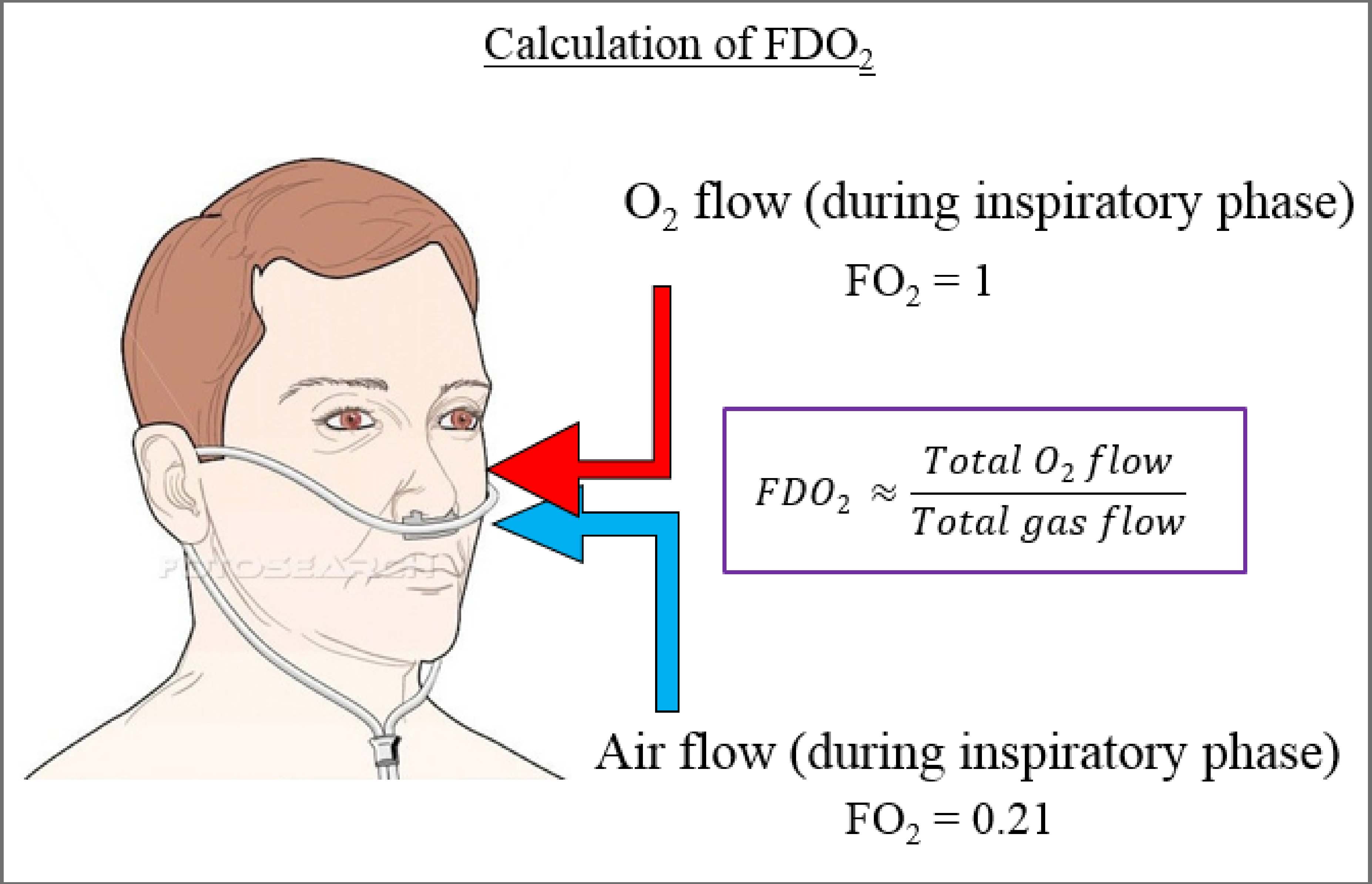
- Hyperoxémie pré-intubation
- DO NOT INTUBATE
- Certains patients Hématologiques
- O.P.H.

