Hirslanden Anaesthesia Symposium 2024

Oxygen demand – how much is too much for our patients

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Conflict of Interest

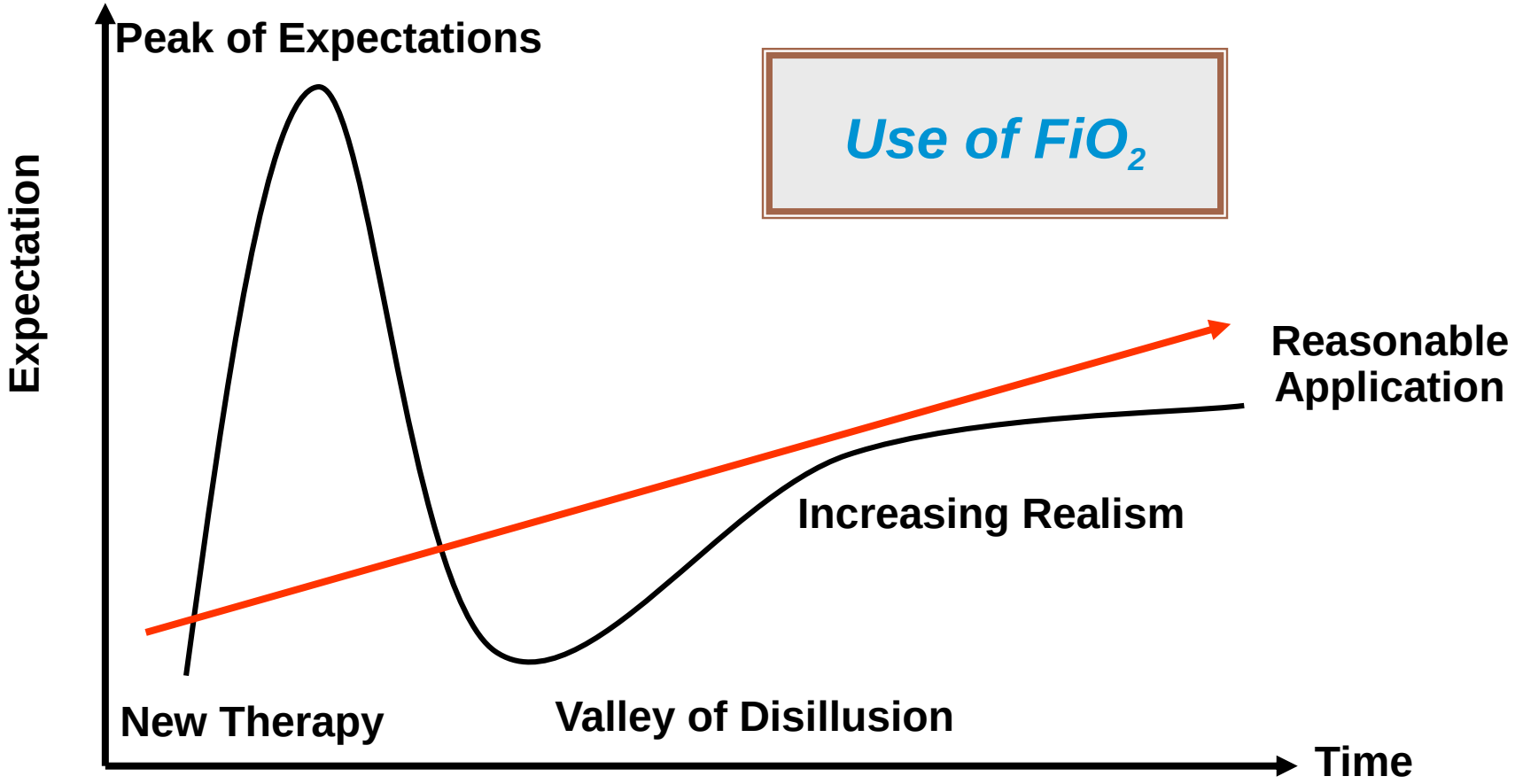
No financial COI

- Airway devices without payment for research: Intersurgical, Karl Storz, Verathon, Aircraft Medical, Prodol Meditec, Venner Medical, Kingsystems, Medtronic, Ambu, VBM, Radiometer, Sentec, Fisher&Paykel

Intellectual COI

- Professor emeritus Anaesthesiology and Intensive Care Medicine, University of Bern, Switzerland
- Professor emeritus Medical Education, Sigmund Freud University Vienna, Austria
- Visiting Professor, Anaesthesiology, University of Torino, Torino, Italy
- Member of Project for Universal Management of Airways (PUMA)
- European Resuscitation Council Board Director of Guidelines and ILCOR
- Chair Task Force Education, Implementation, Team (ILCOR)

Practice of Anaesthesia



What is your routine FiO_2 in OR?

a. 30%

b. 50%

c. 70-80%

d. 100%

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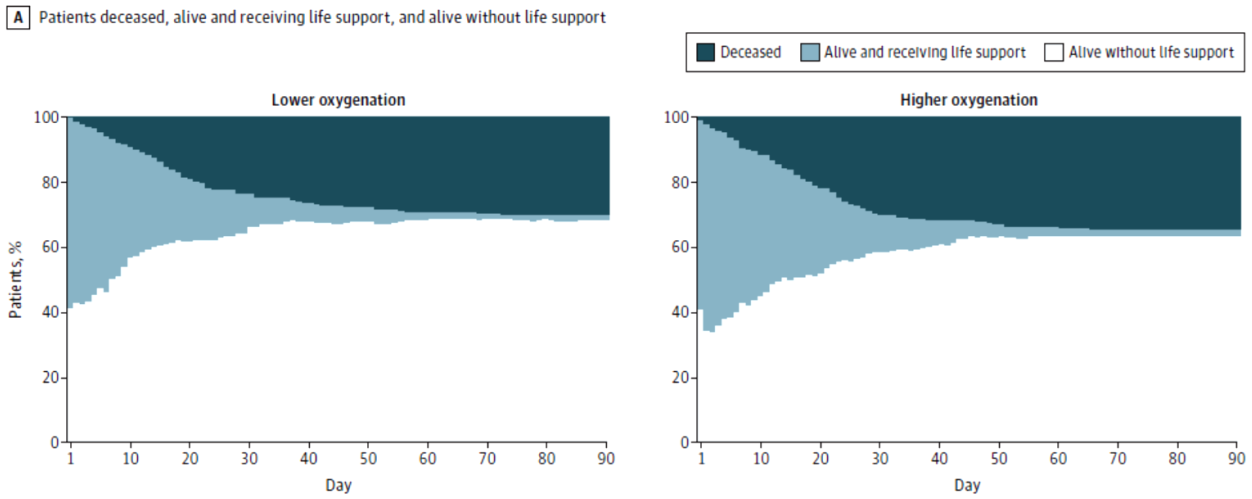
How much oxygen should we administer intraoperatively?

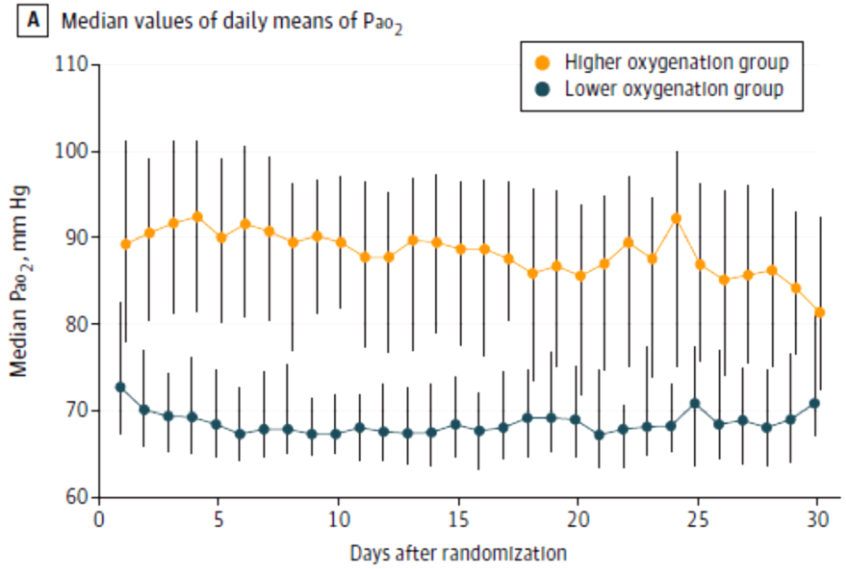
- **The amount needed to avoid Hypoxemia**
- **Without harming patients (suppemental O_2)**

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Lower vs Higher Oxygenation Target and Days Alive Without Life Support in COVID-19

The HOT-COVID Randomized Clinical Trial **JAMA, 2024**





Relevance: adult COVID-19 ICU patients with severe hypoxemia, a PaO_2 of 60mmHg resulted in more days alive without life support in 90 days than targeting a PaO_2 of 90mmHg

