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Perioperative use of high oxygen concentration

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SARTD-CHGUV Sesión de Formación Continuada
10 de Marzo de 2015

REVIEW

February 2015

CURRENT OPINION

Protection strategies during cardiopulmonary bypass: ventilation, anesthetics and oxygen

Carlos Ferrando, Marina Soro, and Francisco J. Belda

Perioperative Hyperoxia

The Debate Is Only Getting Started

Jaume Canet, M.D., Ph.D.,* F. Javier Belda, M.D., Ph.D.†

Anesthesiology 2011; 114:1271–3

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

Supplemental Perioperative Oxygen and the Risk of Surgical Wound Infection

A Randomized Controlled Trial

JAMA. 2005;294:2035-42

Hyperoxia induced lung injury (HILI)

Impairment of innate inmune response

- Reduced phagocytosys AM
- Decreased production of inflammatory mediators
- Impaired bacterial killing….

Edema, proliferation of type II and destruction of type I alveolar epithelial cells, hyaline membrane formation, interstitial fibrosis...

Altemeier WA. Hyperoxia in the intensive care unit: why more is not always better. Curr Opin Crit Care 2007;13:73–78.

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Rats and rabits
Spontaneous breathing, injurious ventilation
Lethal experiences
Exposure to 100%O_2 for several days
Subletal injury: 4 days O_2 + 4 days Room Air

Hiperoxia in healthy humans

Clinical hyperoxia in normal lungs

FiO_2: 80-100% Exposure: hours

Studies: clinical cases, volonteers, divers…

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

Symptoms of O_2 toxicity in normal lungs

100% O_2 ≤ 12 h

80% O2 ≤ 24 h

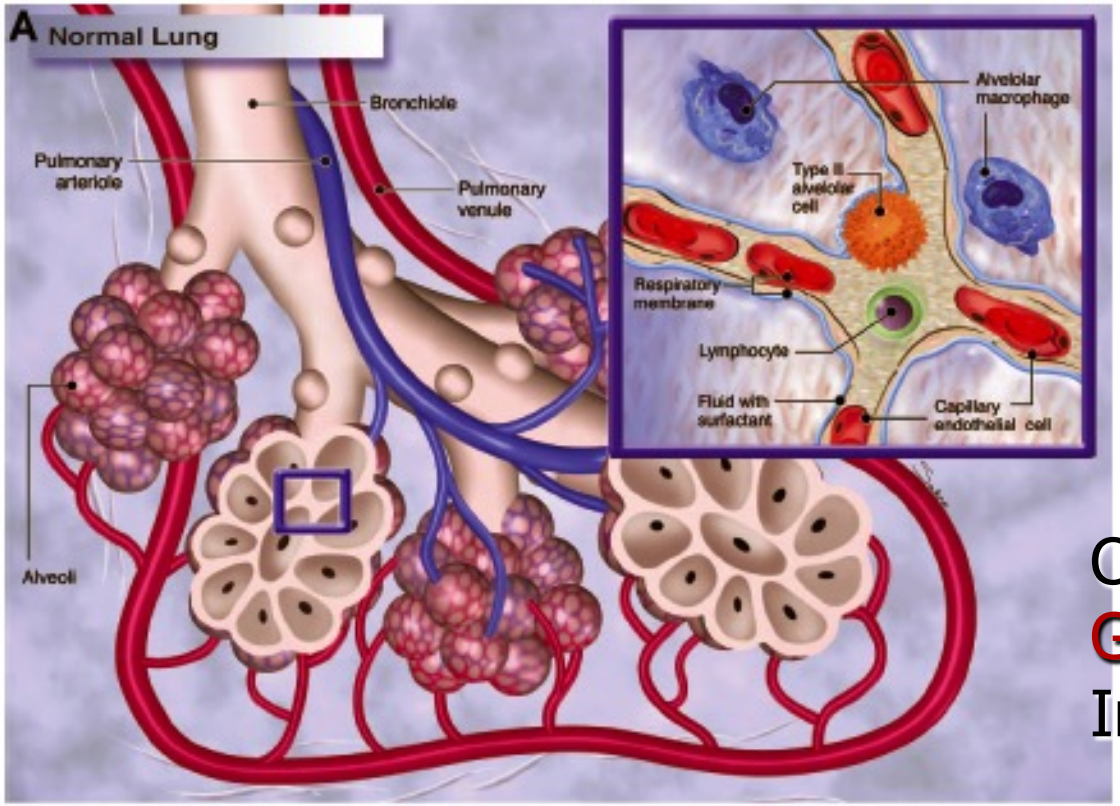
60% O2 ≤ 36 h

< 50% O2 seems completely safe

Atelectasis in Anaesthesia

Pulmonary Atelectasis. A Pathogenic Perioperative Entity

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



Compresion

Gas resorption

Impaired surfactant

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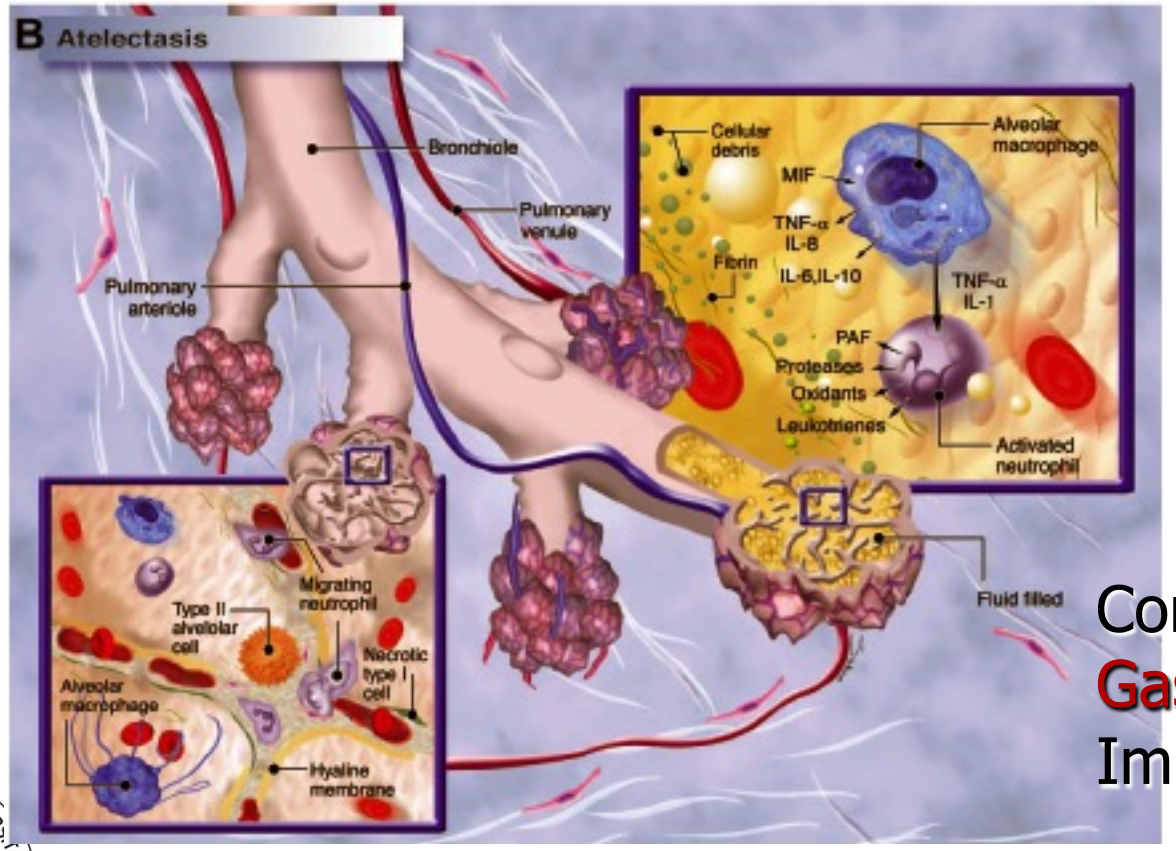


