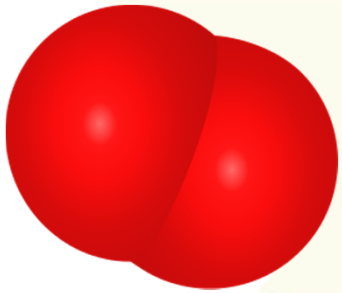


FiO_2 idéale pour l'enfant sous anesthésie ?



Dr Florent BAUDIN
Hôpital Femme Mère Enfant
CHU de Lyon
florent.baudin@chu-lyon.fr



Pas de conflits d'intérêts

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Lyon 1

Dr Florent BAUDIN
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florent.baudin@chu-lyon.fr

Pediatric Anesthesia 2004 **14**: 158–166

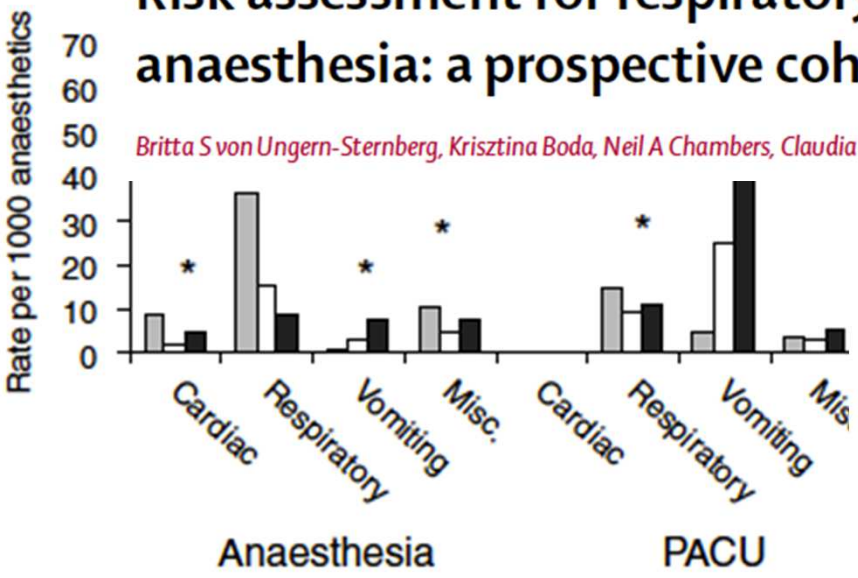
Perioperative anaesthetic morbidity in children: a database of 24 165 anaesthetics over a 30-month period

ISABELLE MURAT MD PhD, ISABELLE CONSTANT MD PhD AND HÉLÈNE MAUD'HUY MD
Service d'Anesthésie-Réanimation, Hôpital d'enfants Armand Trousseau, Assistance Publique-

Lancet 2010; 376: 773–83

Risk assessment for respiratory complications in paediatric anaesthesia: a prospective cohort study

Britta S von Ungern-Sternberg, Krisztina Boda, Neil A Chambers, Claudia Rebmann, Chris Johnson, Peter D Sly, Walid Habre



1392 (15%) of 9297 children had perioperative respiratory adverse events: 193 (2%) had bronchospasm, 351 (4%) laryngospasm, 332 (4%) airway obstruction, 919 (10%) oxygen desaturation, 687 (7%) coughing, and 58 stridor (1%; table 3). Urgent procedures had a higher risk for perioperative respiratory adverse events than did elective procedures (17% [546 of 3291] *vs* 14% [846 of 6006]; RR 1·2, 95% CI 1·1–1·3; p=0·001).

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In association with
ESPA EUROPEAN SOCIETY FOR PAEDIATRIC ANAESTHESIOLOGY

Intensive Care Med (2011) 37:1–3
DOI 10.1007/s00134-010-2034-y

EDITORIAL

Richard D. Branson
Bryce R. H. Robinson

Oxygen: when is more the enemy of good?

Oxygen in neonatal anesthesia: friend or foe?

Augusto Sola[a,b]

Current Opinion in Anaesthesiology 2008, 21:332–339

Editorial

Decalmer S. Anaesthesia 2013, 68, 1–12

Oxygen: friend or foe in peri-operative care?

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RISQUES DE L'O_2

TRAITEMENT DE L'HYPOXEMIE

PREVENTION DE L'HYPOXEMIE ?

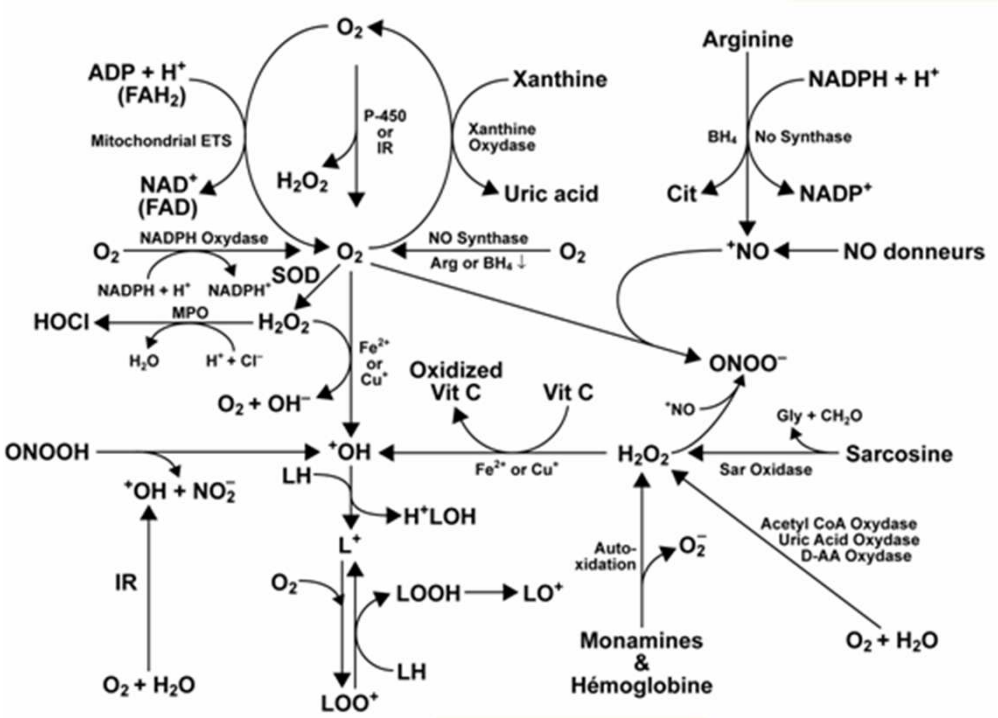


ansm
Agence nationale de sécurité du médicament et des produits de santé

Les gaz médicinaux sont considérés comme des médicaments. Pour l'oxygène AMM en JUIN 1997

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Toxicité de l'O_2

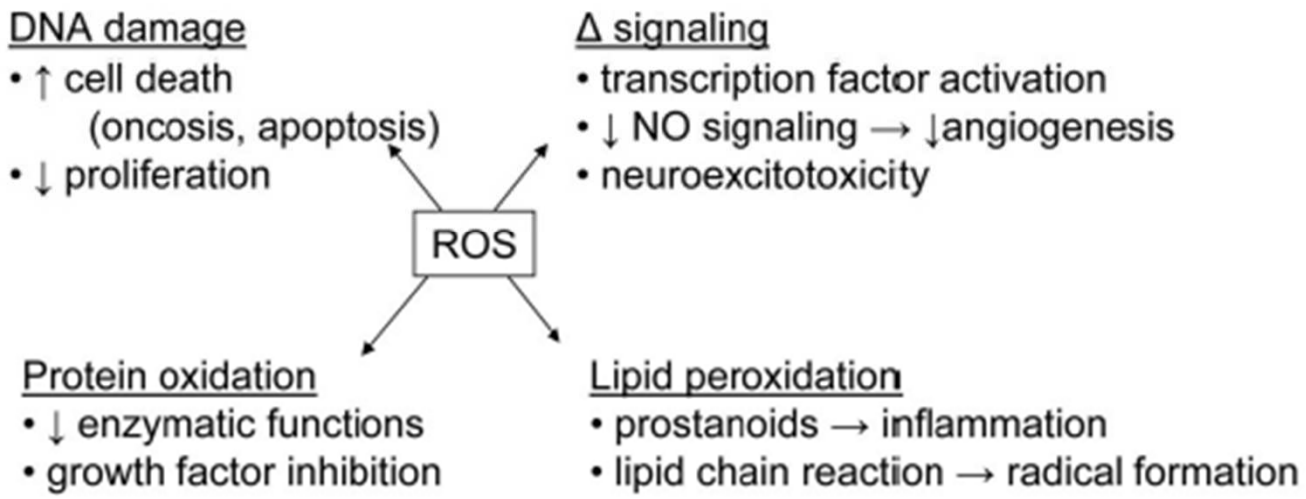


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Toxicité directe de l'oxygène

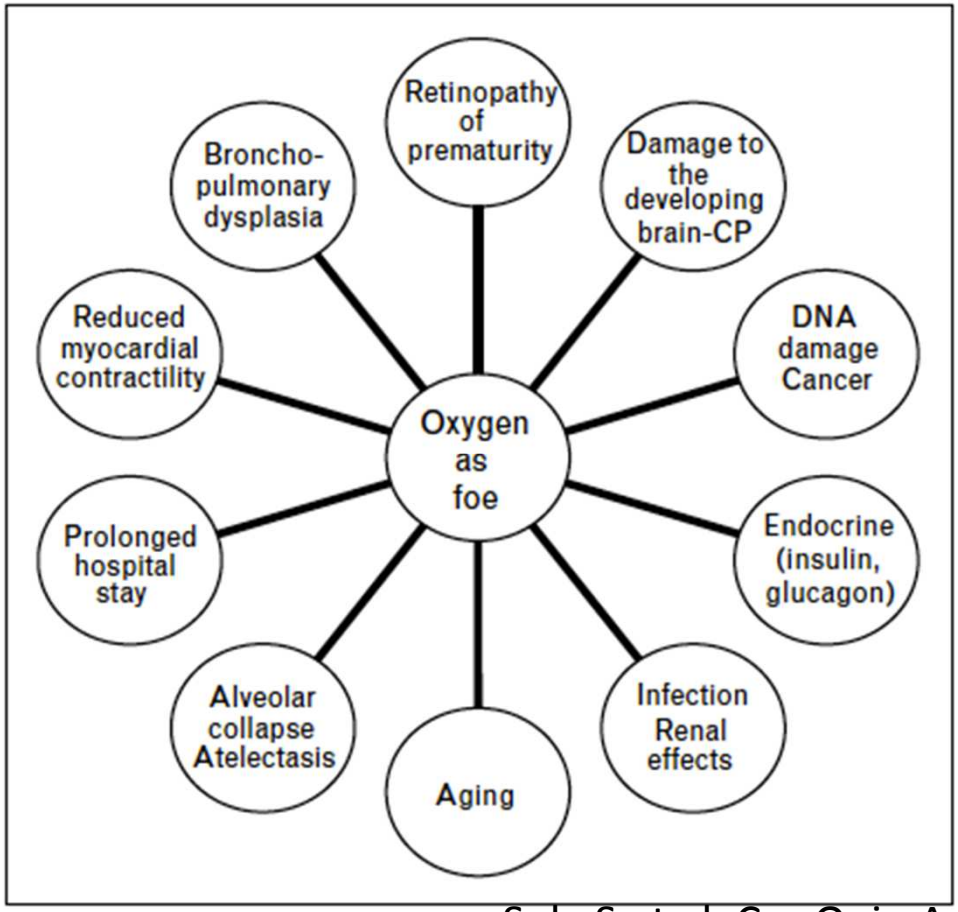
- Stress oxydatif
- Génération de radicaux libres oxygénés
- Même si exposition courte