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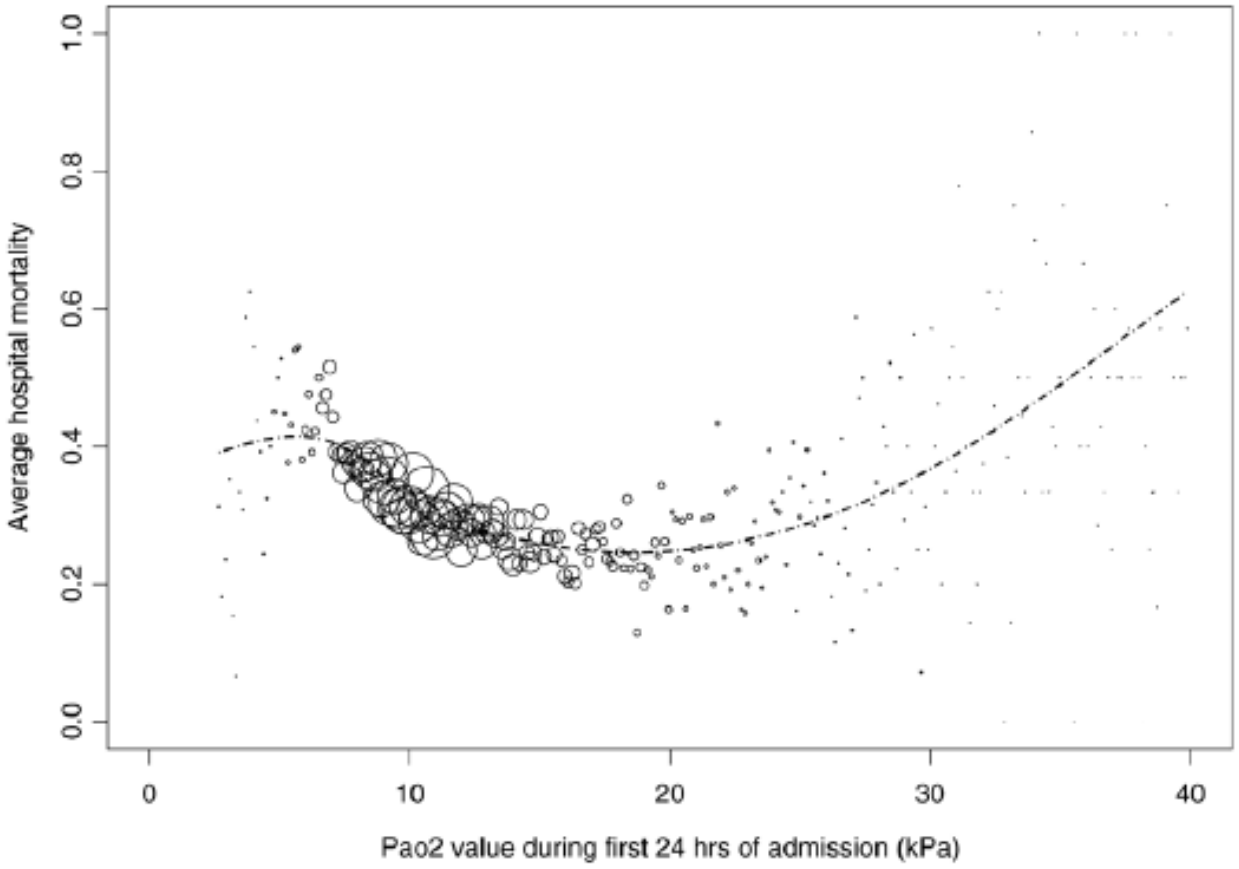
Research *Critical Care* 2008, 12:R156 **Open Access**

Association between administered oxygen, arterial partial oxygen pressure and mortality in mechanically ventilated intensive care unit patients

Evert de Jonge[1], Linda Peelen[2,3], Peter J Keijzers[4], Hans Joore[4], Dylan de Lange[4], Peter HJ van der Voort[5], Robert J Bosman[5], Ruud AL de Waal[6], Ronald Wesselink[7] and Nicolette F de Keizer[2]



PaO_2 (n patients)	OR	95%CI
<65 (6937)	1,2	1,03-1,21
65-80 Reference (7466)	1	
80-95 (6430)	1,11	1,02-1,21
95-110 (7278)	1,08	1,00-1,18
>110 (8196)	1,23	1,13-1,34

Most people suffer from hypoxemia …

… little from hyperoxemia

Association Between Hyperoxia and Mortality After Stroke: A Multicenter Cohort Study*

Fred Rincon, MD, MSc, MBE, FACP, FCCP, FCCM[1,2]; Joon Kang, MD[1]; Mitchell Maltenfort, PhD[3]; Matthew Vibbert, MD[1,2]; Jacqueline Urtecho, MD[1,2]; M. Kamran Athar, MD[2,4]; Jack Jallo, MD, PhD, FACS[2]; Carissa C. Pineda, MD[1,5]; Diana Tzeng, MD[1,5]; William McBride, MD[1,5]; Rodney Bell, MD, FAHA[1,2,5]

Crit Care Med 2014; 42:387–396

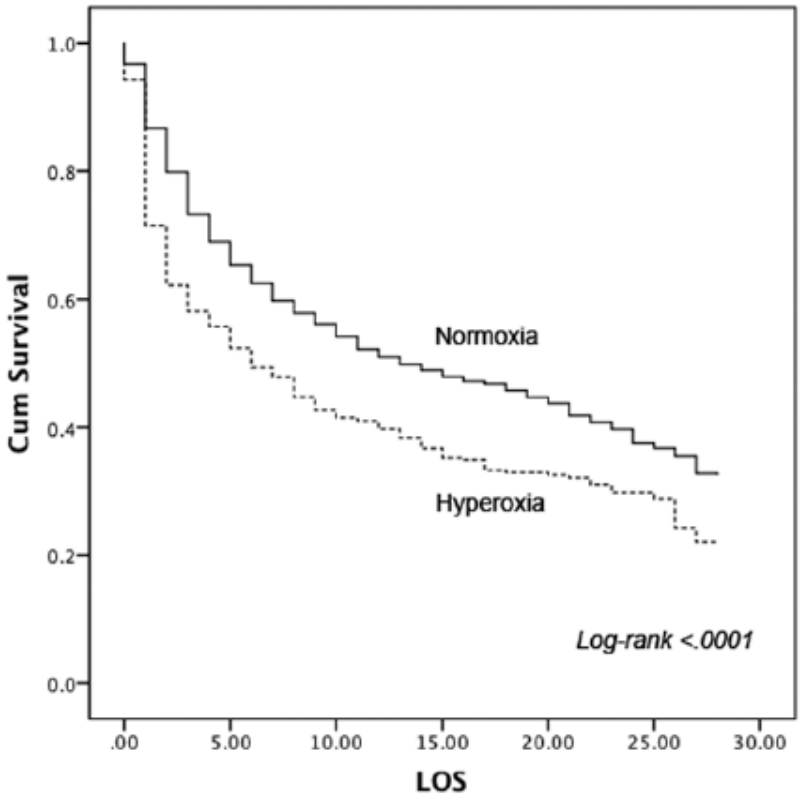


TABLE 3. Outcomes of Ventilated Stroke Patients by Exposure Groups: Primary and Subgroup Analysis

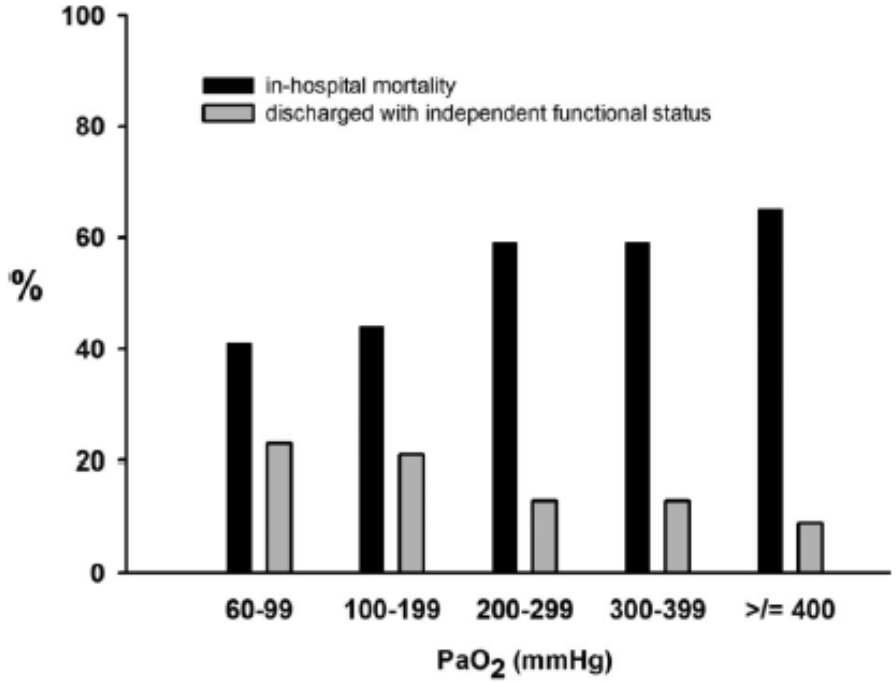
Outcomes of Patients	Total	Hypoxia	Normoxia	Hyperoxia[a]
Primary analysis				
Overall, *n*	2,894	1316	1084	450
Dead, *n* (%; 95% CI)	1,479 (52; 50–54)	690 (53; 49–55)	502 (47; 45–52)	268 (60; 57–65)[b]
Secondary analysis				
Ischemic stroke, *n*	554	268	202	75
Dead, *n* (%; 95% CI)	261 (48; 44–52)	123 (46; 34–48)	95 (47; 43–57)	43 (57; 47–63)[c]
Subarachnoid hemorrhage	936	401	383	135
Dead, *n* (%; 95% CI)	403 (44; 50–54)	176 (45; 41–47)	139 (38; 33–43)	80 (60; 52–68)[d]
Intracerebral hemorrhage	1,404	647	499	240
Dead, *n* (%; 95% CI)	812 (59; 56–62)	391 (61; 57–65)	268 (54; 50–58)	145 (61; 55–67)[e]
Overall hospital length of stay, median (interquartile range)	7 (2–14)	7 (2–14)	7 (3–14)	4 (1–12)[f]

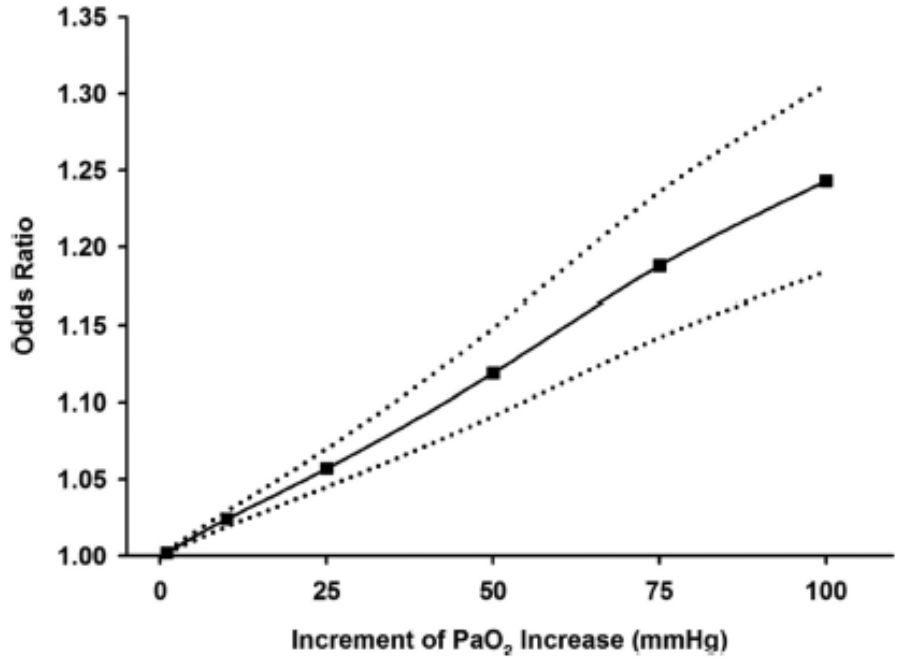
[a]Defined as arterial $Pao_2 \geq 300$ mm Hg (39.99 kPa).