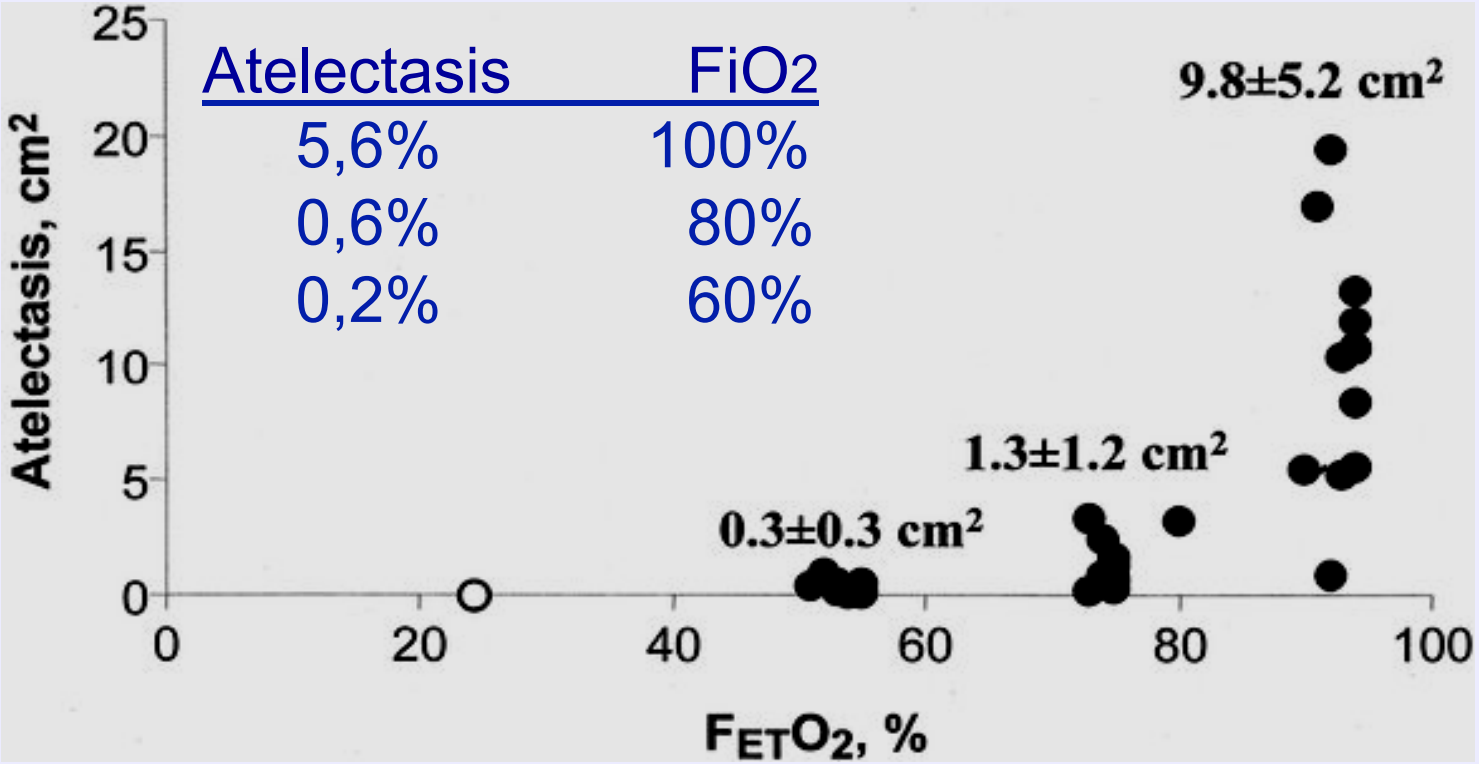
Compresion

Gas resorption

Impaired surfactant

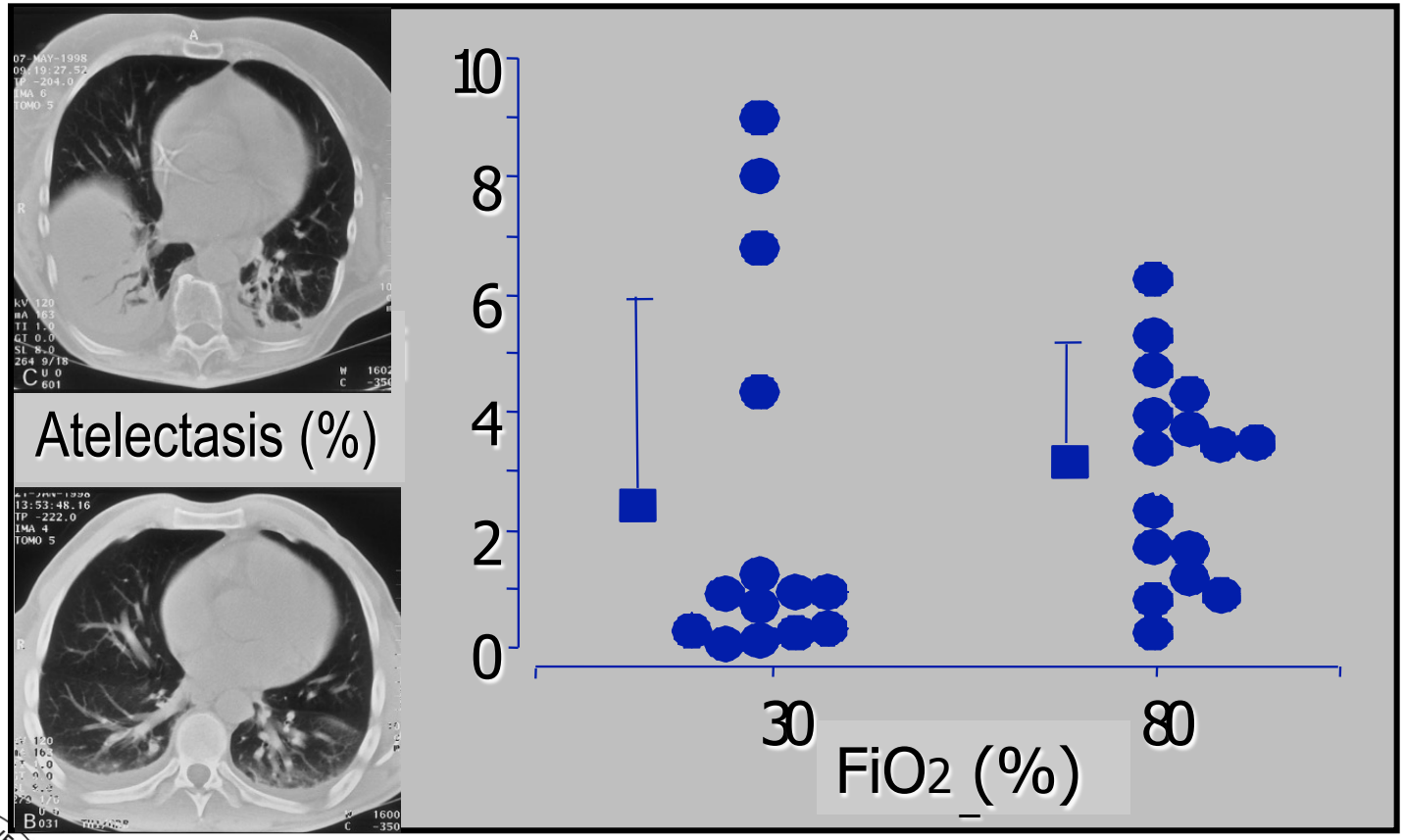
Atelectasis in anesthesia

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



Atelectasis in the postoperative period

Incidence: 85% 1st PO day (Lindberg, Acta Anaesth Scand 1992)
Comparable atelectasis during and 2-h after colon resection
Akca, Anesthesiology 1999



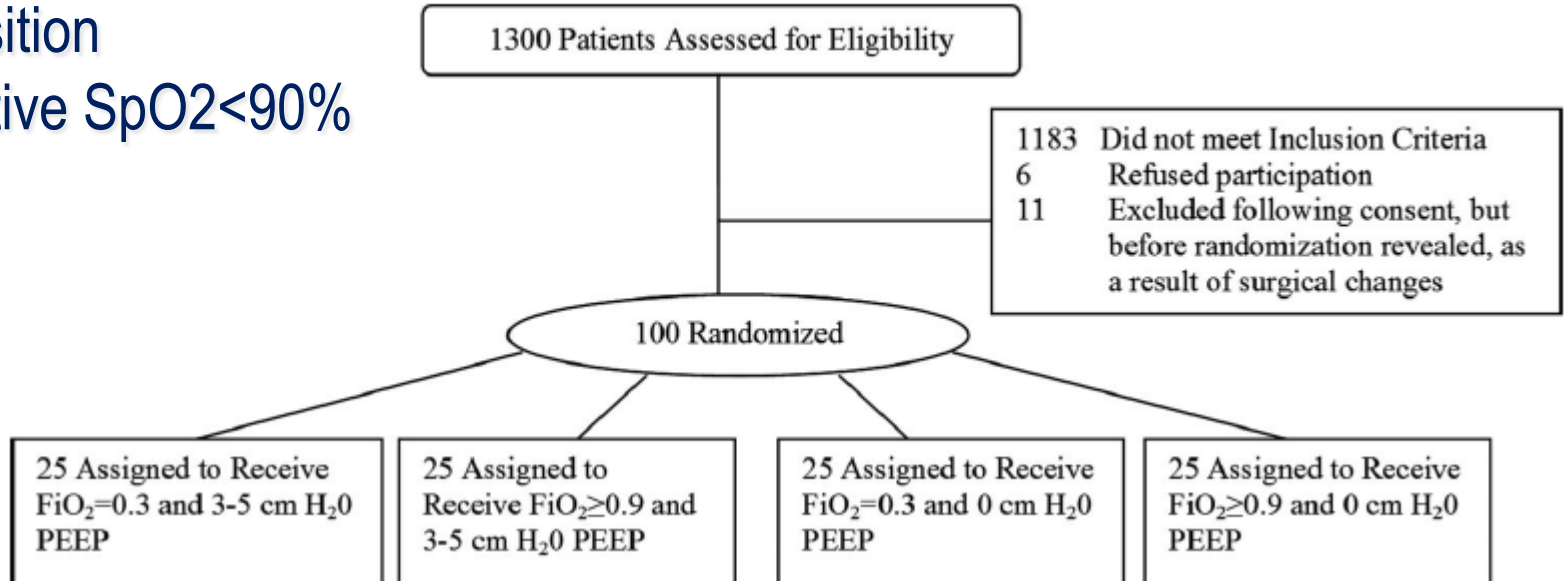
High Intraoperative Inspired Oxygen Does Not Increase Postoperative Supplemental Oxygen Requirements

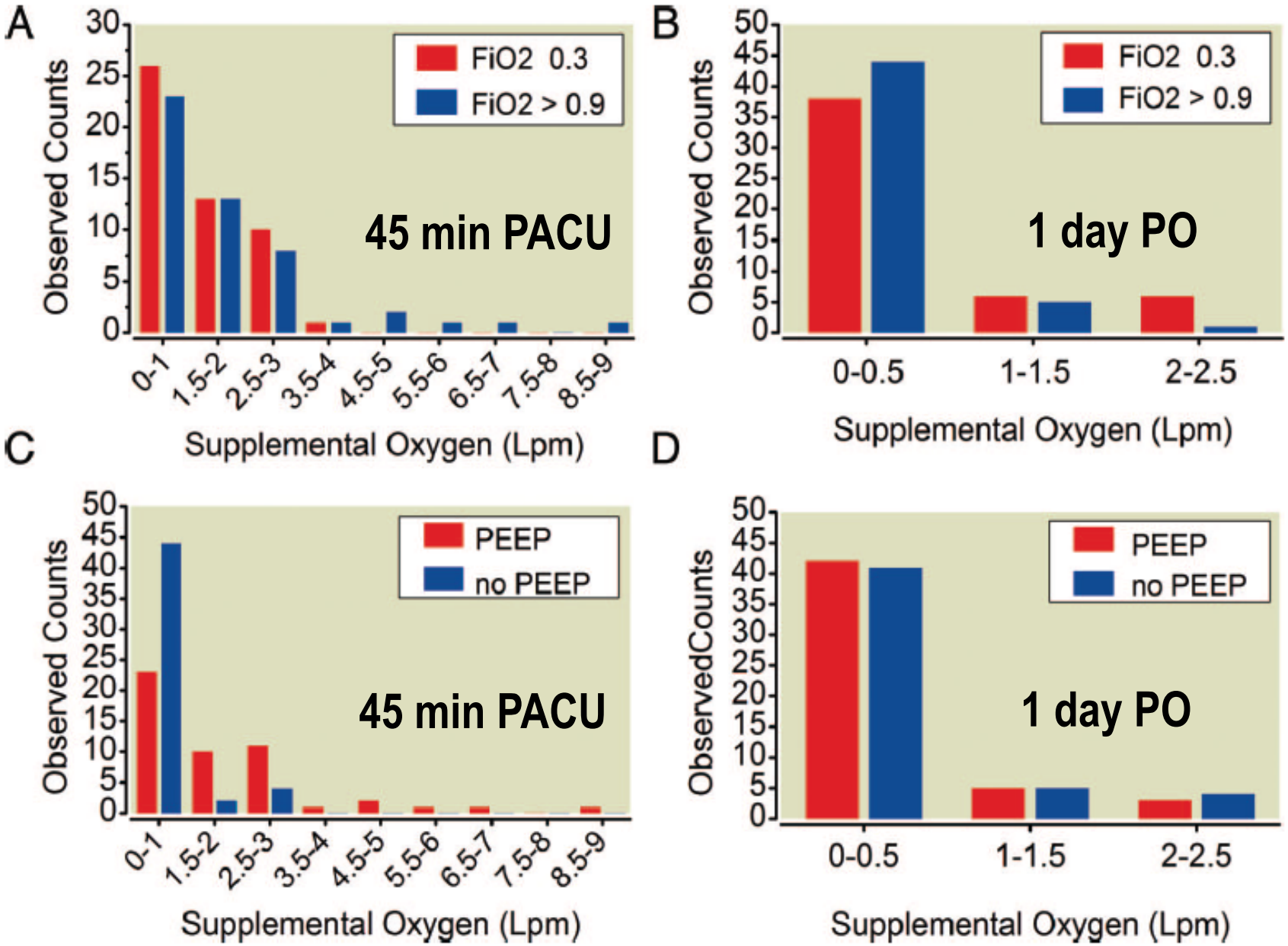
Anesthesiology 2012; 117:271-9

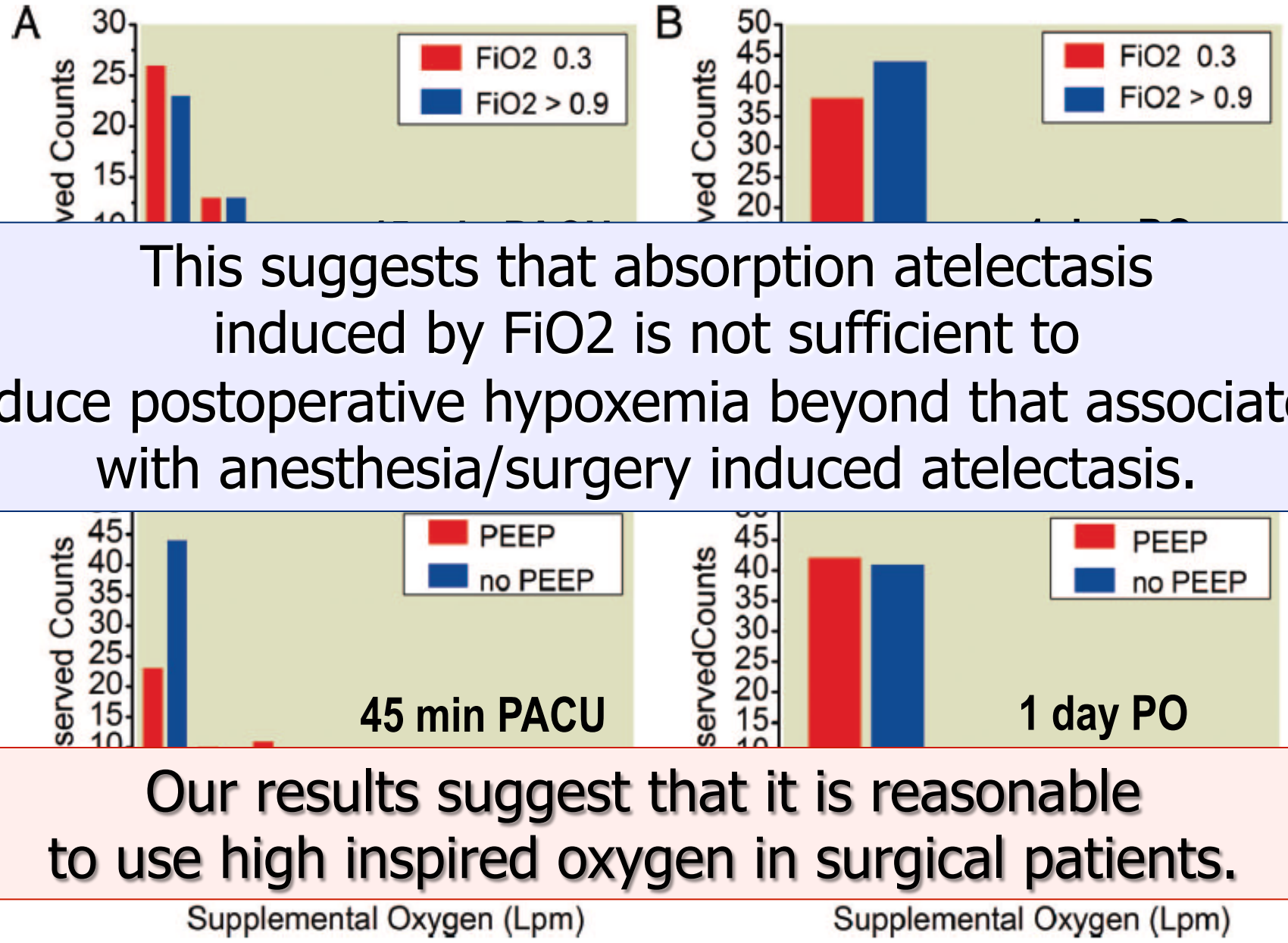
Natalie Mackintosh, M.D.,* Matthew C. Gertsch, B.S.,† Harriet W. Hopf, M.D.,‡
Nathan L. Pace, M.D., M.Stat.,§ Julia White, B.S., R.N., C.C.R.C.,‖ Rebecca Morris, B.S.,#
Candice Morrissey, M.D.,** Victoria Wilding, M.D.,* Seth Herway, M.D.††

Supplemental O_2 required for SpO_2> 90% in PACU

Scheduled adults 18–70 yr; general endotracheal anesthesia,
Expected hospital stay >24 h postoperatively.
Exclusion criteria: major (open) abdominal, spine, or craniotomy; prone position
Preoperative SpO2<90%
OSA.




