Non-invasive ventilation and high flow oxygen therapy

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I have no disclosures.

Case

A 43-year-old man with a history of alcohol use is admitted to the ICU with pancreatitis complicated by acute hypoxemic respiratory failure. He is alert but has increased work of breathing, and saturation is 87% on 10 L nasal cannula. On exam, he has notable abdominal distension and some rhonchi. He is hemodynamically stable and alert. You are asked to recommended the next best therapy to support oxygenation.

NIV: Beginnings

- Iron lung 1927, Boston Children's Hospital

- Delaubier and Rideau:

Intermittent positive pressure ventilation via a nasal mask in patients with muscular dystrophy.

Utilized nasal mask designed by Sullivan in 1980 for applying CPAP for OSA.

Gould, G. (1947). *Untitled (young man in iron lung with nurse, his reflection in mirror), Harvard Library*

The NIV Revolution

Physiological effects of invasive ventilation:

Muscle unloading

Gas exchange improvement

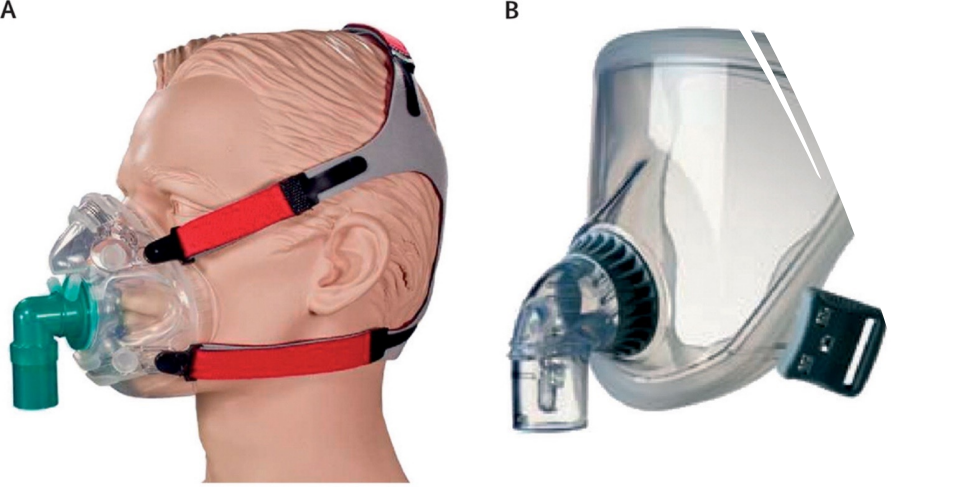
Augmenting alveolar ventilation

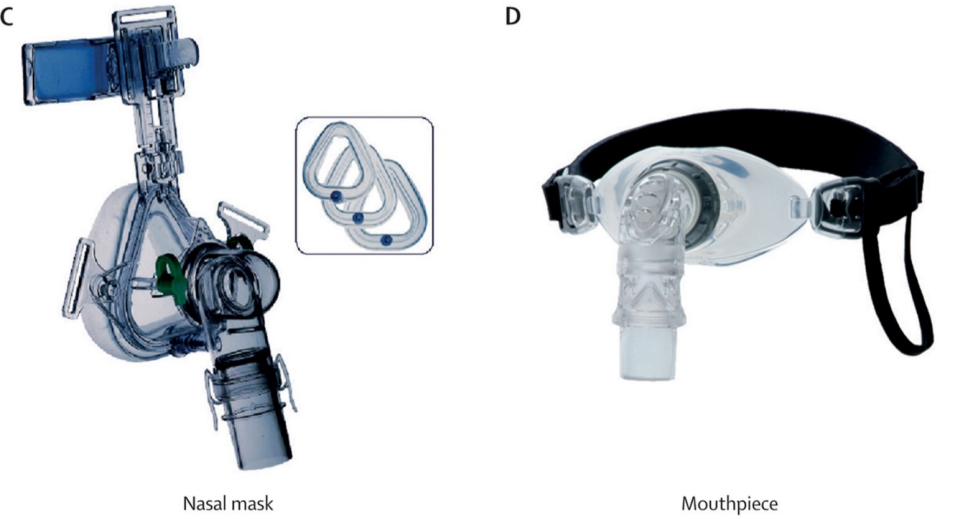
BUT

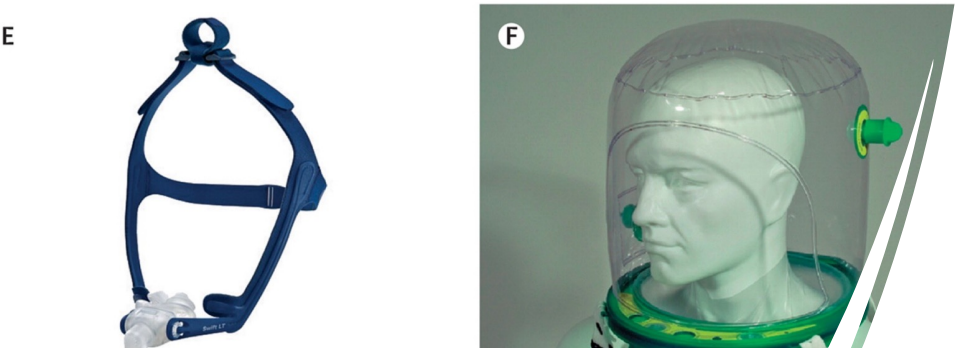
without the risks of an artificial airway.