Relationship Between Supranormal Oxygen Tension and Outcome After Resuscitation From Cardiac Arrest

J. Hope Kilgannon, et al; on behalf of the Emergency Medicine Shock Research Network (EMShockNet) Investigators

Conclusion—In this large sample of postresuscitation patients, we found a dose-dependent association between supranormal oxygen tension and risk of in-hospital death. (*Circulation*. 2011;123:2717-2722.)





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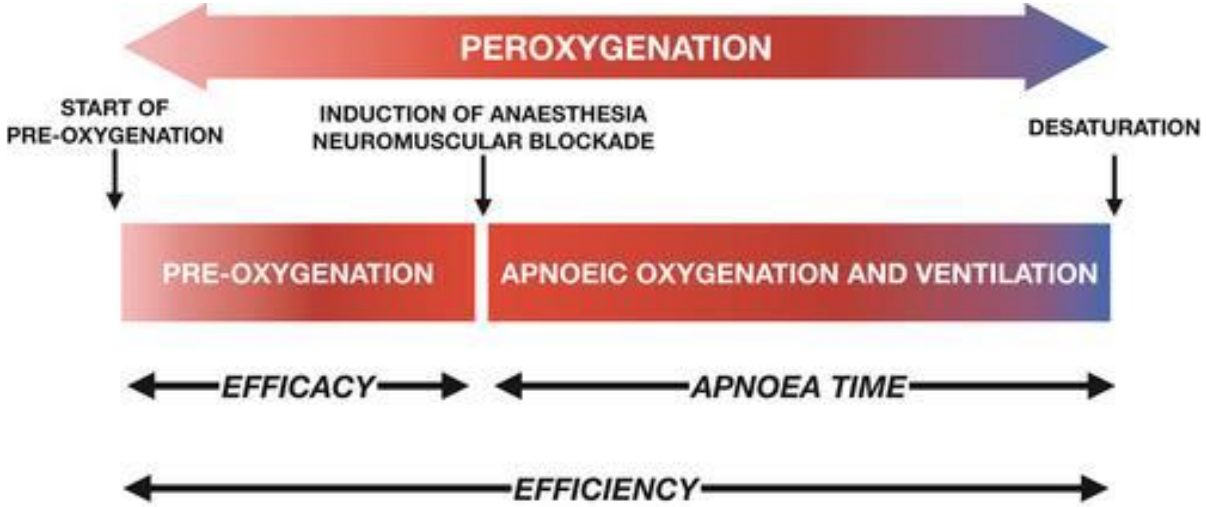
Oxygenation at all times: Peri-Oxygenation



Patel A, El-Boghdadly K.
Apnoeic oxygenation and ventilation: go with the flow.
Anaesthesia 2020;75**:**1002-5.

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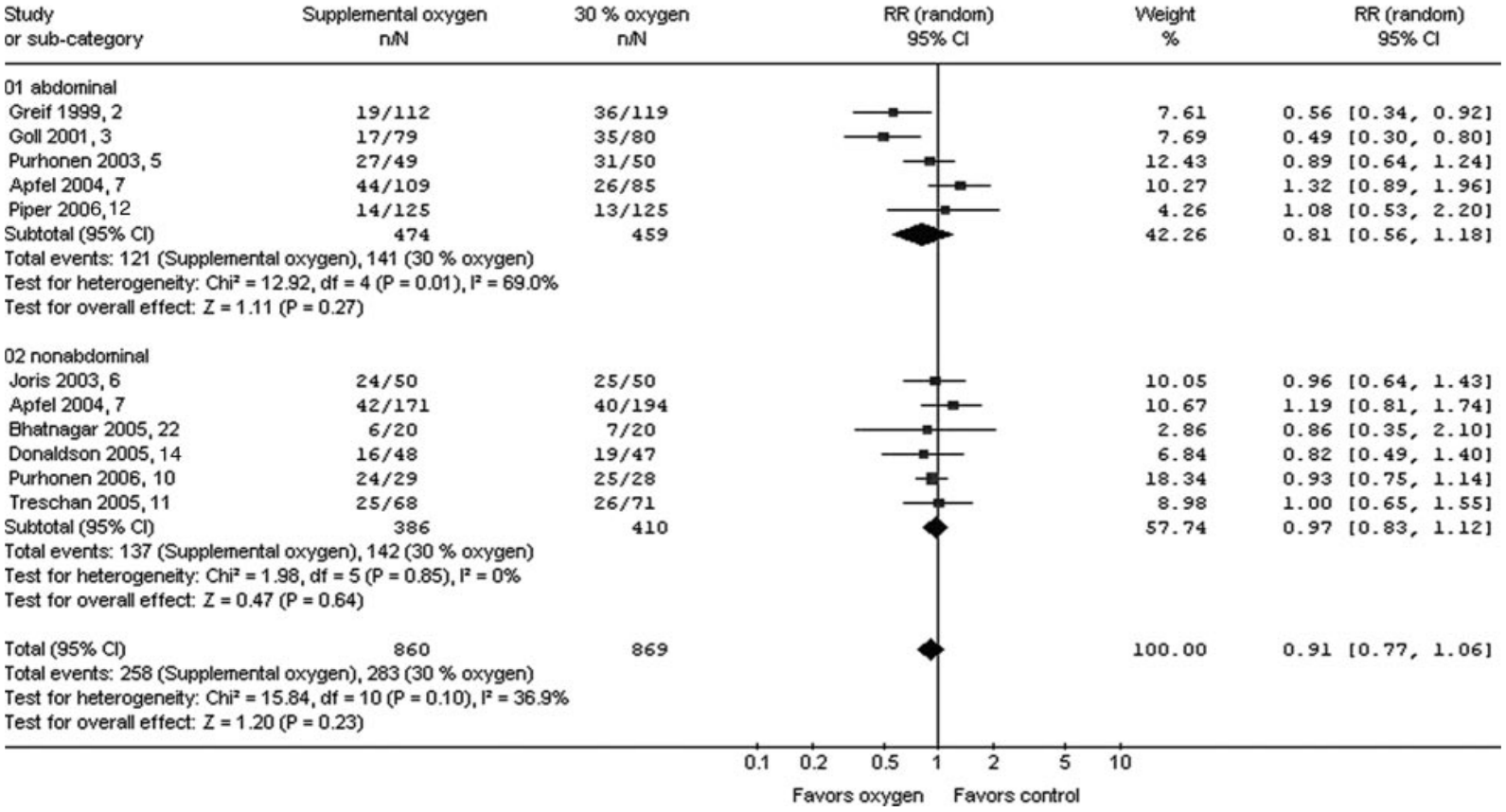
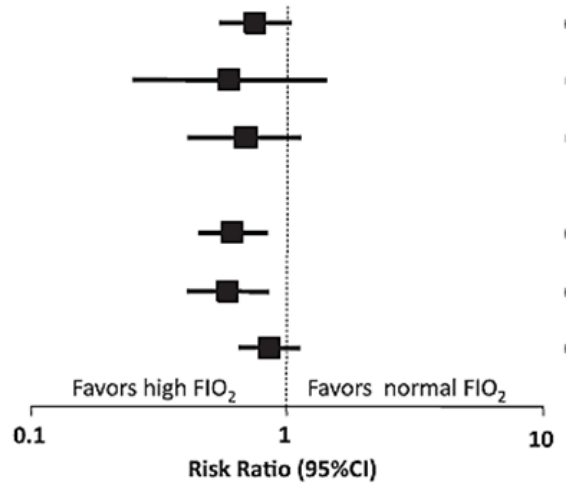
Does Supplemental Oxygen Reduce Postoperative Nausea and Vomiting? A Meta-Analysis of RCT

Orhan M, A&A 2008 : 1733



Effect of Intraoperative High FiO_2 on Surgical Site Infection, PONV, and Pulmonary Function

Hovaguimian F, Tramèr M, et al,
Anesthesiology 2013; 119:303-16



postoperative nausea & vomiting

No reduction of PONV using supplemental O_2

Conflict of Interest & Strong Bias

The NEW ENGLAND JOURNAL of MEDICINE

SUPPLEMENTAL PERIOPERATIVE OXYGEN TO REDUCE THE INCIDENCE OF SURGICAL-WOUND INFECTION

ROBERT GREIF, M.D., OZAN AKÇA, M.D., ERNST-PETER HORN, M.D., ANDREA KURZ, M.D., DANIEL I. SESSLER, M.D., FOR THE OUTCOMES RESEARCH GROUP

Volume 342:161-167 January 20, 2000 Number 3

Ann Surg Oncol
DOI 10.1245/s10434-012-2714-7

Annals of
SURGICAL ONCOLOGY
OFFICIAL JOURNAL OF THE SOCIETY OF SURGICAL ONCOLOGY

ORIGINAL ARTICLE – GASTROINTESTINAL ONCOLOGY

Prevention of Anastomotic Leakage after Total Gastrectomy with Perioperative Supplemental Oxygen Administration: A Prospective Randomized, Double-blind, Controlled, Single-center Trial

Mario Schietroma, MD, Emanuela Marina Cecilia, MD, Francesco Carlei, MD, Federico Sista, MD, Giuseppe De Santis, MD, Federica Piccione, MD, and Gianfranco Amicucci, MD

TABLE 4 Esophagojejunal anastomosis and anastomotic dehiscence

Characteristic	30 % FiO_2 ($n = 85$)	80 % FiO_2 ($n = 86$)	P
Anastomotic dehiscence	17 (20 %)	8 (9.3 %)	<0.05
Reoperation[a]	10	4	
Mortality[b]	8	4	
CT-scan-guided radiological drainage and antibiotics	8	4	

Effects of supplemental oxygen and dexamethasone on surgical site infection: a factorial randomised trial