A
Observed Counts
FiO2 0.3
FiO2 > 0.9
45 min PACU
0-1
1.5-2
2.5-3
3.5-4
4.5-5
5.5-6
6.5-7
7.5-8
8.5-9
Supplemental Oxygen (Lpm)
B
Observed Counts
FiO2 0.3
FiO2 > 0.9
1 day PO
0-0.5
1-1.5
2-2.5
Supplemental Oxygen (Lpm)
C
Observed Counts
PEEP
no PEEP
45 min PACU
0-1
1.5-2
2.5-3
3.5-4
4.5-5
5.5-6
6.5-7
7.5-8
8.5-9
Supplemental Oxygen (Lpm)
D
ObservedCounts
PEEP
no PEEP
1 day PO
0-0.5
1-1.5
2-2.5
Supplemental Oxygen (Lpm)

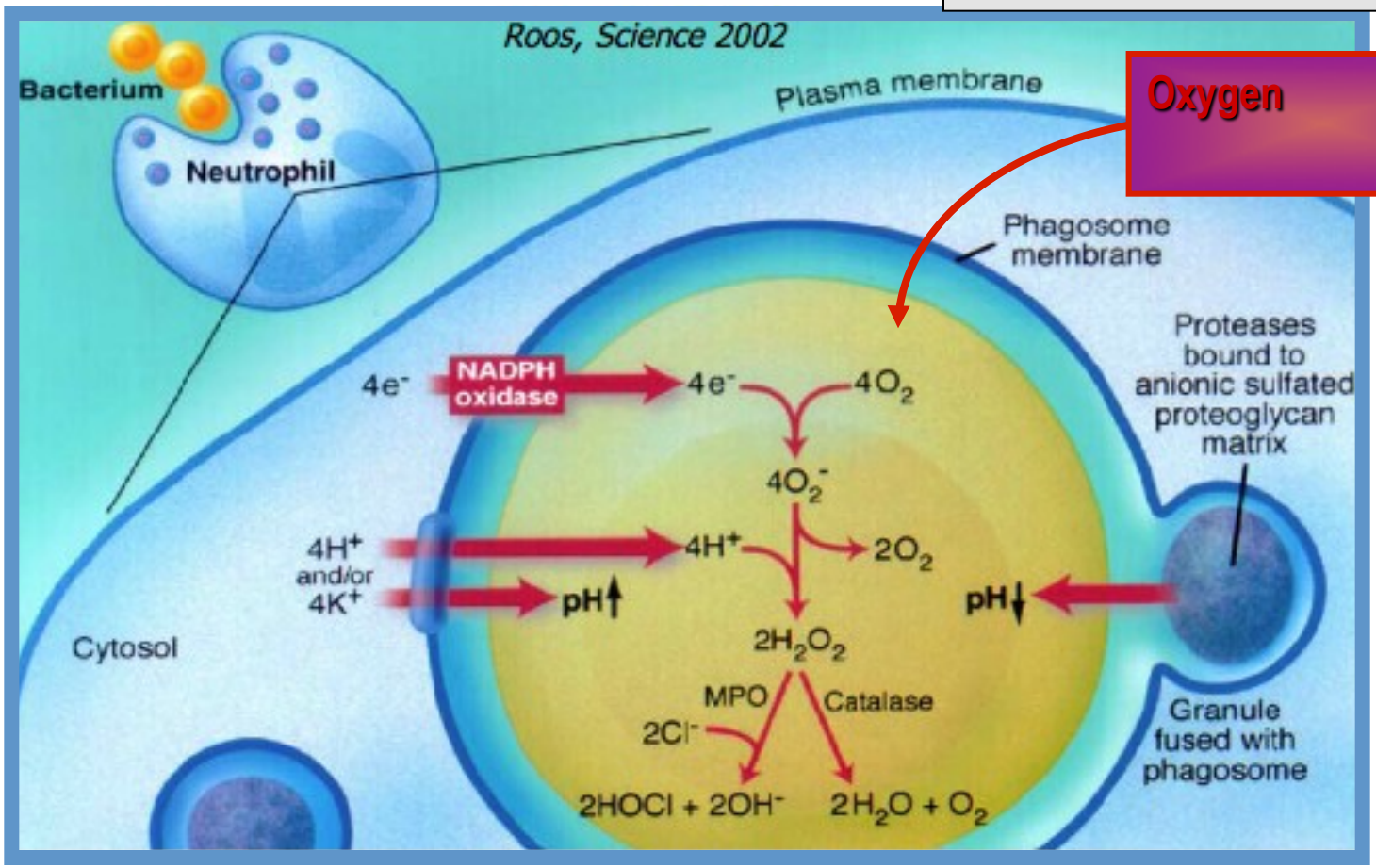


This suggests that absorption atelectasis induced by FiO2 is not sufficient to induce postoperative hypoxemia beyond that associated with anesthesia/surgery induced atelectasis.

Our results suggest that it is reasonable to use high inspired oxygen in surgical patients.

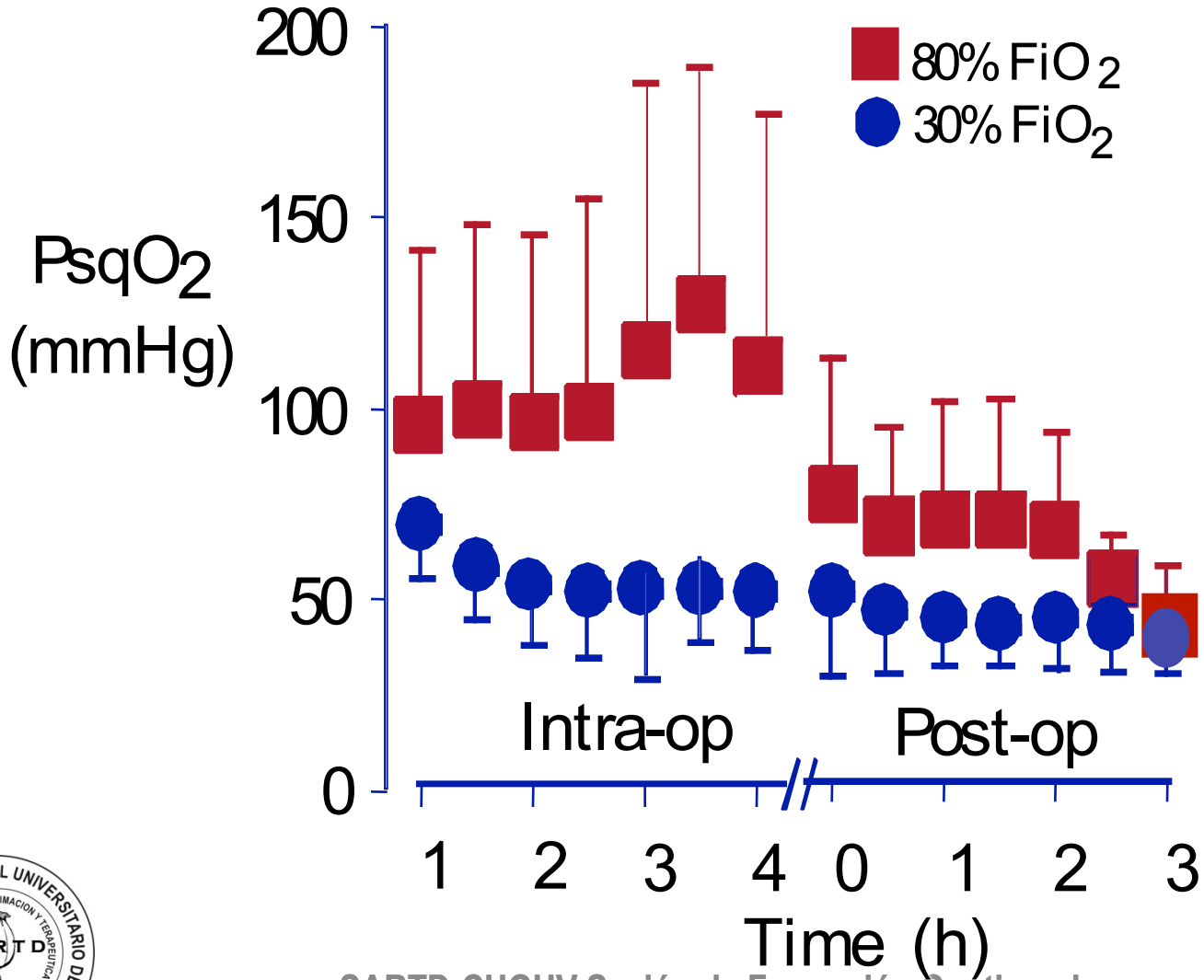
Oxygen-dependent microbial killing by phagocytes

Babior, N Engl J Med 1978



Oxidative killing is a function of tissue oxygen partial pressure.

Subcutaneous Oxygen Tension (n=30)



Greif 2000

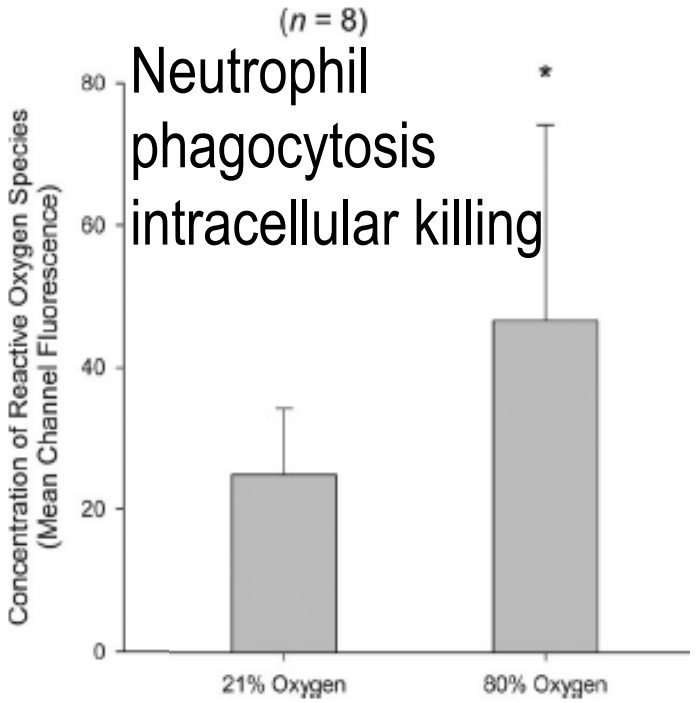
Oxygen and Surgical Site Infection

A Study of Underlying Immunologic Mechanisms

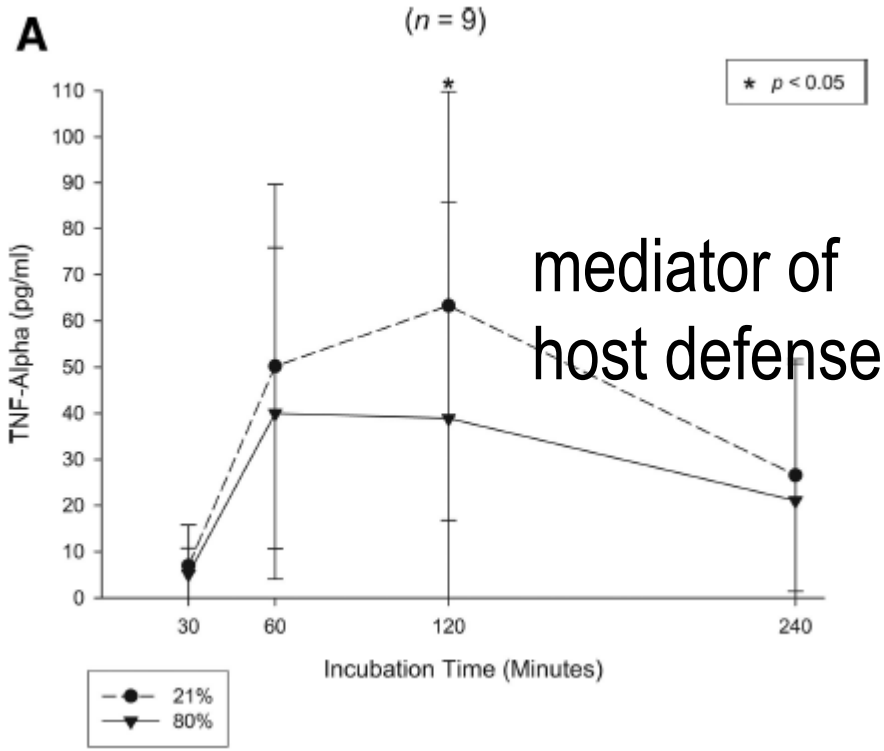
Motaz Qadan, M.D., Ph.D.,* Christopher Battista, B.S.,† Sarah A. Gardner, B.S.,‡
Gary Anderson, Ph.D.,§ Ozan Akca, M.D.