Schauer, S. (1860). *Nicolaus Copernicus (1473-1543), Harvard Library*

NIV- Contraindications and Cautions



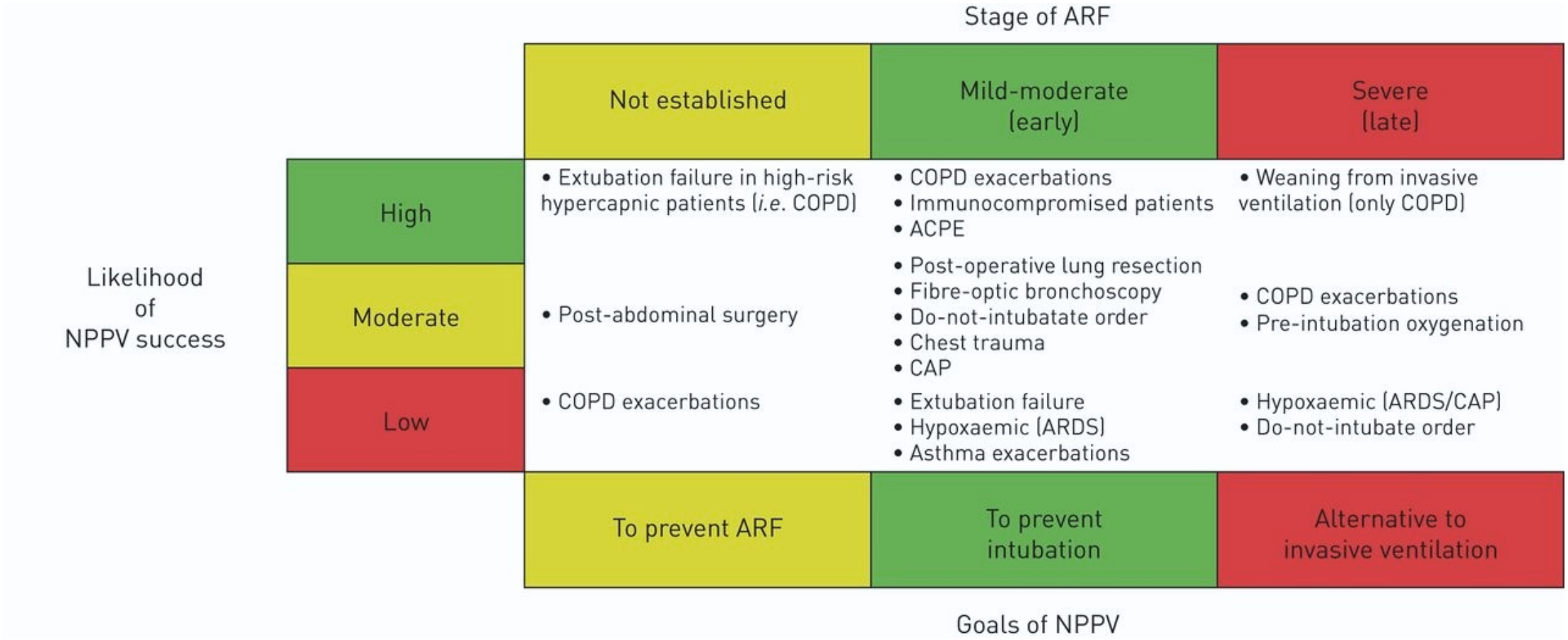




- Cardiorespiratory arrest or significant shock
- Agitation or severe encephalopathy
- Inability to protect airway
- Multiple organ failure
- Rapidly progressive ARDS

The Lancet 374.9685 (2009): 250-259.

Acute use of NIV



Raffaele Scalaand Lara Pisani, European Respiratory Review 2018 27

NIV and AECOPD

- Improves survival
- Decreased need for endotracheal intubation
- Decreased length of stay

TABLE 2

SUMMARY OF RANDOMIZED CONTROLLED STUDIES USING NPPV IN ACUTE RESPIRATORY FAILURE CAUSED BY COPD

Author	Yr	Reference No.	Technique/Mask	Insp/Exp Pressure ($cm\ H_2O$)	Patients* (n)		Diagnosis		Pa_{CO_2} ($mm\ Hg$)		Pa_{O_2} ($mm\ Hg$)	
					NPPV	Control			B	A	B	A
Bott	1993	128	Volume/nasal		30 (3)	30 (9)	COPD		65	55		
Kramer	1995	129	BiPAP/nasal	8/2	16 (5)	15 (11)	COPD†		74	67	67	92
Brochard	1995	130	PSV/oronasal	20	43 (11)	42 (31)	COPD		70	68	41	66
Angus	1996	131	PSV/nasal	14/18	9 (0)	8 (3)	COPD		76	65		
Celikel	1998	132	PSV/oronasal	15/5	15 (1)	15 (6)	COPD		69	64	55	85
Plant	2000	134	VPAP/nasal/oronasal		118 (18)	118 (32)	COPD		66	61	52	56
Barbe	1996	135	BiPAP/nasal	14.8/5	14 (4)	10 (0)	COPD		59		45	
Totals					245 (42)	238 (29)		Means	68	60	54	67
Success rate					83%	61%						

