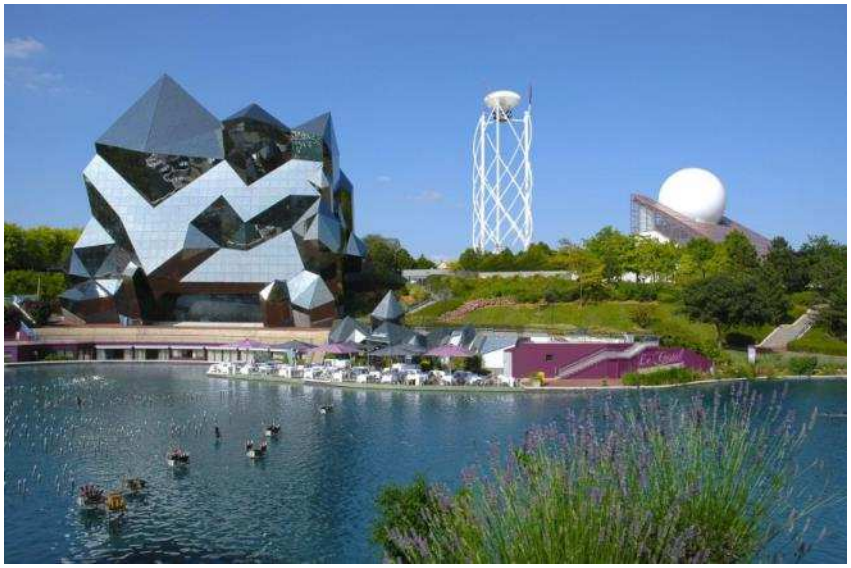
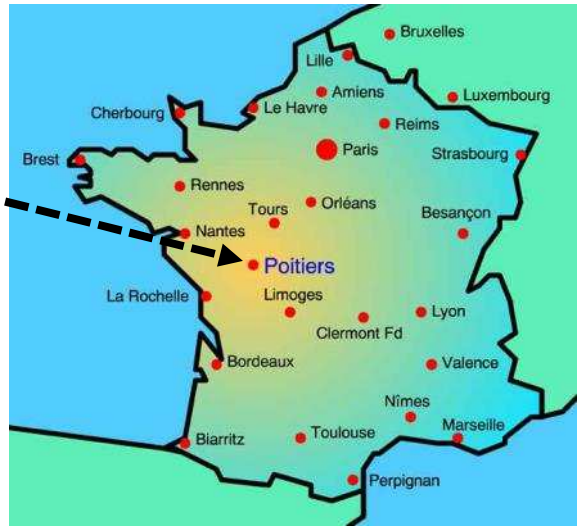


Oxygénothérapie à Haut Débit

Pr. Arnaud W. THILLE
MD-PhD,
Medical ICU,
University Hospital of Poitiers

INSERM CIC 1402, Equipe 5 ALIVE
(Acute Lung Injury and VEntilation)
aw.thille@gmail.com



Quelle stratégie d'oxygénation?

1

Oxygène standard

2

VNI

Oxygène Standard

1

Oxygène standard

1. Gaz très sec

2. FiO_2 maximale environ 60%

3. Assistance respiratoire = 0

VNI: Avantages

2

VNI

1. Gaz humidifié (filtres-humidificateur)

2. FiO_2 maximale à 100% (sans fuites)

3. Assistance respiratoire = AI

VNI: Problèmes

2

VNI

1. Intolérance / Asynchronies

2. Intubation retardée

3. Barotraumatisme / ARDS

Thille *et al. Critical Care* 2013, **17**:R269
http://ccforum.com/content/17/6/R269

CRITICAL CARE

RESEARCH Open Access

Non-invasive ventilation for acute hypoxemic respiratory failure: intubation rate and risk factors

Arnaud W Thille[1,2,3*], Damien Contou[1,3], Chiara Fragnoli[1], Ana Córdoba-Izquierdo[1], Florence Boissier[1] and Christian Brun-Buisson[1,3]

430 patients received NIV over a 3 year-period

Exclusion

242 Hypercapnic

69 CPE

6 without pulmonary infiltrates

113 with acute hypoxemic respiratory failure

Non-ARDS

N= 31 (27%)

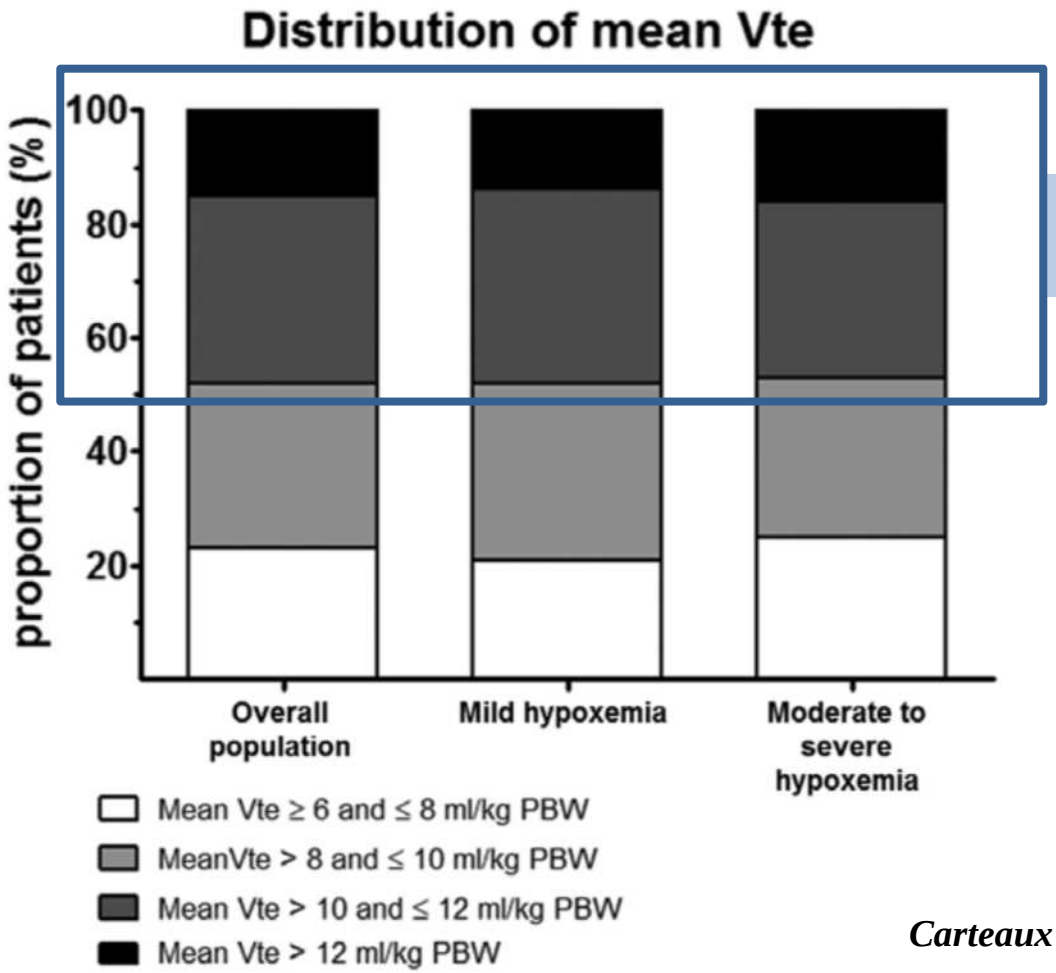
ARDS

N= 82 (73%)

What is the matter with NIV?

Failure of Noninvasive Ventilation for De Novo Acute Hypoxemic Respiratory Failure: Role of Tidal Volume

Guillaume Carteaux, MD[1,2,3]; Teresa Millán-Guilarte, MD[4]; Nicolas De Prost, MD, PhD[1,2,3]; Keyvan Razazi, MD[1,2,3]; Shariq Abid, MD, PhD[3]; Arnaud W. Thille, MD, PhD[5]; Frédérique Schortgen, MD, PhD[1,3]; Laurent Brochard, MD[3,6,7]; Christian Brun-Buisson, MD[1,2,8]; Armand Mekontso Dessap, MD, PhD[1,2,3]



> 10 ml/kg

Increased risk of intubation!

Carteaux et al., Crit Care Med 2016; 44:282-290.

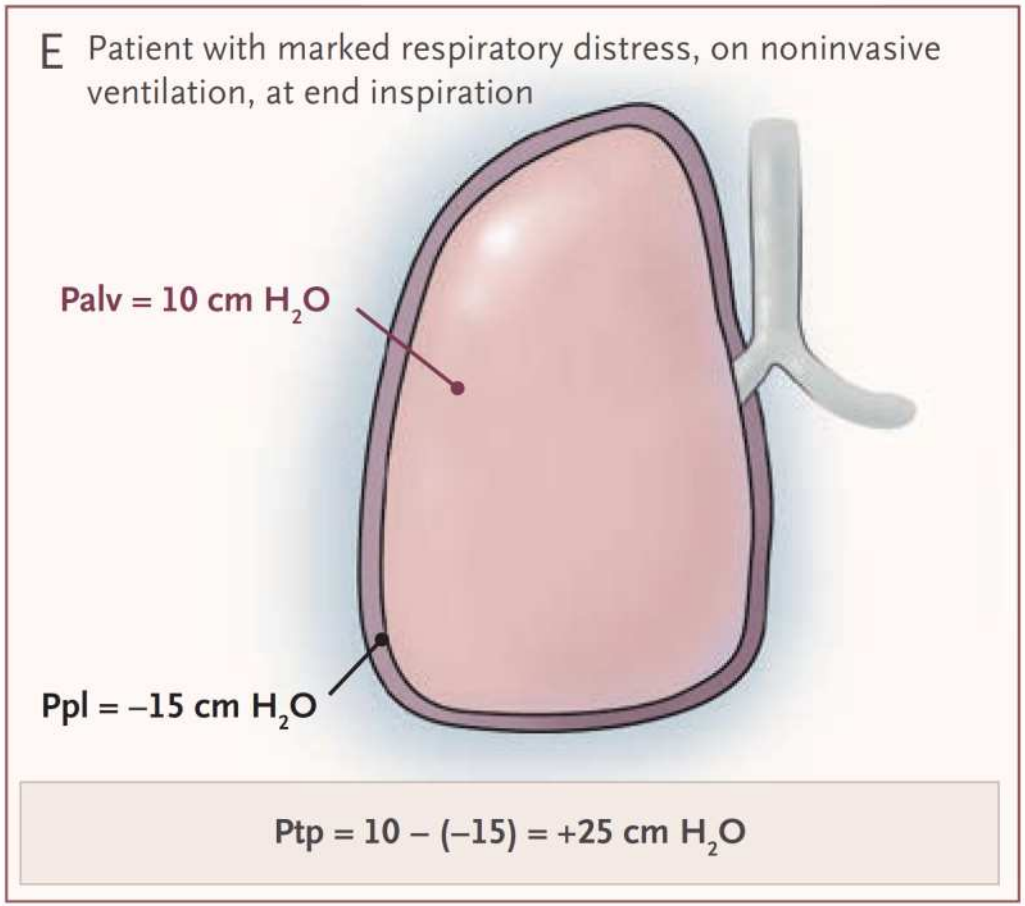
The NEW ENGLAND JOURNAL of MEDICINE

REVIEW ARTICLE

Ventilator-Induced Lung Injury

Arthur S. Slutsky, M.D., and V. Marco Ranieri, M.D.

N Engl J Med 2013;369:2126-36.



Oxygène à haut débit: quels bénéfices?

1. **Confort:** via lunettes et humidification
2. **Effet PEP:** Oxygénation - Prévention des atélectasies?
3. **Oxygénation:** Haut Débit = Haute FiO_2
4. **Lavage espace mort:** $PaCO_2$

▶ **Augmentation de la PaO_2**
Diminution de l'effort et de la fréquence respiratoire

1 **Confort:** via lunettes et humidification

L'air inspiré à l'état physiologique…

- Réchauffé à 37°C
- Humidifié à 100%: 44 mg H_2O/L

Table S5. Assessment of tolerance to the oxygenation strategy at inclusion and 1 hour after inclusion *

	High-Flow Oxygen group (n=106)	Standard Oxygen group (n=94)	NIV group (n=110)	P Value
Respiratory patient-discomfort at inclusion – mm †	38±31	44±29	46±30	0.20
Respiratory patient-discomfort at H1– mm †	29	40	43	<0.01
Grade of dyspnea at H1‡	76%	42%	58%	<0.001
Marked improvement – no. (%)	19 (22.1)	5 (6.8)	13 (14.3)	
Slight improvement– no. (%)	46 (53.5)	26 (35.1)	40 (44.0)	
No change– no. (%)	18 (20.9)	33 (44.6)	23 (25.3)	
Slight deterioration – no. (%)	3 (3.5)	9 (12.2)	8 (8.8)	
Marked deterioration – no. (%)	0 (0.0)	1 (1.3)	7 (7.7)	
Respiratory rate– breaths/min				
H1	28±7	31±7	31±8	<0.01
H6	27±7	29±8	29±7	0.13

Frat JP, Thille AW et al., New England Journal of Medicine 2015; 372:2185-2196.