Solbeg et al. Pediatr Res 2007; 62:559-63



Auten RL et al. Pediatr Res 2009;66: 121–127

Toxicité directe de l'oxygène



Sola S et al. Cur Opin Anesth 2008;21:332-339
Hartman et al. Am J Physiol Lung Cell Mol Physiol 303: L711



Toxicité de l'oxygène

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MAY 27, 2010 VOL. 362 NO. 21

Target Ranges of Oxygen Saturation in Extremely

The NEW ENGLAND JOURNAL of MEDICINE

AUGMENTATION DE LA MORTALITE

Groupe SpO_2 85-89%

vs SpO_2 91-95%

2016

Outcomes of Two Trials of Oxygen-Saturation Targets in Preterm Infants

The BOOST-II Australia and United Kingdom Collaborative Groups

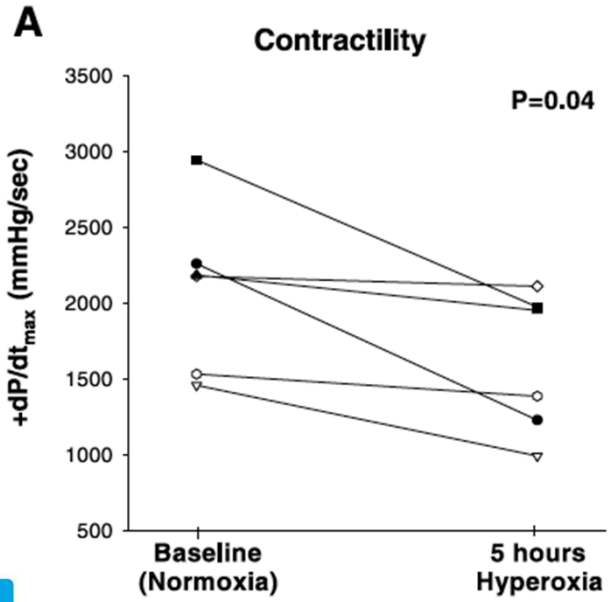
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Oxygène et conséquences hémodynamiques



O_2 et hémodynamique

- Diminution des résistances vasculaires pulmonaires
- Augmentation des résistances vasculaires systémiques
- Diminution de la contractilité et du débit cardiaque



Beekman et al. Am J Cardiol 1983; 52:106-111

Anderson et al. EJA 2005; 22: 420–425

Anderson et al. Anaesthesia 2010; 65: 167–71

Bandali KS et al. Am J Physiol Heart Circ Physiol 2004; 287:H553–H559

O_2 et hémodynamique

- Augmentation des résistances vasculaires cérébrales
- Diminution du débit sanguin cérébral

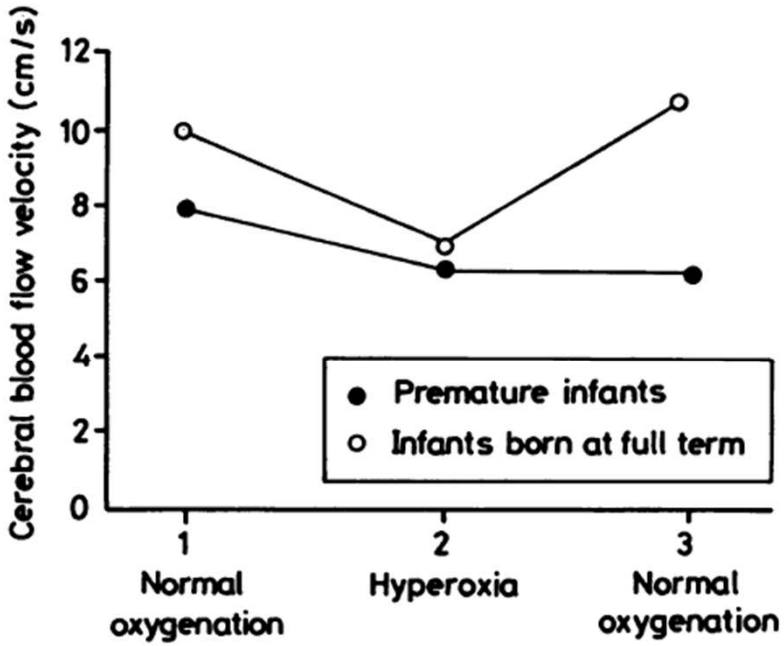


Fig 3 *Median changes in cerebral blood flow velocity at the three assessments.*

Niijima Arch Dis Child 1988, 63, 1126-1130

0031-3998/01/5006-0712
PEDIATRIC RESEARCH
Copyright © 2001 International Pediatric Research Foundation, Inc.
Vol. 50, No. 6, 2001
Printed in U.S.A.

Hypocapnia and Other Ventilation-Related Risk Factors for Cerebral Palsy in Low Birth Weight Infants

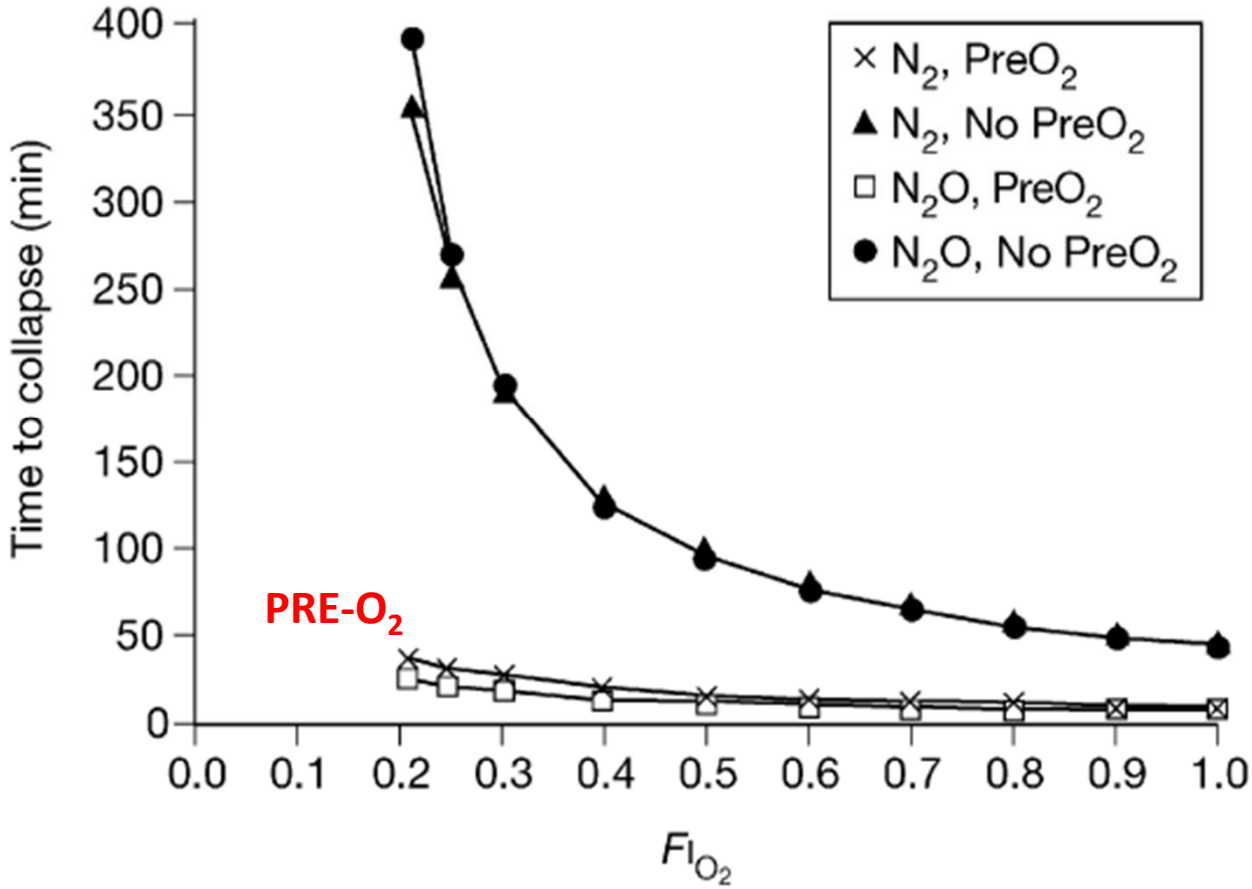
Risk factor	Model 2* (N = 400)
Cumulative hypocapnia	2.2 (1.1, 4.5) $p = 0.03$
Cumulative hyperoxemia	2.5 (1.3, 5.1) $p = 0.01$
Prolonged ventilation	2.9 (1.5, 5.6) $p = 0.002$

Collins et al. Pediatr Res 50: 712–719, 2001

Oxygène et conséquences respiratoires



O_2 et atélectasies



Joyce C et al. J Appl Physiol 1999;86: 1116–1125

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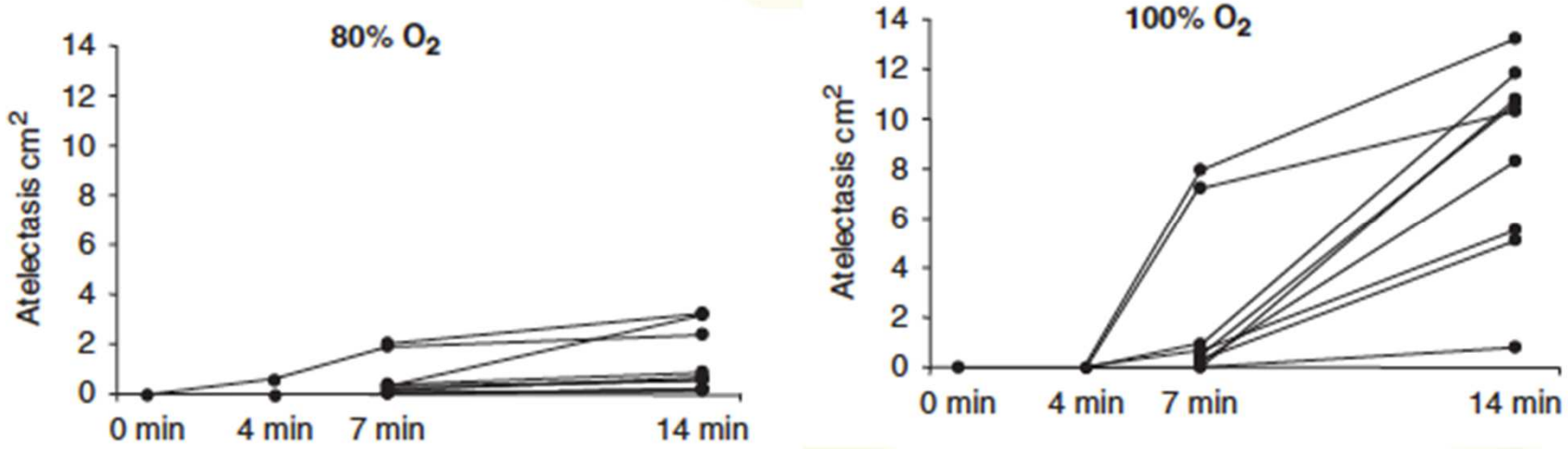
Pré oxygénation ?