Merci pour votre

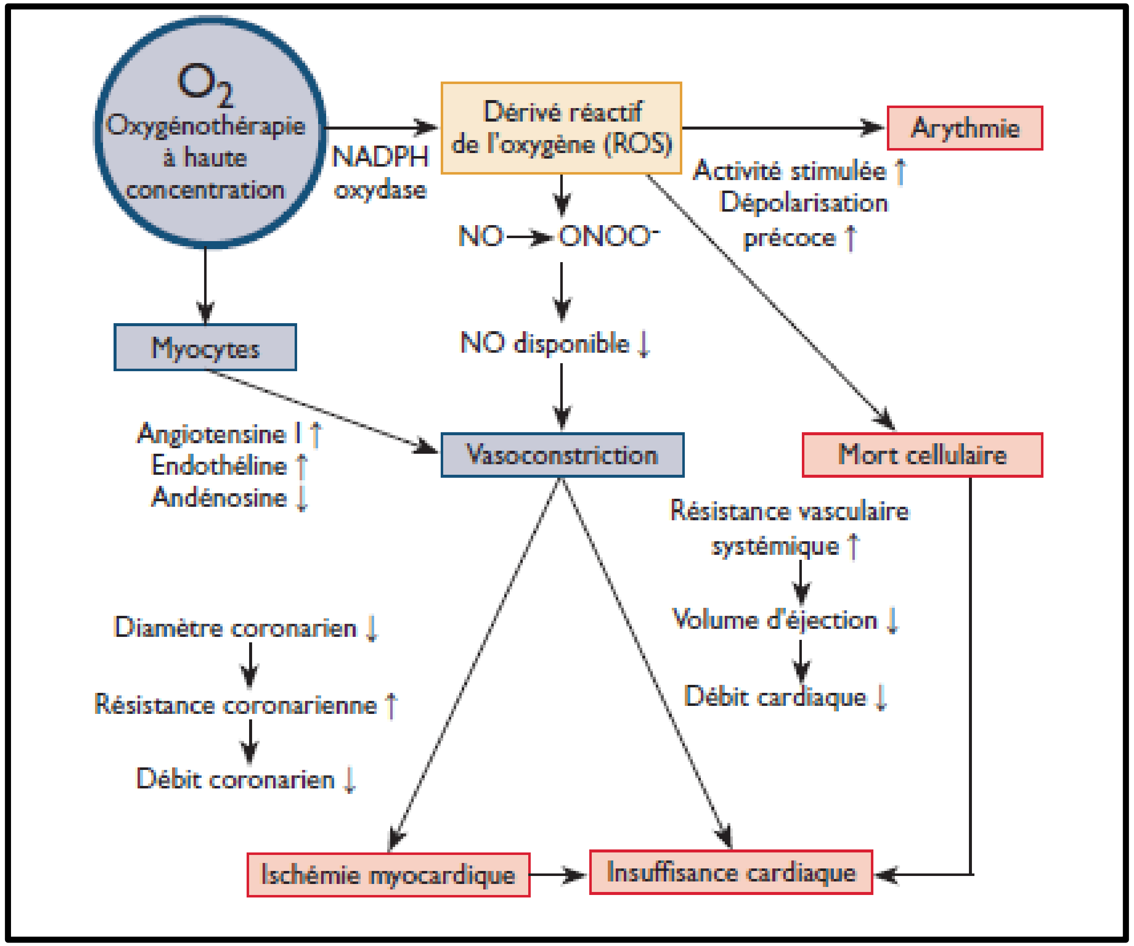
ATTENTION

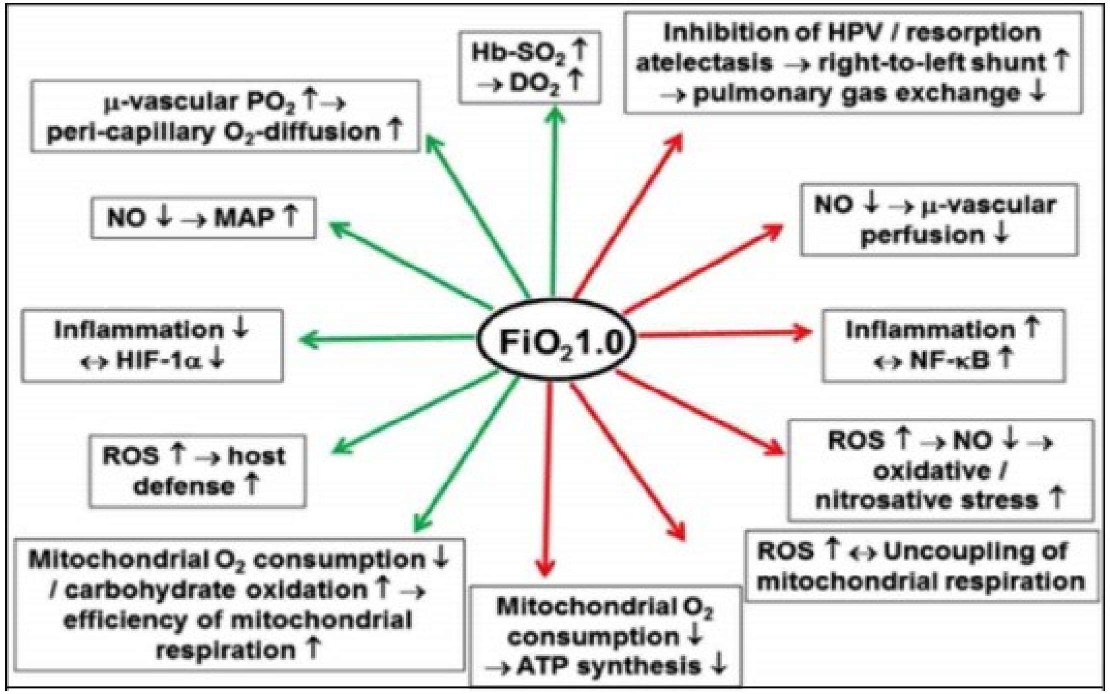
Questions-réponses

1) Exactitude des débitmètres muraux et bouteilles ? (risques ?)
2) Ciblage SpO_2 ?
3) O_2 n'est pas « more is better »
4) Hypo et hyperoxémie = NEFASTES (sauf CO, choc hémorragique, pneumothorax)