Am J Respir Crit Care Med. 2001;163:540–77

NIV and Acute Pulmonary Edema

- Improved oxygenation
- Decreased intubation rate

TABLE 1

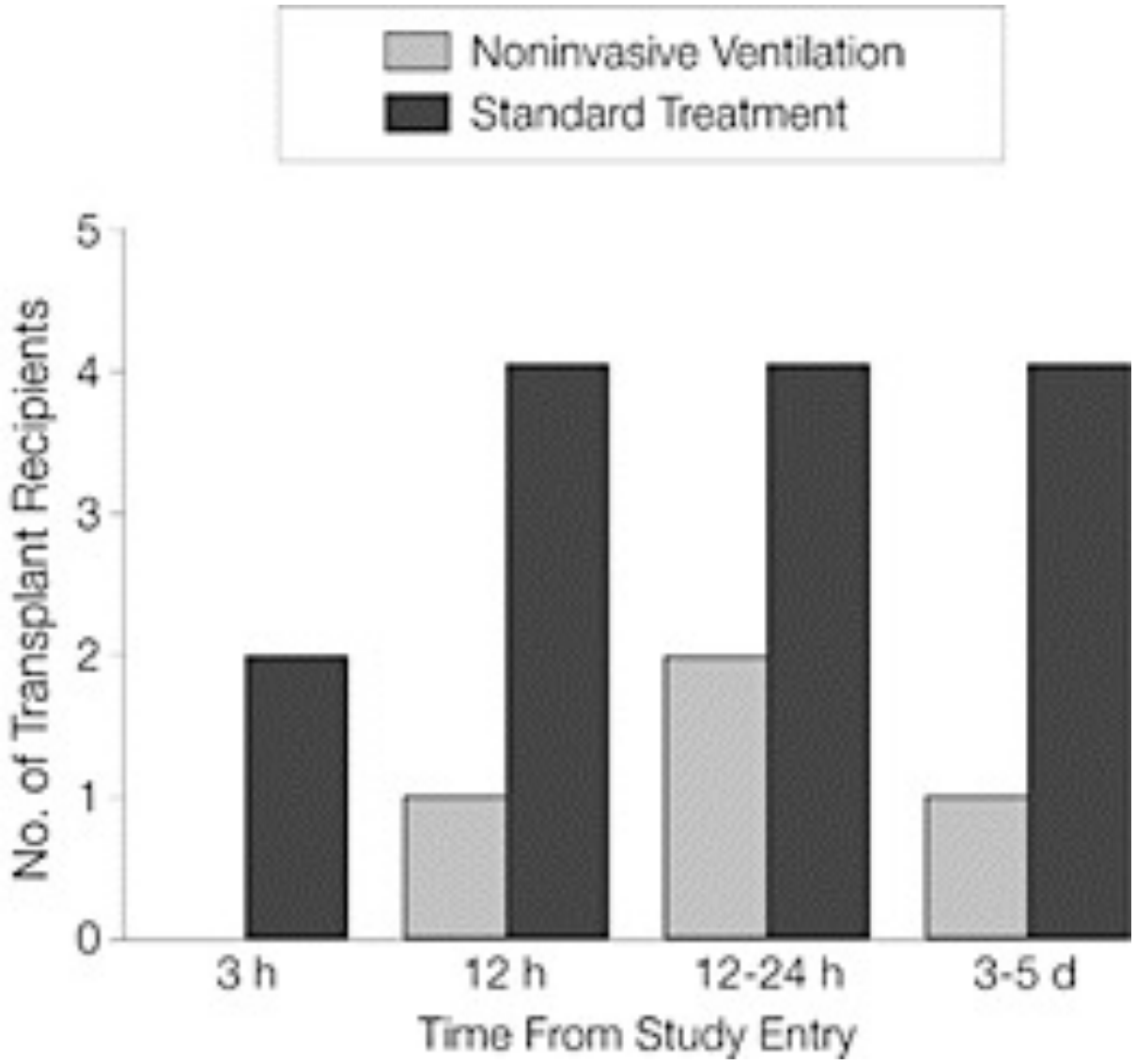
STUDIES ON THE EFFICACY OF CONTINUOUS POSITIVE AIRWAY PRESSURE IN ACUTE PULMONARY EDEMA

Author	Yr	Reference No.	Technique*	Positive Pressure ($cm\ H_2O$)	Patients† (n)			Pa_{CO_2} ($mm\ Hg$)		Pa_{O_2} ($mm\ Hg$)	
					CPAP	Control		B	A	B	A
Rasanen	1985	95	CPAP	10	20 (7)	20 (13)		41	39	52	60
Viasanen	1987	96	CPAP	10	40 (7)			36	35	55	79
Lin	1991	97	CPAP	12.5	25 (7)	30 (18)		30	32	326	416
Bersten	1991	98	CPAP	10	19 (0)	20 (7)		58	46	138‡	206‡
Lin	1995	99	CPAP	12.5	50 (8)	50 (18)					
Totals					154 (29)	120 (56)	Means	41	38		
Success rate					81%	53%					

Am J Respir Crit Care Med. 2001;163:540–77

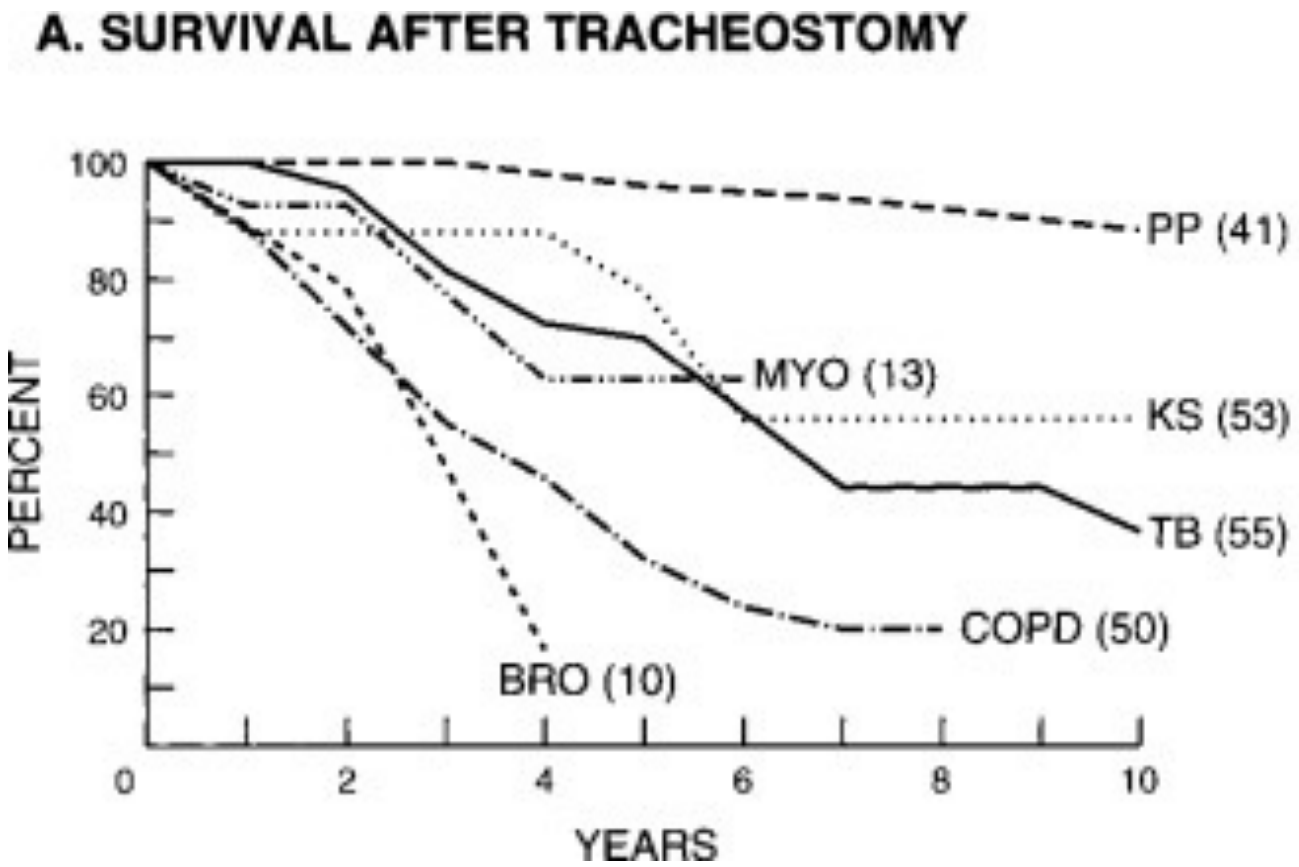
NIV in immunocompromised patients with respiratory failure