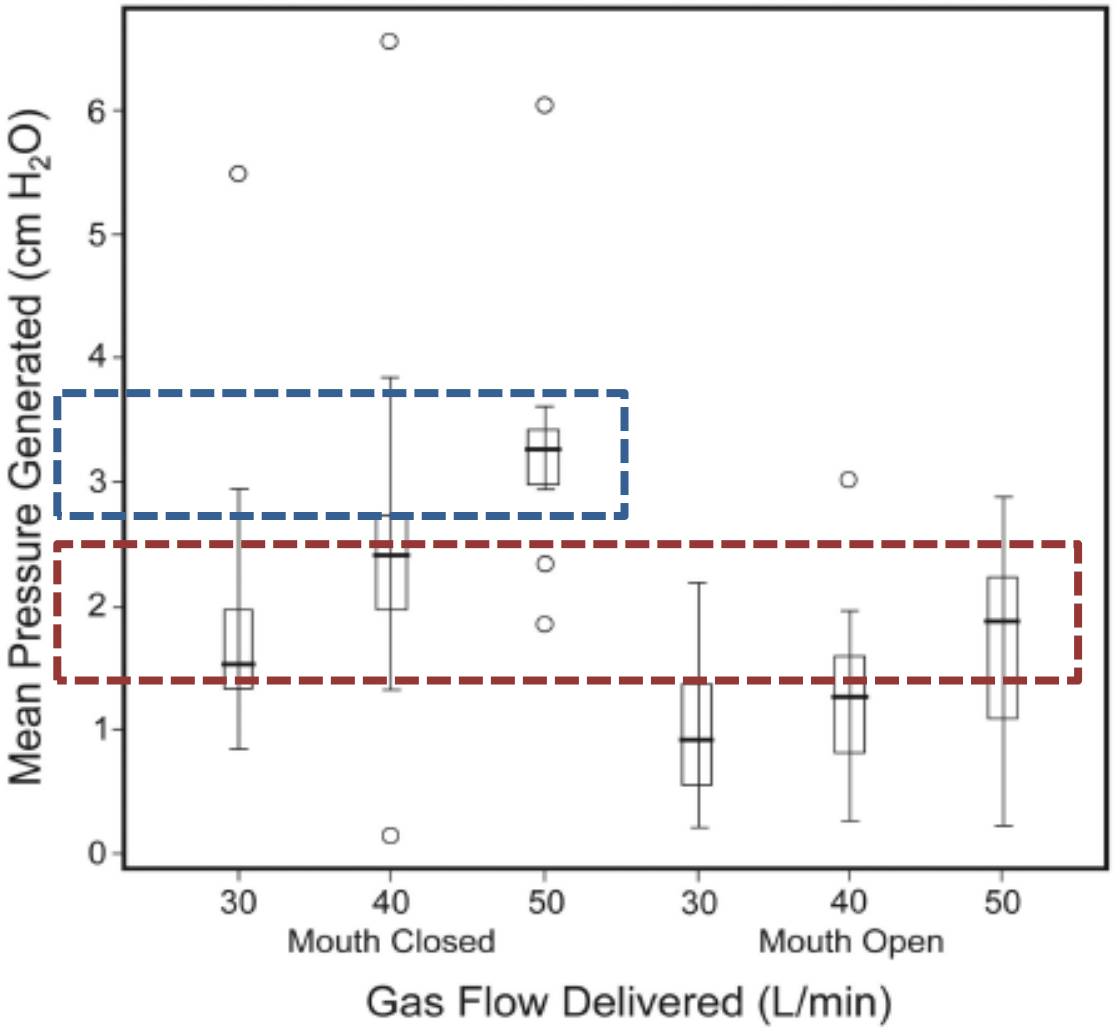
2

Effet PEEP: Oxygénation? Prévention atélectasies?

The Effects of Flow on Airway Pressure During Nasal High-Flow Oxygen Therapy

Rachael L Parke RN MHSc, Michelle L Eccleston RN, and Shay P McGuinness MB ChB

Respir Care 2011;56(8):1151–1155.



3

Oxygénation: Haut Débit = Haute FiO_2

Quelle FiO_2 avec l'O_2 standard?

Avec un masque à réserve
et un débit à10-15 L/min
FiO_2 entre 60 et 65%

Débit inspiratoire
Entre 30 et 40 L/min
>> 15L/min

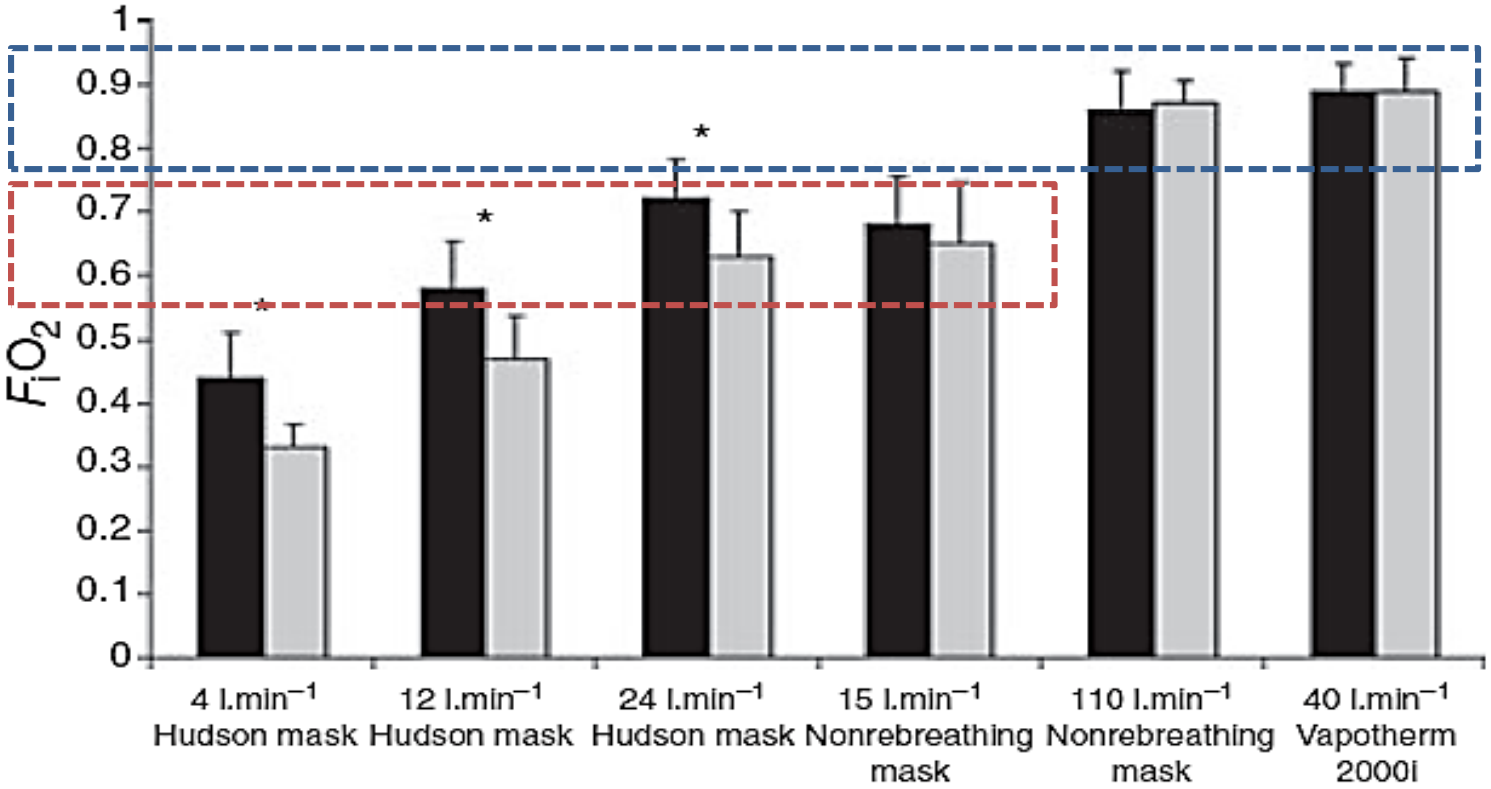
Katz et al., Anesthesiology 1985; 63:598-607.

Quelle FiO_2 avec l'O_2 standard?

Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2008, **63**, pages 938–940 doi:10.1111/j.1365-2044.2008.05536.x

Performance of oxygen delivery devices when the breathing pattern of respiratory failure is simulated*

M. A. B. Sim,[1] P. Dean,[2] J. Kinsella,[3] R. Black,[4] R. Carter[5] and M. Hughes[6]



Sequential Application of Oxygen Therapy Via High-Flow Nasal Cannula and Noninvasive Ventilation in Acute Respiratory Failure: An Observational Pilot Study

Jean-Pierre Frat MD, Benjamin Brugiere MD, Stéphanie Ragot PharmD PhD, Delphine Chatellier MD, Anne Veinstein MD, Véronique Goudet MD, Rémi Coudroy MD, Franck Petitpas MD, René Robert MD PhD, Arnaud W Thille MD PhD, and Christophe Girault MD PhD

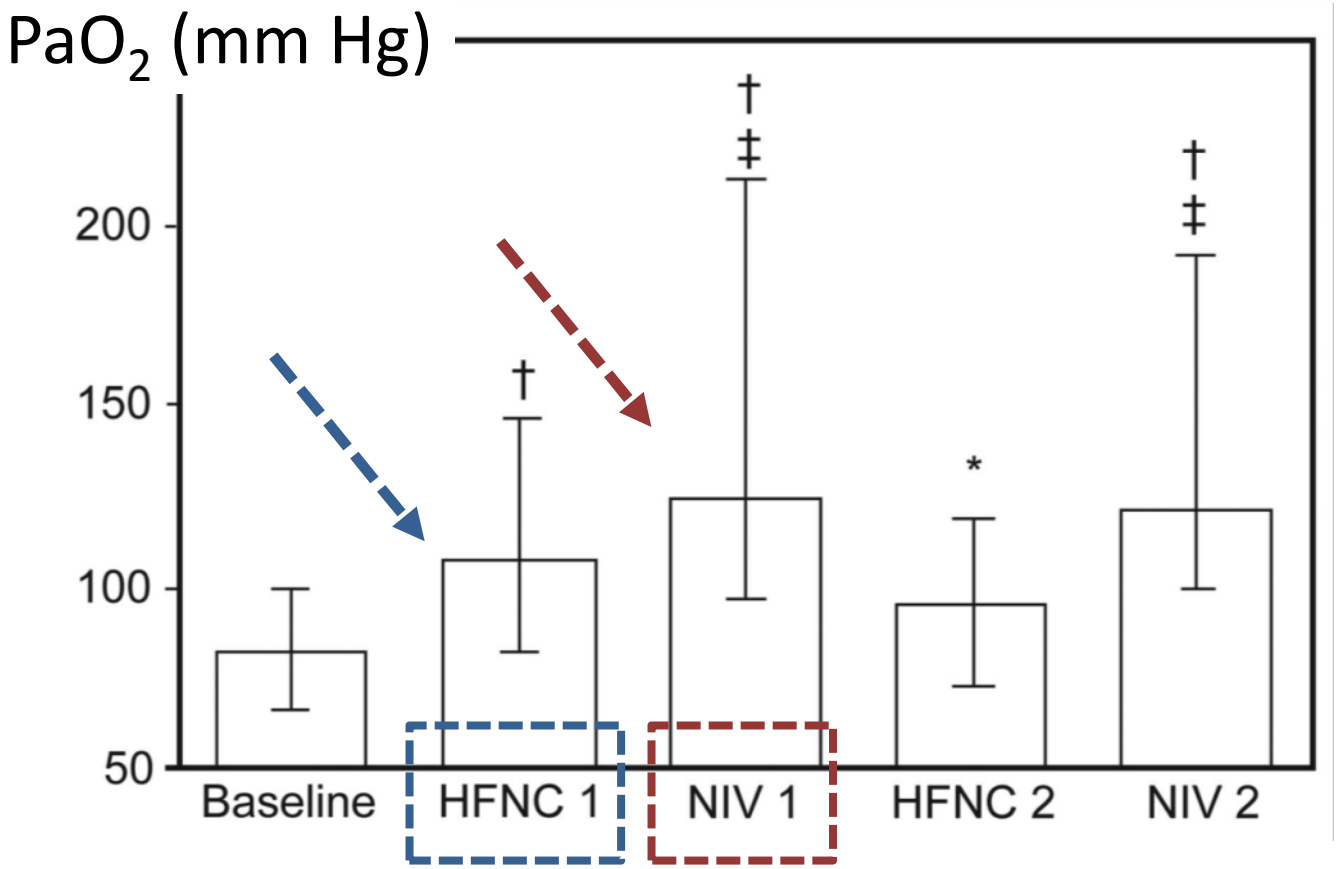


Table S5. Assessment of tolerance to the oxygenation strategy at inclusion and 1 hour after inclusion *