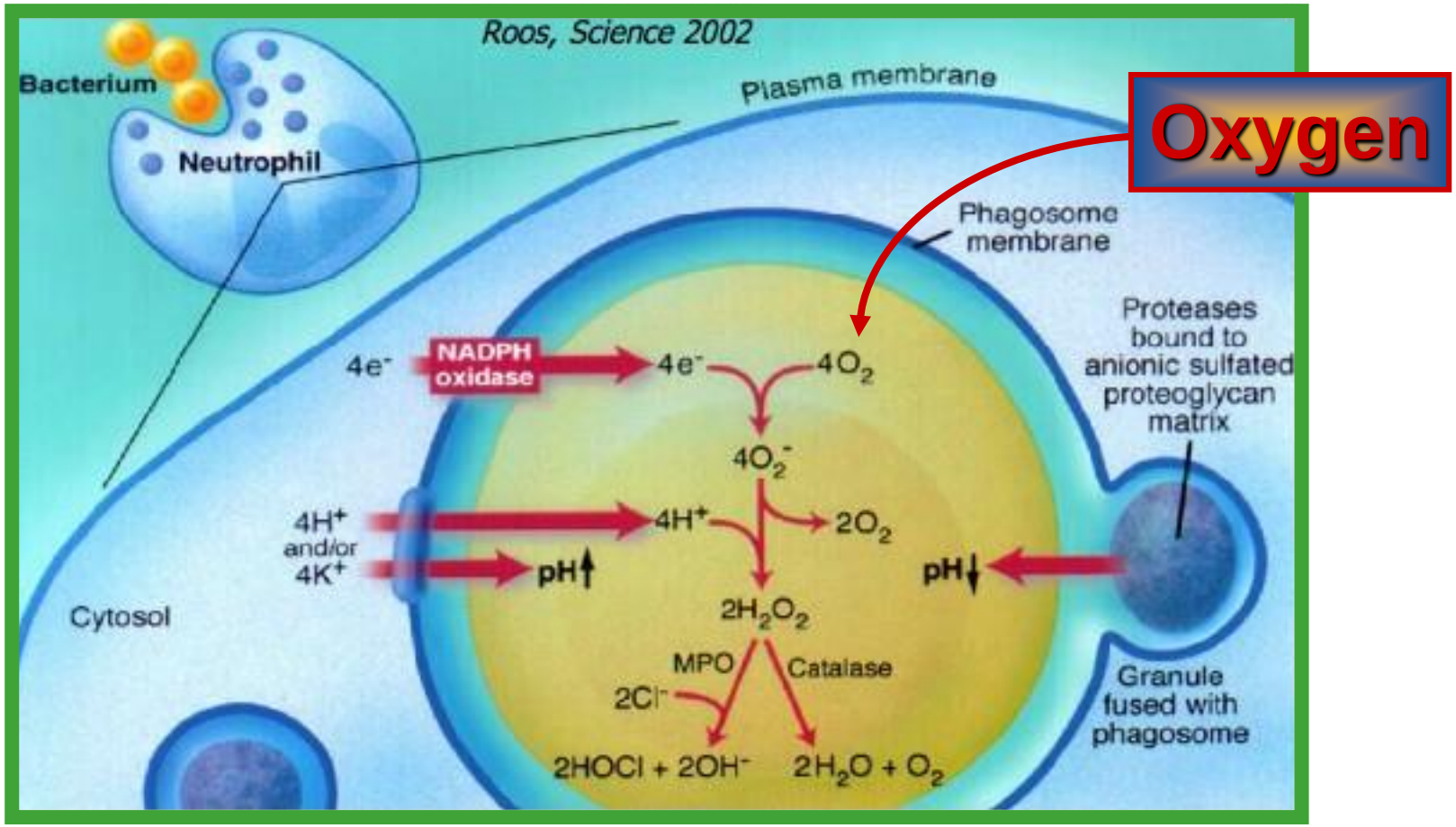
A. Kurz[1], E. Fleischmann[2], D. I. Sessler[1,*], D. J. Buggy[3], C. Apfel[4] and O. Akça[5], the Factorial Trial Investigators†

British Journal of Anaesthesia, 2015, 1–10

PaO_2 60 – 99 mm Hg, SSI 18% (n = 10/ 56);
PaO_2 100 –199 mm Hg, SSI 9% (n = 11/127);
PaO_2 200 –299 mm Hg, SSI 5% (n = 6/112);
PaO_2 >300 mm Hg, SSI 8% (n = 11/144).

Oxygen-dependent microbial killing by phagocytes

Babior, N Engl J Med 1978



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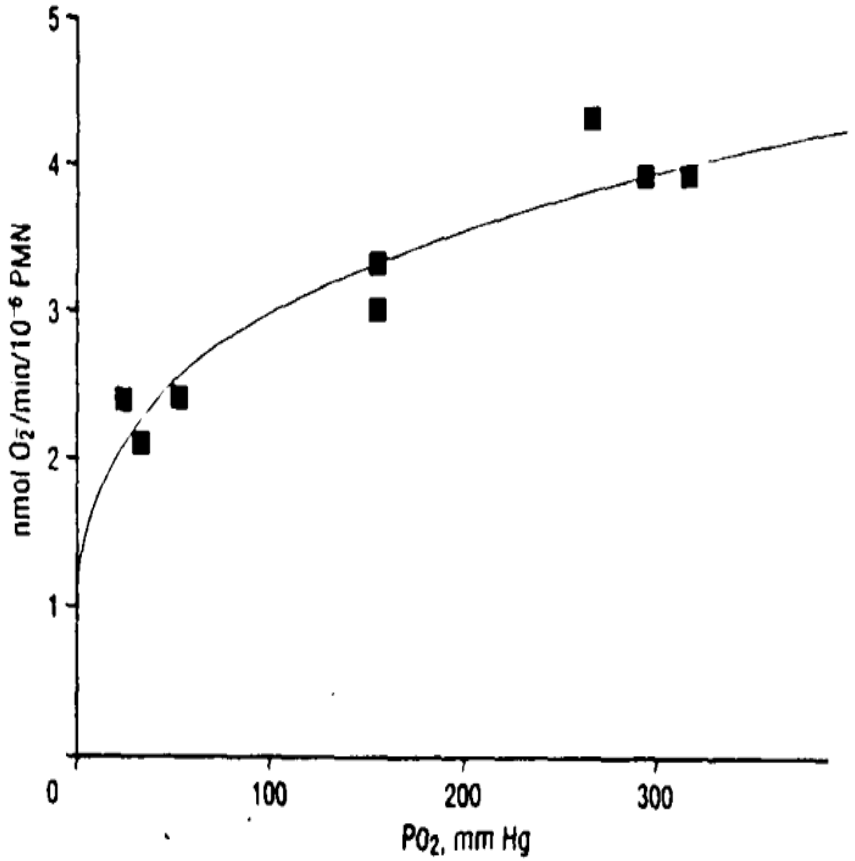
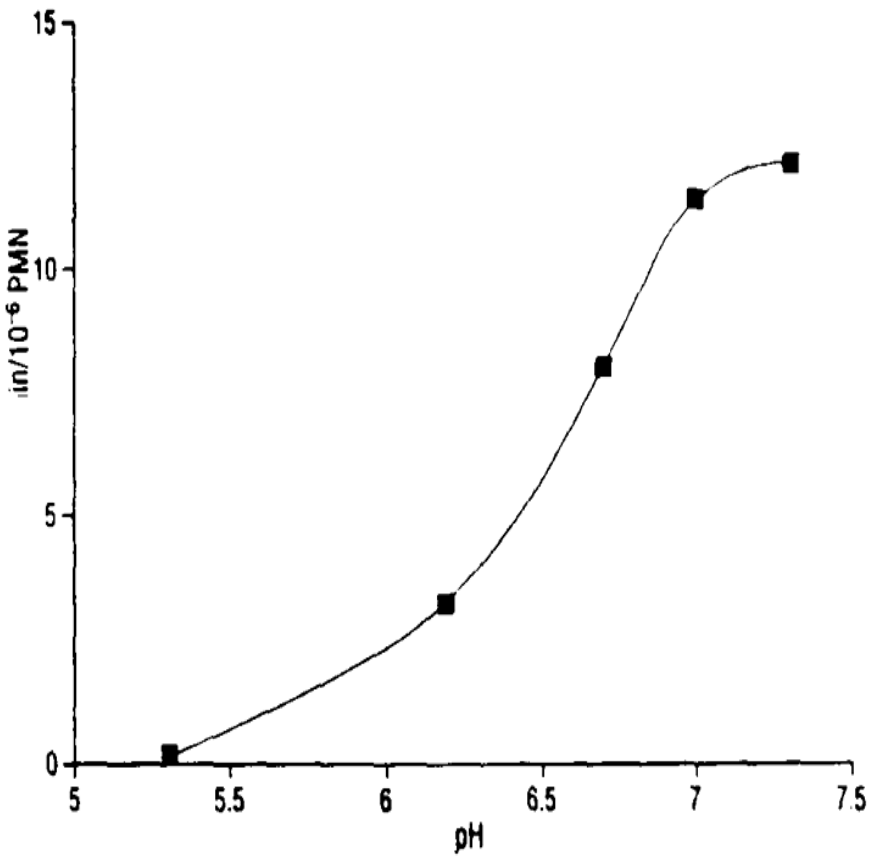
Wound hypoxia and acidosis limit neutrophil bacterial killing mechanism

Allen, Arch Surg 1997





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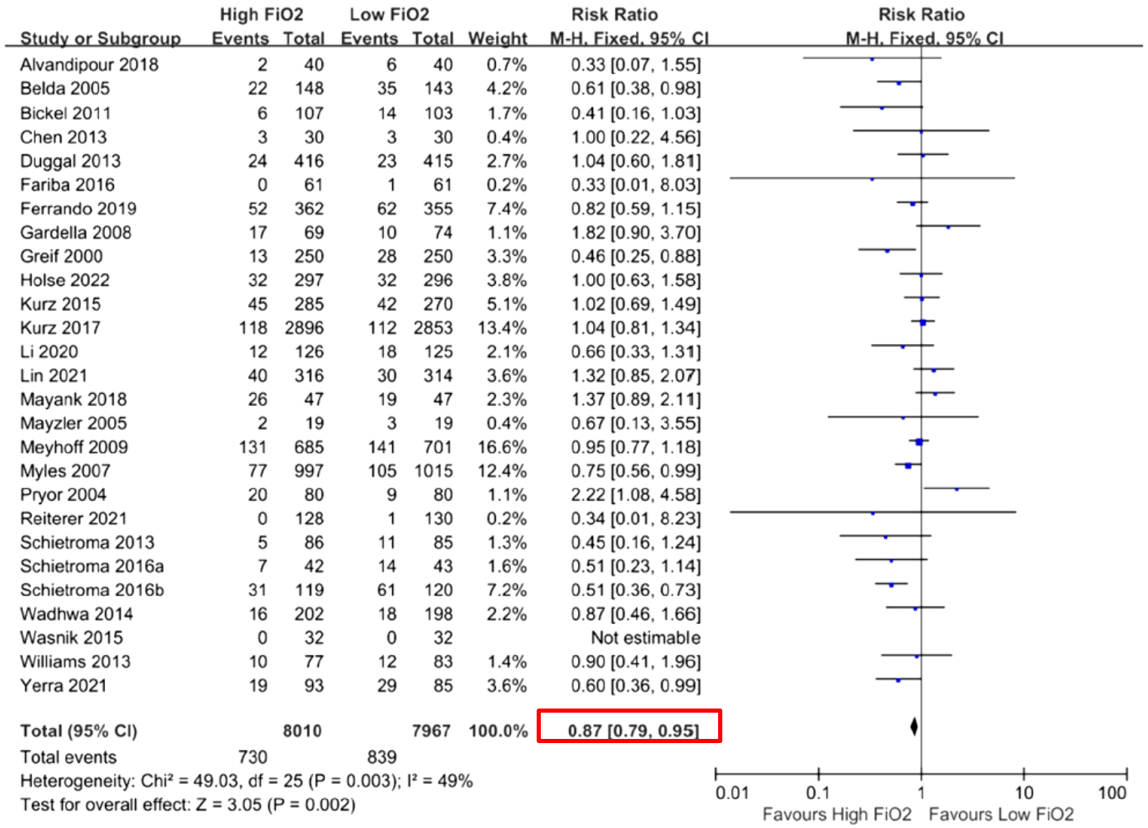
The effect of high perioperative inspiratory oxygen fraction for abdominal surgery on surgical site infection: a systematic review and meta-analysis