O_2 et atélectasies

Oxygen concentration and characteristics of progressive atelectasis formation during anaesthesia

Acta Anaesthesiol Scand 2011; 55: 75–81

L. Edmark[1], U. Auner[2], M. Enlund[1], E. Östberg[1] and G. Hedenstierna[3]
Departments of [1]Anaesthesiology and Intensive Care, [2]Radiology, Central Hospital, Västerås, Sweden and [3]Department of Medical Sciences, Clinical Physiology, University Hospital, Uppsala, Sweden



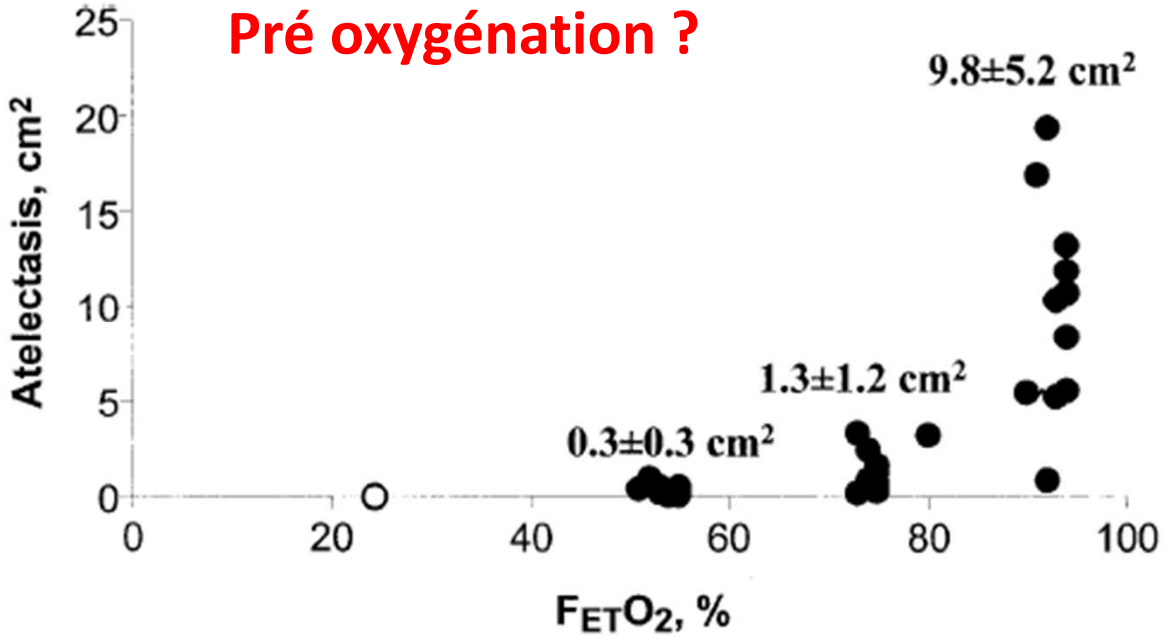
O_2 et atélectasies

Optimal Oxygen Concentration during Induction of General Anesthesia

Lennart Edmark, M.D., D.E.A.A., Kamelia Kostova-Aherdan, M.D.,† Mats Enlund, M.D., Ph.D.,‡ Göran Hedenstierna, M.D., Ph.D.§*

Anesthesiology 2003; 98:28–33

Pré oxygénation ?



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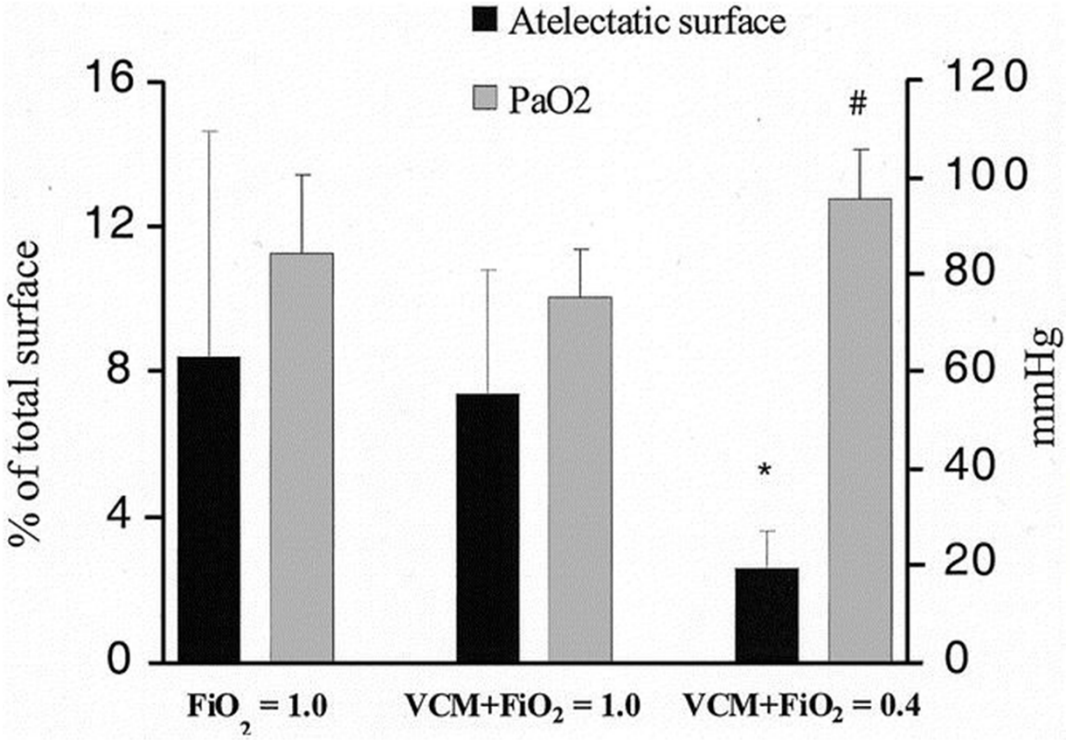
O_2 et atélectasies

The Effect of Increased F_{IO_2} Before Tracheal Extubation on Postoperative Atelectasis

Anesth Analg 2002;95:1777–81

Zilgia Benoît, MD*, Stephan Wicky, MD†, Jean-François Fischer, MD‡,
Philippe Frascarolo, PhD*, Carine Chapuis, MD*, Donat R. Spahn, MD*,
and Lennart Magnusson, MD, PhD*

Avant l'extubation?

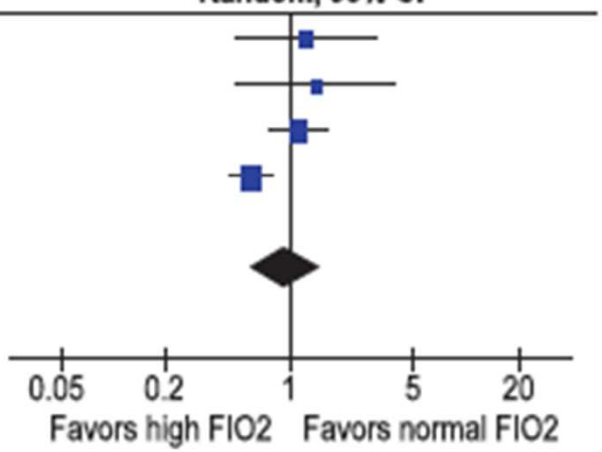


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O_2 et atélectasies

Study or Subgroup	High FIO2 Events	Total	Normal FIO2 Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Akça 1999 [56]	7	16	5	14	16.1%	1.23 [0.50, 3.00]
Kotani 2000 [60]	7	30	5	30	13.4%	1.40 [0.50, 3.92]
Meyhoff 2009 [63]	54	685	50	701	33.3%	1.11 [0.76, 1.60]
Myles 2007 [64]	75	997	127	1015	37.1%	0.60 [0.46, 0.79]
Total (95% CI)		**1728**		**1760**	**100.0%**	**0.93 [0.59, 1.46]**
Total events	143		187			

Heterogeneity: $Tau^2 = 0.13$; $Chi^2 = 9.16$, df = 3 (P = 0.03); $I^2 = 67\%$
Test for overall effect: Z = 0.33 (P = 0.74)



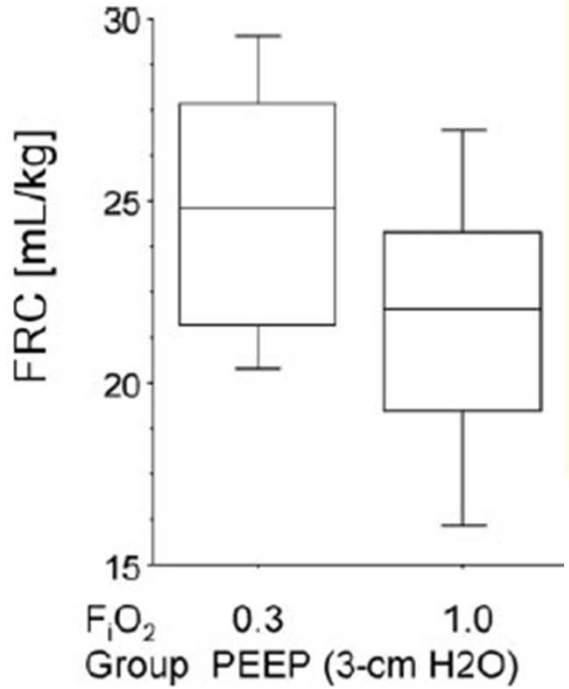
Hovaguimian et al. Anesthesiology 2013; 119:303-16

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O_2 et atélectasies

Chez l'enfant?

The Impact of Positive End-Expiratory Pressure on Functional Residual Capacity and Ventilation Homogeneity Impairment in Anesthetized Children Exposed to High Levels of Inspired Oxygen Anesth Analg 2007;104:1364 –8



Bénéfices de l'hyperoxie ?





Bénéfices de l'hyperoxie?

- Hyperoxie et NVPO?