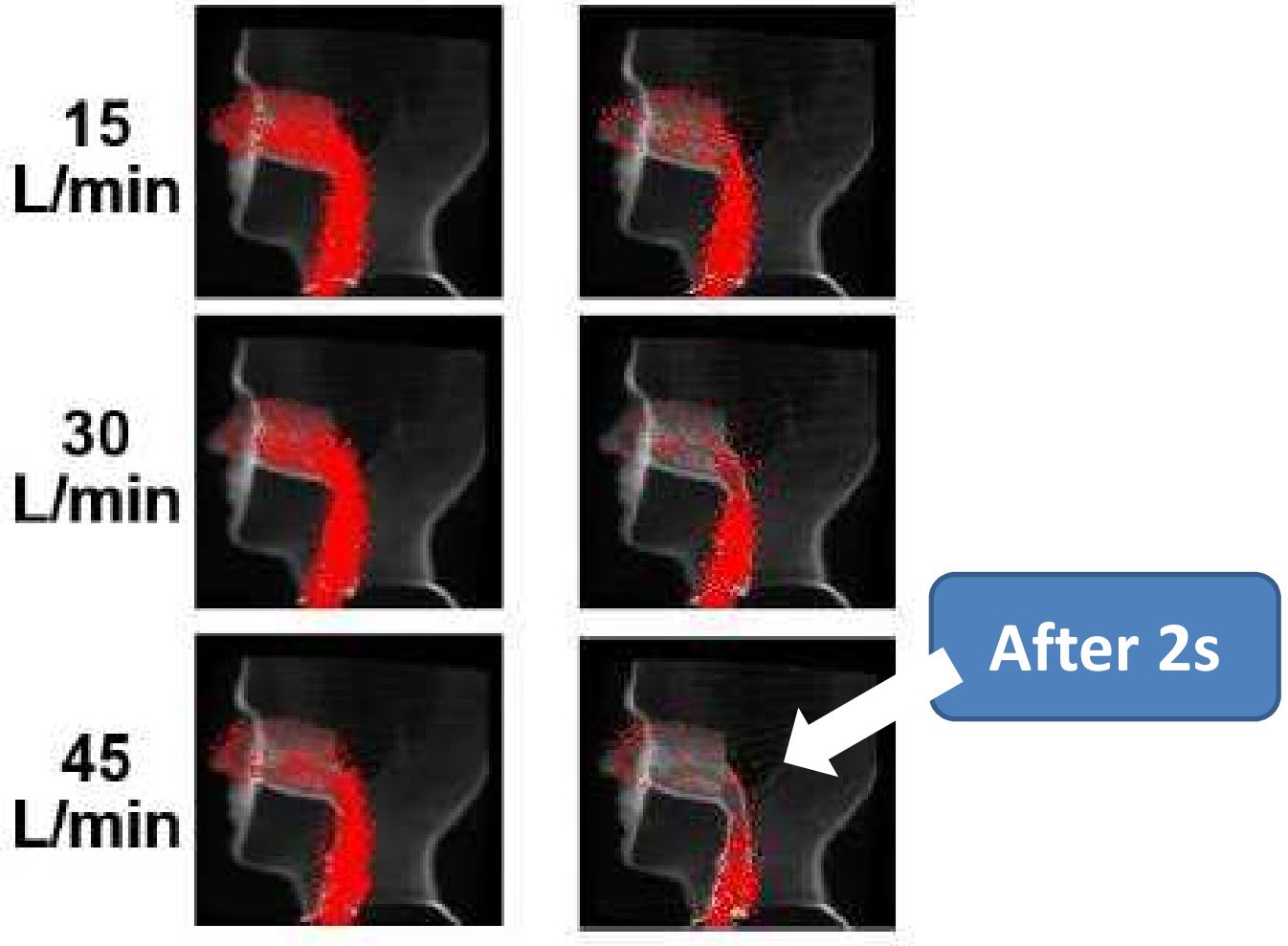
	High-Flow Oxygen group (n=106)	Standard Oxygen group (n=94)	NIV group (n=110)	P Value
PaO_2 – mm Hg				<0.05
H1	106	91	118±72	<0.05
H6	90±35	93±36	111±59	<0.01
FIO_2 §				
H1	82 %	66 %	0.67±0.24	<0.001
H6	0.75±0.22	0.64±0.18	0.63±0.21	<0.001
PaO_2:FIO_2 ratio– mm Hg				
H1	133	146	183	<0.001
H6	130±60	161±77	186±85	<0.001
$PaCO_2$ – mmHg				
H1	35±7	35±6	35±7	0.84

Frat JP, Thille AW et al., New England Journal of Medicine 2015; 372:2185-2196.

4 **Lavage espace mort:** $PaCO_2$

Nasal high flow clears anatomical dead space in upper airway models

Winfried Möller,[1,2] Gülnaz Celik,[1,2] Sheng Feng,[3] Peter Bartenstein,[4] Gabriele Meyer,[5] Oliver Eickelberg,[1,2,6] Otmar Schmid,[1,2] and Stanislav Tatkov[3]

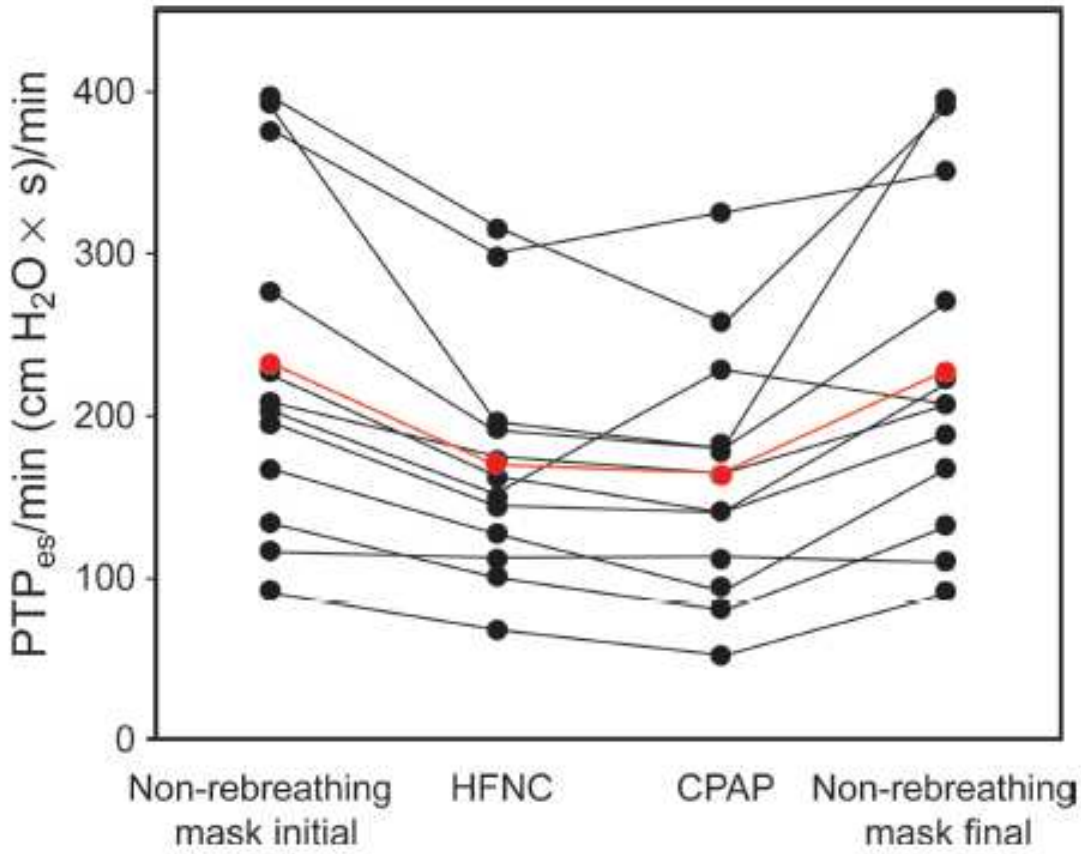


J Appl Physiol 118: 1525–1532, 2015.

Effort et fréquence respiratoire

Physiologic Effects of High-Flow Nasal Cannula Oxygen in Critical Care Subjects

Frederic Vargas MD PhD, Mélanie Saint-Leger MD, Alexandre Boyer MD PhD, Nam H Bui MD, and Gilles Hilbert MD PhD



Respir Care 2015;60(10):1369–1376

Use of HFNC: what is the evidence?

1. Acute hypoxemic respiratory failure - ARDS?
2. Pre-Oxygenation
3. Post-Extubation / Post-Op.
4. COPD, CPE ???

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 4, 2015 VOL. 372 NO. 23

High-Flow Oxygen through Nasal Cannula in Acute Hypoxemic Respiratory Failure

Jean-Pierre Frat, Arnaud W Thille, Alain Mercat et al.

310 patients with acute respiratory failure

79% with bilateral infiltrates

77% with $PaO_2/FiO_2 \leq 200$ mm Hg

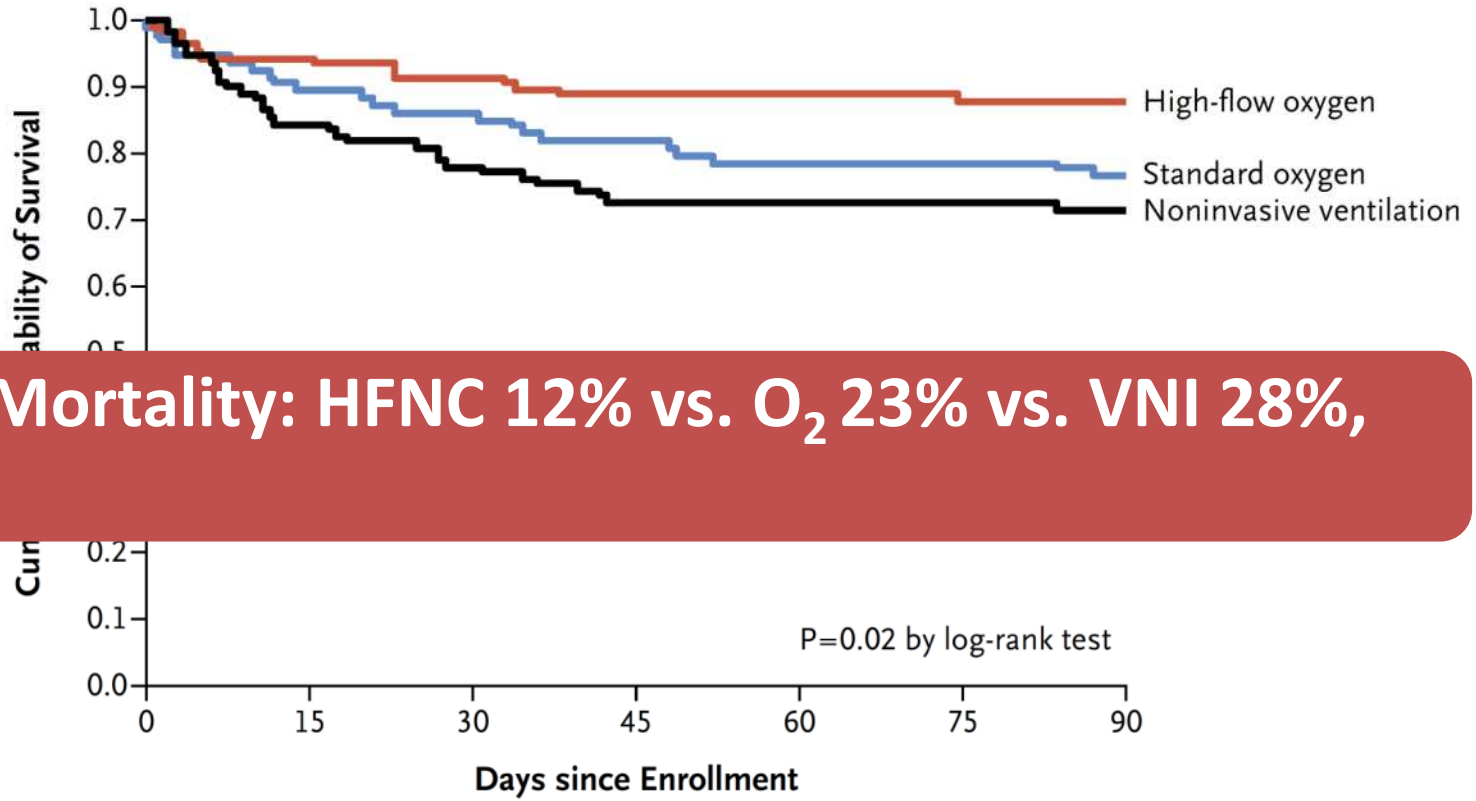
Critères d'inclusion

Insuffisance respiratoire aiguë hypoxémique
FR >25 /min ; $PaO_2/FiO_2 \leq 300$,
$PaCO_2 \leq 45$ mm Hg