Anesthesiology 2010; 113:369–77

Human blood samples incubated at 21 or 80% O2 following a 1 ng/ml lipopolysaccharide challenge



Neutrophil phagocytosis intracellular killing



mediator of host defense

Oxygen and Surgical Site Infection

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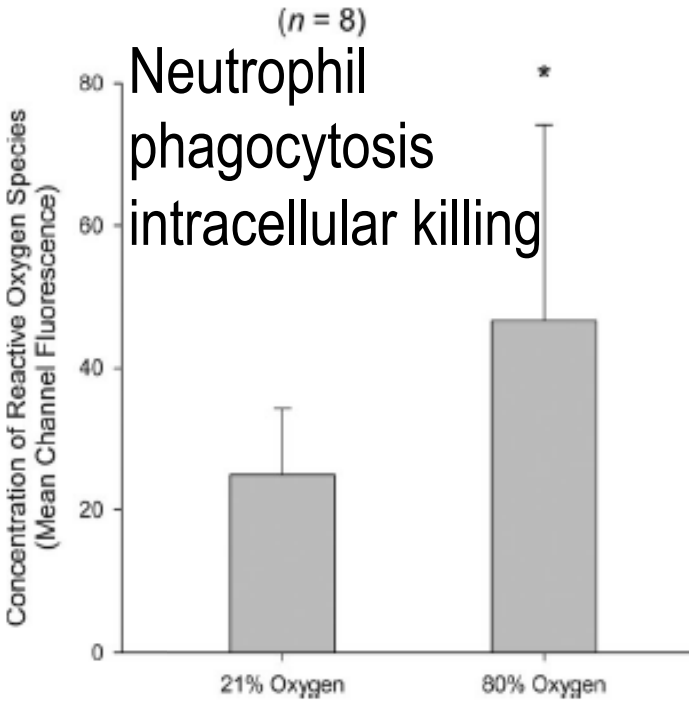

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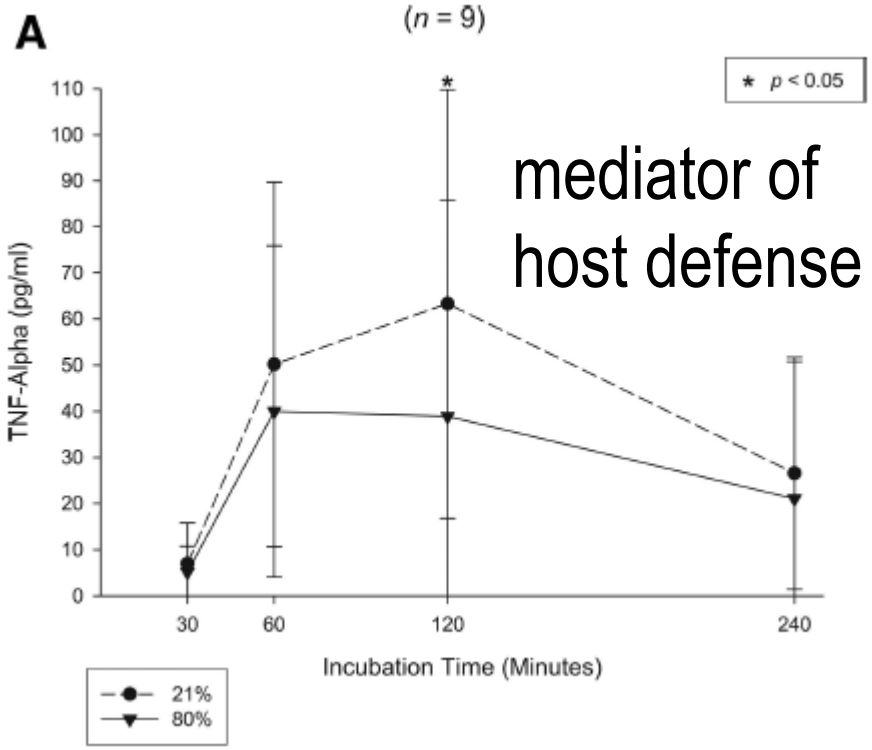

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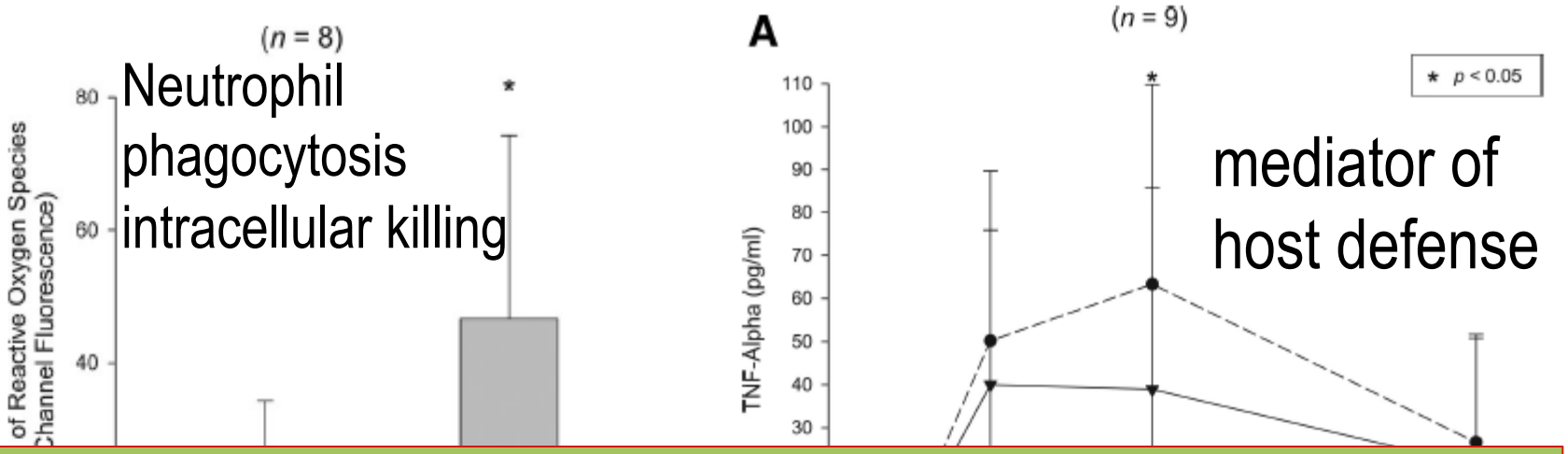


Hyperoxia exerts significant effects on multiple cellular and immunologic parameters, providing a potential mechanism for benefits from the use of supplemental oxygen.

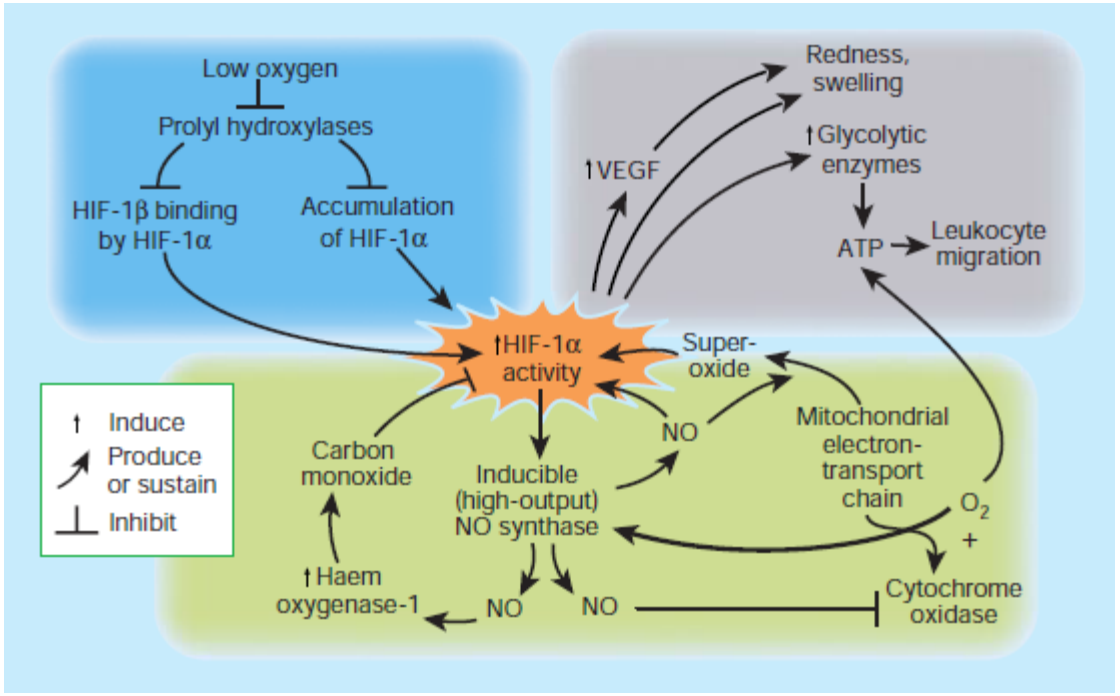
Immunology

Oxygen and the inflammatory cell

Carl Nathan

news and views

Nature 2003,17:675-676



A single protein allows certain immune cells both to respond to low oxygen levels and to induce inflammation

Supplemental Perioperative Oxygen and the Risk of Surgical Wound Infection

A Randomized Controlled Trial

Belda FJ and the Spanish RETIQ group. JAMA 2005

Multicenter, prospective, randomized, double blind

300 patients, colorectal surgery

2 groups: 30% or 80% O_2 in air, during OP + 4 h. post-OP

Infection rate: 24%

Table 2. Comparative Outcomes Between High and Low FIO_2 Groups

	30% FIO_2 (n = 143)	80% FIO_2 (n = 148)	*P* Value*
No. of patients (%)			
Surgical site infection	35 (24.4)	22 (14.9)	.04
Daily ASEPSIS score ≥20 at any time	37 (25.9)	25 (16.9)	.06
ICU admission	5 (3.5)	4 (2.7)	.74
Time after surgery, mean (SE), d			
Bowel function	3.1 (1.7)	3.0 (1.5)	.54
First solid food intake	4.4 (2.0)	4.2 (2.2)	.57
Walking	4.2 (2.6)	3.9 (2.2)	.28
Staples removed	10.3 (3.0)	10.5 (3.6)	.71
Hospitalization after surgery	10.5 (4.4)	11.7 (7.0)	.09

The risk of SSI was reduced 54% in patients with 80% oxygen (RR: 0.46; 95% CI: 0.22-0.95; P = .04)

Effect of High Perioperative Oxygen Fraction on Surgical Site Infection and Pulmonary Complications After Abdominal Surgery

The PROXI Randomized Clinical Trial

Meyhoff et al. JAMA. 2009;302(14):1543-1550

Table 2. Perioperative Characteristics of 1386 Patients Scheduled for Laparotomy[a]

Characteristic	80% Oxygen (n = 685)	30% Oxygen (n = 701)
Surgical procedure, No. (%)		
Colorectal procedures	303 (44.2)	330 (47.1)
Gynecological procedures	139 (20.3)	129 (18.4)
Small-bowel surgery	78 (11.4)	80 (11.4)
Appendectomy	61 (8.9)	63 (9.0)
Other[b]	104 (15.2)	99 (14.1)
Diagnosis, No. (%)		
Cancer	352 (51.4)	362 (51.6)
Benign neoplasm	63 (9.2)	45 (6.4)
Appendicitis	61 (8.9)	60 (8.6)
Intestinal obstruction due to benign disease	58 (8.5)	66 (9.4)
Inflammatory bowel disease	37 (5.4)	42 (6.0)
Diverticulitis	23 (3.4)	34 (4.9)
Other[c]	91 (13.3)	92 (13.1)
Preoperative hemoglobin, median (5%-95%), g/dL	13 (10 to 16)	13 (9 to 16)
Preoperative glucose, median (5%-95%), mg/dL (n = 605 vs 623)	110 (76 to 175)	112 (77 to 180)
Perioperative glucose change, median (5%-95%), mg/dL (n = 560 vs 564)	16 (–27 to 79)	14 (–40 to 83)
Duration of anesthesia, median (5%-95%), min	190 (75 to 396)	195 (75 to 371)
Duration of surgery, median (5%-95%), min	128 (38 to 310)	132 (35 to 295)

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Duration of anesthesia, median (5%-95%), min	190 (75 to 396)	195 (75 to 371)
Duration of surgery, median (5%-95%), min	128 (38 to 310)	132 (35 to 295)

Outcome	80% Oxygen (n = 685)	30% Oxygen (n = 701)
Surgical site infection	131 (19.1)	141 (20.1)
Infection location		
Superficial	75 (57.3)	76 (53.9)
Deep	20 (15.3)	26 (18.4)
Organ/space	36 (27.5)	39 (27.7)
ASEPSIS score >20[b]	32 (4.7)	36 (5.1)

SEVEN Meta-analysis

Chura et al. Surgical site infections and supplemental perioperative oxygen in colorectal surgery patients: a systematic review.**Surg Infect 2007; 8: 455**

Brar MS et al. Perioperative supplemental oxygen in colorectal patients: a meta-analysis. **J Surg Res 2009; 166: 227**

Al-Niaimi A, Safdar N. Supplemental perioperative oxygen for reducing surgical site infection: a meta-analysis. **J Eval Clin Pract 2009;15:360**

Qadan M et al. Perioperative supplemental oxygen therapy and surgical site infection: a meta-analysis of randomized controlled trials. **Arch Surg 2009;144:359**

Togioka B et al. The role of perioperative high inspired oxygen therapy in reducing surgical site infection: a meta-analysis. **Anesth Analg 2012;114:334**

Kao LS et al. Should perioperative supplemental oxygen be routinely recommended for surgery patients? A Bayesian meta-analysis. **Ann Surg 2012;256:894**

Should Perioperative Supplemental Oxygen Be Routinely Recommended for Surgery Patients?