CME **Consensus Guidelines for the Management of Postoperative Nausea and Vomiting**

Tong J. Gan, MD, MHS, FRCA,* Pierre Diemunsch, MD, PhD,† Ashraf S. Habib, MB, FRCA,* Anthony Kovac, MD,† Peter Kranke, MD, PhD, MBA,§ Tricia A. Meyer, PharmD, MS, FASHP,‖ Mehernoor Watcha, MD,¶ Frances Chung, MBBS,# Shane Angus, AA-C, MS,** Christian C. Apfel, MD, PhD,†† Sergio D. Bergese, MD,‡‡ Keith A. Candiotti, MD,§§ Matthew TV Chan, MB, BS, FANZCA,‖‖ Peter J. Davis, MD,¶¶ Vallire D. Hooper, PhD, RN, CPAN, FAAN,## Sandhya Lagoo-Deenadayalan, MD, PhD,*** Paul Myles, MD,††† Greg Nezat, CRNA, CDR, USN, PhD,§§§ Beverly K. Philip, MD,‖‖‖ and Martin R. Tramèr, MD, DPhil¶¶¶

Anesth Analg 2014;118:85–113)

Two meta-analyses have addressed the impact of intraoperative supplemental oxygen on the incidence of PONV.[64,220] There is no convincing evidence that high inspired oxygen fraction reduces PONV.

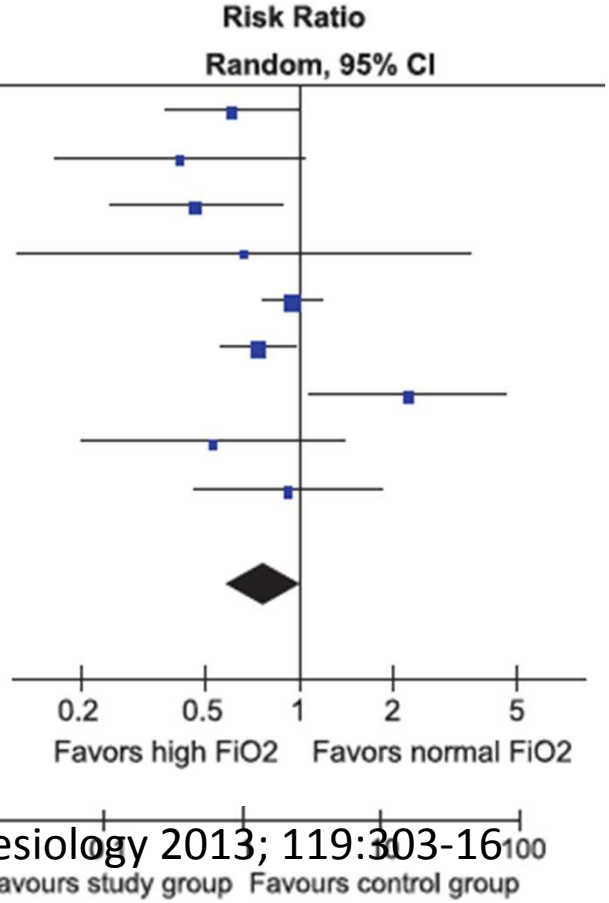
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Bénéfices de l'hyperoxie?

Study or Subgroup	High FiO2 Events	Total	Normal FiO2 Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Belda 2005 [4]	22	148	35	143	14.1%	0.61 [0.38, 0.98]
Bickel 2011 [58]	6	107	14	103	6.4%	0.41 [0.16, 1.03]
Greif 2000 [5]	13	250	28	250	10.5%	0.46 [0.25, 0.88]
Mayzler 2005 [62]	2	19	3	19	2.3%	0.67 [0.13, 3.55]
Meyhoff 2009 [63]	131	685	141	701	22.2%	0.95 [0.77, 1.18]
Myles 2007 [64]	77	997	106	1015	20.1%	0.74 [0.56, 0.98]
Pryor 2004 [66]	20	80	9	80	8.9%	2.22 [1.08, 4.58]
Schietroma 2011 [28]	5	35	10	37	5.9%	0.53 [0.20, 1.39]
Thibon 2012 [30]	15	226	15	208	9.5%	0.92 [0.46, 1.84]
Total (95% CI)		**2547**		**2556**	**100.0%**	**0.77 [0.59, 1.00]**
Total events	291		361			

Heterogeneity: Tau² = 0.07; Chi² = 17.39, df = 8 (P = 0.03); I² = 54%

Test for overall effect: Z = 1.93 (P = 0.05)



Heterogeneity: Tau² = 0.07; Chi² = 23.98, df = 11 (P = 0.01); I² = 54%

Test for overall effect: Z = 0.89 (P = 0.37)

Hovaguimian et al. Anesthesiology 2013; 119:303-16

Wang et al. Int Wound J 2015: doi: 10.1111/iwj.12548

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Bénéfices de l'hyperoxie?

- Hyperoxie et NVPO?
- Hyperoxie et ISO?

In conclusion, intraoperative high F_{IO_2} may be regarded as a supplemental strategy to further decrease the risk of SSI in patients receiving prophylactic antibiotics. Indirect comparison suggests that the degree of efficacy is similar to antibiotic prophylaxis in many surgical settings. However, the efficacy of high F_{IO_2} *per se*, and in the absence of antibiotic prophylaxis, remains unknown. High F_{IO_2} reduces the risk

Hovaguimian et al. Anesthesiology 2013; 119:303-16

L'oxygène dans le traitement de l'hypoxémie?



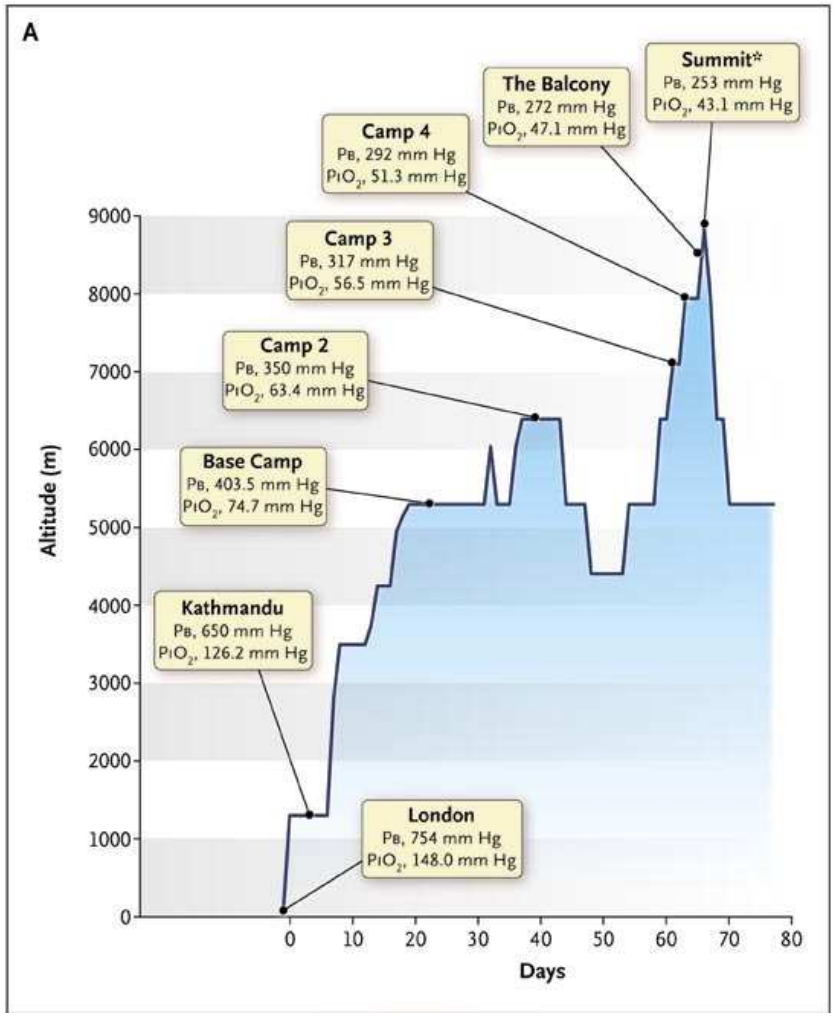
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Déterminants de l'hypoxémie