O_2 Standard

Haut débit O_2

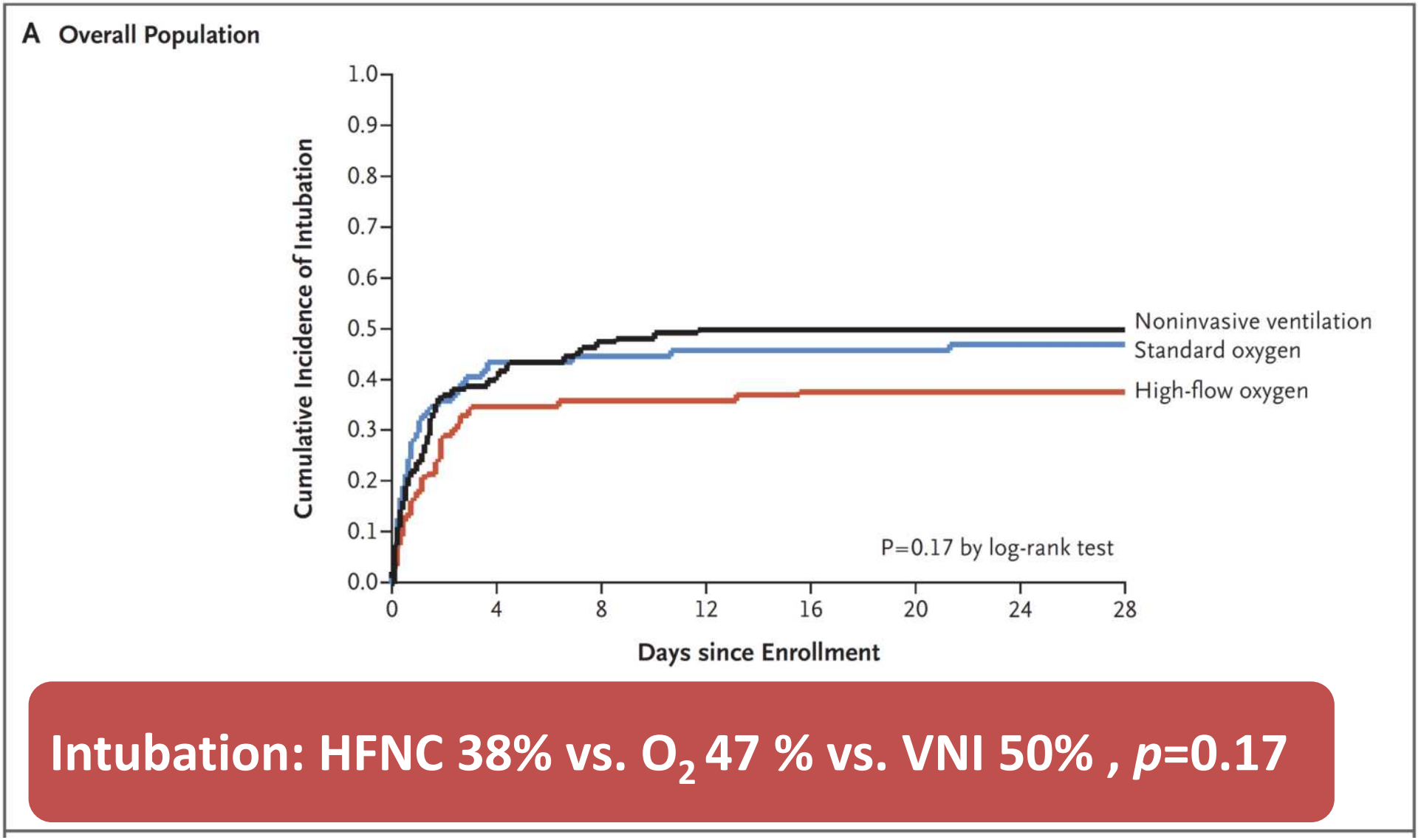
Haut débit O_2 + VNI 8h/j



90-day Mortality: HFNC 12% vs. O_2 23% vs. VNI 28%, *p*=0.02

No. at Risk							
High-flow oxygen	106	100	97	94	94	93	93
Standard oxygen	94	84	81	77	74	73	72
Noninvasive ventilation	110	93	86	80	79	78	77

Figure 3. Kaplan–Meier Plot of the Probability of Survival from Randomization to Day 90.

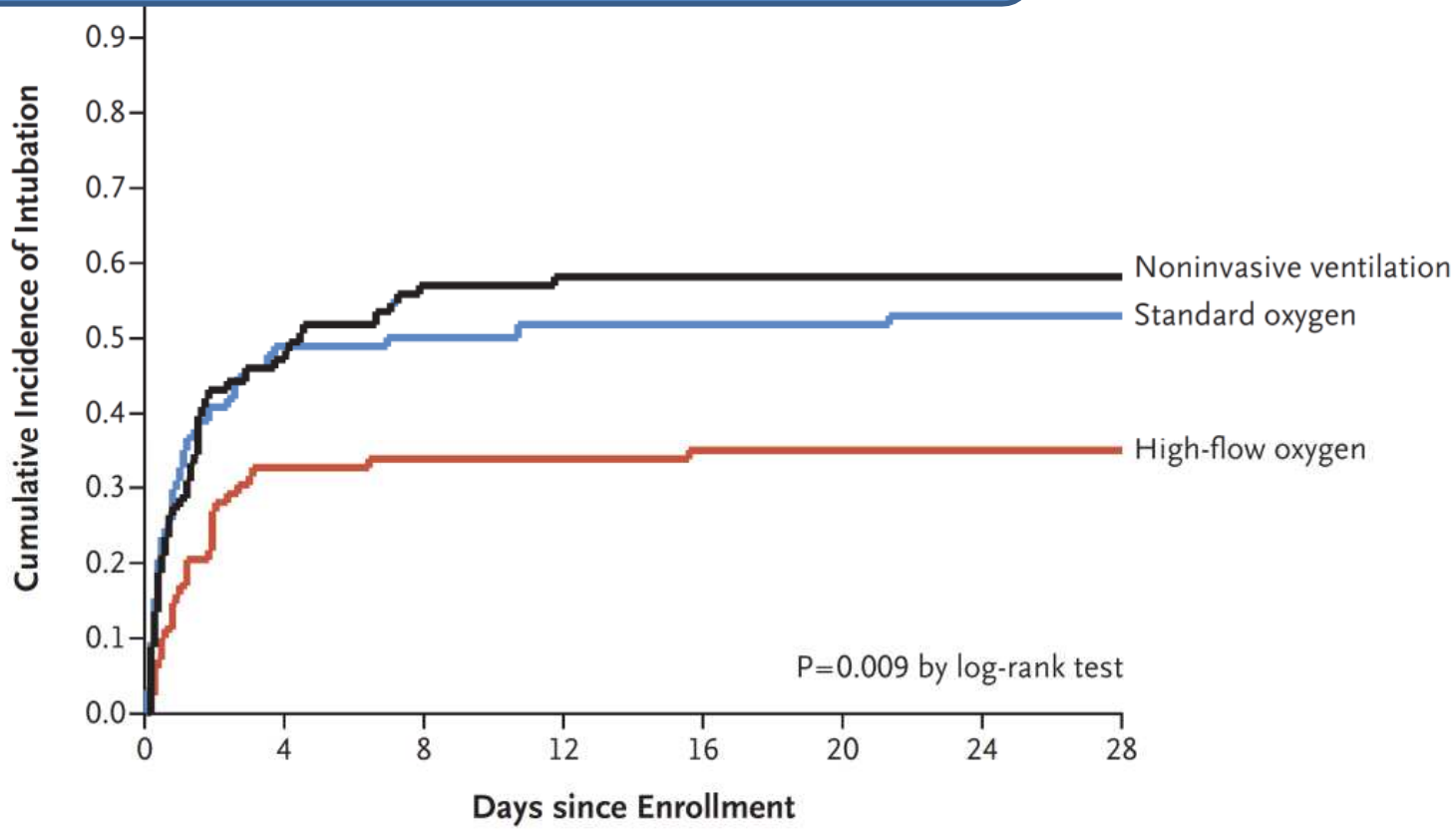


Intubation: HFNC 38% vs. O_2 47 % vs. VNI 50% , *p*=0.17

Figure 2. Kaplan–Meier Plots of the Cumulative Incidence of Intubation from Randomization to Day 28.

Comment expliquer une telle baisse de mortalité?

238 patients avec un $PaO_2/FiO_2 \leq 200$ mm Hg (77%)



Intubation: HFNC 35% vs. O_2 53 % vs. VNI 58% , $p<0.01$

Figure 2. Kaplan–Meier Plots of the Cumulative Incidence of Intubation from Randomization to Day 28.

Table 2. (Continued.)

Outcome	Study Group			P Value†	Odds Ratio or Hazard Ratio (95% CI)	
	High-Flow Oxygen (N=106)	Standard Oxygen (N=94)	Noninvasive Ventilation (N=110)		Standard Oxygen vs. High-Flow Oxygen	Noninvasive Ventilation vs. High-Flow Oxygen
Death						
In ICU						
Unadjusted analysis				0.047	1.85 (0.84–4.09)	2.55 (1.21–5.35)
No. of patients	12	18	27			
% of patients (95% CI)	11 (6–19)	19 (12–28)	25 (17–33)			
Adjusted analysis**	—	—	—	—	2.55 (1.07–6.08)	2.60 (1.20–5.63)
At day 90						
Overall population						
Unadjusted analysis				0.02	2.01 (1.01–3.99)	2.50 (1.31–4.78)
No. of patients	13	22	31			
% of patients (95% CI)	12 (7–20)	23 (16–33)	28 (21–37)			
Adjusted analysis**	—	—	—	—	2.36 (1.18–4.70)	2.33 (1.22–4.47)
Intubated patients				0.16		
No. of patients/total. no.						
% of patients (95% CI)						

30% 45% 49%

Table 2. Primary and Secondary Outcomes, According to Study Group.*

Outcome	Study Group			P Value†	Odds Ratio or Hazard Ratio (95% CI)	
	High-Flow Oxygen (N=106)	Standard Oxygen (N=94)	Noninvasive Ventilation (N=110)		Standard Oxygen vs. High-Flow Oxygen	Noninvasive Ventilation vs. High-Flow Oxygen
Intubation at day 28						
Overall population				0.18	1.45 (0.83–2.55)	1.65 (0.96–2.84)
No. of patients	40	44	55			
% of patients (95% CI)	38 (29–47)	47 (37–57)	50 (41–59)			
Patients with Pao_2:FIO_2 ≤200 mm Hg‡						
Unadjusted analysis				0.009	2.07 (1.09–3.94)	2.57 (1.37–4.84)
No. of patients/total no.	29/83	39/74	47/81			
% of patients (95% CI)	35 (26–46)	53 (42–64)	58 (47–68)			
Adjusted analysis§	—	—	—	0.01	2.14 (1.08–4.22)	2.60 (1.36–4.96)
Interval between enrollment and intubation — hr¶						
Overall population				0.27	—	—
Median	27h	15h	27h			
Interquartile range						

Pre-determined Intubation Criteria

1

Hemodynamic Failure:
SAP< 90 mm Hg, vasopressors

2

Neurologic Failure:
Altered consciousness, agitation

3

Persistent Respiratory Failure

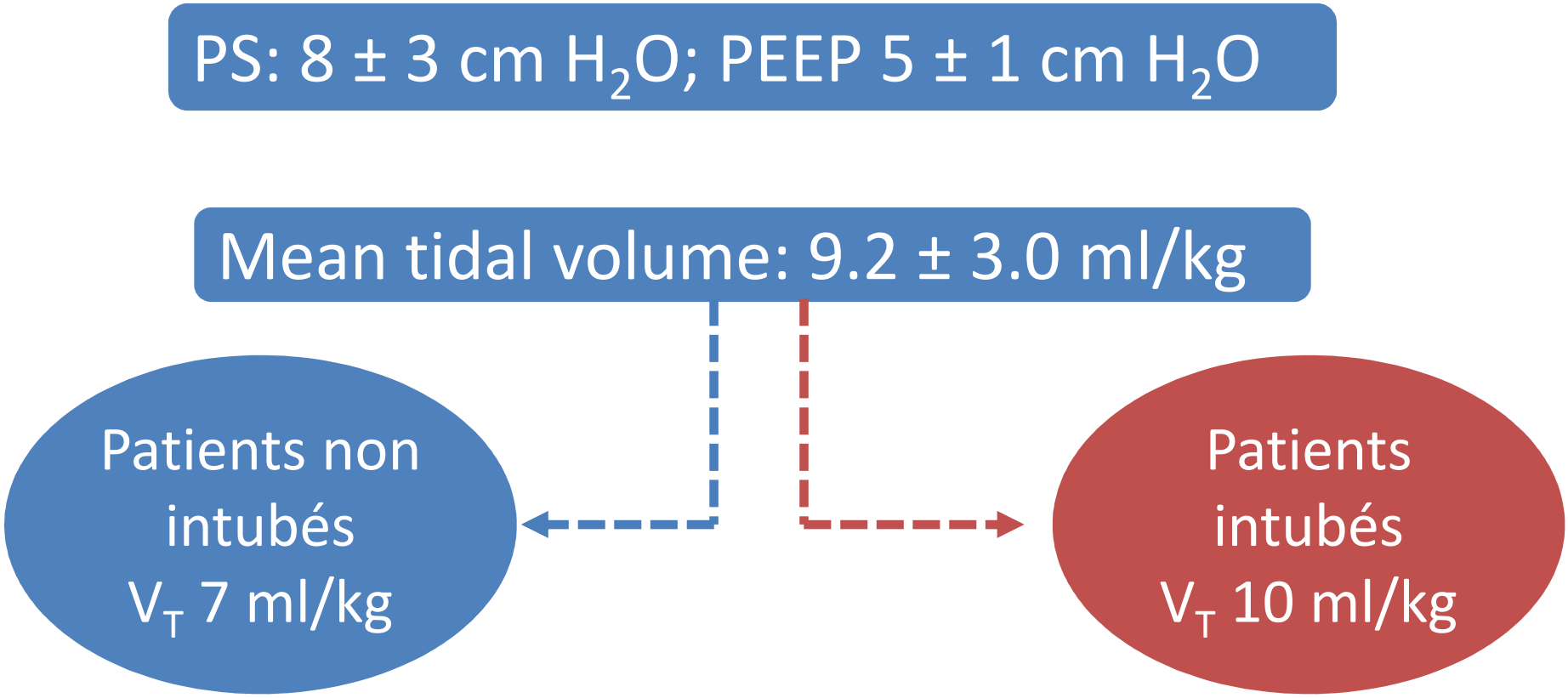
Pre-determined Intubation Criteria

3

Persistent Respiratory Failure: 2 criteria

- ***Clinical signs suggesting respiratory distress***
- ***RR > 40/min***
- ***SpO_2 < 90%***
- ***pH < 7,35***
- ***Abundant secretions***
- ***Intolerance or dependence to NIV > 12h***