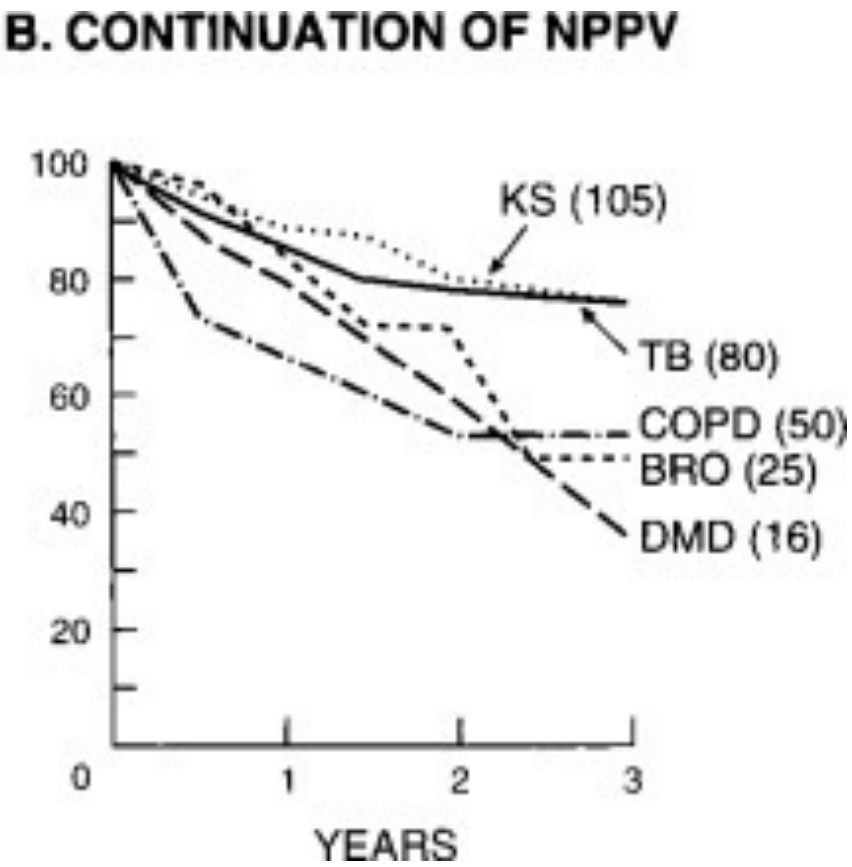
- Decreased intubation rate
- Decreased ICU mortality



JAMA, 12 (2000), pp. 235-241

Clinical indications for noninvasive positive pressure ventilation in chronic respiratory failure due to restrictive lung disease, COPD, and nocturnal hypoventilation: a Consensus Conference Report.