A Bayesian Meta-Analysis

Lillian S. Kao, MD, MS,†‡ Stefanos G. Millas, MD,‡ Claudia Pedroza, PhD,* Jon E. Tyson, MD, MPH,*†§ and Kevin P. Lally, MD, MS†‡||*

Bayesian methods directly assess the probability of benefit

Probability of reduction in SSIs

Any reduction: Probability 77% to 85%

Reduction of 10% Probability 57% to 68%

Reduction of 20% : Probability 31% to 41%.

Colorectal surgery

Any reduction: Probability 86% to 92%,

Ann Surg 2012;256:894–901

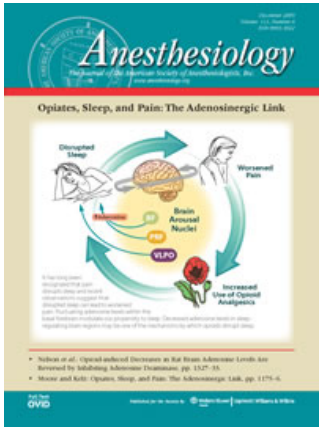
Effect of Intraoperative High Inspired Oxygen Fraction on Surgical Site Infection, Postoperative Nausea and Vomiting, and Pulmonary Function

Systematic Review and Meta-analysis of Randomized Controlled Trials

Frédérique Hovaguimian, M.D.,* Christopher Lysakowski, M.D.,† Nadia Elia, M.D., M.Sc.,‡ Martin R. Tramèr, M.D., D.Phil.§

Anesthesiology 2013;119:303-16.

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



Perioperative Hyperoxia

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Anesthesiology 2011; 114:1271–3

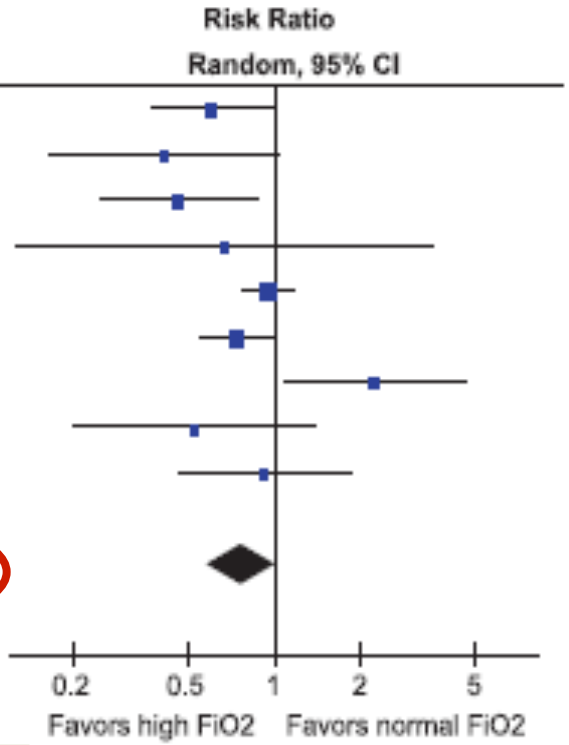
SARTD-CHGUV Sesión de Formación Continuada
10 de Marzo de 2015

A Included all surgeries.

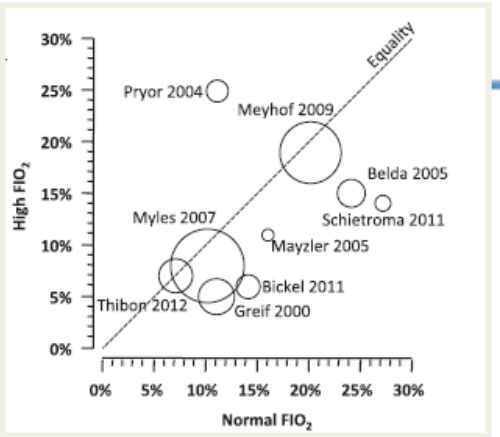
Study or Subgroup	High FiO2 Events	Total	Normal FiO2 Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
Belda 2005 [4]	22	148	35	143	14.1%	0.61 [0.38, 0.98]
Bickel 2011 [58]	6	107	14	103	6.4%	0.41 [0.16, 1.03]
Greif 2000 [5]	13	250	28	250	10.5%	0.46 [0.25, 0.88]
Mayzler 2005 [62]	2	19	3	19	2.3%	0.67 [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)



Colorectal, appendectomy, abdominal, major abdominal, and gynecologic inclusive breast any except cardiac or one-lung



B Included colorectal surgery only

Study or Subgroup	High FIO2 Events	Total	Normal FIO2 Events	Total	Weight	Risk Ratio M-H, Random, 95% CI
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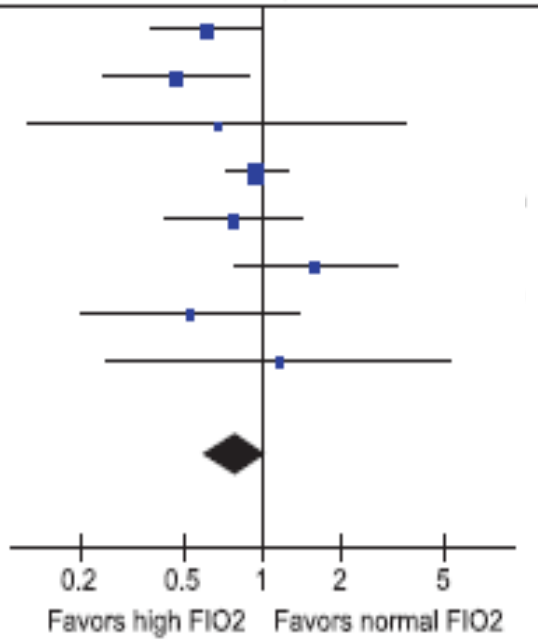
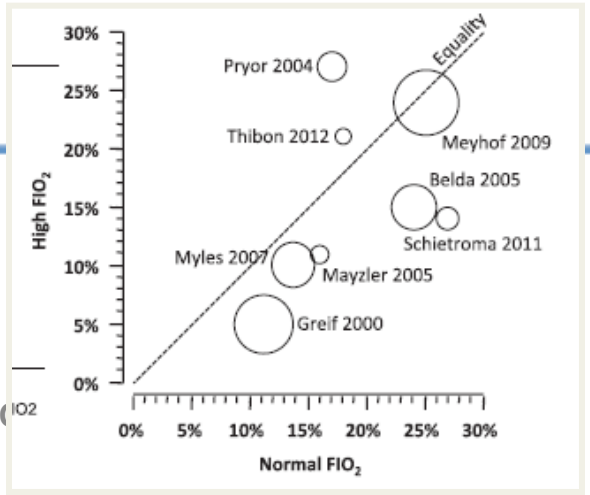
Mayzler 2005 [62]	2	19	3	19	2.5%	0.67 [0.13, 3.55]
Meyhoff 2009 [63]	72	303	83	330	31.3%	0.94 [0.72, 1.24]
Myles 2007 [64]	17	157	20	142	14.0%	0.77 [0.42, 1.41]
Pryor 2004 [66]	16	60	9	54	10.6%	1.60 [0.77, 3.32]
Schietroma 2011 [28]	5	35	10	37	6.7%	0.53 [0.20, 1.39]
Thibon 2012 [30]	4	19	2	11	3.0%	1.16 [0.25, 5.33]
Total (95% CI)		**991**		**986**	**100.0%**	**0.78 [0.60, 1.02]**
Total events	151		190			

Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 9.96$, df = 7 (P = 0.19); $I^2 = 30\%$

Test for overall effect: Z = 1.79 (P = 0.07)





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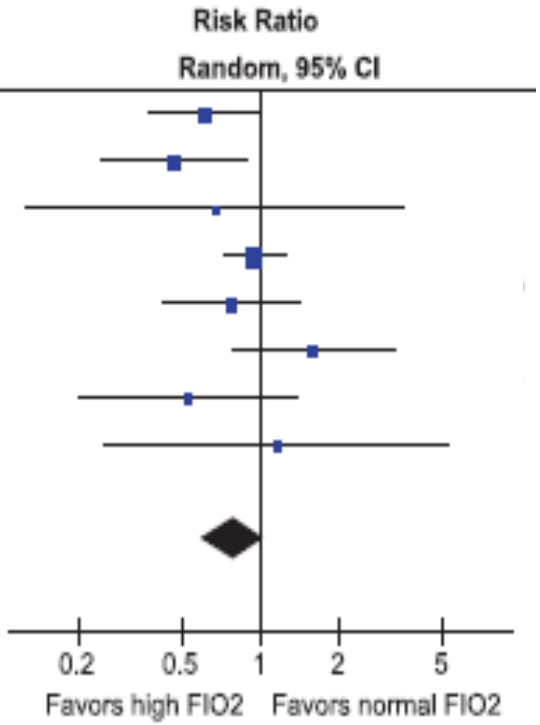
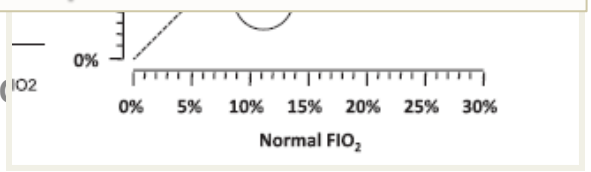
Heterogeneity: $Tau^2 = 0.04$; $Chi^2 = 9.96$, df = 7 (P = 0.19); $I^2 = 30\%$

Test for overall effect: Z = 1.79 (P = 0.07)



What This Article Tells Us That Is New

Intraoperative high inspired oxygen fraction decreases the risk of surgical site infection in surgical patients receiving prophylactic antibiotics and does not increase the risk of postoperative atelectasis.