- Diminution de la PiO_2

$PAO_2 = (PB – 47) \times FiO_2 - (PaCO_2/R)$

TRAITEMENT:
- Augmentation de la PB
- Augmentation de la FiO_2



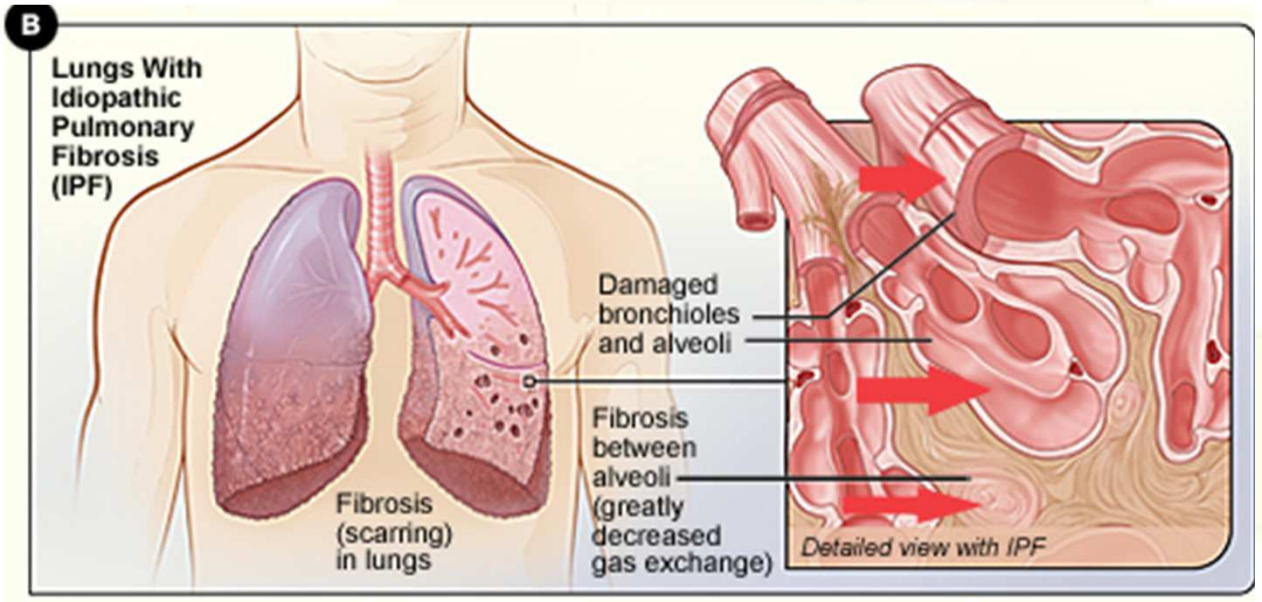
Grocott, NEJM 2009; 360:140-149

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Déterminants de l'hypoxémie

- Diminution de la PiO_2
- Trouble de la diffusion

Fibrose pulmonaire? => Augmentation de la FiO_2



Déterminants de l'hypoxémie

- Diminution de la PiO_2
- Trouble de la diffusion
- Hypoventilation alvéolaire

=> HYPOXIE et HYPERCAPNIE

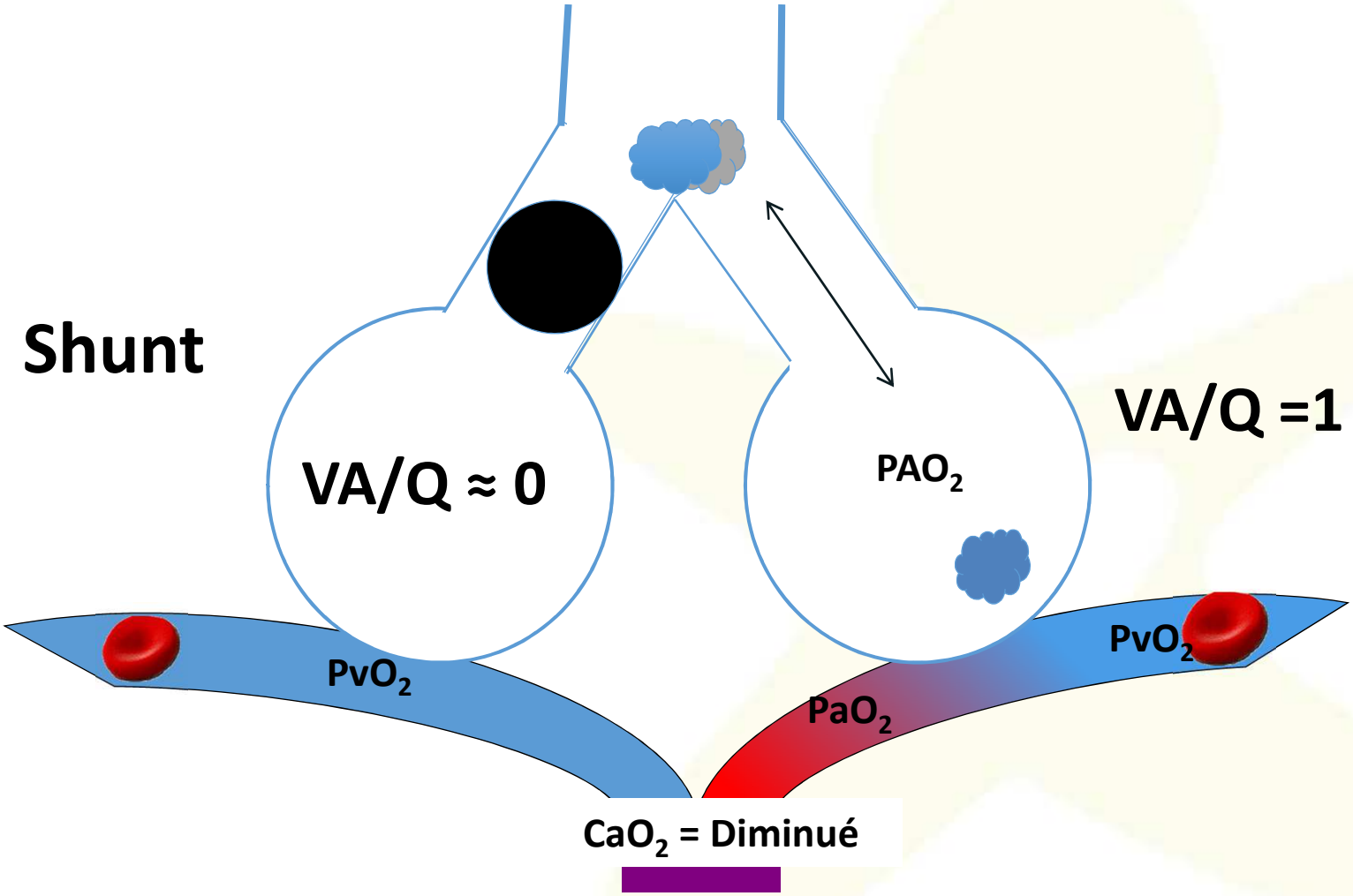
$$\mathbf{PAO_2 = (PB - 47) \times FiO_2 - (PaCO_2/R)}$$

FIO_2 corrige la PAO_2

↗Pa CO_2 = ↘Pa O_2

Déterminants de l'hypoxémie

- Diminution de la PiO_2
- Trouble de la diffusion
- Hypoventilation alvéolaire
- Shunt

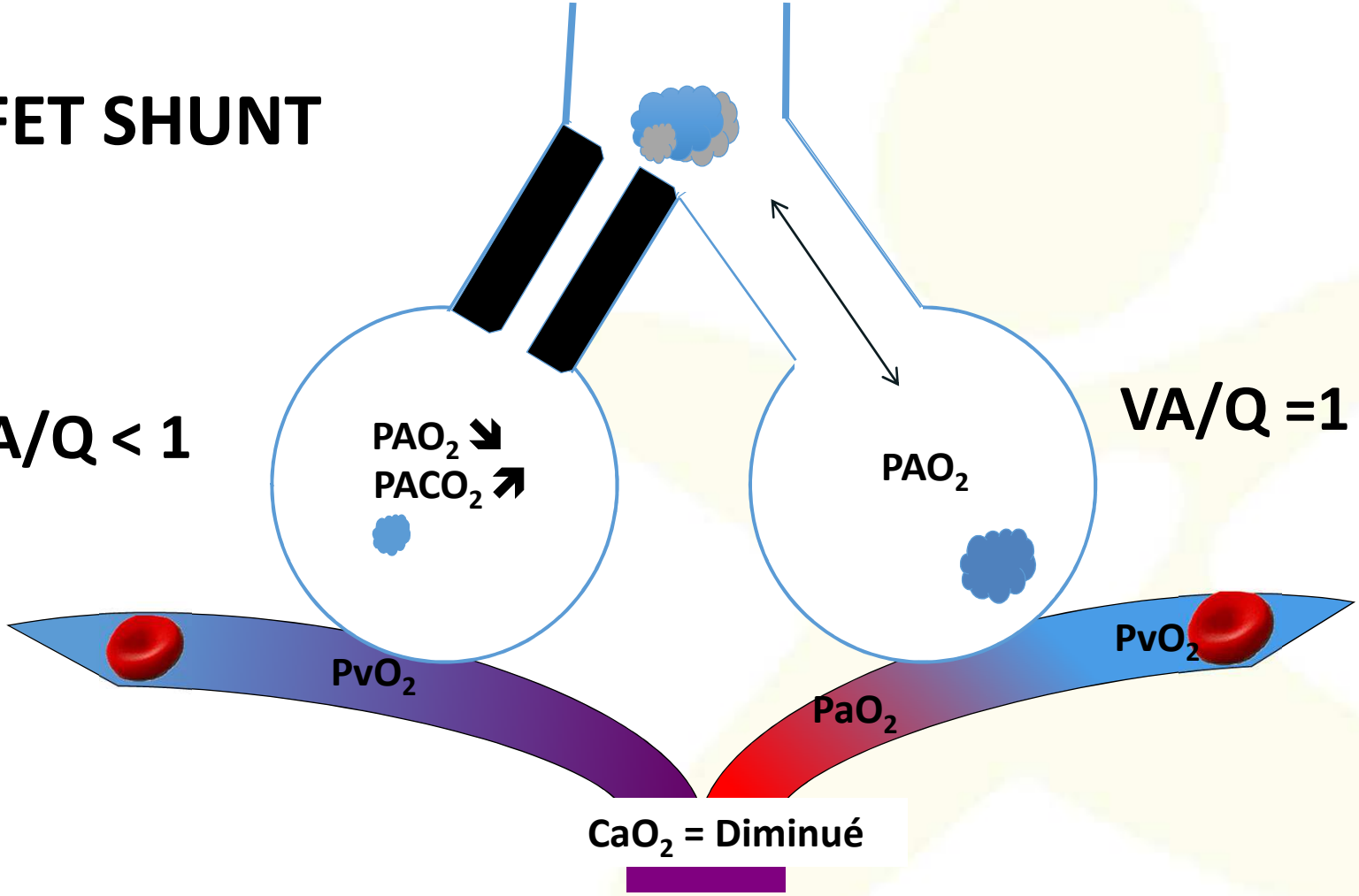


$CaO_2 = 1{,}34.Hb.SaO2 + 0{,}003.PaO2$

Déterminants de l'hypoxémie

- Diminution de la PiO_2
- Trouble de la diffusion
- Hypoventilation alvéolaire
- Shunt
- Anomalies des rapports ventilation perfusion

EFFET SHUNT



$CaO_2 = 1,34.Hb.SaO2 + 0,003.PaO2$

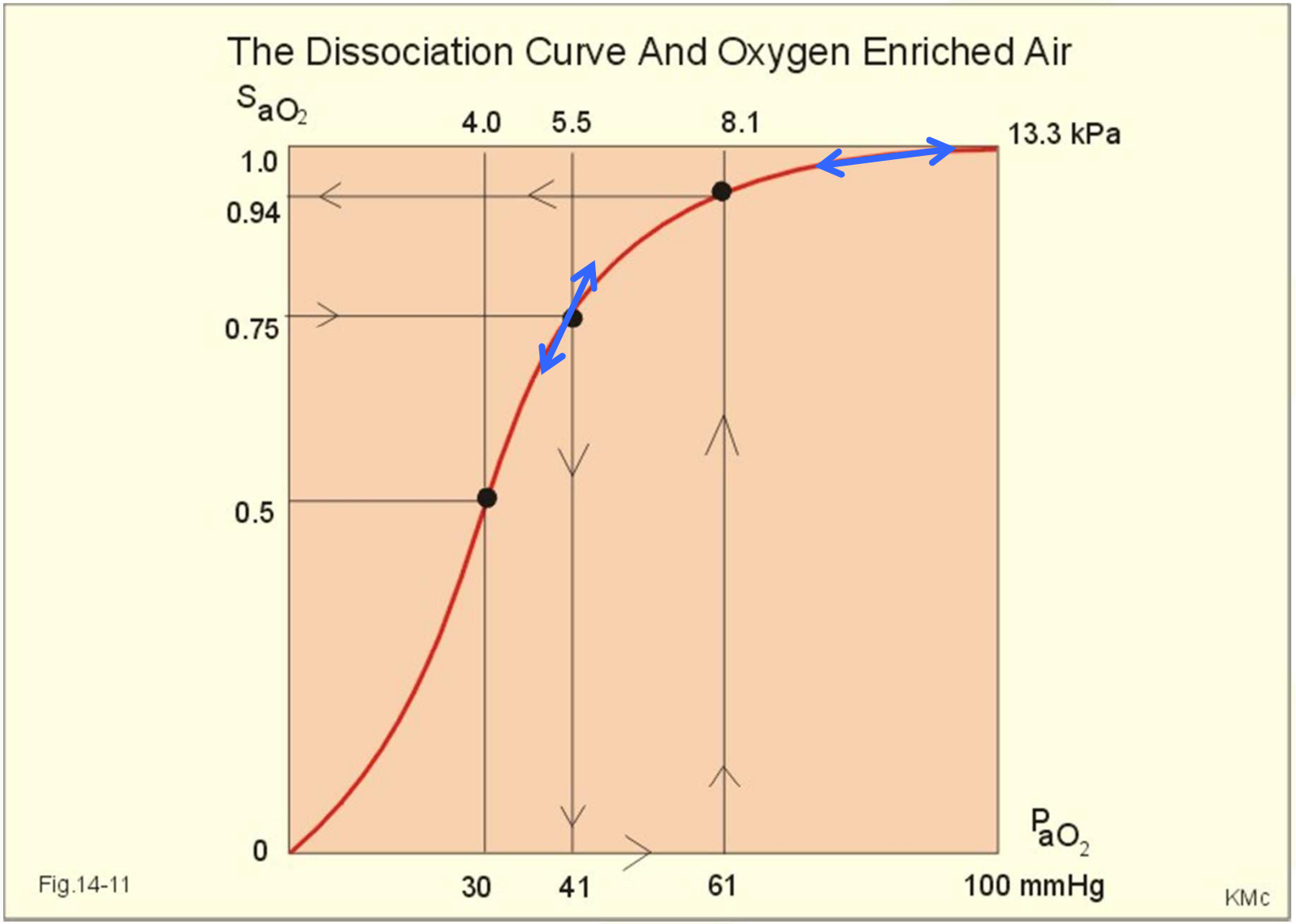

The Dissociation Curve And Oxygen Enriched Air
S_{aO_2}
4.0
5.5
8.1
13.3 kPa
1.0
0.94
0.75
0.5
0
P_{aO_2}
30
41
61
100 mmHg
KMc