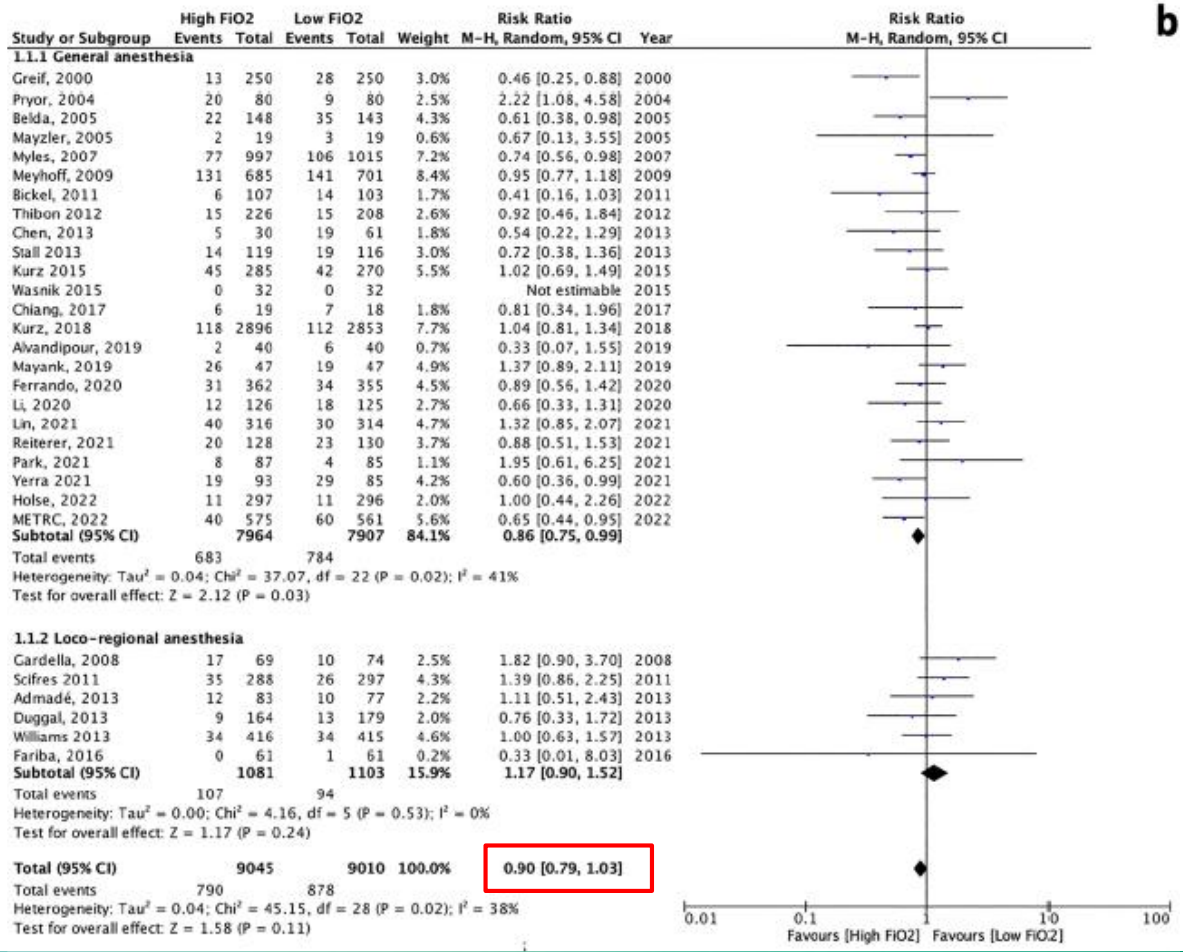
2023;13:15599

www.nature.com
Scientific Reports

2023;13:2465

Updated meta-analysis on intraoperative inspired fraction of oxygen and the risk of surgical site infection in adults undergoing general and regional anesthesia





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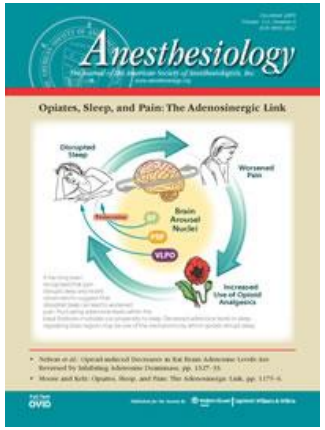


ANESTHESIOLOGY
The Journal of the American Society of Anesthesiologists, Inc. • anesthesiology.org

Intraoperative High Inspired Oxygen Fraction: Are There Real Benefits?

Christian S. Meyhoff, M.D., Ph.D., Lars N. Jorgensen, M.D., D.M.Sc., Jørn Wetterslev, M.D., Ph.D., Lars S. Rasmussen, M.D., D.M.Sc. Copenhagen University Hospital, Herlev, Copenhagen, Denmark (C.S.M.). christianmeyhoff@gmail.com

Anesthesiology 2014; 120:1050

23% RRR 3,916 patients needed

Benefits and Risks of Intraoperative High Inspired Oxygen Therapy: Firm Conclusions Are Still Far Off

F. Javier Belda, M.D., Ph.D., Ferrán Catalá-López, Pharm.D., M.P.H., Ph.D., Robert Greif, M.D., M.M.E., F.E.R.C., Jaume Canet, M.D., Ph.D. Hospital Universitari Germans Trias i Pujol, Badalona, Spain (J.C.). jcanet.germanstrias@gencat.cat

Anesthesiology 2014; 120:1050-9

Effect size of 22%
3,200 patients required meta-analysis.
1,200 more cases would be needed.

Open access Protocol

BMJ Open

Benefits and harms of perioperative high fraction inspired oxygen for surgical site infection prevention: a protocol for a systematic review and meta-analysis of individual patient data of randomised controlled trials

Stijn W de Jonge [1,2,3] Rick H Hulskes [1,2] Maedeh Zokaei Nikoo,[4] Robert P Weenink,[2] Christian S Meyhoff,[5] Kate Leslie,[6] Paul Myles [7] Andrew Forbes,[8] Robert Greif,[9] Ozan Akca [10] Andrea Kurz,[4,11] Daniel I Sessler,[4,11] Janet Martin,[12] Marcel GW Dijkgraaf [13,14] Kane Pryor [15] F Javier Belda,[16,17] Carlos Ferrando,[18,19] Gabriel M Gurman,[20] Christina M Scifres,[21] David S McKenna,[22] Matthew TV Chan,[23] Pascal Thibon,[24] Jannicke Mellin-Olsen,[25] Benedetta Allegranzi,[26] Marja Boermeester,[1,3] Markus W Hollmann[2]

BMJ Open 2023;13:e067243

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Individual participant data meta-analysis (IPD MA) of (quasi-)randomised controlled trials provides the best possible analysis of the available data on the participant level, permitting the investigation of potential effect modifiers.
⇒ IPD MA requires the collaboration of all investigators that have published data on the relevant topic and leads to a broad consensus on the outcome and interpretation of the analysis
⇒ IPD MA depends on the quality of data that is made available by the authors of the original studies.

The purpose of this individual participant data meta-analysis is to assess the described benefits and harms of intraoperative high FiO_2 compared with regular (0.21–0.40) FiO_2 and its potential effect modifiers.
WHO, WFSA encouraged


not all
That's Folks!

Look at the “real” anesthesia world

Cross sectional survey

- Dept. Anaesthesia University Hospital Bern
- What is your standard FiO_2 & why?
- 65 anaesthetists & 13 nurses (1 day)

- ***Physicians***

FiO_2	%
0.3 – 0.5	41
0.5 – 0.7	35
0.7. – 0.8	24

Nurses

0.3 – 0.5 100% (>50% FiO_2<0.3)

Why do you use that FiO_2?

less	24%	Atelectasis ⇑
	12%	Toxicity ⇑
	< 3%	Costs ⇑, Seizures ⇑
	8%	no need for more
more	22%	PONV ⇓
	11%	Surgical wound infection ⇓
	< 3%	Tissue oxygenation ⇑
	6%	Safety margin ⇑
	10%	no clue

Oxygen Toxicity

O_2-Seizures (Paul-Bert-Effect)