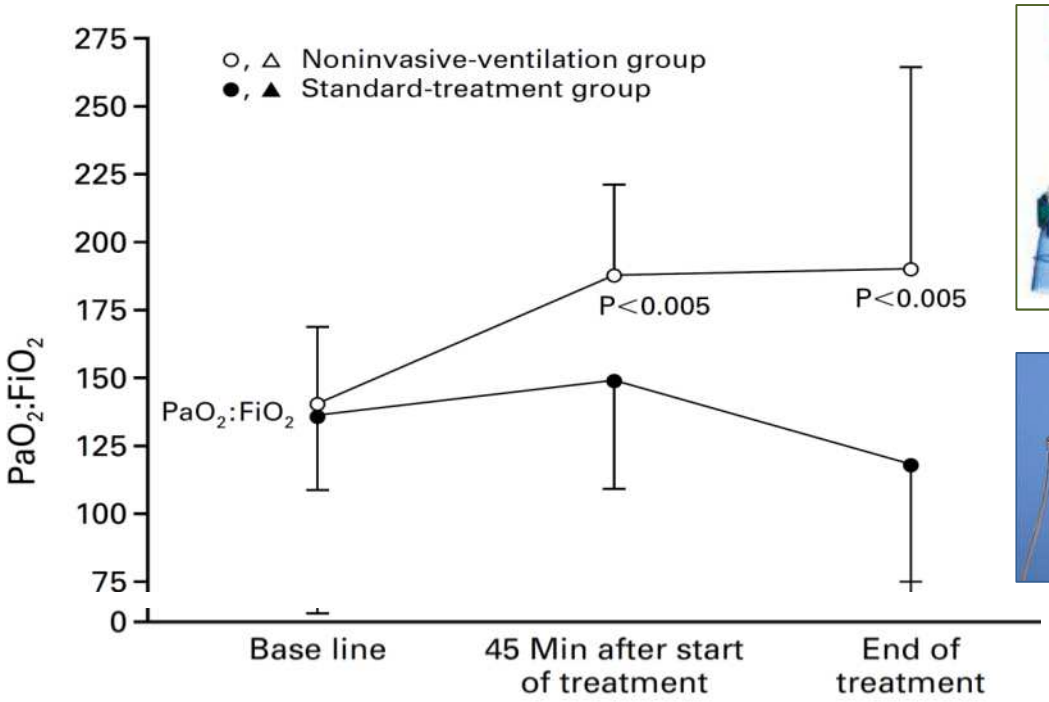
Quel est le problème sous VNI?



Et pour les Immunodéprimés?

NONINVASIVE VENTILATION IN IMMUNOSUPPRESSED PATIENTS WITH PULMONARY INFILTRATES, FEVER, AND ACUTE RESPIRATORY FAILURE

GILLES HILBERT, M.D., DIDIER GRUSON, M.D., FRÉDERIC VARGAS, M.D., RUDDY VALENTINO, M.D., GEORGES GBIKPI-BENISSAN, M.D., MICHEL DUPON, M.D., JOSY REIFFERS, M.D., AND JEAN P. CARDINAUD, M.D.



In-ICU Mortality: 38% vs. 69%, p=0.03

Research

JAMA. 2015;314(16):1711-1719. doi:10.1001/jama.2015.12402
Published online October 7, 2015.

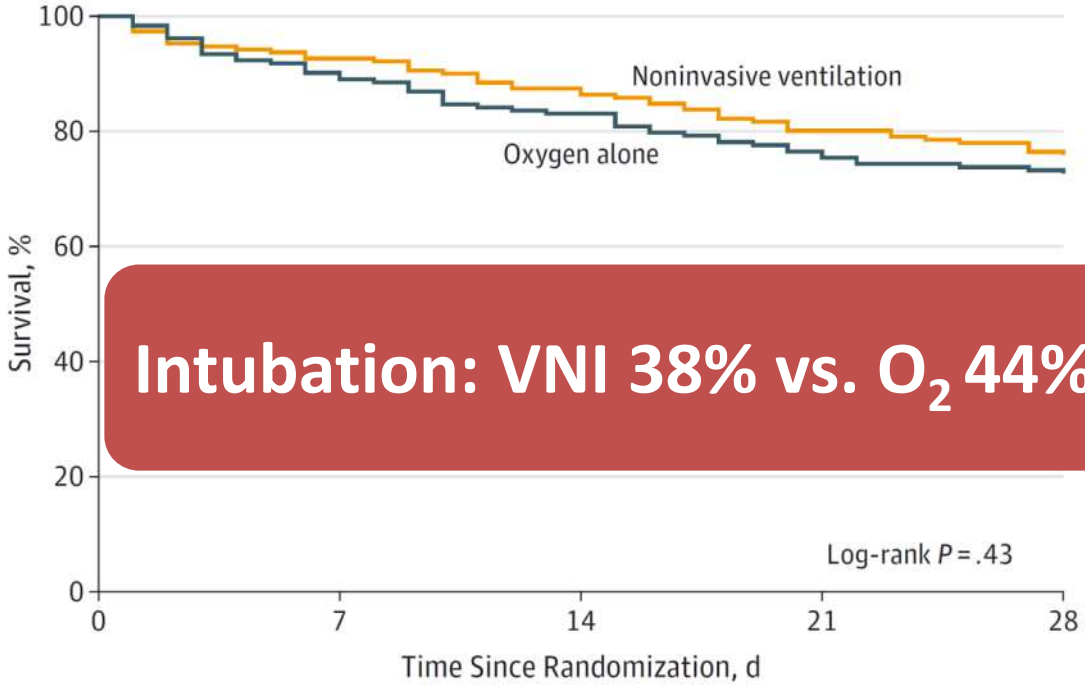
Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Noninvasive Ventilation vs Oxygen Therapy on Mortality Among Immunocompromised Patients With Acute Respiratory Failure

A Randomized Clinical Trial

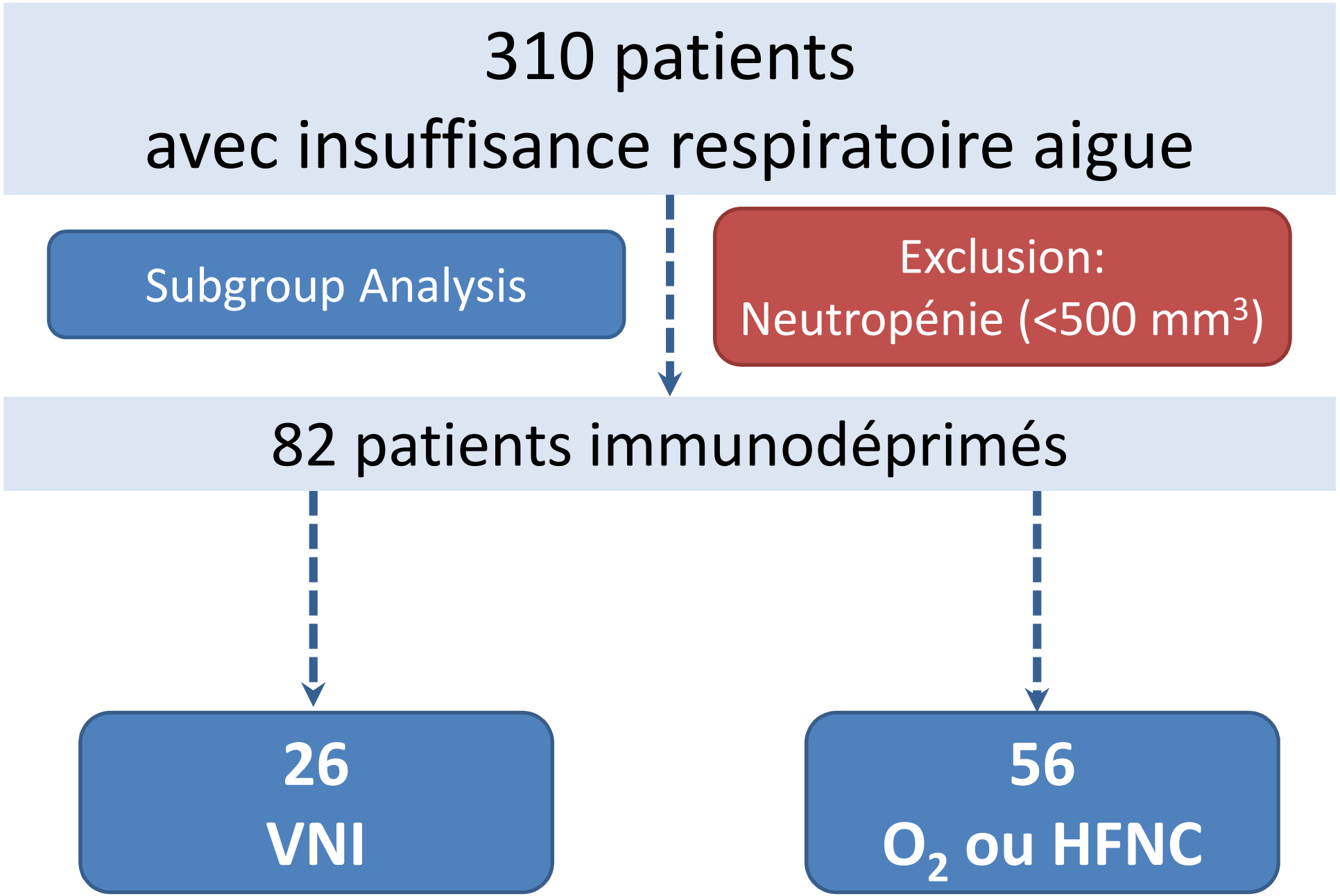
374 patients

Figure 2. Probability of Survival at Day 28



Intubation: VNI 38% vs. O_2 44%, *p*=0.20

No. at risk					
Noninvasive ventilation	191	177	167	153	146
Oxygen alone	183	165	152	140	134