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

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

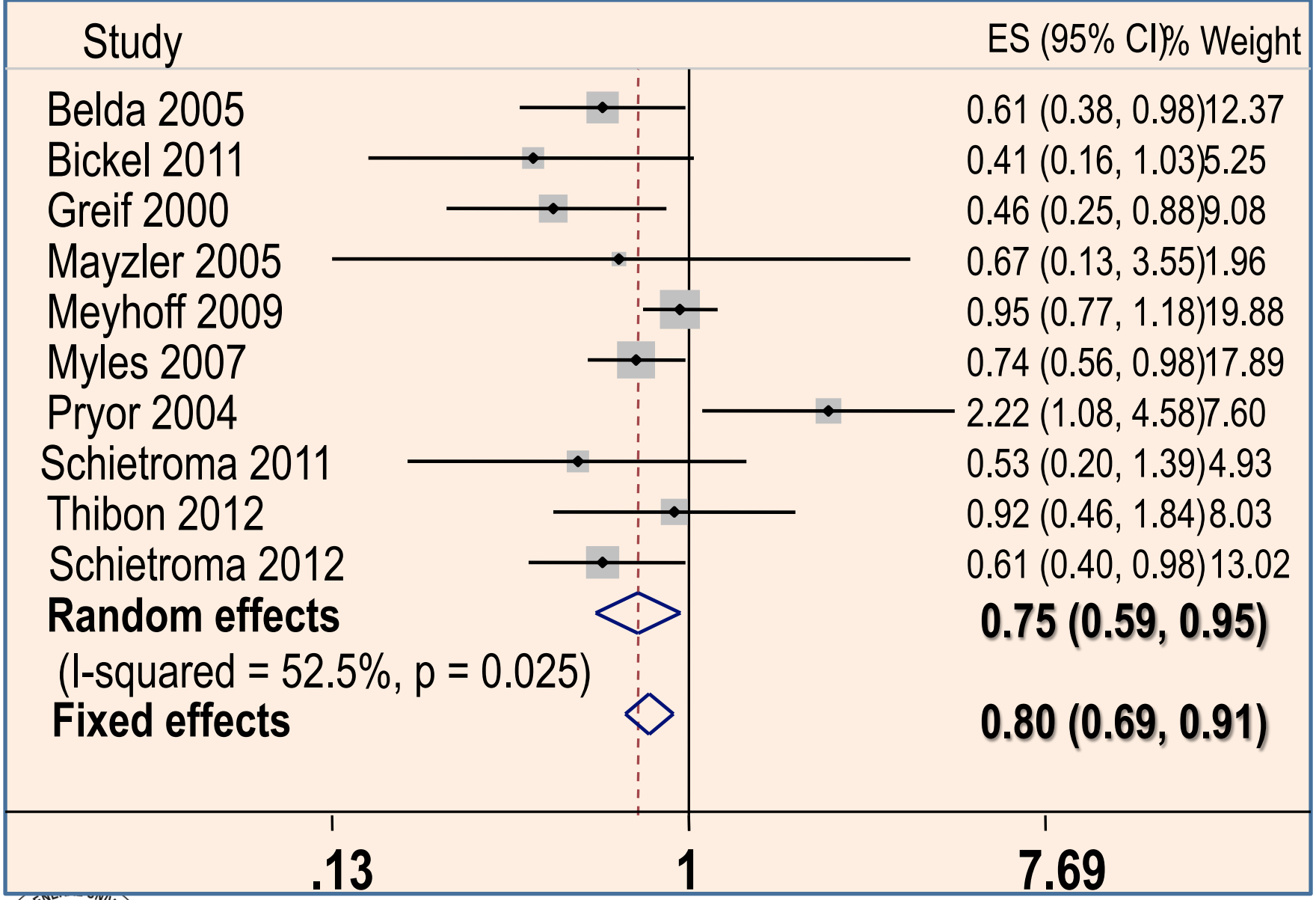
ORIGINAL ARTICLE – GASTROINTESTINAL ONCOLOGY

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	

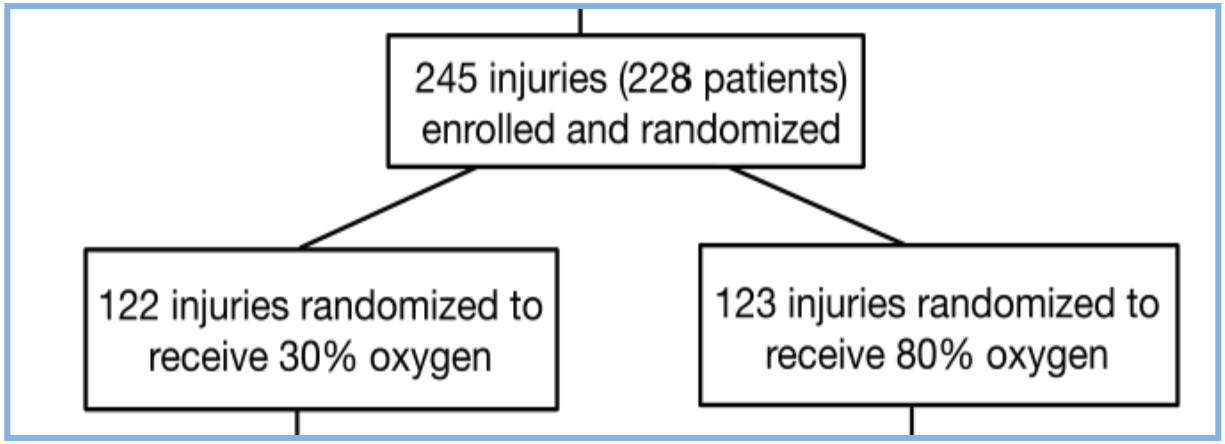


Belda FJ, Catala F 2015 Unpublished data

Perioperative supplemental oxygen to reduce surgical site infection after open fixation of high-risk fractures: A randomized controlled pilot trial

Alec Stall, MD, Ebrahim Paryavi, MD, Rishi Gupta, MD, Mary Zadnik, ScD, Emily Hui, MPH, *and* Robert V. O'Toole, MD, *Baltimore, Maryland*

J Trauma Acute Care Surg. 2013;75: 657-663



FiO2 80% during the perioperative period is safe and shows a trend toward reduction of surgical site infection

PeerJ 2:e613; DOI 10.7717/peerj.613 October 2014

PeerJ

Pure oxygen ventilation during general anaesthesia does not result in increased postoperative respiratory morbidity but decreases surgical site infection. An observational clinical study

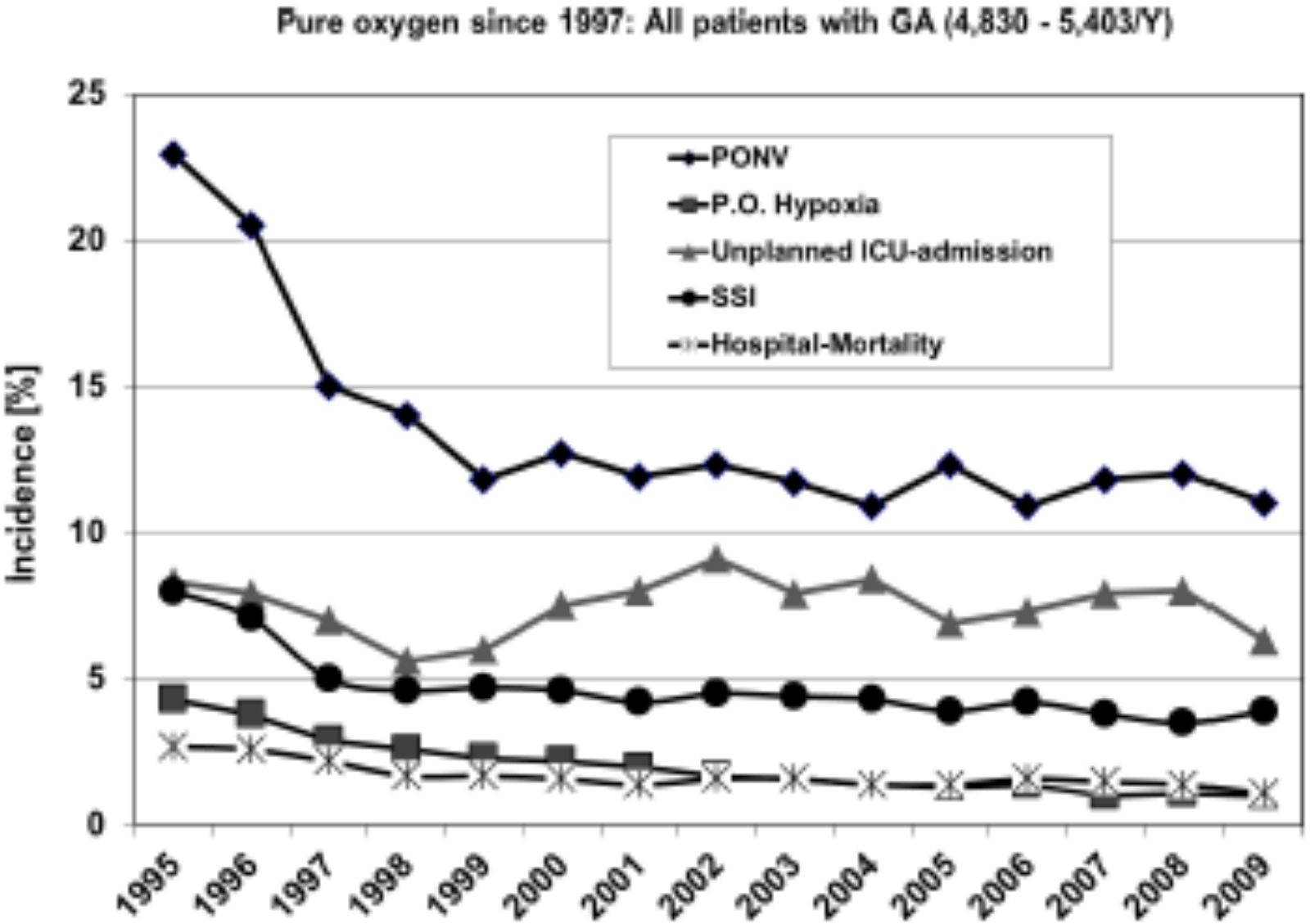
Benno von Bormann[1], Sirilak Suksompong[1], Jürgen Weiler[2] and Rolf Zander[3]

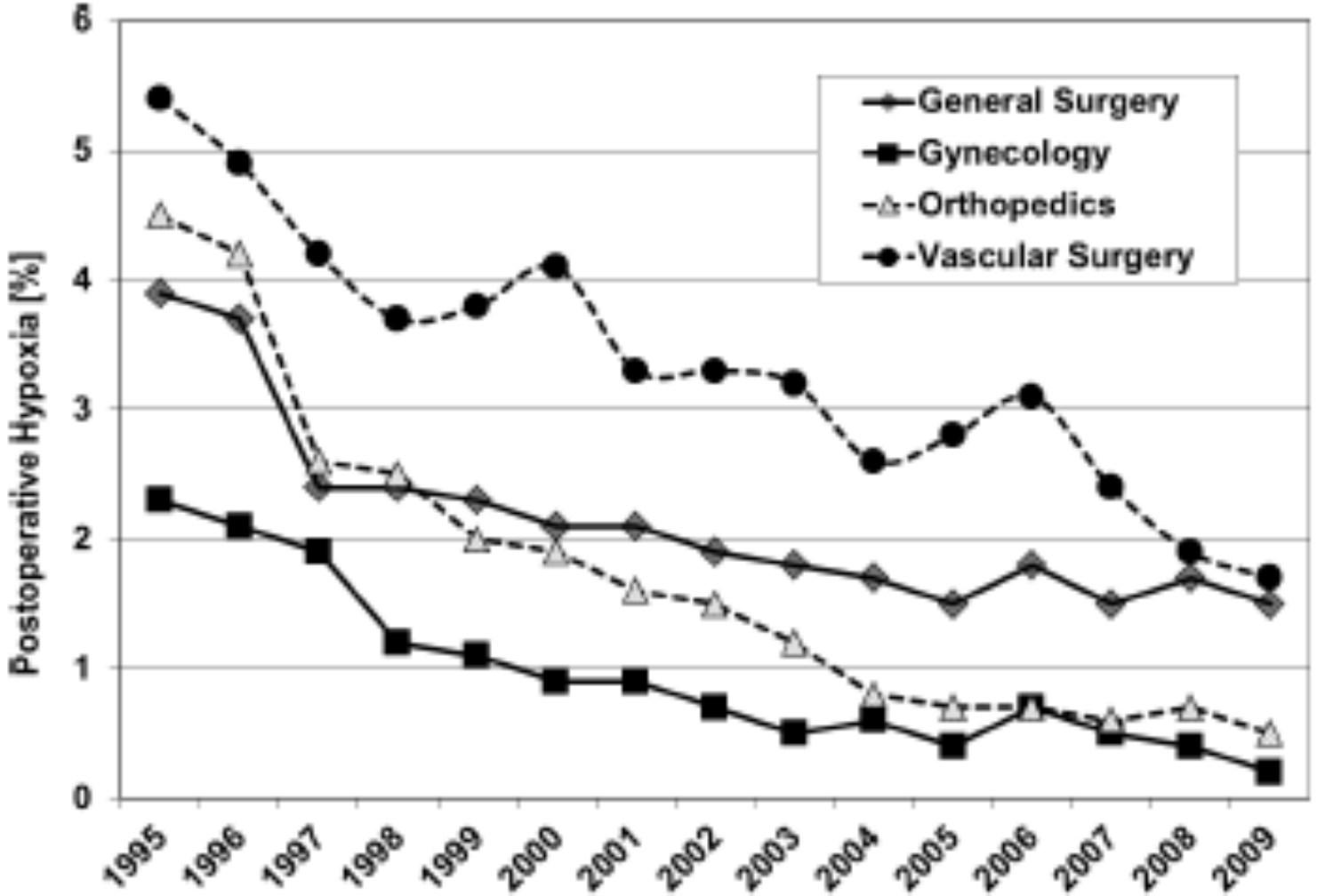
[1] Department of Anesthesiology, Siriraj Hospital, Mahidol-University, Bangkoknoi, Bangkok, Thailand
[2] Anästhesie Team Nordrhein, Dinslaken, Germany
[3] Department of Physiology, Johannes Guten

Table 2 Characteristics of surgical procedures in 1995 and 1997.