5) Formule prédiction FiO_2 qui tient compte de la VM ?
6) Effet de l'adjonction du DTM sur High flow (PaO_2, $PaCO_2$)

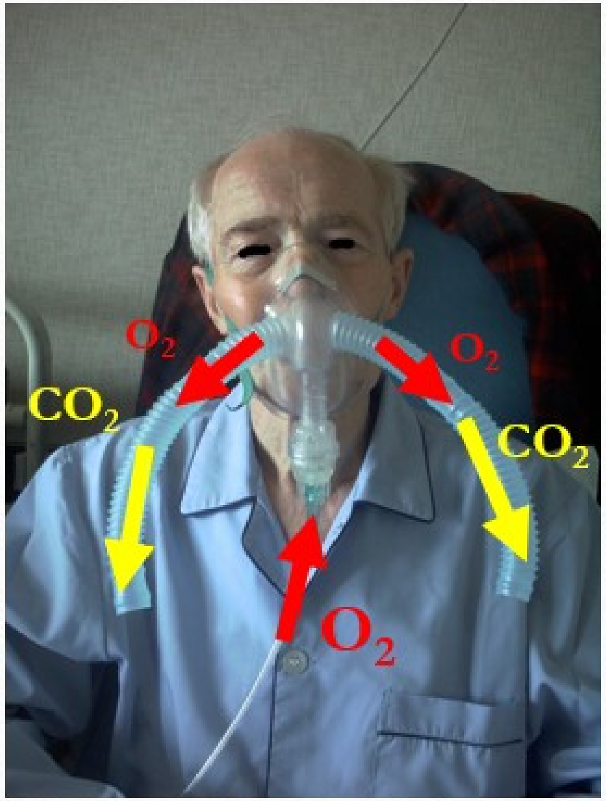


Duprez F. Evaluation of FDO_2 between nasal cannula and nasal O_2 catheter. *Annals of Intensive Care* 2017, 7