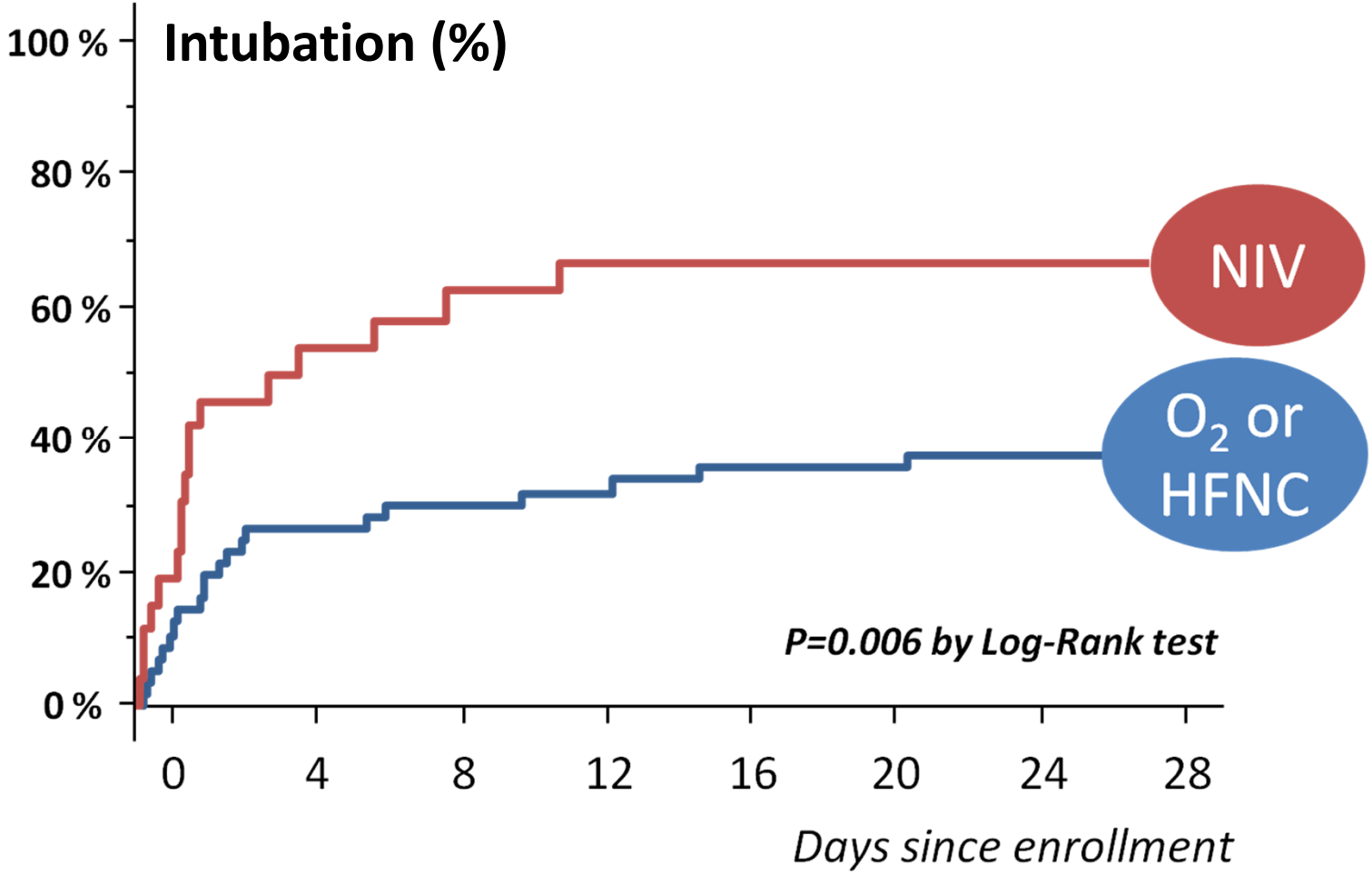

310 patients
avec insuffisance respiratoire aigue
Subgroup Analysis
Exclusion:
Neutropénie (<500 mm3)
82 patients immunodéprimés
26
VNI
56
O2 ou HFNC

Effect of non-invasive oxygenation strategies in immunocompromised patients with severe acute respiratory failure: a post-hoc analysis of a randomised trial

Jean-Pierre Frat, Stéphanie Ragot, Christophe Girault, Sébastien Perbet, Gwénael Prat, Thierry Boulain, Alexandre Demoule, Jean-Damien Ricard, Rémi Coudroy, René Robert, Alain Mercat, Laurent Brochard, Arnaud W Thille, for the REVA network

Lancet Respir Med 2016

Published Online
May 27, 2016



Coudroy et al. Ann. Intensive Care (2016) 6:45
DOI 10.1186/s13613-016-0151-7

Annals of Intensive Care

RESEARCH Open Access

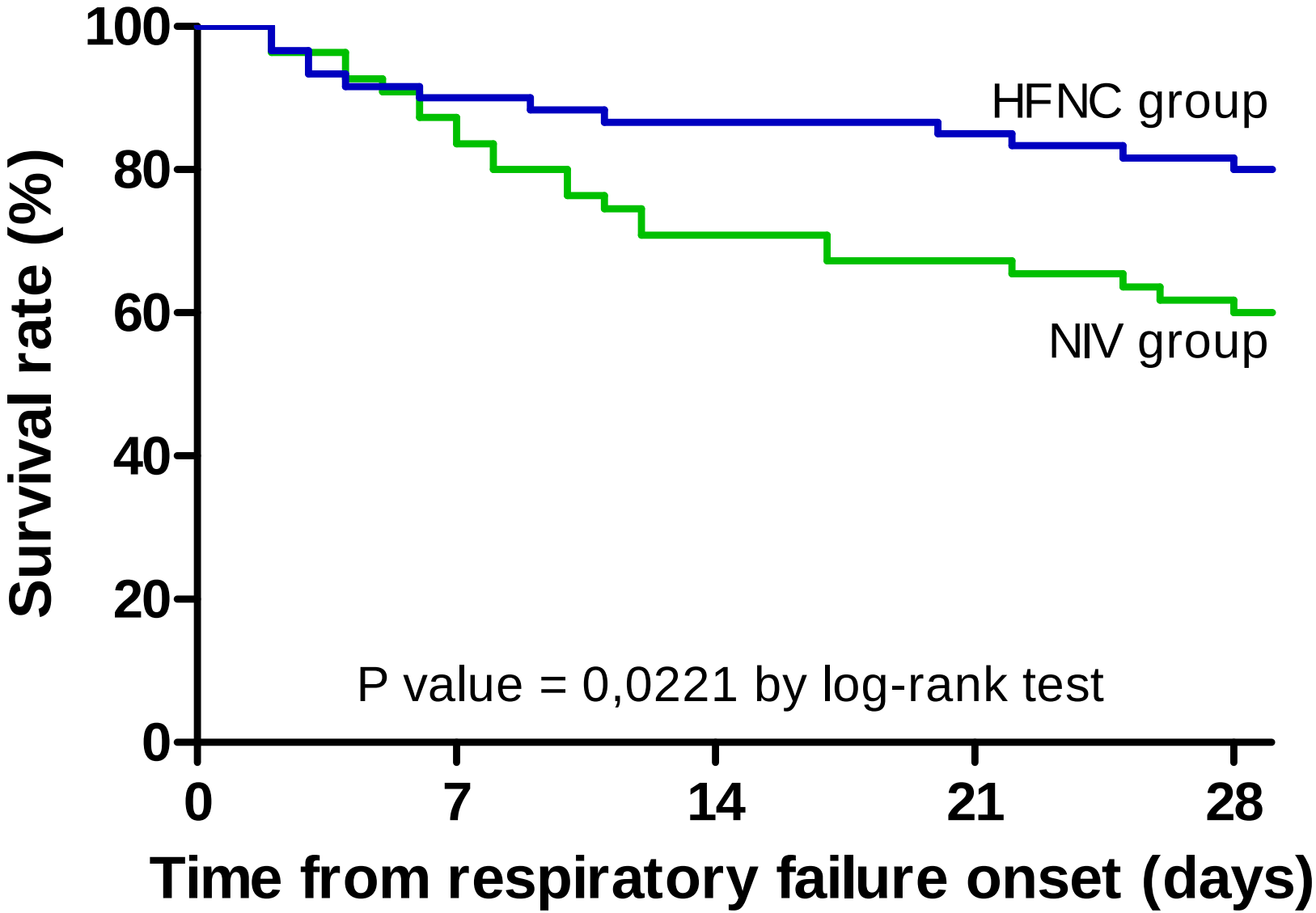
High-flow nasal cannula oxygen therapy versus noninvasive ventilation in immunocompromised patients with acute respiratory failure: an observational cohort study

Rémi Coudroy[1,2*], Angéline Jamet[1], Philippe Petua[1], René Robert[1,2], Jean-Pierre Frat[1,2] and Arnaud W. Thille[1,2]

115 immunocompromised patients admitted for acute respiratory failure and requiring a first-line treatment with NIV and/or HFNC

55 patients treated with NIV

60 patients treated with HFNC


100
80
60
40
20
0
Survival rate (%)
HFNC group
NIV group
P value = 0,0221 by log-rank test
0
7
14
21
28
Time from respiratory failure onset (days)

Pré-oxygénation: HFNC vs. O_2

Use of High-Flow Nasal Cannula Oxygen Therapy to Prevent Desaturation During Tracheal Intubation of Intensive Care Patients With Mild-to-Moderate Hypoxemia

Romain Miguel-Montanes, MD[1]; David Hajage, MD[2]; Jonathan Messika, MD[1,3,4]; Fabrice Bertrand, MD[1]; Stéphane Gaudry, MD[1,3,4]; Cédric Rafat, MD[1]; Vincent Labbé, MD[1]; Nicolas Dufour, MD[1,3,4]; Sylvain Jean-Baptiste, MD[1]; Alexandre Bedet, MD[1]; Didier Dreyfuss, MD[1,3,4]; Jean-Damien Ricard, MD, PhD[1,3,4]

Critical Care Medicine 2014

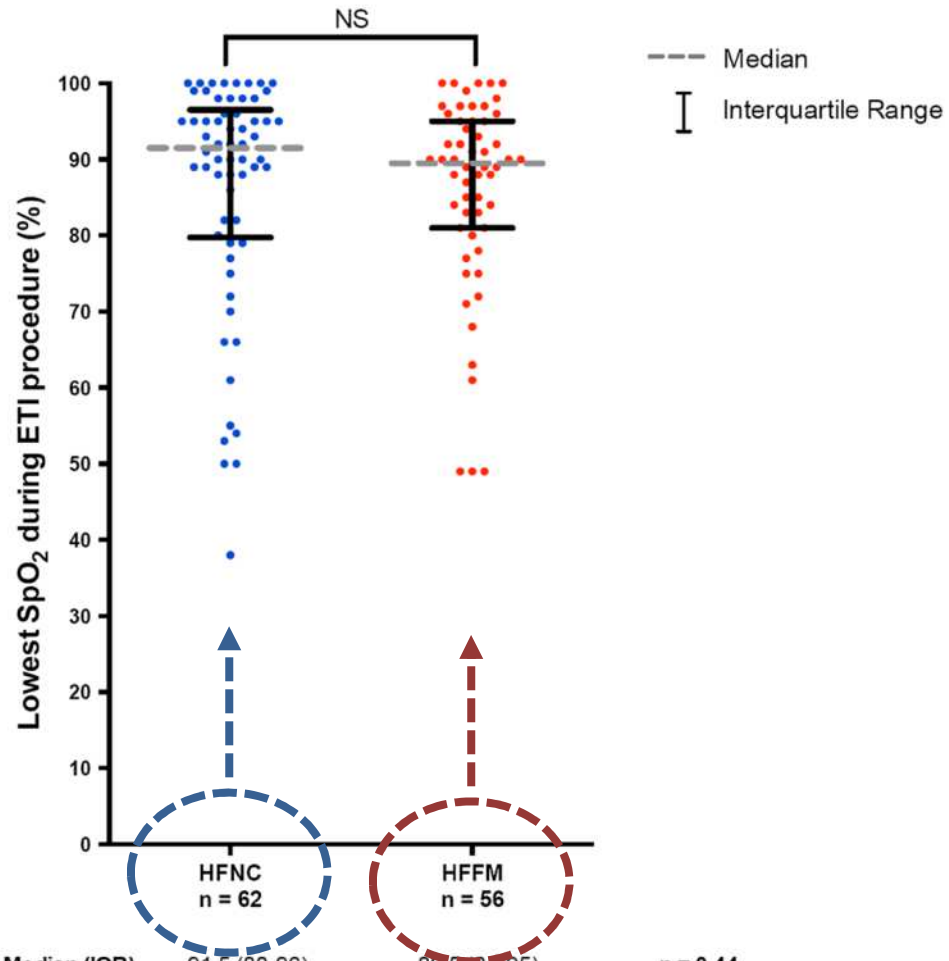
Variable	Nonrebreathing Bag Reservoir Facemask *n* = 50	High-Flow Nasal Cannula Oxygen *n* = 51	*p*
Spo_2 after preoxygenation, %, median (IQR)	**94 %**	**100 %**	0.01[a]
Lowest Spo_2, median (IQR)	94 (83–98)	100 (95–100)	< 0.0001[b]
Spo_2 < 80%, *n* (%)	**14 %**	**2 %**	0.03[a]

Intensive Care Med (2015) 41:1538–1548
DOI 10.1007/s00134-015-3796-z

SEVEN-DAY PROFILE PUBLICATION

Mickaël Vourc'h
Pierre Asfar
Christelle Volteau
Konstantinos Bachoumas
Noëmie Clavieras
Pierre-Yves Egreteau
Karim Asehnoune
Alain Mercat
Jean Reignier
Samir Jaber
Gwenaël Prat
Antoine Roquilly
Noëlle Brule
Daniel Villers
Cédric Bretonniere
Christophe Guitton