Surgical discipline	Surgical procedure	1995 ($FiO_2 = 0.3$)	1997 ($FiO_2 = 1.0$)
ALL		5,255	5,245
General surgery	ALL	1,322	1,351
	Minor	765	838
	Major	231	220
	Colorectal	326	293
Gynaecology	ALL	779	736
	Minor	510	471
	Major	189	190
	Mamma	80	75
Orthopaedic surgery	ALL	1,769	1,749
	Minor	997	990
	Major	693	656
	Spine	79	103
Vascular surgery	ALL	1,443	1,409
	Minor	342	350
	Aortic	271	244
	Major artery	630	620
	Cerebral artery	200	195

SARTD-CHGUV Sesión de Formación Continuada
10 de Marzo de 2015


Pure oxygen since 1997: All patients with GA (4,830 - 5,403/Y)
Incidence [%]
25
20
15
10
5
0
PONV
P.O. Hypoxia
Unplanned ICU-admission
SSI
Hospital-Mortality
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009


Postoperative Hypoxia [%]
0
1
2
3
4
5
6
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
General Surgery
Gynecology
Orthopedics
Vascular Surgery

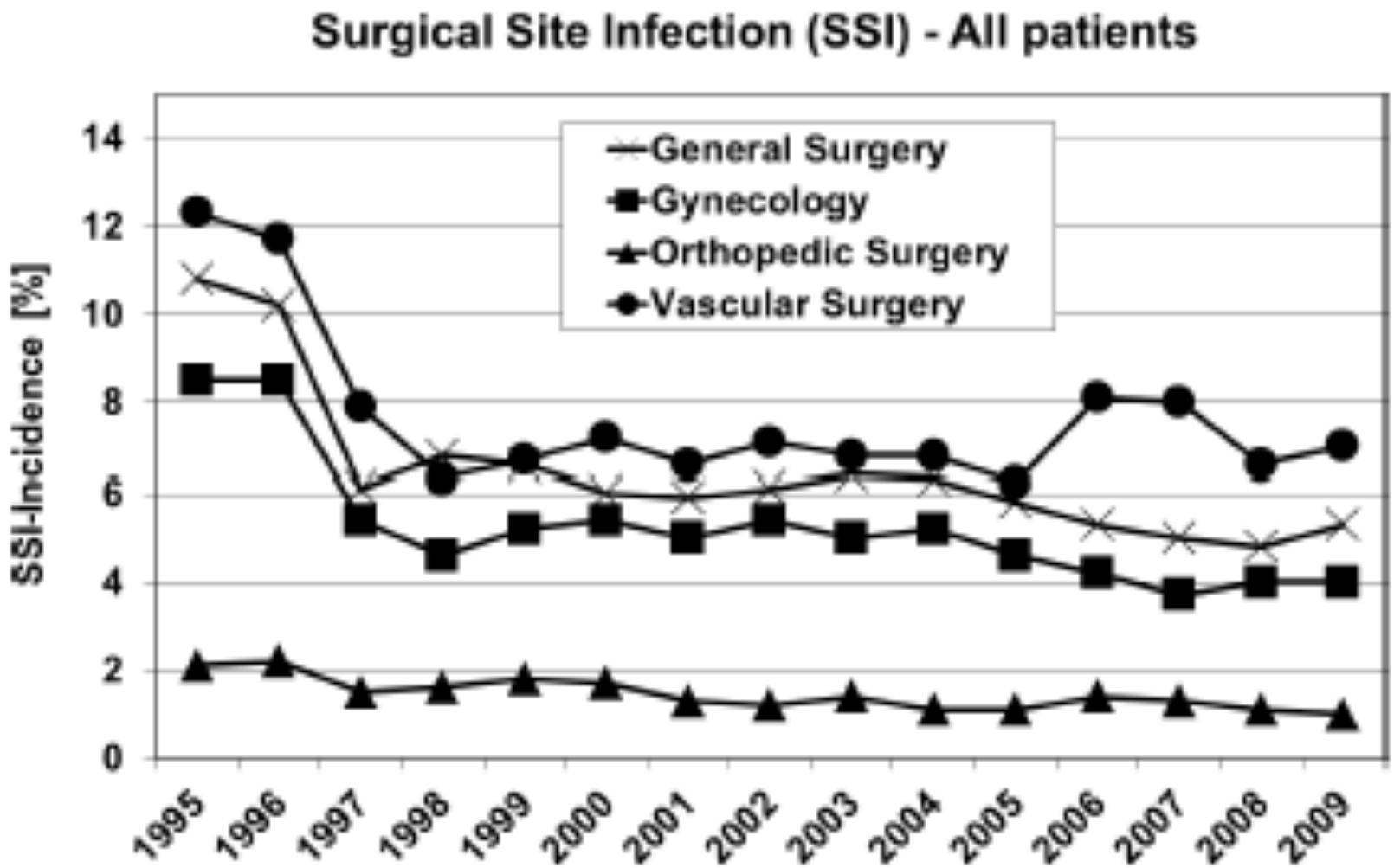

Surgical Site Infection (SSI) - All patients
SSI-Incidence [%]
0
2
4
6
8
10
12
14
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
General Surgery
Gynecology
Orthopedic Surgery
Vascular Surgery

Table 4 Outcome data of surgical patients 1995 (30% oxygen) and 1997 (100% oxygen).

Surgical group	N		Postop. Hypoxia (%)			U-ICU (%)			SSI (%)			PONV (%)		
	1995	1997	1995	1997	*P*	1995	1997	*P*	1995	1997	*P*	1995	1997	*P*
ALL	5,313	5,245	4.3	3.0	<0.0001	1.1	0.9	0.18	8.0	5.0	<0.0001	21.6	17.5	<0.0001
General surgery	1,322	1,351	3.9	2.7	0.026	0.8	0.8	0.959	10.8	6.1	<0.0001	23.5	19.0	0.004
Colorectal	326	293	3.4	2.7	0.643	0[a]	0[a]		22.4	14.7	0.014	20.6	17.7	0.377
Major	231	220	3.5	2.3	0.514	0[a]	0[a]		17.3	10.9	0.051	25.6	20.9	0.245
Minor	765	838	4.1	2.7	0.114	1.4	1.3		3.9	1.8	<0.01	24.2	19.0	0.011
Gynecology	779	736	2.3	2.2	0.581	0.5	0.1	0.20	8.5	5.4	0.021	21.3	16.8	0.027
Major	189	190	5.8	4.2	0.473	2.1	0.5	0.175	12.7	7.9	0.124	20.1	14.2	0.128
Mastectomy	80	75	3.8	4.0	0.936	0	0		13.8	8.0	0.252	23.8	18.7	0.44
Minor	510	471	0.8	0.6	0.784	0	0		6.1	4.0	0.146	21.4	17.6	0.139
Orthopedics	1,769	1,749	4.5	2.6	0.003	0.6	0.4	0.357	2.1	1.5	0.224	20.6	16.5	0.002
Spine	79	103	6.3	3.9	0.451	0[a]	0[a]		1.3	1.0	0.850	31.6	21.4	0.116
Major, Arthroplasty	693	656	4.6	2.3	0.020	1.0	0.3	0.112	2.7	1.8	0.264	20.5	16.9	0.093
Minor	997	990	4.3	2.7	0.055	0.4	0.2	0.418	1.7	1.4	0.601	20.2	15.8	0.011
Vascular surgery	1,443	1,409	5.4	4.9	0.128	2.2	1.8	0.481	12.3	7.9	<0.0001	21.3	17.5	0.009
Aorta	271	244	8.1	6.1	0.387	0[a]	0[a]		6.3	3.3	0.114	18.1	14.8	0.300
Periph. Arteries	630	620	6.5	5.5	0.446	4.4	3.7	0.511	21.9	14.7	<0.001	25.1	20.0	0.053
Cerebral Arteries	200	195	2.0	0.5	0.186	0[a]	0[a]		5.5	3.1	0.235			0.151
Minor	342	350	3.2	2.6	0.613	1.2	1.0	0.681	3.5	2.0	0.225	17.0	13.4	0.196

Increased Long-Term Mortality After a High Perioperative Inspiratory Oxygen Fraction During Abdominal Surgery: Follow-Up of a Randomized Clinical Trial

Christian S. Meyhoff, MD, PhD,* Lars N. Jorgensen, MD, DMSc,† Jørn Wetterslev, MD, PhD,‡ Karl B. Christensen, PhD,§ Lars S. Rasmussen, MD, PhD, DMSc,* and PROXI Trial Group

Follow-up study of the PROXI trial 1382 patients
median follow-up of 2.3 years (range 1.3 to 3.4 years).

At follow up: Deaths over the period

O_2 80%: 159/685 (23.2%)

O_2 30%: 128 /701 (18.3%)

Hazard Ratio: 1.30 (1.03 - 1.64) *P =0.03*

Cancer surgery: HR: 1.45 (1.10-1.90) *P = 0.009*

Noncancer surgery: HR: 1.06 (0.69 -1.65) *P = 0.79*

Critical Care 2008, 12:R156

Research

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]

give additional oxygen 'to be on the safe side'. Hyperoxia, however, is also to be avoided as oxygen may be toxic. First, it is long known that high fraction of oxygen in inspired air (FiO_2) may be toxic for the lungs. In animals, prolonged hyperoxia causes histopathological changes similar to those seen in ARDS [5]. Baboons exposed to 100% oxygen demonstrated a progressive reduction in forced vital capacity and functional residual capacity [6] and proliferative epithelial changes and interstitial fibrosis [7]. In healthy humans, exposure to 100% oxygen may lead to atelectasis, impaired mucocilliary clearance and tracheobronchitis, alveolar protein leakage and enhanced expression of leukotrienes by alveolar macrophages and increases in alveolar neutrophils [8]. Apart from its effects on the lungs, oxygen may also lead to systemic toxicity. It has been associated with an increase in vascular resistance and a decrease in cardiac output [9]. Hyperoxia may result in the generation of central nervous system, hepatic and pulmonary free radicals. Cardiopulmonary resuscitation following cardiac arrest in a canine model is associated with a worsened neurologic outcome when performed in the presence of hyperoxia vs normoxia [8,10].

In animals....

In healthy humans....

Summary of cons

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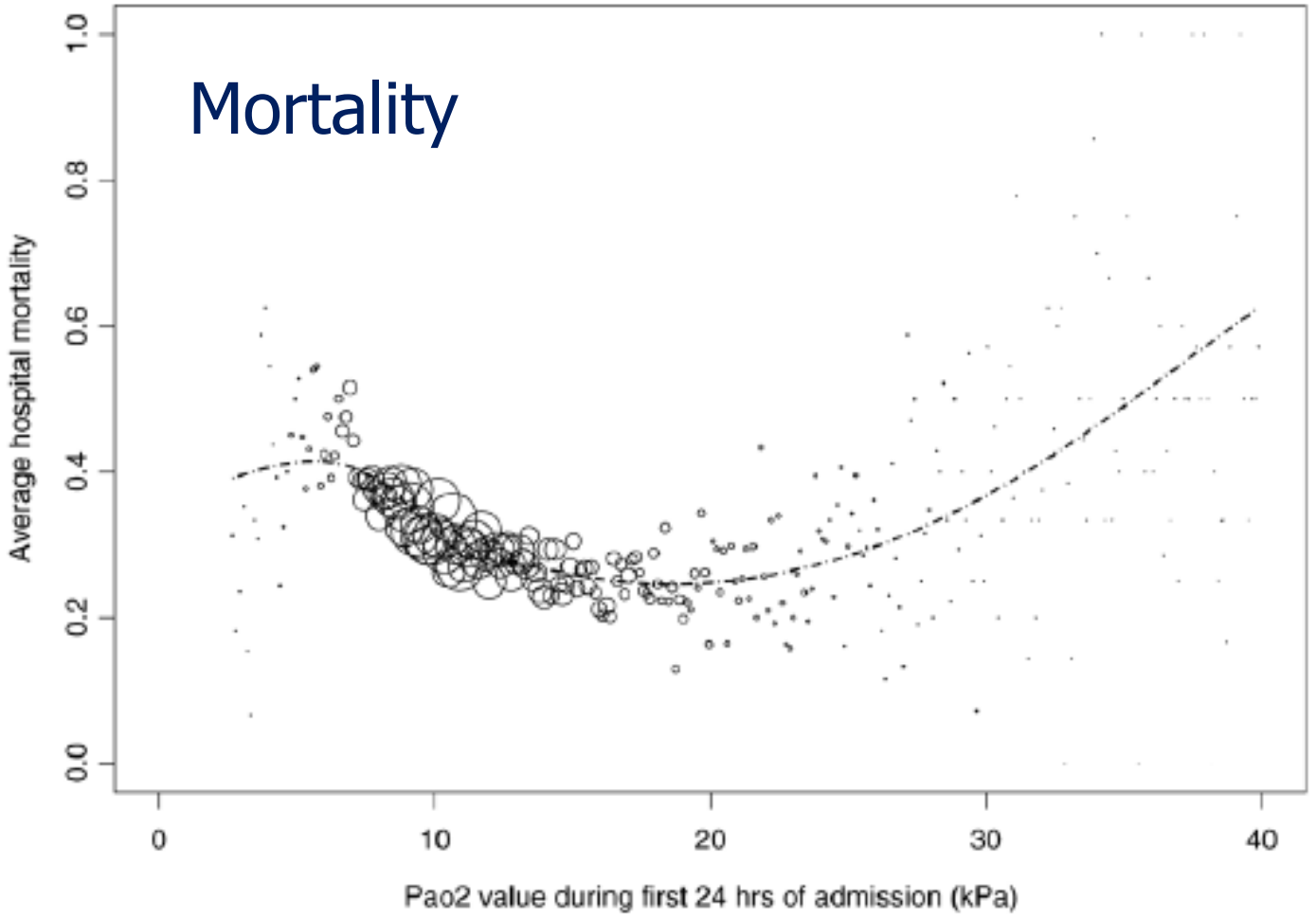
~~In animals…~~

~~In healthy humans…~~

Apart from its effects on the lungs,
oxygen may also lead to systemic toxicity.
NO REFERENCE
It has been associated with an increase in vascular resistance and a decrease in cardiac output

Lodato RF: Decreased O_2 consumption and cardiac output during normobaric hyperoxia in conscious dogs. *J Appl Physiol* 1989, 67:1551-59.

Mortality



Research

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De Jonge CC 2008

Mortality

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

Indicating severity

"It is possible that physicians recognised some marker of severity and purposefully gave higher concentrations of oxygen to achieve higher levels of PaO2 in these high-risk patients".

Research

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]

De Jonge CC 2008

Although oxygen toxicity is a well known entity

Mao C et al. A quantitative assessment of how Canadian intensivists believe they utilize oxygen in the intensive care unit. *Crit Care Med 1999*,27:2806-11.

it appears that physicians are more concerned about avoiding hypoxia and ischaemia than about the risks of hyperoxia.

Prospective, controlled trials are necessary to show a causal relationship between high FiO_2 and mortality.

Research

Open Access

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

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De Jonge CC 2008

Hyperoxia after nontraumatic cardiac arrest

Kilgannon JH et al. Emergency Medicine Shock Research Network (EMShockNet) Investigators:
Association between arterial hyperoxia following resuscitation from cardiac arrest and in-hospital mortality. *JAMA 2010,*303:2165-2171.