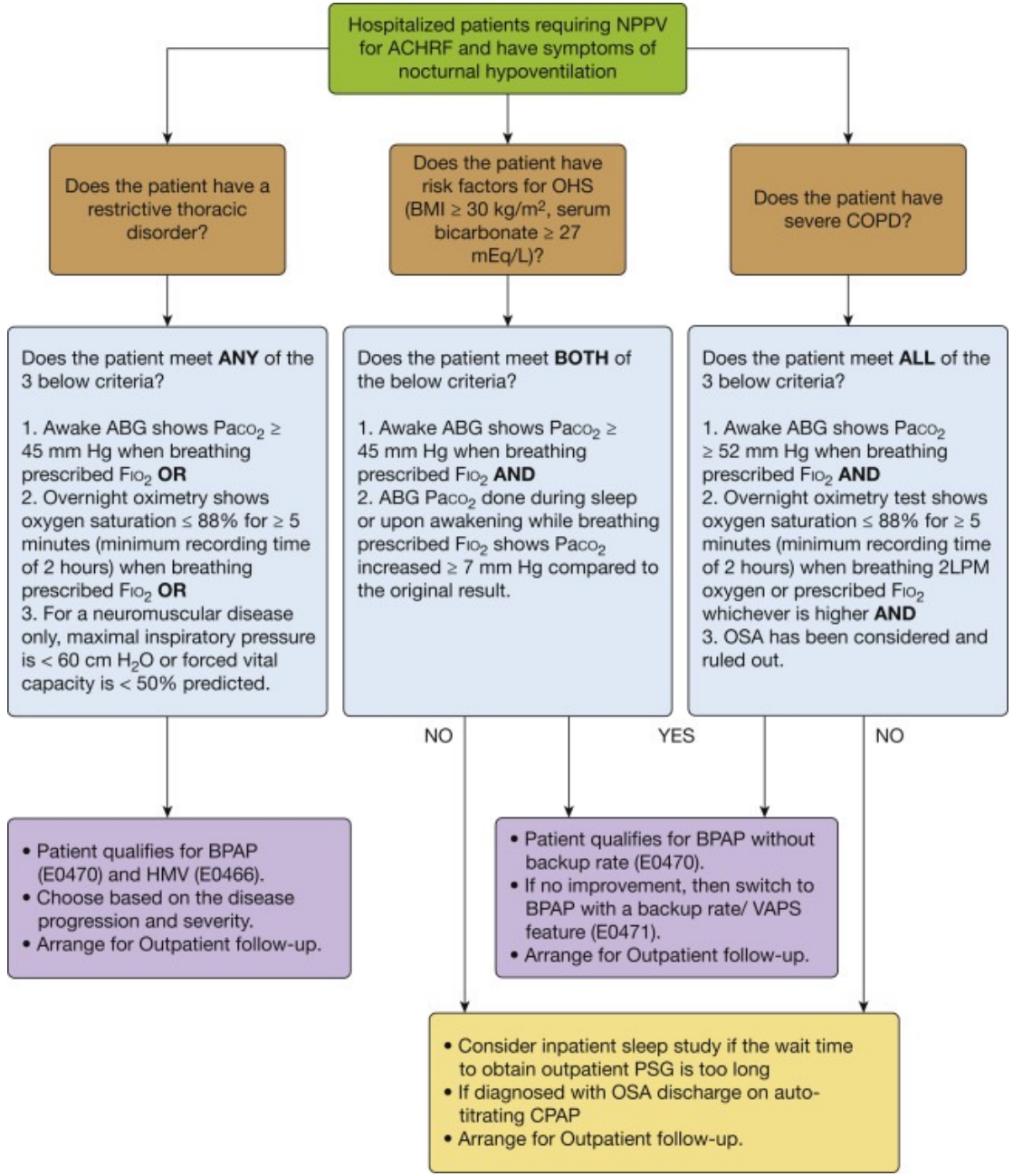




Chest, 116 (1999), pp. 521-534

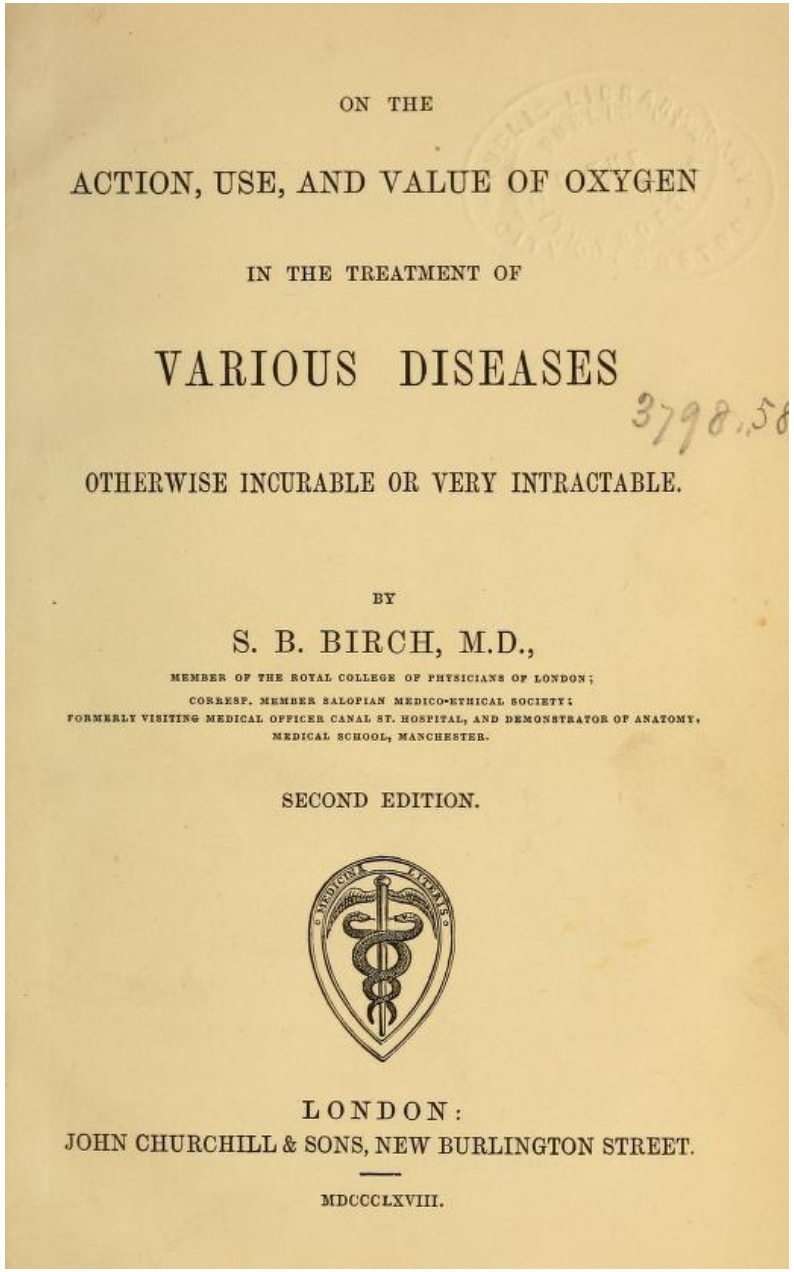
Chronic respiratory failure indications for NIV

- Symptoms and signs of hypoventilation after treatment for underlying disease
- Daytime hypercapnia
- Disease specific indications for neuromuscular disease (VC <50%, desaturations at night)



CHEST, Volume 158, issue 8, P2524-2531, 12, 2020

High flow oxygen therapy



ON THE

ACTION, USE, AND VALUE OF OXYGEN

IN THE TREATMENT OF

VARIOUS DISEASES

3798.58

OTHERWISE INCURABLE OR VERY INTRACTABLE.