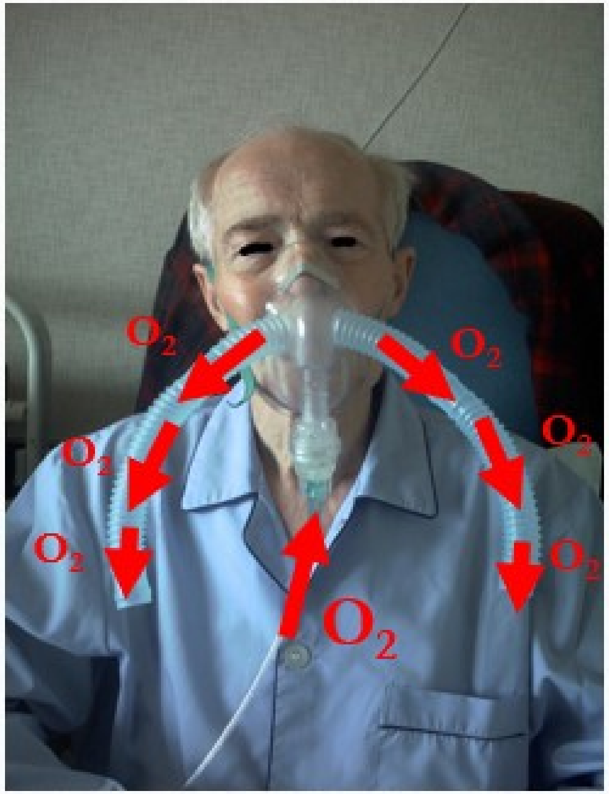

O_2
Oxygénothérapie à haute concentration
NADPH oxydase
Dérivé réactif de l'oxygène (ROS)
Arythmie
Activité stimulée ↑
Dépolarisation précoce ↑
NO → ONOO-
NO disponible ↓
Myocytes
Angiotensine I ↑
Endothéline ↑
Andénosine ↓
Vasoconstriction
Mort cellulaire
Résistance vasculaire systémique ↑
Volume d'éjection ↓
Débit cardiaque ↓
Diamètre coronarien ↓
Résistance coronarienne ↑
Débit coronarien ↓
Ischémie myocardique
Insuffisance cardiaque


FiO_2 1.0
μ-vascular PO_2 ↑ → peri-capillary O_2-diffusion ↑
Hb-SO_2 ↑ → DO_2 ↑
Inhibition of HPV / resorption atelectasis → right-to-left shunt ↑ → pulmonary gas exchange ↓
NO ↓ → MAP ↑
NO ↓ → μ-vascular perfusion ↓
Inflammation ↓ ↔ HIF-1α ↓
Inflammation ↑ ↔ NF-κB ↑
ROS ↑ → host defense ↑
ROS ↑ → NO ↓ → oxidative / nitrosative stress ↑
Mitochondrial O_2 consumption ↓ / carbohydrate oxidation ↑ → efficiency of mitochondrial respiration ↑
Mitochondrial O_2 consumption ↓ → ATP synthesis ↓
ROS ↑ ↔ Uncoupling of mitochondrial respiration

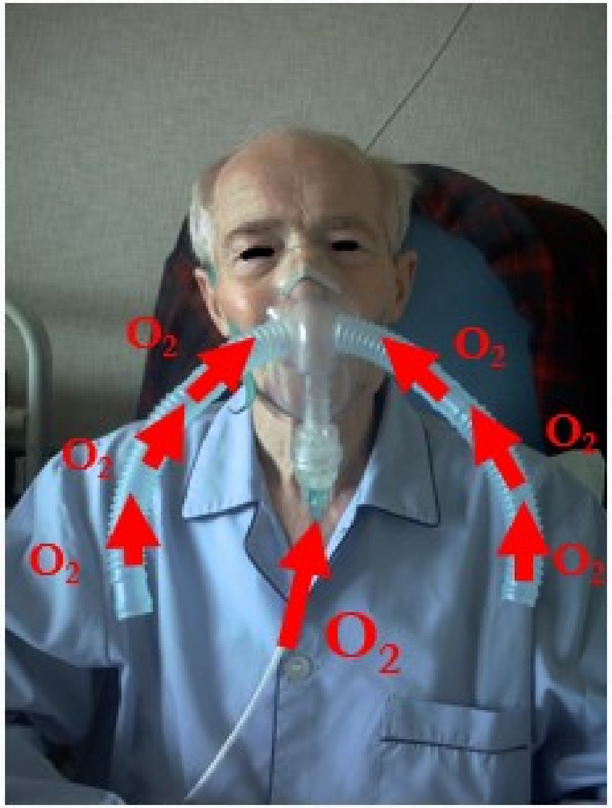
Fonctionnement du DTM ?



Début Expiration



Fin Expiration



Début Inspiration