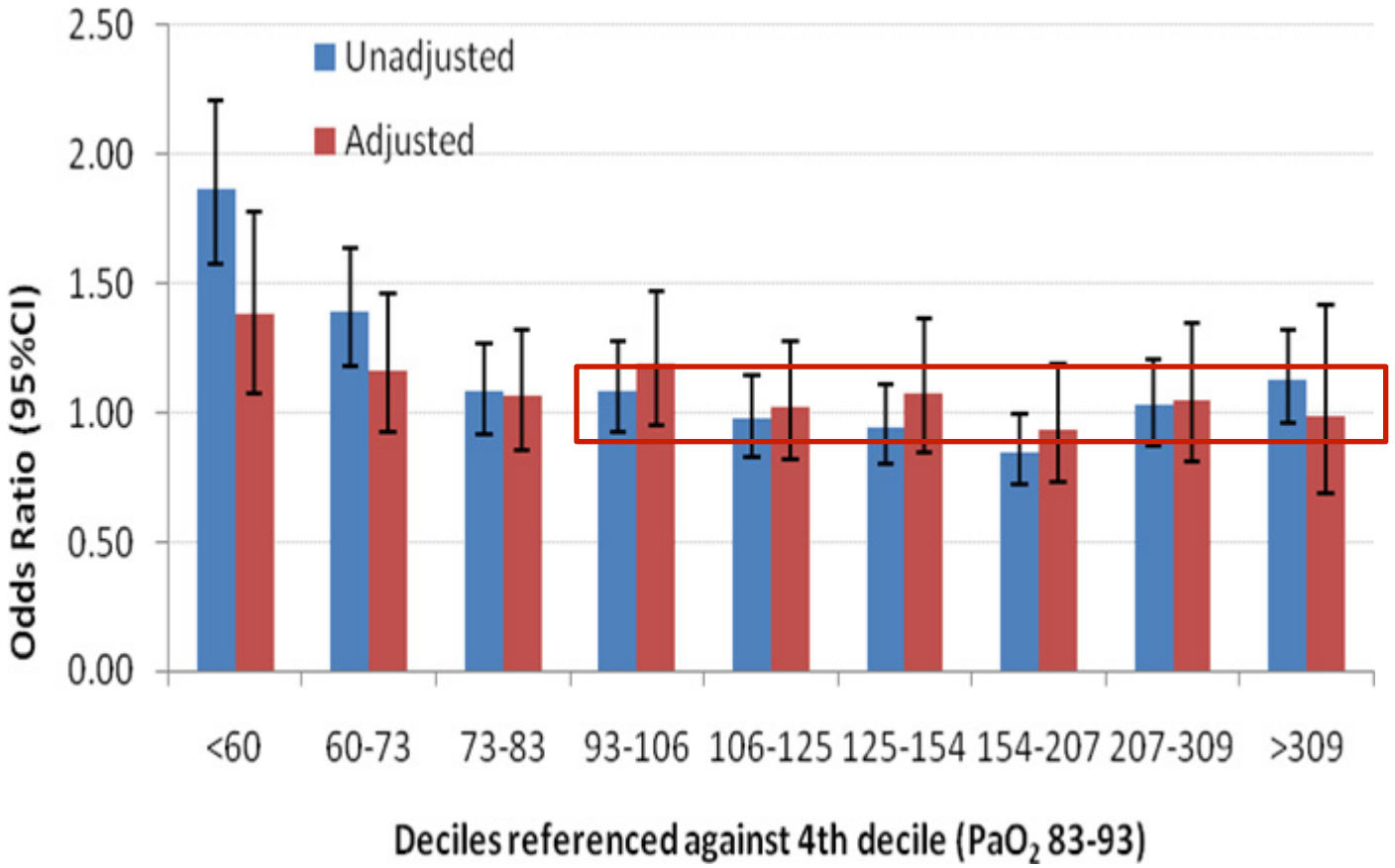
6,326 USA patients after nontraumatic cardiac arrest

Bellomo R et al. Study of Oxygen in Criticial Care Group.
Arterial hyperoxia and in-hospital mortality after resuscitation from cardiac arrest. *Crit Care 2011, 15:R90.*

12,108 AUS patients after nontraumatic cardiac arrest

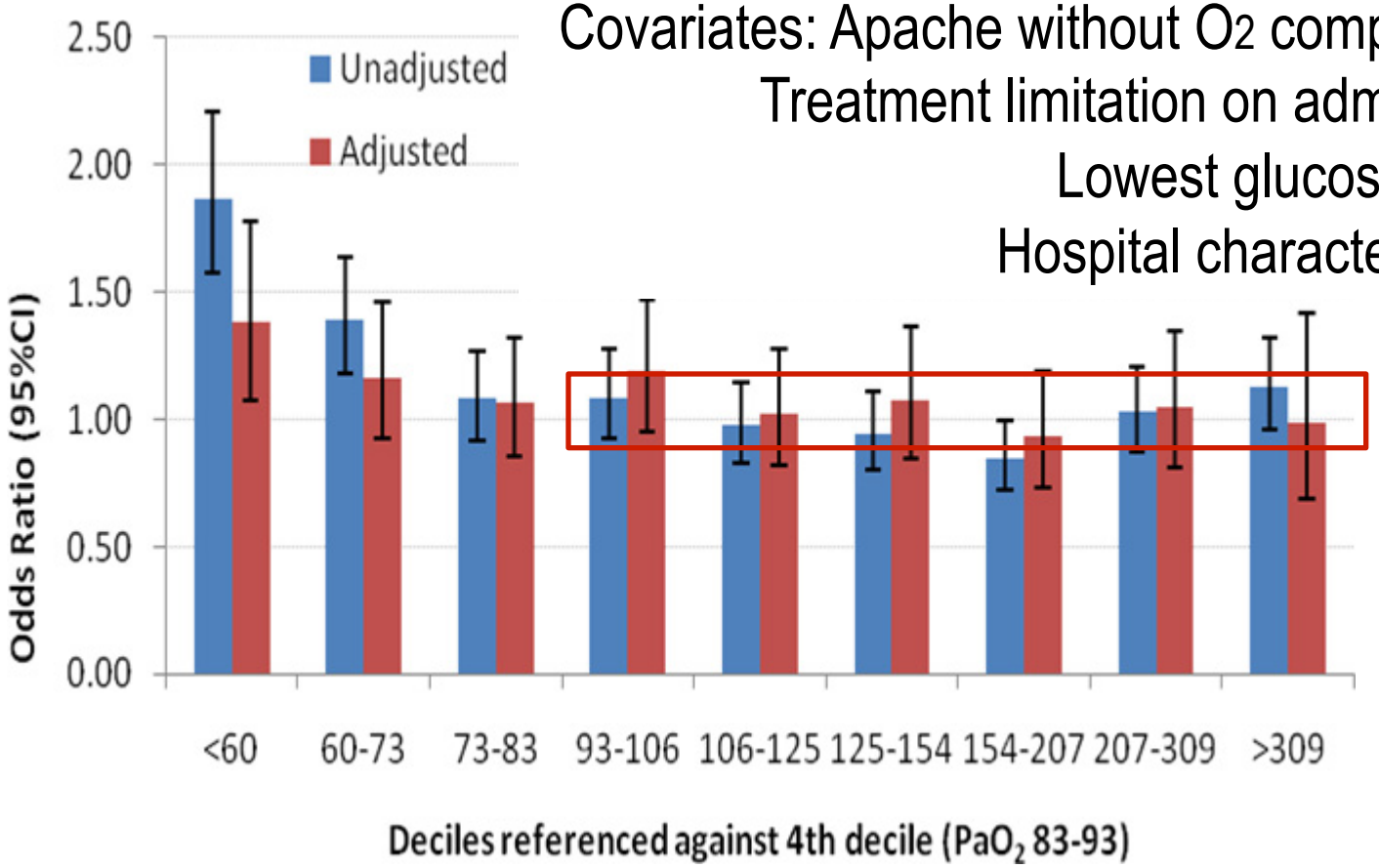
Hyperoxia higher mortality: OR 1.2-1.3

Bellomo R et al. Crit Care 2011, 15:R90.



Bellomo R et al. Crit Care 2011, 15:R90.

Covariates: Apache without O_2 component
Treatment limitation on admission
Lowest glucose 24 h
Hospital characteristics



Hyperoxia was not independently associated with mortality

Bellomo R et al. Crit Care 2011, 15:R90.

Our findings are against policies of deliberate decreases in FiO_2

unless accurate and reliable SpO_2 monitoring is available.

Oxygen Therapy in Critical Illness: Precise Control of Arterial Oxygenation and Permissive Hypoxemia*

Crit Care Med 2013; 41:423–432

Daniel Stuart Martin, BSc, MBChB, PhD, FRCA, FFICM[1,2];
Michael Patrick William Grocott, MBBS, MD, FRCA, FRCP, FFICM[1,3,4]

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www.medscape.com

Oxygen Therapy in Anaesthesia

The Yin and Yang of O2

D. S. Martin, M. P. W. Grocott

Br J Anaesth. 2013;111(6):867-871.

BJA
Original articles from all branches of anaesthesia

1. Perioperative care
2. Critical care
3. Resuscitation.

Oxygen Therapy in Anaesthesia

The Yin and Yang of O2

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Br J Anaesth. 2013;111(6):867-871.

BJA
Original articles from all branches of anaesthesia

Human response to hypobaric hypoxia (high altitude) is well described and characterized by the restoration of convective oxygen delivery through increases in alveolar ventilation, cardiac output, and red blood cell mass.

It is unlikely that critically ill patients mount such effective cardiorespiratory countermeasures to increase oxygen delivery as a result of their underlying pathology

"Clinical studies of ARDS concluded that P/F ratio was not a reliable predictor of outcome"

Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

	Acute Respiratory Distress Syndrome
Oxygenation[b]	
Mild	200 mm Hg < PaO_2/FIO_2 ≤ 300 mm Hg with PEEP or CPAP ≥5 cm H_2O[c]
Moderate	100 mm Hg < PaO_2/FIO_2 ≤ 200 mm Hg with PEEP ≥5 cm H_2O
Severe	PaO_2/FIO_2 ≤ 100 mm Hg with PEEP ≥5 cm H_2O

Table 5. Predictive Validity of ARDS Definitions in the Physiologic Database

	Modified AECC Definition[a]		Berlin Definition ARDS[a]		
	ALI Non-ARDS	ARDS	Mild	Moderate	Severe
No. (%) [95% CI] of patients	66 (25) [19-30]	203 (75) [70-80]	66 (25) [20-30]	161 (59) [54-66]	42 (16) [11-21]
Mortality, No. (%) [95% CI][b]	13 (20) [11-31]	84 (43) [36-50]	13 (20) [11-31]	62 (41) [33-49]	22 (52) [36-68]
Ventilator-free days					
Median (IQR)	8.5 (0-23.5)	0 (0-16.0)	8.5 (0-23.5)	0 (0-16.5)	0 (0-6.5)
Missing, No.	10	26	10	25	1
Duration of mechanical ventilation in survivors, median (IQR), d	6.0 (3.3-20.8)	13.0 (5.0-25.5)	6.0 (3.3-20.8)	12.0 (5.0-19.3)	19.0 (9.0-48.0)
Lung weight, mg[c]					
Mean (SD)	1371 (360.4)	1602 (508.1)	1371 (360.4)	1556 (469.7)	1828 (630.2)
Missing, No.	16	48	16	32	16
Shunt, mean (SD), %[c,d]	21 (21)	32 (13)	21 (12)	29 (11)	40 (16)

Permissive hypoxemia

"Implementation of PH is more speculative

(and potentially harmful)

and evaluation of the safety and feasibility of

this approach in perioperative and critical care settings is needed before clinical trials are contemplated."

www.medscape.com

Oxygen Therapy in Anaesthesia

The Yin and Yang of O2

D. S. Martin, M. P. W. Grocott

Br J Anaesth. 2013;111(6):867-871.

BJA
Original articles from all branches of anaesthesia

Can we optimize long-term outcomes in acute respiratory distress syndrome by targeting normoxemia?

Mikkelsen ME et al. Ann Am Thorac Soc, 2014 Mar 12.
[Epub ahead of print]

The association between lower oxygenation values and long-term cognitive impairment is observed in 25% of ARDS survivors

Am J RCCM 2012;185:1307-1315.

PLoS One 2011;6(7):e22512

BMJ 2013;346;f1532

Can we optimize long-term outcomes in acute respiratory distress syndrome by targeting normoxemia?

Mikkelsen ME et al. Ann Am Thorac Soc, 2014 Mar 12. [Epub ahead of print]

It seems plausible that raising the target range for PaO_2 to 85 -110 mm Hg and SpO_2 94-98% may reduce the risk of long-term cognitive impairment in ARDS survivors

Conclussions:

Perioperative *hyperoxia*

Does not increase the risk of postoperative atelectasis.

Does not induce postoperative hypoxemia

Reduce the risk of SSI and maybe infections

No demonstrated long-term mortality

No real toxicity demonstrated in critical patients

Permisive hypoxemia seems a dangerous concept

THANK YOU VERY MUCH
FOR YOUR ATTENTION