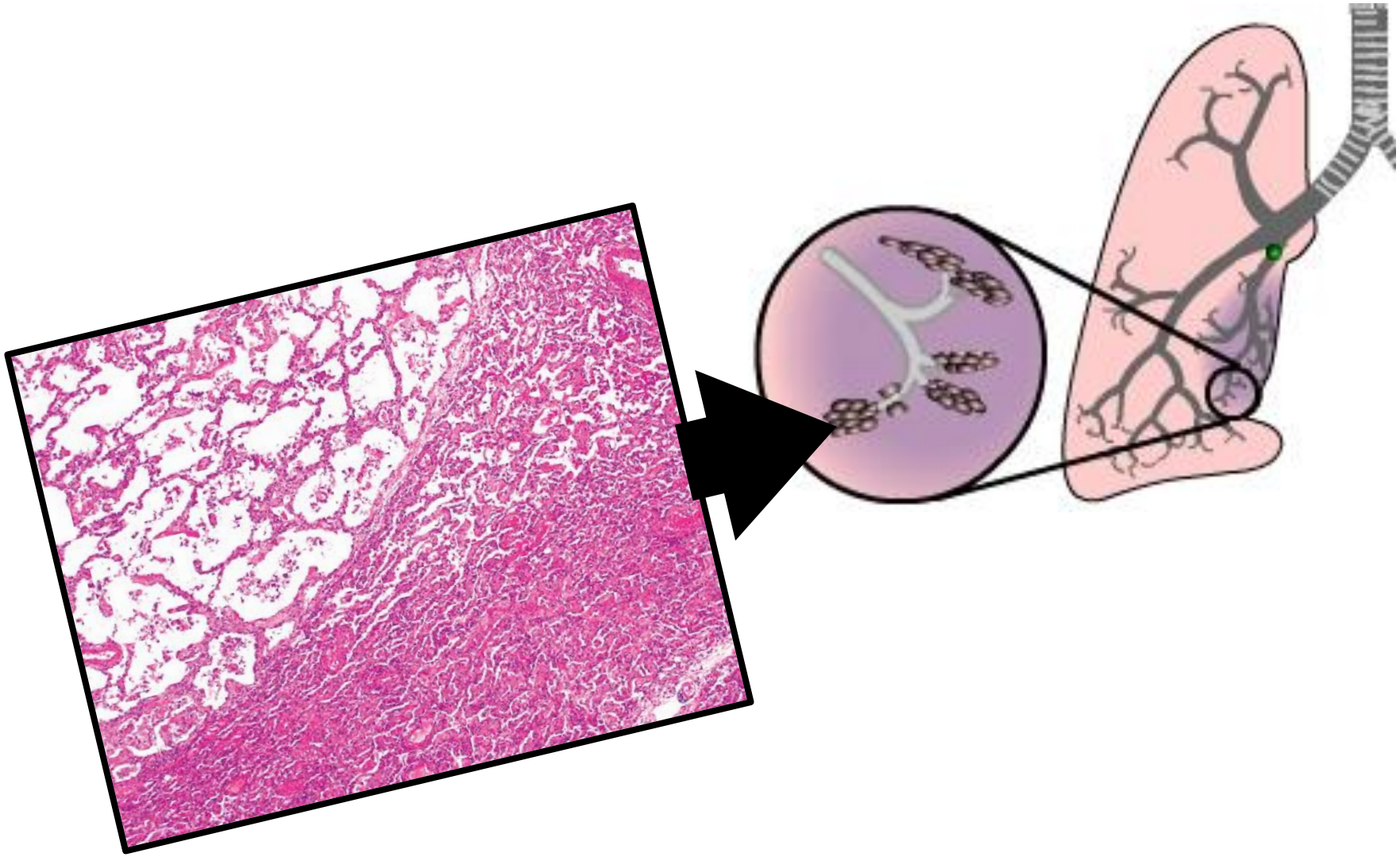
>3 atm, GABA-Interaction
HBO, deep scuba diving

Lung Toxicity

100% O_2 < 12 h
80% O_2 < 24 h
60% O_2 < 36 h
< 50% safe

Clark, J. Pulmonary Oxygen Tolerance in Man and Derivation of Pulmonary Oxygen Tolerance Curves 1970, IFEM Report No.1-70

Pulmonary Atelectasis in Anaesthesia



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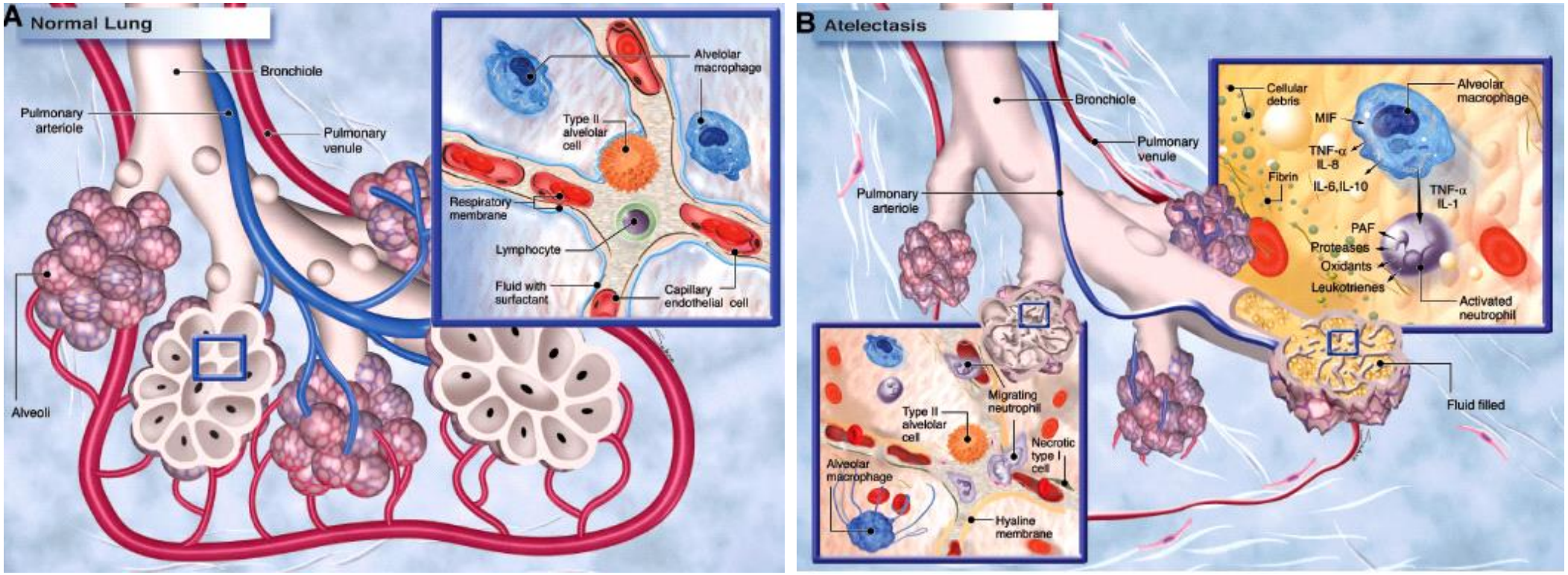
Pulmonary Atelectasis: A Pathogenic Perioperative Entity

M. Duggan, BP Kavanagh; Anesthesiology 2005;102:838-54



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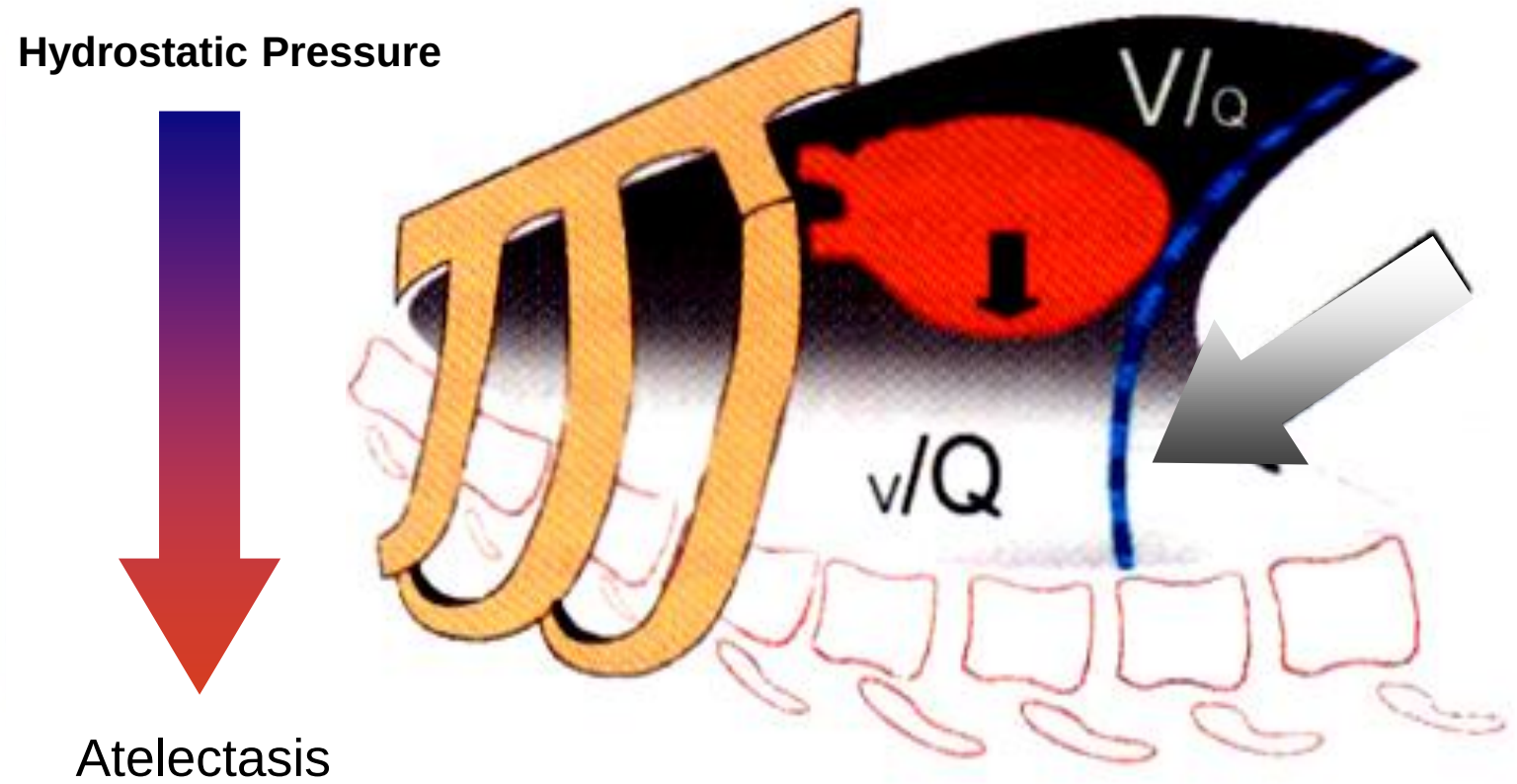
During Anesthesia: Ventilation/Perfusion Mismatch