Fig.14-11

Déterminants de l'hypoxémie

- Diminution de la PiO_2
- Trouble de la diffusion
- Hypoventilation alvéolaire
- Shunt
- Anomalies des rapports ventilation perfusion

Corrigées par:

⇒ **L'OXYGENE**

⇒ **LA PEEP et MANŒUVRES DE RECRUTEMENT+++**

Anesthesiology 2003; 98:14–22
© 2003 American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins, Inc.

Effects of Recruitment Maneuver on Atelectasis in Anesthetized Children

Gerardo Tusman, M.D., Stephan H. Böhm, M.D.,† Alejandro Tempra, M.D.,‡ Fernando Melkun, M.D.,* Eduardo García, M.D.,‡ Elsio Turchetto, M.D.,§ Paul G. H. Mulder, M.S., Ph.D.,‖ Burkhard Lachmann, M.D., Ph.D.#*

Réponses à l'hypoxémie

- DIMINUTION DE LA PiO_2 **=> OXYGENE**
- TROUBLE DE LA DIFFUSION **=> OXYGENE ?**
- HYPOVENTILATION ALVEOLAIRE **=> REGLAGE VM**
- SHUNT **=> RECRUTEMENT SI INTRAPULMONAIRE ?**
- ANOMALIES DES RAPPORTS VENTILATION PERFUSION
  => RECRUTEMENT ET PEEP

L'oxygène dans la prévention de l'hypoxémie?

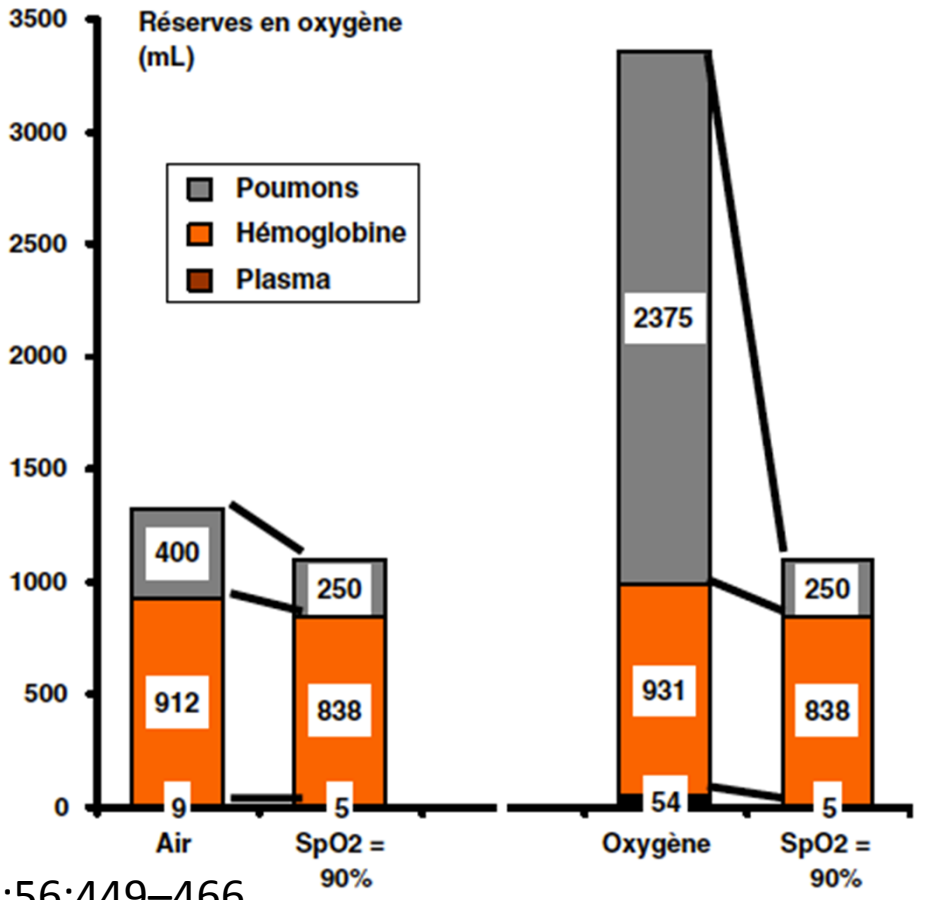


Prévention de l'hypoxémie

- OUI => Dans le cadre de l'intubation

0_2 et pré-oxygénation

- Réserve de l'organisme en O_2

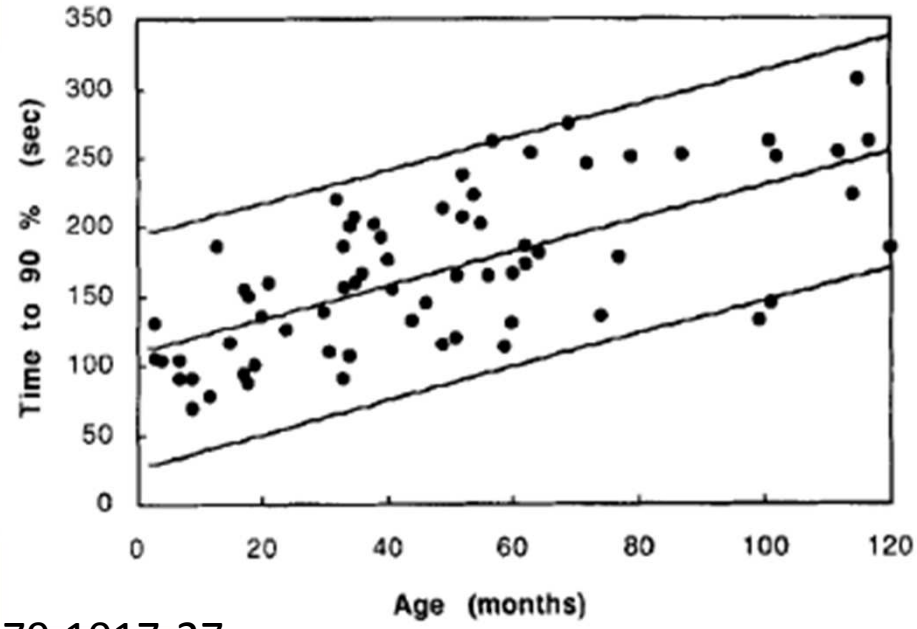


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Tanoubi et al. Can J Anesth 2009;56:449–466

0_2 et pré-oxygénation

- Réserve de l'organisme en O_2
- CRF basse chez l'enfant = **Réserve diminuée**
- Ventilation alvéolaire augmentée
- VO_2 + élevée



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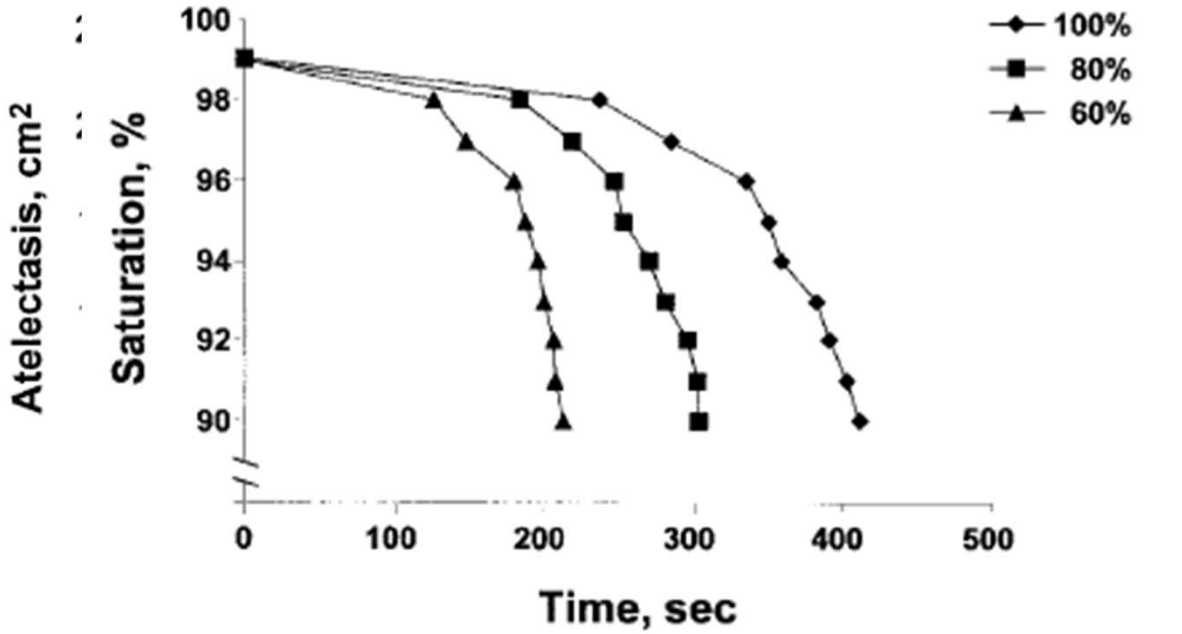
Dupeyrat et al. Anesth Analg 1994;79:1017-27
Patel R et al. Can J Anaesth 1994;41:771-4