BY

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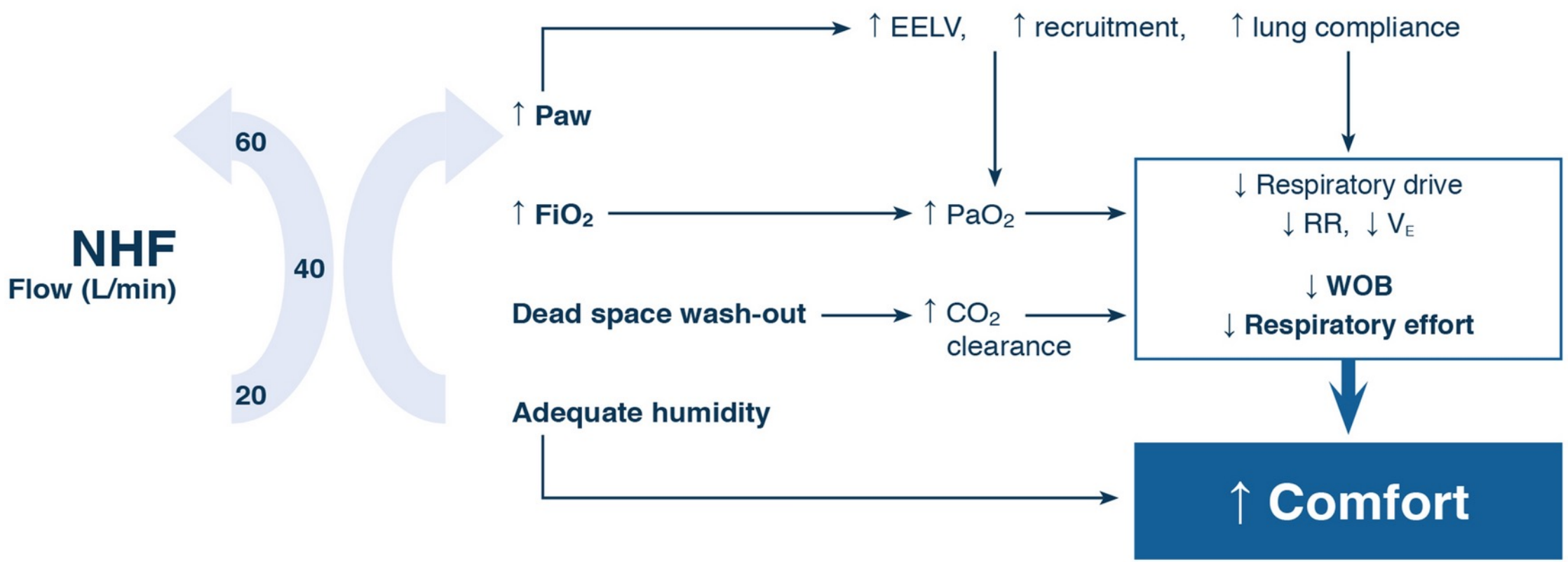
SECOND EDITION.

LONDON:
JOHN CHURCHILL & SONS, NEW BURLINGTON STREET.

MDCCCLXVIII.

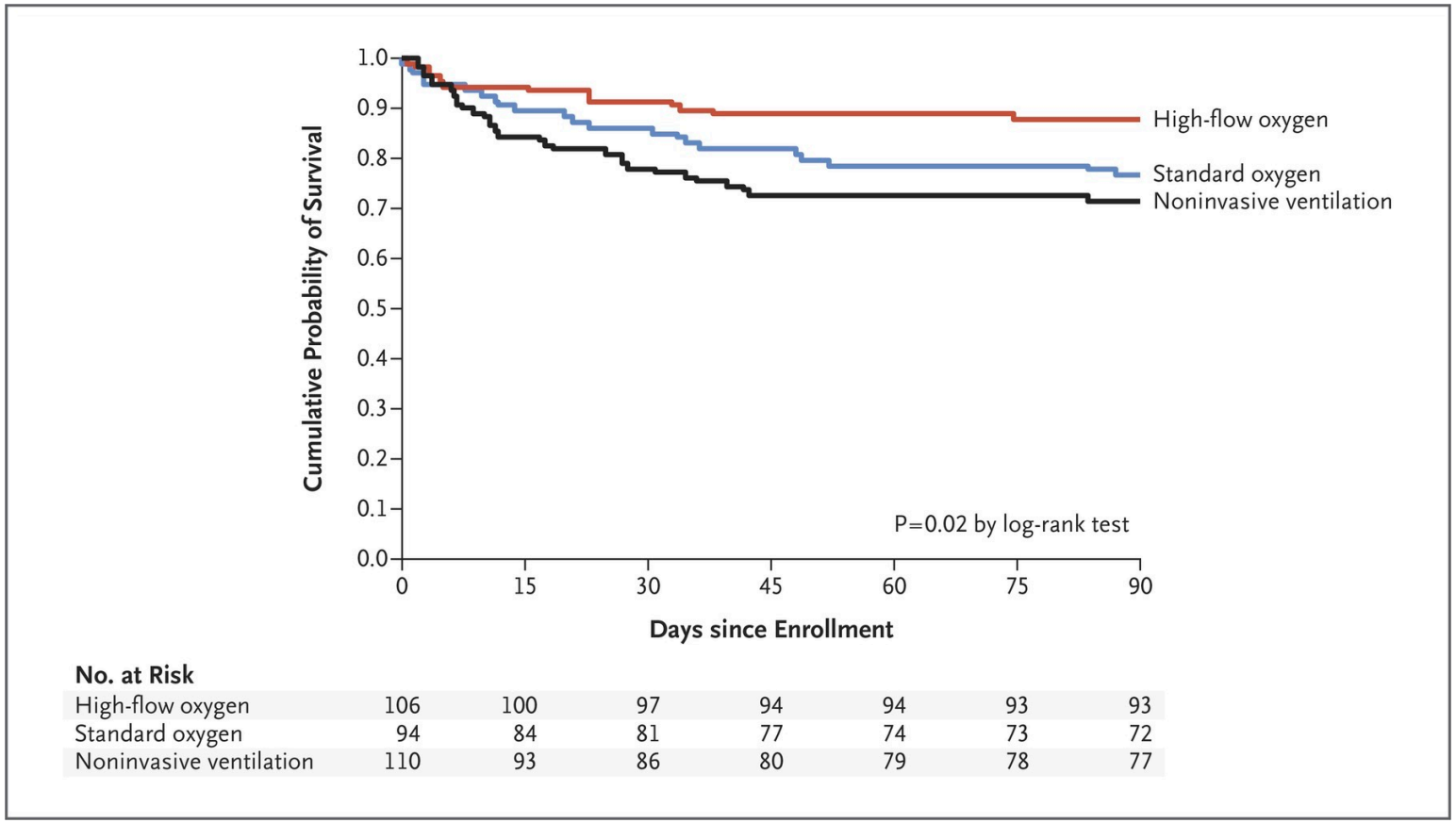
John Churchill, 1868; FrancisCountwayLibrary