High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial

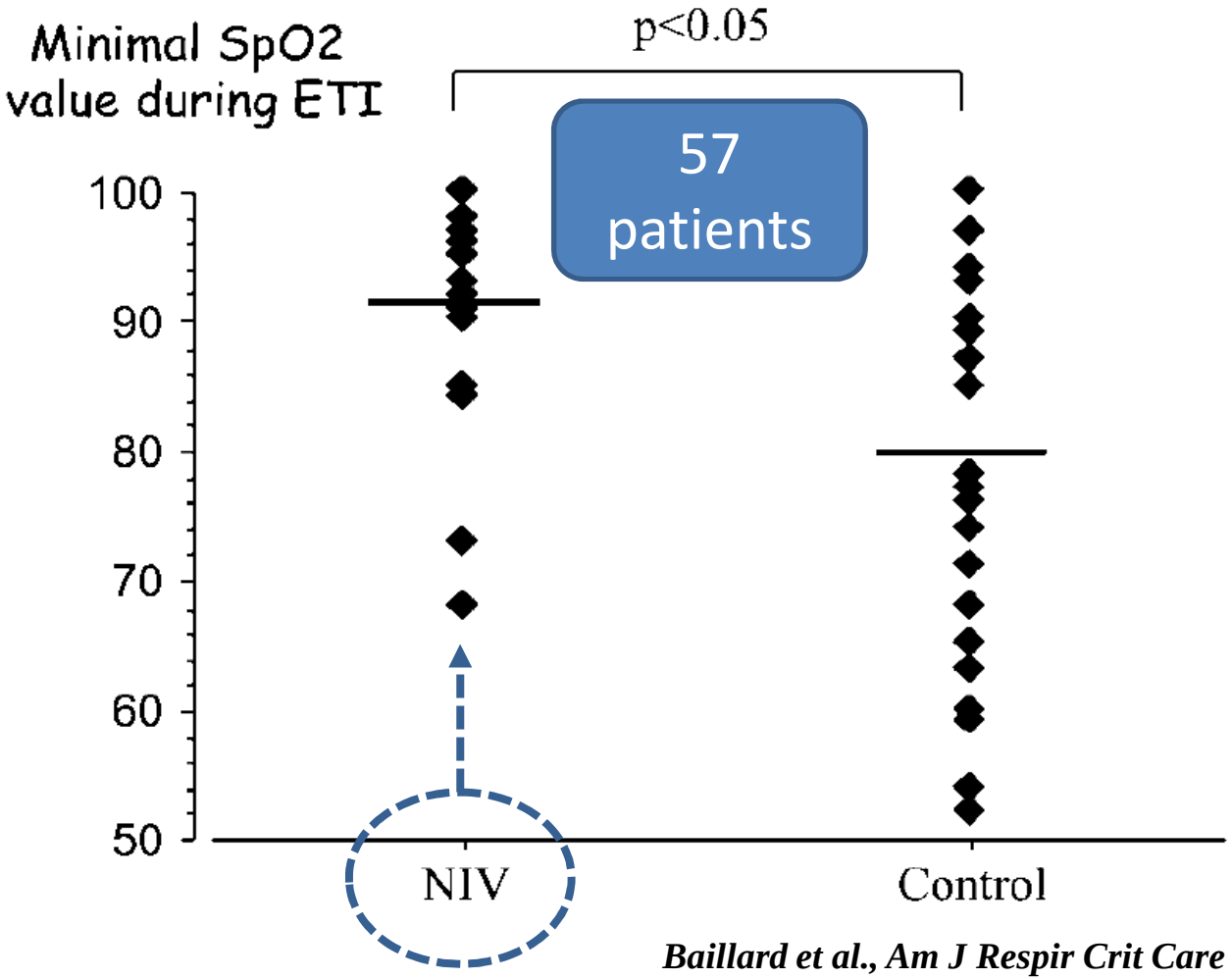


Pré-oxygénation: VNI vs. O_2

Noninvasive Ventilation Improves Preoxygenation before Intubation of Hypoxic Patients

Christophe Baillard, Jean-Philippe Fosse, Mustapha Sebbane, Gérald Chanques, François Vincent, Patricia Courouble, Yves Cohen, Jean-Jacques Eledjam, Frédéric Adnet, and Samir Jaber

Department of Anesthesiology and Intensive Care, and SAMU 93, Avicenne Hospital, Paris 13 University–AP-HP, Bobigny; Intensive Care Unit, Department of Anesthesiology, DAR B University Hospital of Montpellier, and Saint Eloi Hospital, Montpellier University, Montpellier, France

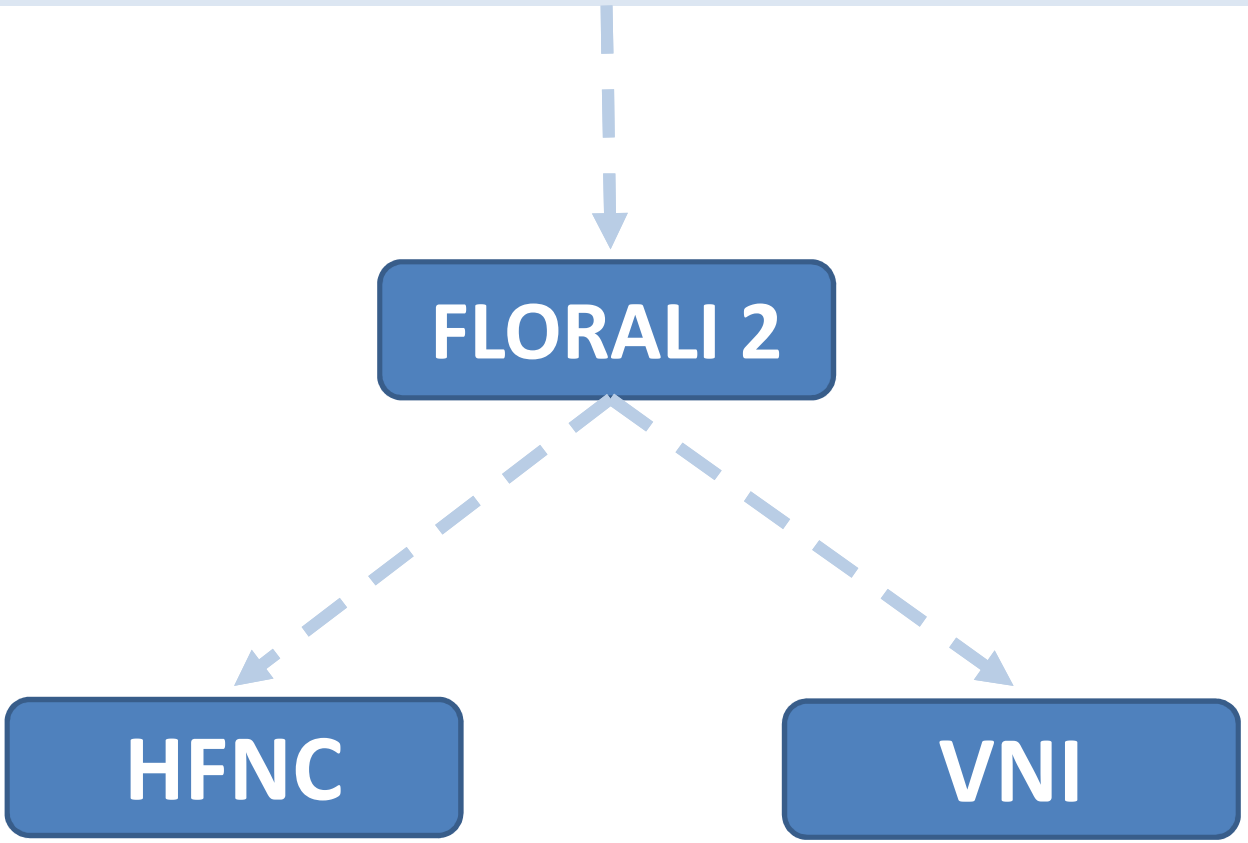


Baillard et al., Am J Respir Crit Care Med 2006; 174:171-177.

Pré-oxygénation: VNI vs. HFNC

Insuffisance respiratoire aiguë

FR >25/min, P/F <300



Post-Extubation

ORIGINAL ARTICLE

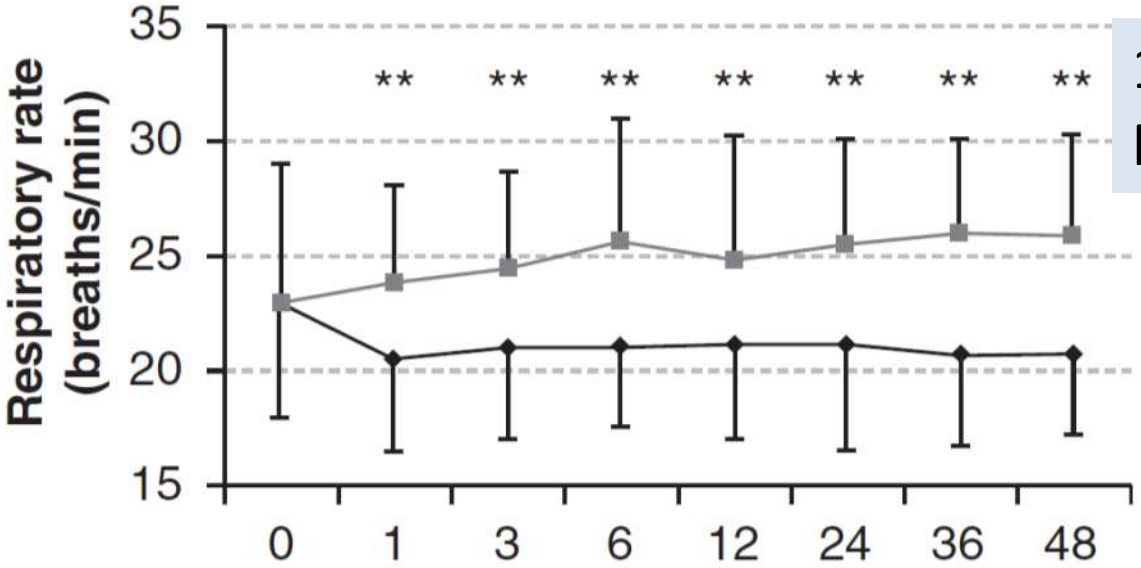
Nasal High-Flow versus Venturi Mask Oxygen Therapy after Extubation

Effects on Oxygenation, Comfort, and Clinical Outcome

Salvatore Maurizio Maggiore[1], Francesco Antonio Idone[1], Rosanna Vaschetto[2], Rossano Festa[1], Andrea Cataldo[1], Federica Antonicelli[1], Luca Montini[1], Andrea De Gaetano[3], Paolo Navalesi[4,5,6], and Massimo Antonelli[1]

[1]Department of Anesthesiology and Intensive Care, Agostino Gemelli Hospital, Università Cattolica del Sacro Cuore, Rome, Italy; [2]Department of Anesthesia and Intensive Care, Maggiore della Carità Hospital, Novara, Italy; [3]Consiglio Nazionale delle Ricerche, Istituto di Analisi dei Sistemi e Informatica "A. Ruberti," Rome, Italy; [4]Department of Translational Medicine, Università del Piemonte Orientale "A. Avogadro," Alessandria-Novara-Vercelli, Italy; [5]Anesthesia and Intensive Care, Sant'Andrea Hospital, Vercelli, Italy; and [6]CRRF Mons. L. Novarese, Moncrivello (VC), Italy

Am J Respir Crit Care Med Vol 190, Iss 3, pp 282–288, Aug 1, 2014



105 patients hypoxémiques:
PF < 300 mm Hg

Reintubation:
O_2 21% vs. HFNC 4%,
p=0.005

Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

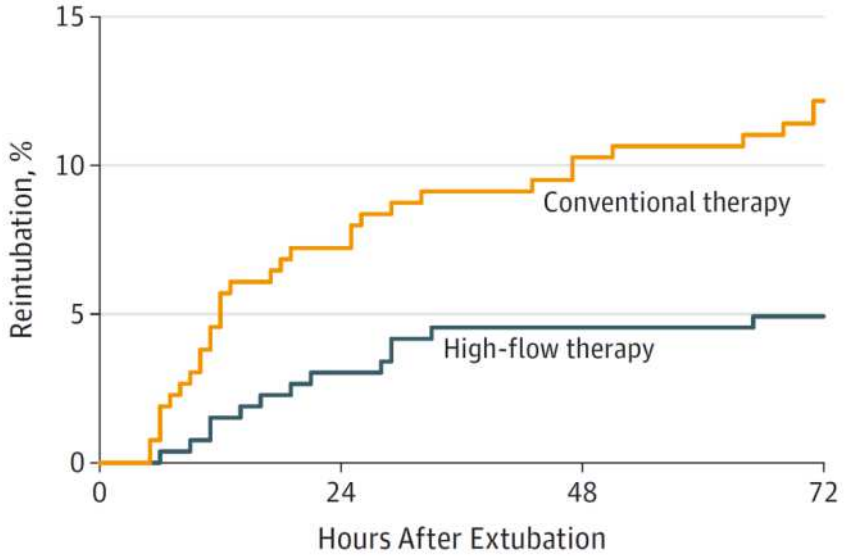
Effect of Postextubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients

A Randomized Clinical Trial

JAMA. 2016;315(13):1354-1361. doi:10.1001/jama.2016.2711

Gonzalo Hernández, MD, PhD; Concepción Vaquero, MD; Paloma González, MD; Carles Subira, MD; Fernando Frutos-Vivar, MD; Gemma Rialp, MD; Cesar Laborda, MD; Laura Colinas, MD; Rafael Cuena, MD; Rafael Fernández, MD, PhD