0_2 et pré-oxygénation

Optimal Oxygen Concentration during Induction of General Anesthesia

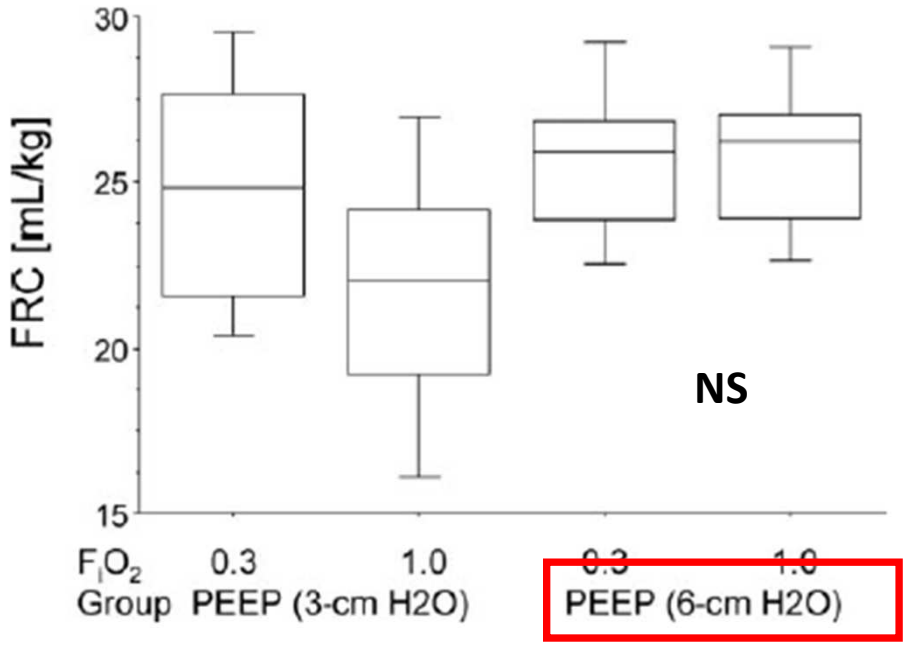
Lennart Edmark, M.D., D.E.A.A., Kamelia Kostova-Aherdan, M.D.,† Mats Enlund, M.D., Ph.D.,‡ Göran Hedenstierna, M.D., Ph.D.§*

Anesthesiology 2003; 98:28–33



0_2 et pré-oxygénation

The Impact of Positive End-Expiratory Pressure on Functional Residual Capacity and Ventilation Homogeneity Impairment in Anesthetized Children Exposed to High Levels of Inspired Oxygen Anesth Analg 2007;104:1364 –8



PEEP + RM

Hospices Civils de Lyon



Prévention de l'hypoxémie

- OUI => Dans le cadre de l'intubation
- **NON au cours de l'ANESTHESIE !!!!!**

Has Oxygen Administration Delayed Appropriate Respiratory Care? Fallacies Regarding Oxygen Therapy

Respi Care 2003; 48:611-620

John B Downs MD

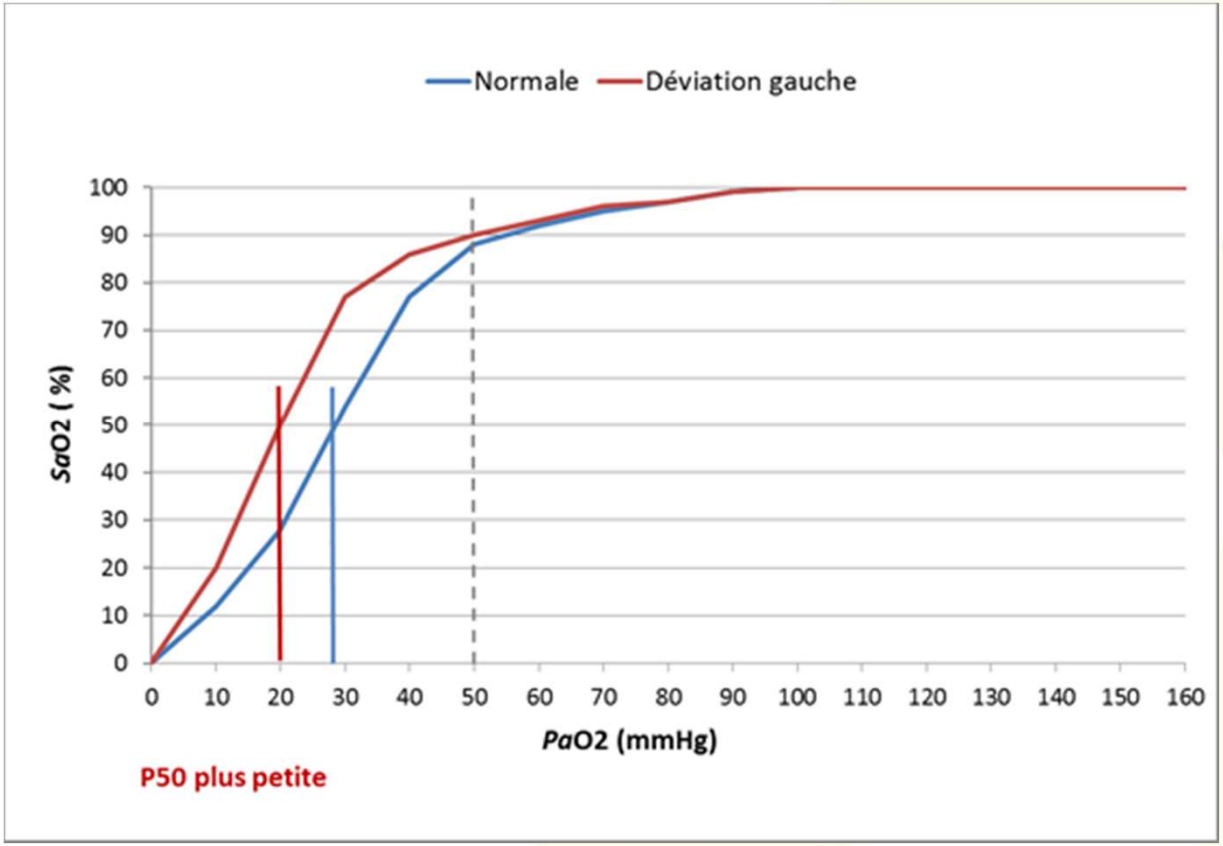
Supplemental Oxygen Compromises the Use of Pulse Oximetry for Detection of Apnea and Hypoventilation During Sedation in Simulated Pediatric Patients

Ilan Keidan, MD[a,b], Dietrich Gravenstein, MD[b], Haim Berkenstadt, MD[a,c], Amital Ziv, MD[c], Itay Shavit, MD[d], Avner Sidi, MD[a,b]

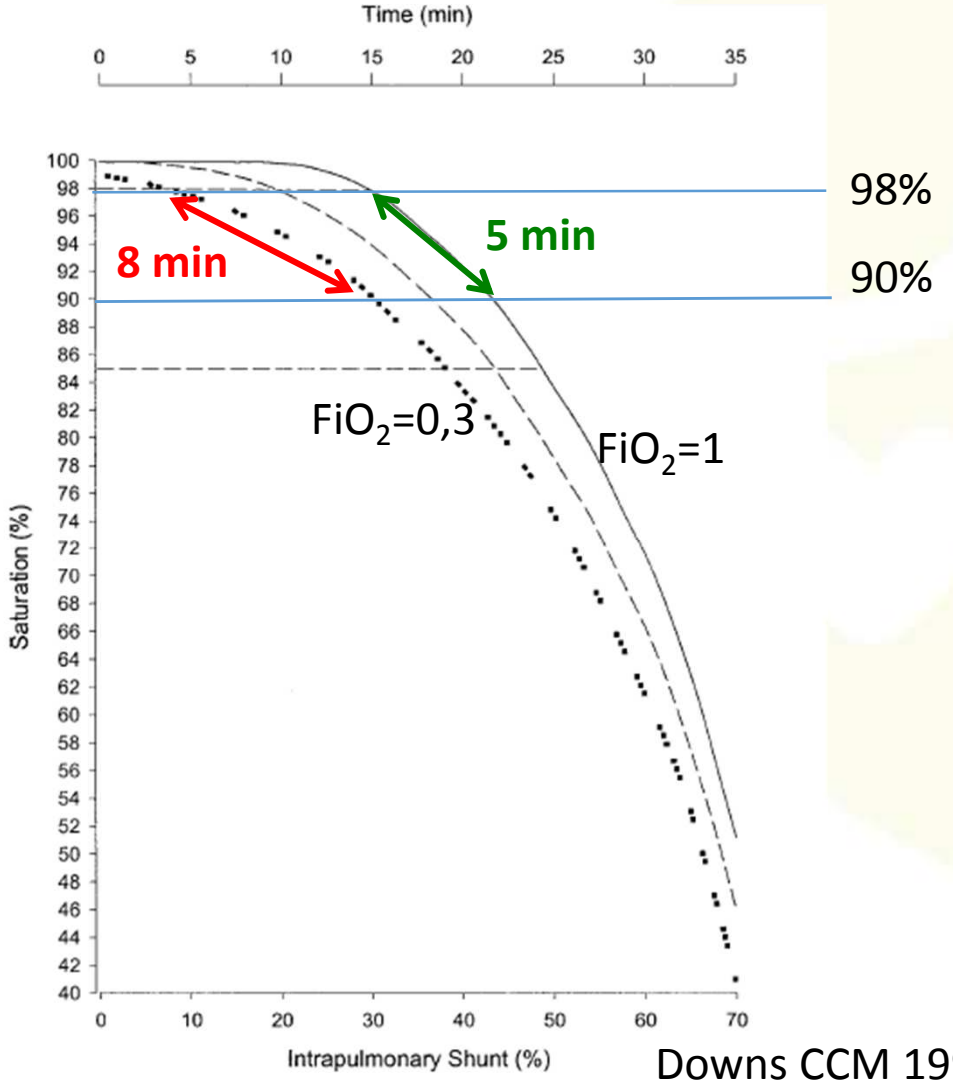
Pediatric 2008;122:293-298

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Prévention de l'hypoxémie



Prévention de l'hypoxémie



Downs CCM 1999;27:2844-2846

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CONCLUSIONS. Hypoventilation and apnea are detected more quickly when patients undergoing sedation breathe only air. Supplemental oxygen not only does not prevent oxygen desaturation but also delays the recognition of apnea. *Pediatrics* 2008;122:293–298



In association with
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SYNTHESE