Habashi N., Curr Opin Crit Care 2004,10:540



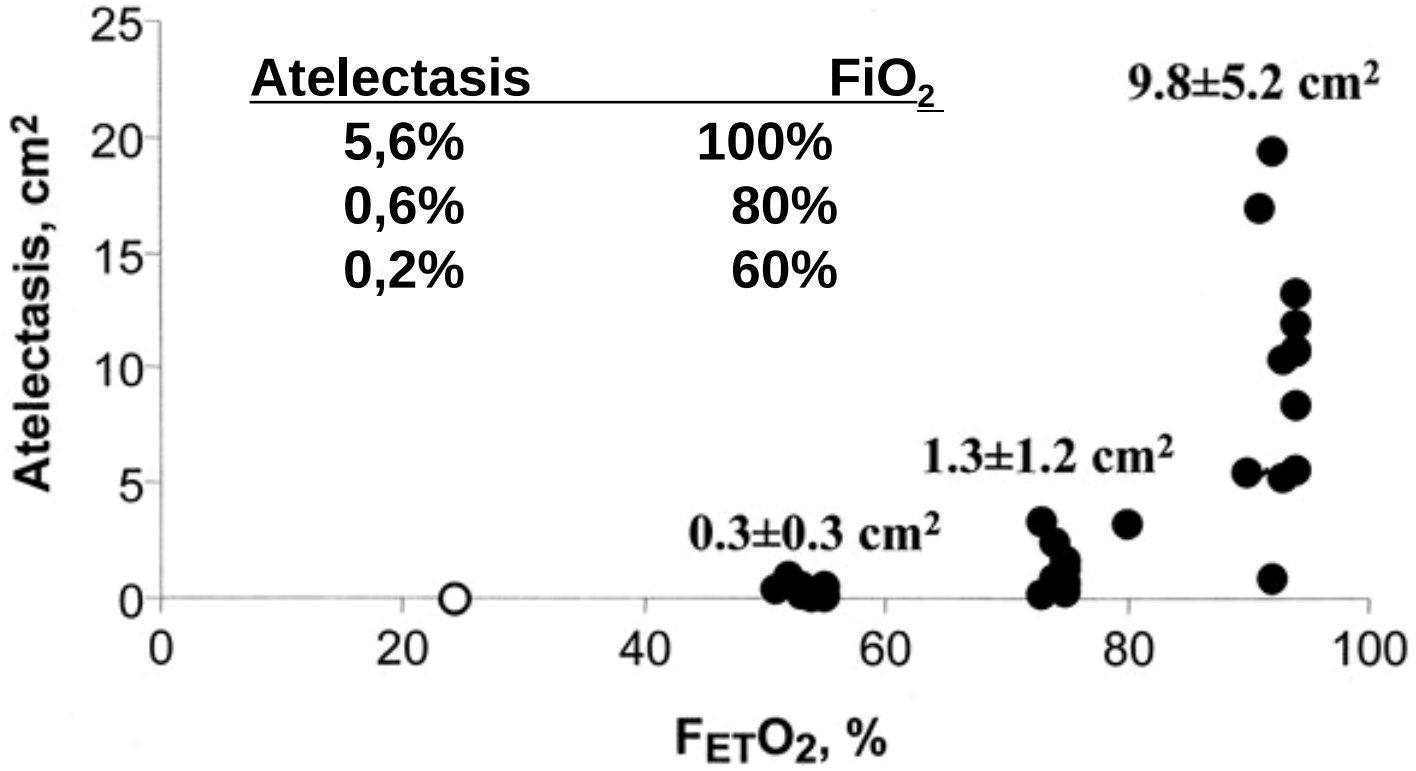
Atelectasis

- 75 -90% healthy patients
- dorsal lung areas
- Ø Volume 29 ± 10 ml

Warner, Anesthesiology 1996

Optimal O_2-concentration during induction of general anesthesia

Edmark, Anesthesiology 2003



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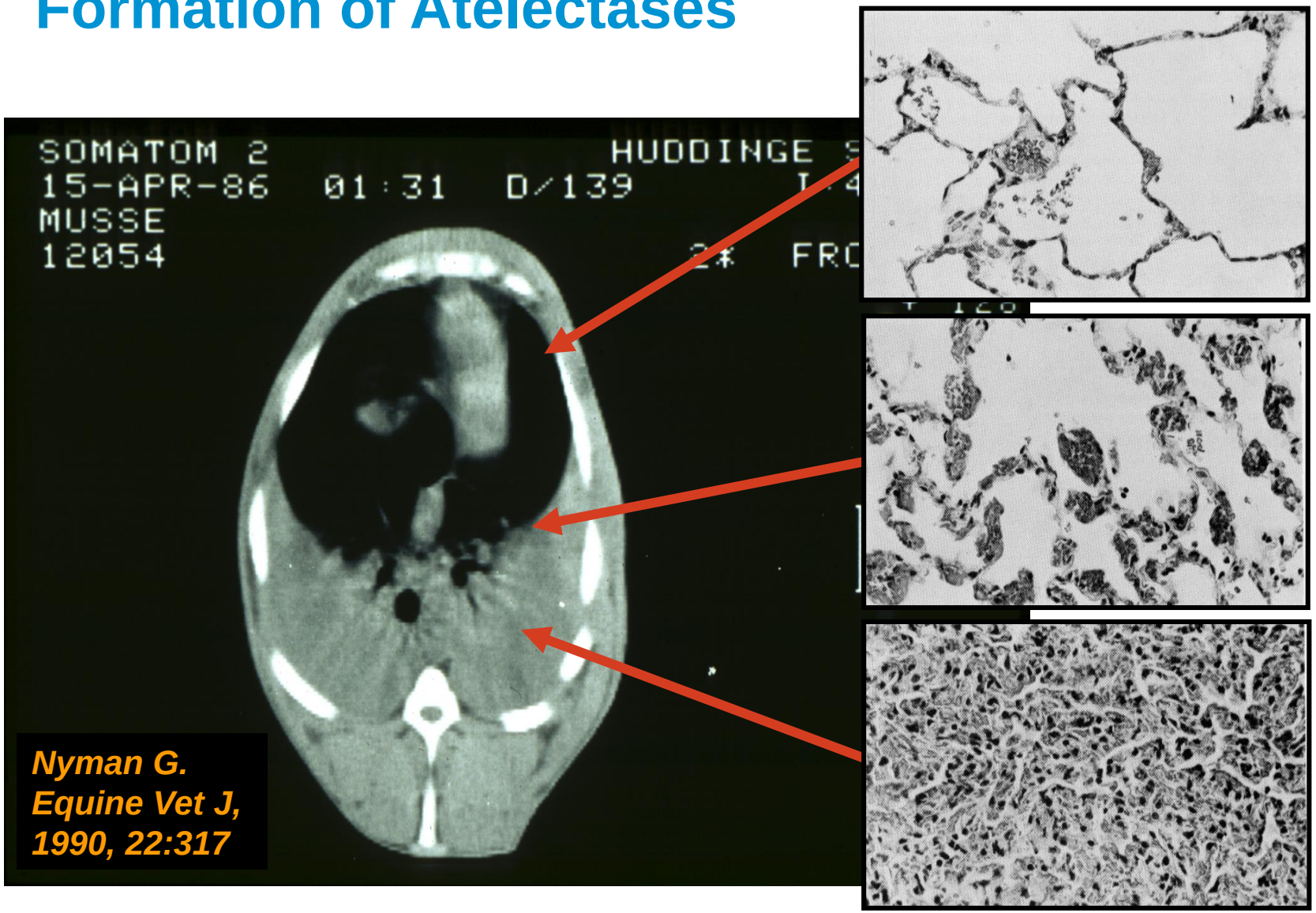
Formation of Atelectases



Formation of Atelectases

Nyman G., Equine Vet J, 1990, 22:317

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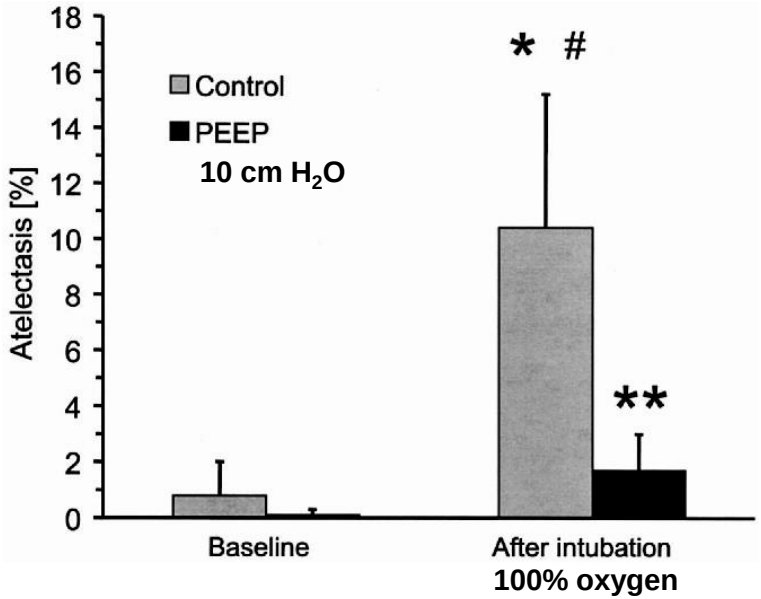
Oxygen and Atelectasis during Anesthesia

Therapy: Recruitment Maneuvers

- 7- 8 sec inflation of the lung - 40 cm H_2O *(Rothen, BJA 1999)*
- PEEP 15, P_{plat} 40 cm H_2O over 10 cycles *(Tusman, CJA 2004)*

Prevention

- 10 cm H_2O PEEP (100% O_2) *(Neumann, Acta Anaesth Scand 1999)*
- CPAP + 6 cm H_2O PEEP *(Rusca, A&A 2003)*
- Morbidly of obese patients (BMI >35 kg/m^2) *(Coussa, A&A 2004)*



#*P* < 0.0001 compared with PEEP

**P* = 0.0001 compared with baseline

***P* = 0.006 compared with baseline

Oxygen and Atelectasis

Edmark, Anesthesiology 2003: **… preoxygenation with 80% oxygen seemed to be beneficial in reducing atelectasis formation during anesthesia induction, compared with 100% oxygen,** but with a reduction in apnea tolerance. This reduction in apnea tolerance can make a difference in unpredictable, complicated situations during anesthesia induction. Until a large clinical trial can prove significant morbidity from atelectasis during or after anesthesia, the standard of using 100% oxygen for preoxygenation should continue.