Physiology



Intensive care medicine (2020): 1-10

HF versus NIV in non-hypercapnic respiratory failure



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

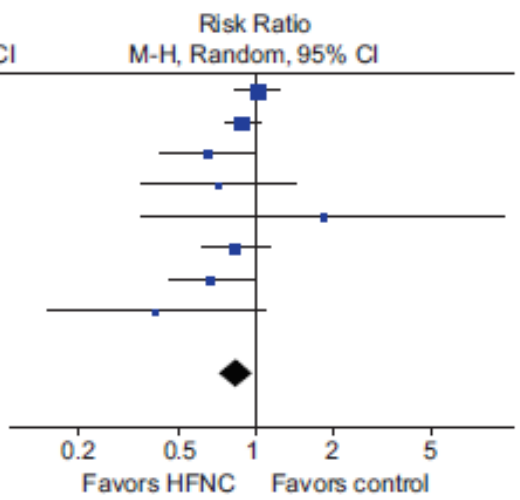
New England Journal of Medicine 372.23 (2015): 2185-2196

HF for immunocompromised patients

- Decreased intubation
- No clear improvement in mortality compared with NIV.

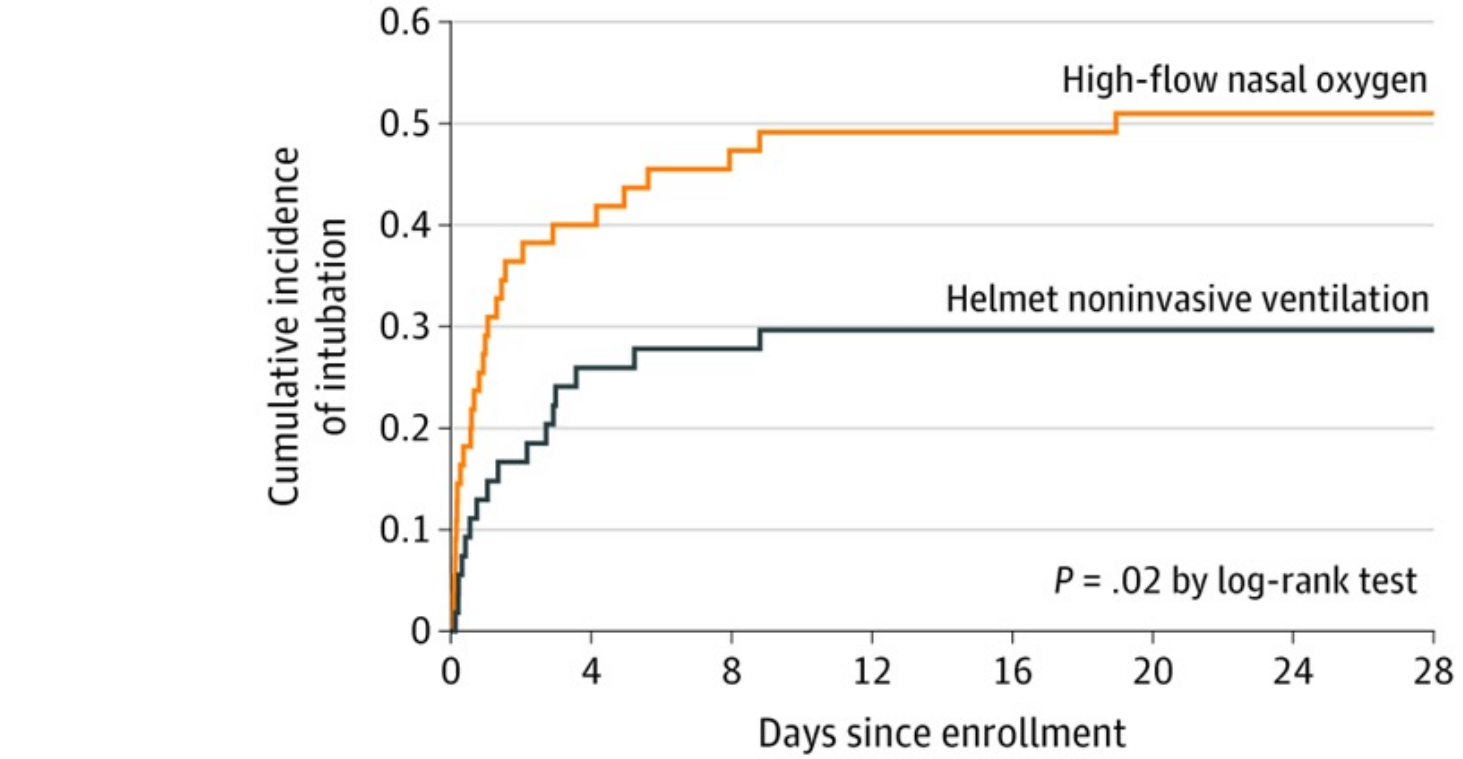
Study	HFNC Events	HFNC Total	Control Events	Control Total	Weight, %	Risk Ratio M-H, Random, 95% CI
Azoulay 2017	77	187	263	649	26.2	1.02 (0.84–1.23)
Azoulay 2018	150	388	170	388	29.6	0.88 (0.75–1.04)
Coudroy 2016	21	60	30	55	9.9	0.64 (0.42–0.98)
Frat 2016	8	26	13	30	4.0	0.71 (0.35–1.44)
Lemiale 2015	4	52	2	48	0.8	1.85 (0.35–9.63)
Lemiale 2016	40	90	48	90	16.1	0.83 (0.62–1.13)
Roca 2015	13	22	16	18	11.4	0.66 (0.45–0.98)
Tu 2017	4	20	9	18	2.1	0.40 (0.15–1.08)
Total (95% CI)		845		1296	100	0.83 (0.72–0.97)
Total events	317		551			

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 9.95$, df = 7 ($P = .19$); $I^2 = 30\%$
Test for overall effect: Z = 2.39 ($P = .02$)



Respiratory care 65.3 (2020): 369-376

HF versus NIV in Covid pneumonia



No. at risk								
High-flow nasal oxygen	55	34	30	28	28	27	27	27
Helmet noninvasive ventilation	54	41	39	38	38	38	38	38