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BJA

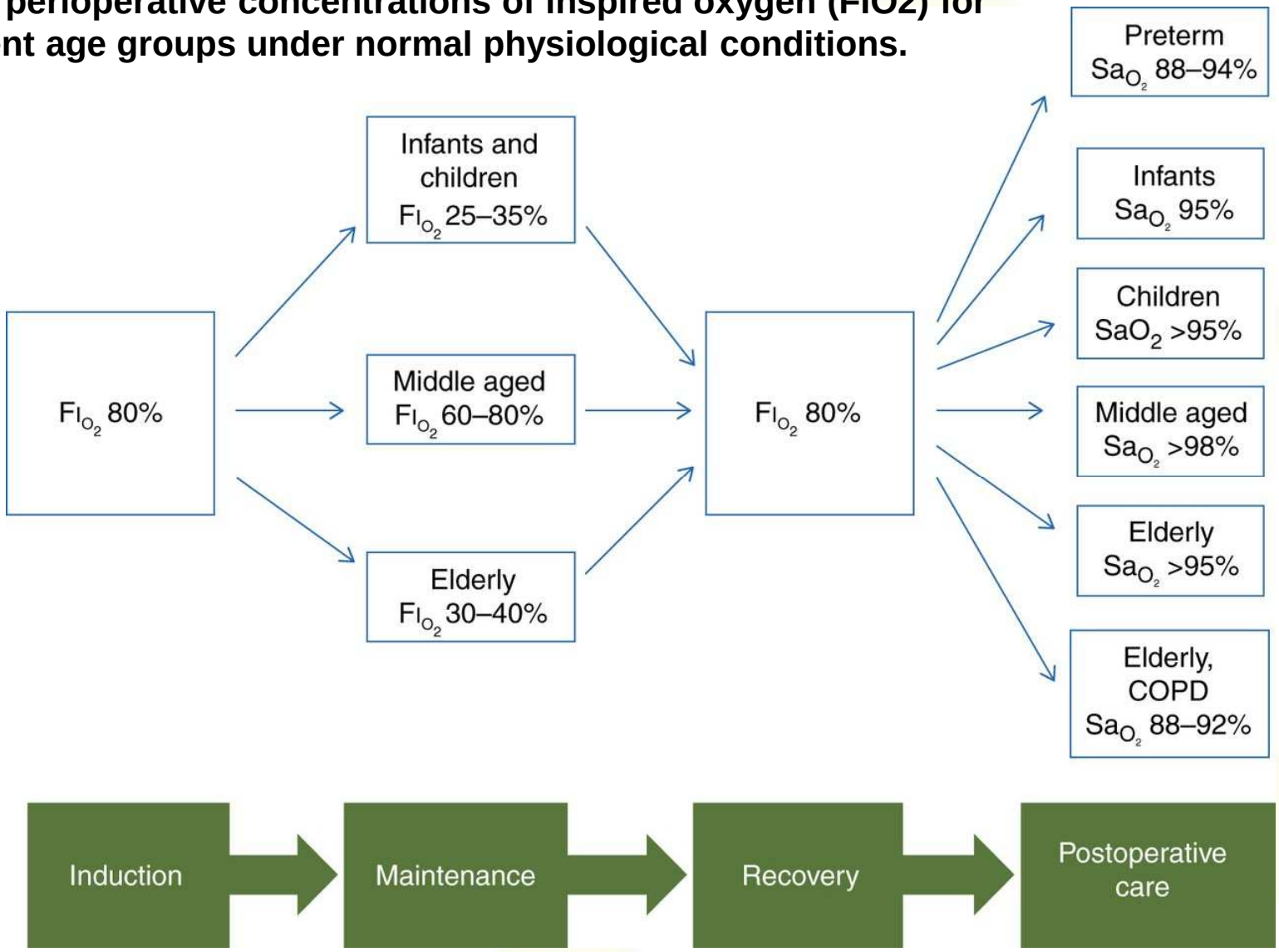
CLINICAL PRACTICE

Perioperative use of oxygen: variabilities across age

W. Habre[1,2*] and F. Peták[2,3]

Hospices Civils de Lyon

Suggested perioperative concentrations of inspired oxygen (FIO2) for different age groups under normal physiological conditions.



W. Habre, and F. Peták Br. J. Anaesth. 2014;113:ii26-ii36

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TAKE HOME MESSAGE

- Toxicité de l'O_2 et PREMATURITE
- O_2 et ATELECTASIE
- O_2 ne protège pas de l'hypoxémie
- O_2 ne traite pas toutes les causes d'hypoxémie

- FiO_2 pour induction= 80%
- FiO_2 pour entretien de l'anesthésie entre 21% et 30%
- Monitorage +++

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MERCI POUR VOTRE ATTENTION

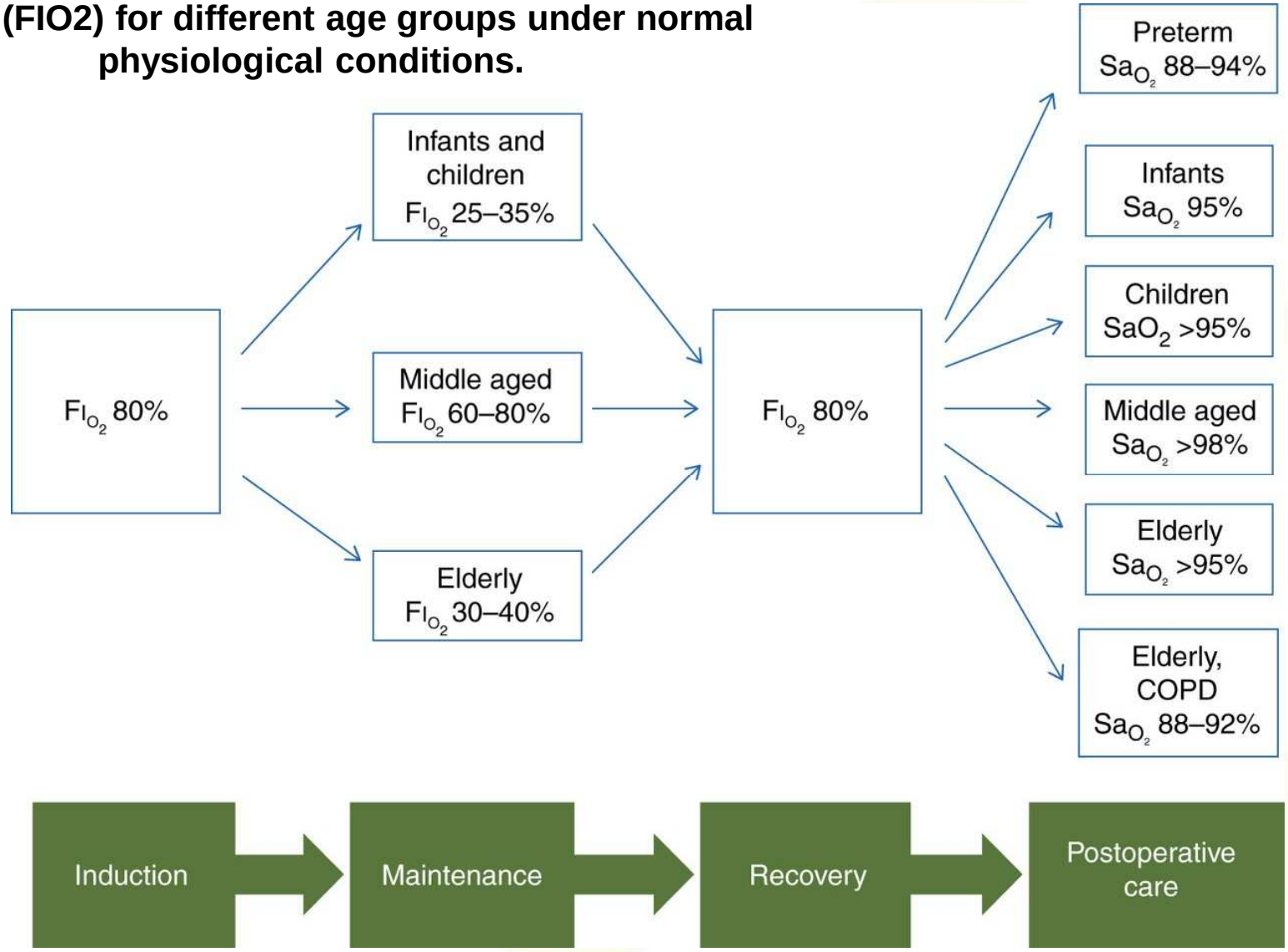
ADARPEF

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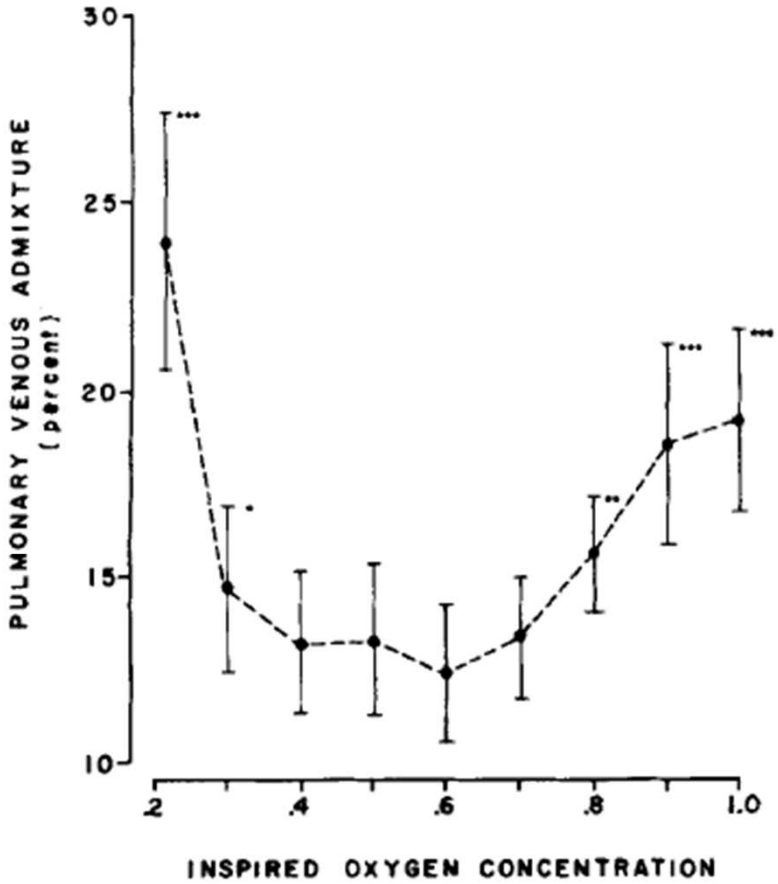


FIGURE. Calculated mean pulmonary venous admixture as a function of inspired O_2 concentration. Values represent mean ± 2 SE of 30 observations. (Asterisks indicate significant difference from value observed at $F_{IO_2} = 0.6$; $*p<0.05$, $**p<0.01$, $***p<0.001$.)

Douglas et al Anesth Analg 1976;55

Table 2 Preoxygenation before induction and before intubation

	Preoxygenation = yes	Before induction FiO_2 80–100%	FiO_2 = 100%	Before intubation FiO_2 = 100%
< 1 month	80% [74–86], *n* = 161	68% [61–75], *n* = 161	53% [45–61], *n* = 161	77% [71–84], *n* = 161*
1 month–1 year	72% [65–79], *n* = 176	65% [58–72], *n* = 182	56% [49–63], *n* = 182	77% [71–83], *n* = 178*
1–3 years	70% [64–76], *n* = 196	62% [55–69], *n* = 197	53% [46–60], *n* = 197	73% [67–79], *n* = 195*
3–15 years	76% [70–82], *n* = 197	65% [58–72], *n* = 200	59% [52–66], *n* = 200	69% [63–75], *n* = 198*
>15 years	83% [78–88], *n* = 198	77% [71–83], *n* = 193	73% [67–79], *n* = 193	71% [65–78], *n* = 190
Obese	95% [92–98], *n* = 198	92% [87–95], *n* = 200	87% [82–92], *n* = 200	–
Full stomach	96% [93–99], *n* = 200	95% [90–97], *n* = 200	92% [87–95], *n* = 200	–
Difficult Intubation	98% [96–100], *n* = 191	95% [91–98], *n* = 192	92% [88–96], *n* = 192	–