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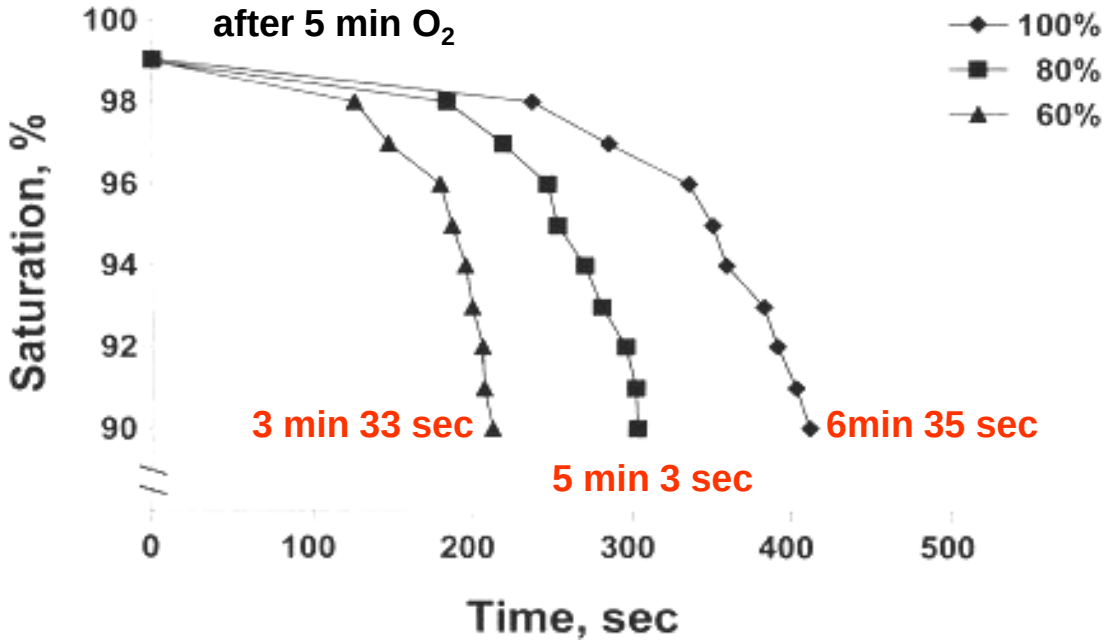
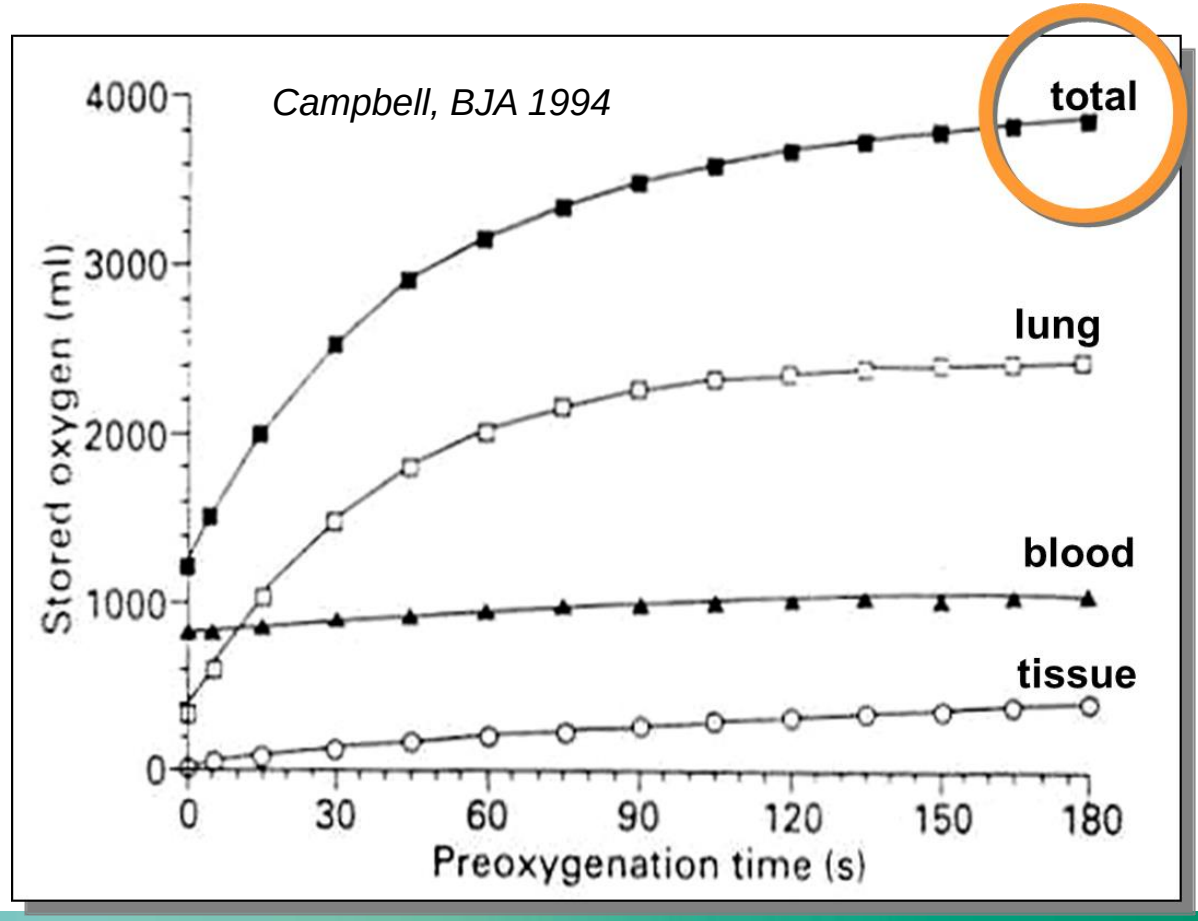
Oxygen and Preoxygenation

Optimal O_2-concentration during induction of general anesthesia
Edmark, Anesthesiology 2003

Until a large clinical trial can prove significant morbidity from atelectasis during or after anesthesia, the standard of using 100% oxygen for preoxygenation should continue.



SpO_2 decrease during apnea (end of apnea = 90% SpO_2)



Induction of Anesthesia – "O_2-Reservoir"

February 2017 • Volume 124 • Number 2
www.anesthesia-analgesia.org

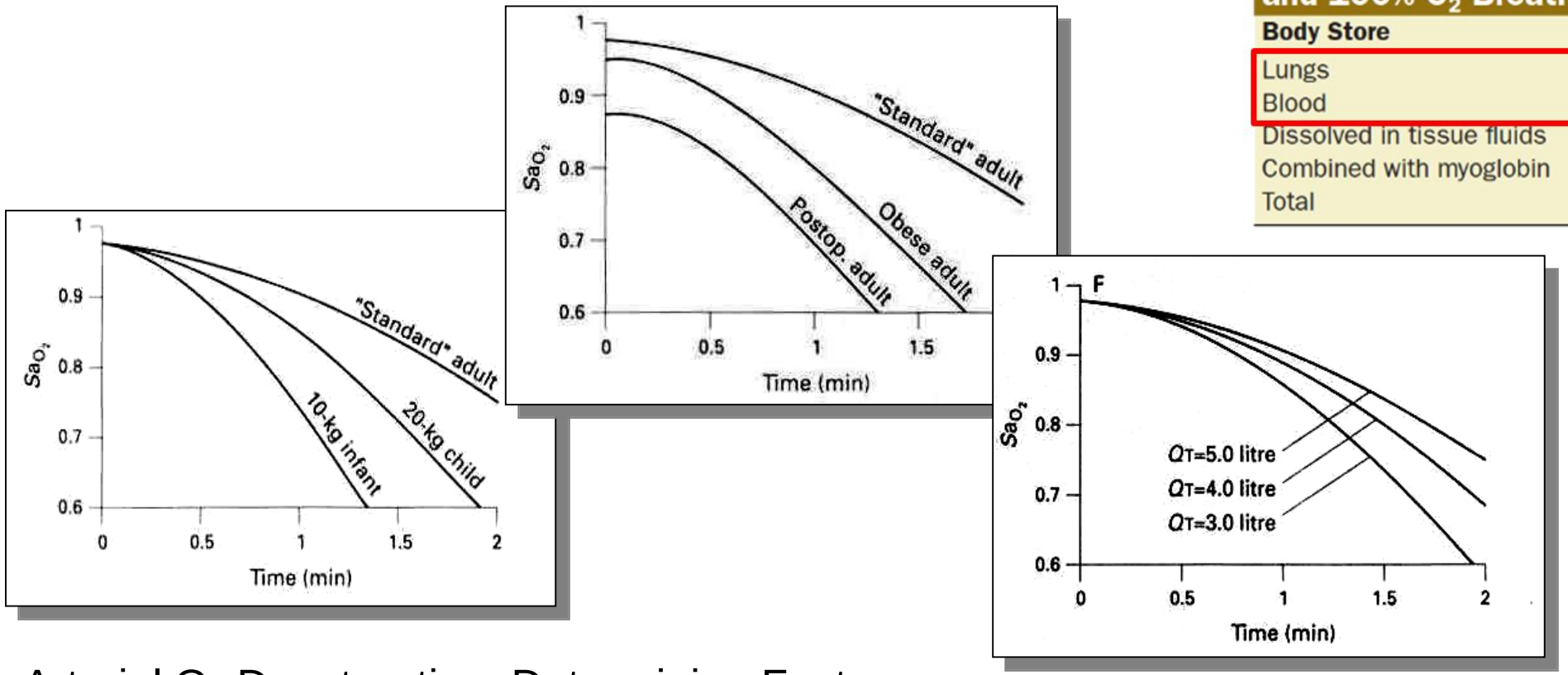
- Lung ≈ 400 ml + Blood ≈ 950 ml O_2
- O_2 consumption ≈ 250 ml/min
- calculated reserve: 1350/250 = 5 minutes

Preoxygenation: Physiologic Basis, Benefits, and Potential Risks

Usharani Nimmagadda, MD,*† M. Ramez Salem, MD,*† and George J. Crystal, PhD†

Table 1. Body O_2 Stores (in mL) During Room Air and 100% O_2 Breathing

Body Store	Room Air	100 % O_2
Lungs	450	3000
Blood	850	950
Dissolved in tissue fluids	50	100
Combined with myoglobin	200	200
Total	1550	4250



Arterial O_2 Desaturation: Determining Factors *Farmery, BJA 1996*

Avoid hypoxemia - use supplemental O_2
$\Rightarrow$ increases patient safety

AWARE

AWAke tRachEal intubation

An International Multicenter Survey

https://www.surveymonkey.com/r/RB89H9D