JAMA. 2021;325(17):1731-1743

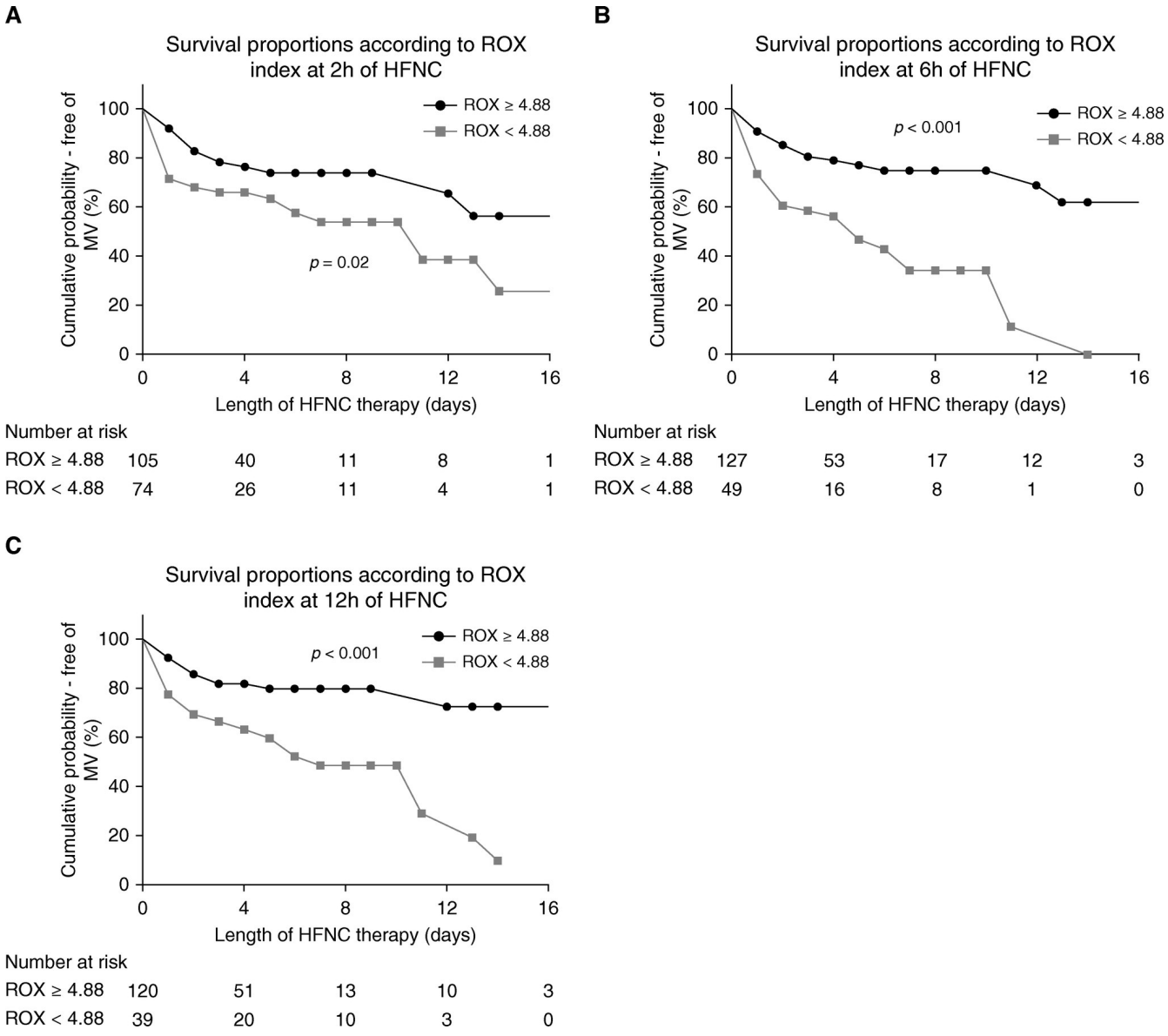
Predictors of failure of HF: ROX index

ROX= Ratio of $(Sp_{O2})/FI_{O2}$ to respiratory rate

After 12 hours:

ROX > 4.88= success likely

ROX < 3.85= failure likely



American journal of respiratory and critical care medicine, *199*(11), 1368-137.

Case continued. . . .

- The patient is placed on HFNC at 60% fio2 and 40 L. He initially has improvement in work of breathing, but over the day he has a decline in urine output and an increase in lactate, with a worsening metabolic acidosis by blood gas. His oxygenation continues to decline and he meets criteria for ARDS. Given the overall trajectory, he is intubated and placed on low tidal volume ventilation. He requires paralysis for significant hypoxemia but after several weeks in the ICU he is extubated and ultimately discharged from the hospital without supplemental oxygen.

Summary

- NIV is the appropriate first choice for most patients with acute respiratory failure secondary to COPD or heart failure exacerbations.
- NIV is also the most appropriate therapy for most patients with acute on chronic hypercapnic respiratory failure.
- For patients with de novo acute hypoxemic respiratory failure, high flow nasal oxygen therapy may decrease the need for intubation and may have a mortality benefit.
- For either therapy, close monitoring is required as delayed intubation is associated with an increase in mortality.

Question 1: Which of the following patients is the most appropriate candidate for initiation of NIV?

A. 63-year-old man with acute chest pain and ST elevations in the anterior leads on ECG
B. 72-year-old man with severe COPD admitted with rhinovirus infection and increased work of breathing.
C. 32-year-old man found obtunded after presumed polysubstance overdose.
D. 36-year-old woman with rapidly progressive hypoxemia secondary to Covid pneumonia.

Question 2: Which of the following patients is the most appropriate candidate for HFNC therapy?

- A. 74-year-old man with obesity hypoventilation and volume overload.
- B. 60-year-old woman with refractory shock secondary to gram negative rod bacteremia in the setting of neutropenia.
- C. 36-year-old woman with influenza pneumonia, a saturation of 90% on 8 L nasal cannula, and a mild increase in work of breathing.
- D. 23-year-old woman with an acute asthma exacerbation.