Figure 2. Kaplan-Meier Analysis of Time From Extubation to Reintubation



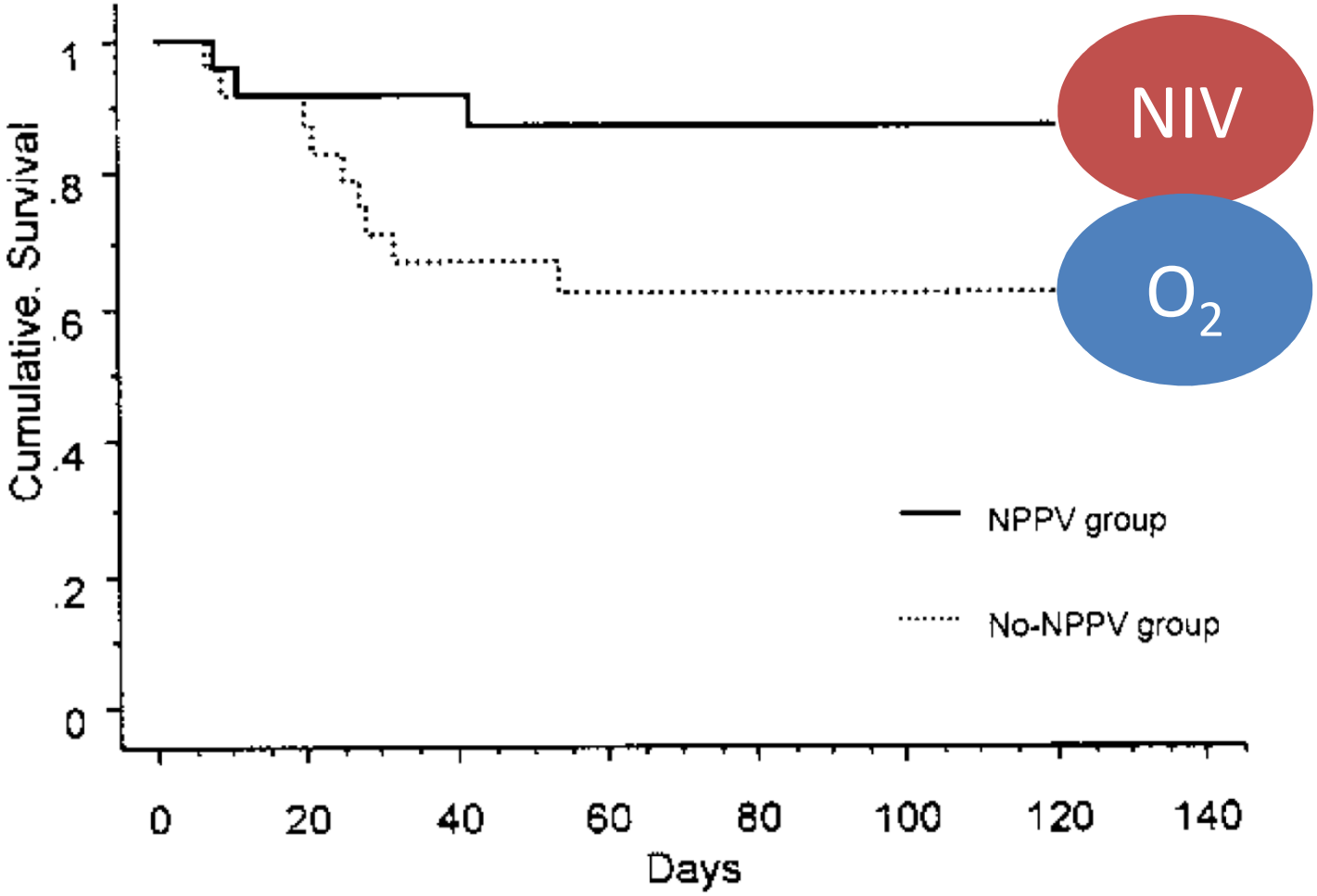
No. at risk				
Conventional therapy	263	244	236	231
High-flow therapy	264	256	252	251

527 patients à faible risque de réintubation

Reintubation:
O_2 12% vs. HFNC 5%,
p=0.004

Post-Op

Acute respiratory failure after thoracic Surgery (lung resection) 48 patients



Auriant et al., Am J Respir Crit Care Med 2001; 164:1231-1235

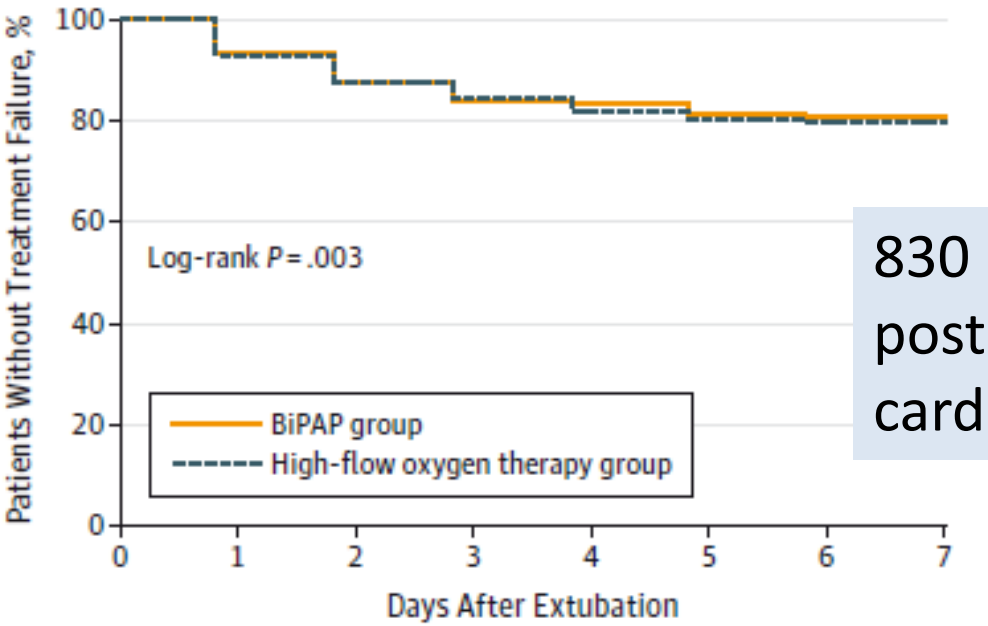
High-Flow Nasal Oxygen vs Noninvasive Positive Airway Pressure in Hypoxemic Patients After Cardiothoracic Surgery

A Randomized Clinical Trial

JAMA. 2015;313(23):2331-2339. doi:10.1001/jama.2015.5213

François Stéphan, MD, PhD; Benoit Barrucand, MD; Pascal Petit, MD; Saida Rézaiguia-Delclaux, MD; Anne Médard, MD; Bertrand Delannoy, MD; Bernard Cosserant, MD; Guillaume Flicoteaux, MD; Audrey Imbert, MD; Catherine Pilorge, MD; Laurence Bérard, MD; for the BiPOP Study Group

OBJECTIVE To determine whether high-flow nasal oxygen therapy was not inferior to BiPAP for preventing or resolving acute respiratory failure after cardiothoracic surgery.



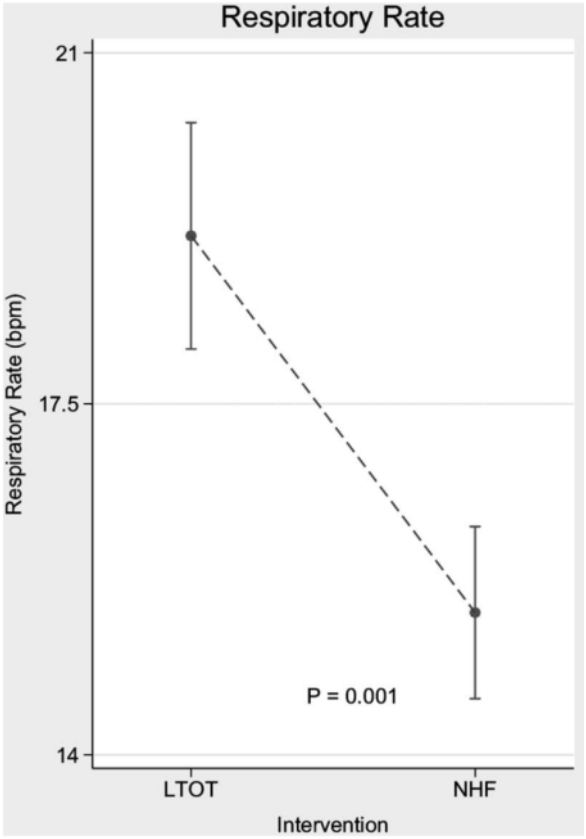
No. at risk								
BiPAP	416	385	363	348	339	333	331	329
High-flow oxygen therapy	414	385	361	346	342	334	333	331

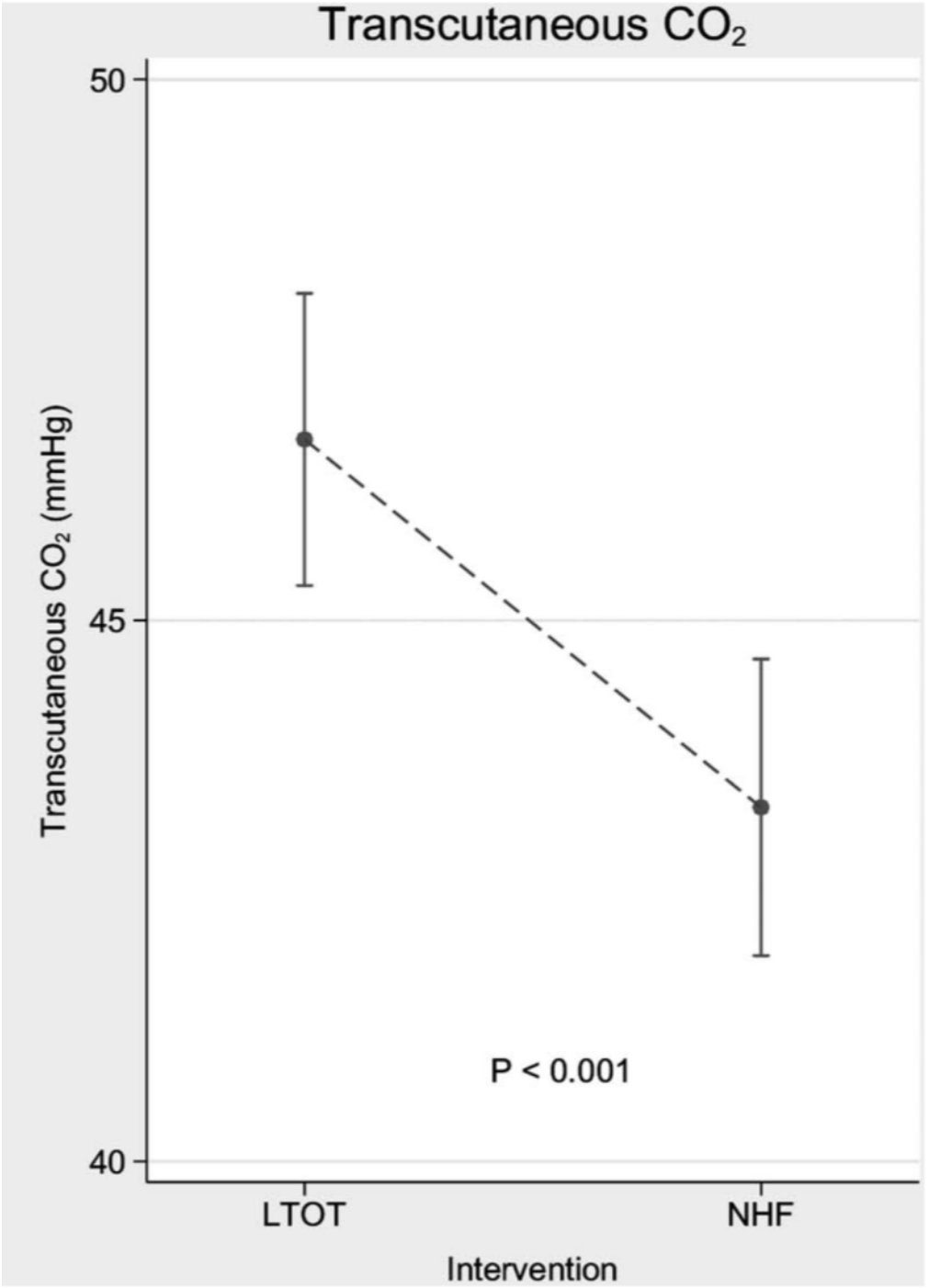
830 patients en postopératoire de chirurgie cardiaque ou thoracique

Et les BPCO?

Nasal high flow oxygen therapy in patients with COPD reduces respiratory rate and tissue carbon dioxide while increasing tidal and end-expiratory lung volumes: a randomised crossover trial

Fraser et al., Thorax 2016





Quelles conclusions ?

Dans l'IRA hypoxémique - ARDS

Pas différence entre VNI et oxygène standard:
La VNI pourrait éviter l'intubation chez certains patients mais aggraver ceux qui sont finalement intubés

Il ne faut probablement pas faire de VNI en cas de SDRA: Risque de barotraumatisme

Il faut probablement utiliser l'oxygène à haut débit en cas d'IRA hypoxémique: ***diminution de mortalité***

Et les immunodéprimés??

Et chez les autres ?

Il faut probablement utiliser l'oxygène à haut débit en post-extubation: ***diminution du taux de réintubation***

La VNI est probablement plus efficace en pré-oxygénation: ***éviter la désaturation***

BPCO / OAP / Postoperative???

Et la VNI?

La VNI reste le traitement de première ligne pour:

1. **L'OAP**
2. **BPCO et insuffisances respiratoires chroniques**
3. **Les détresses respiratoires postopératoires:**
   Chirurgie abdominale ou thoracique