義大醫療財團法人
E-DA HEALTHCARE GROUP

Clinical application of non-invasive positive pressure ventilation (NIPPV) in critical care

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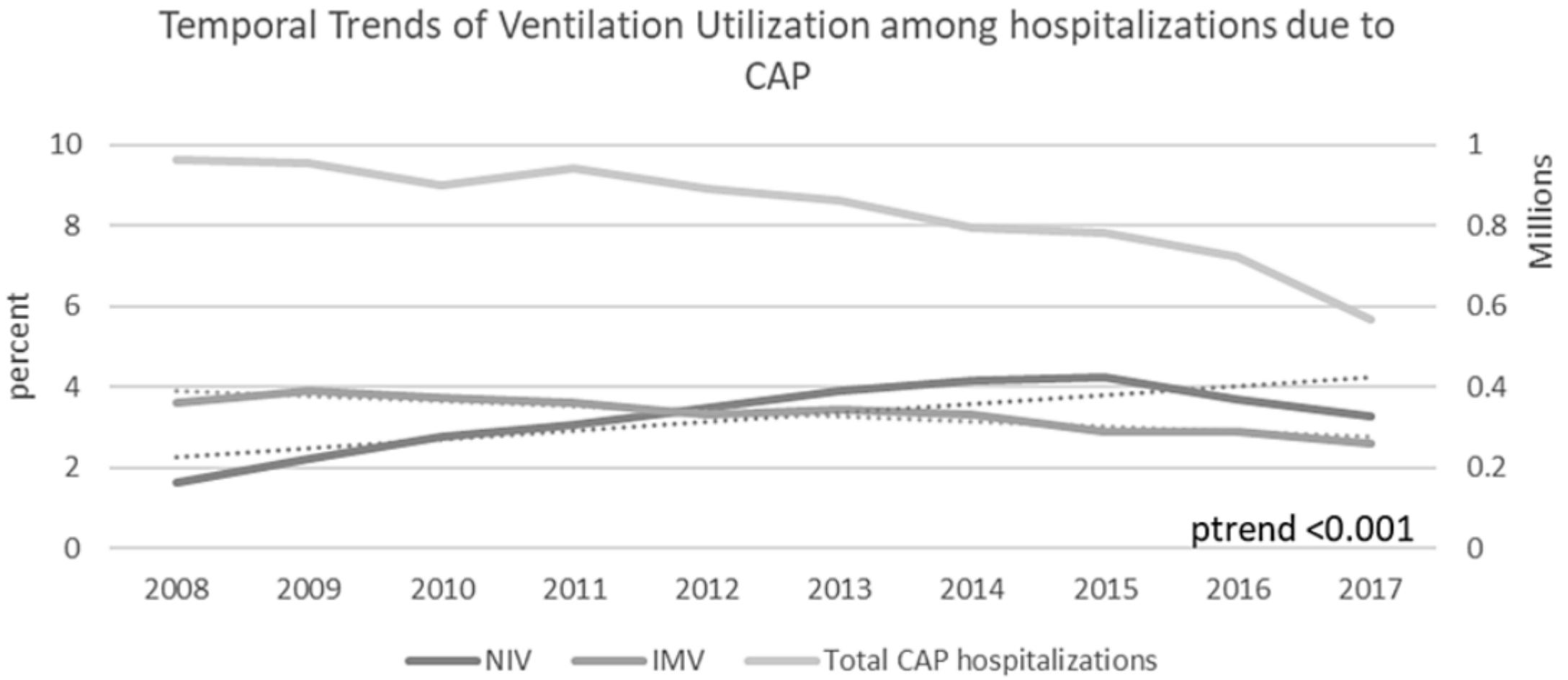
17 July 2022

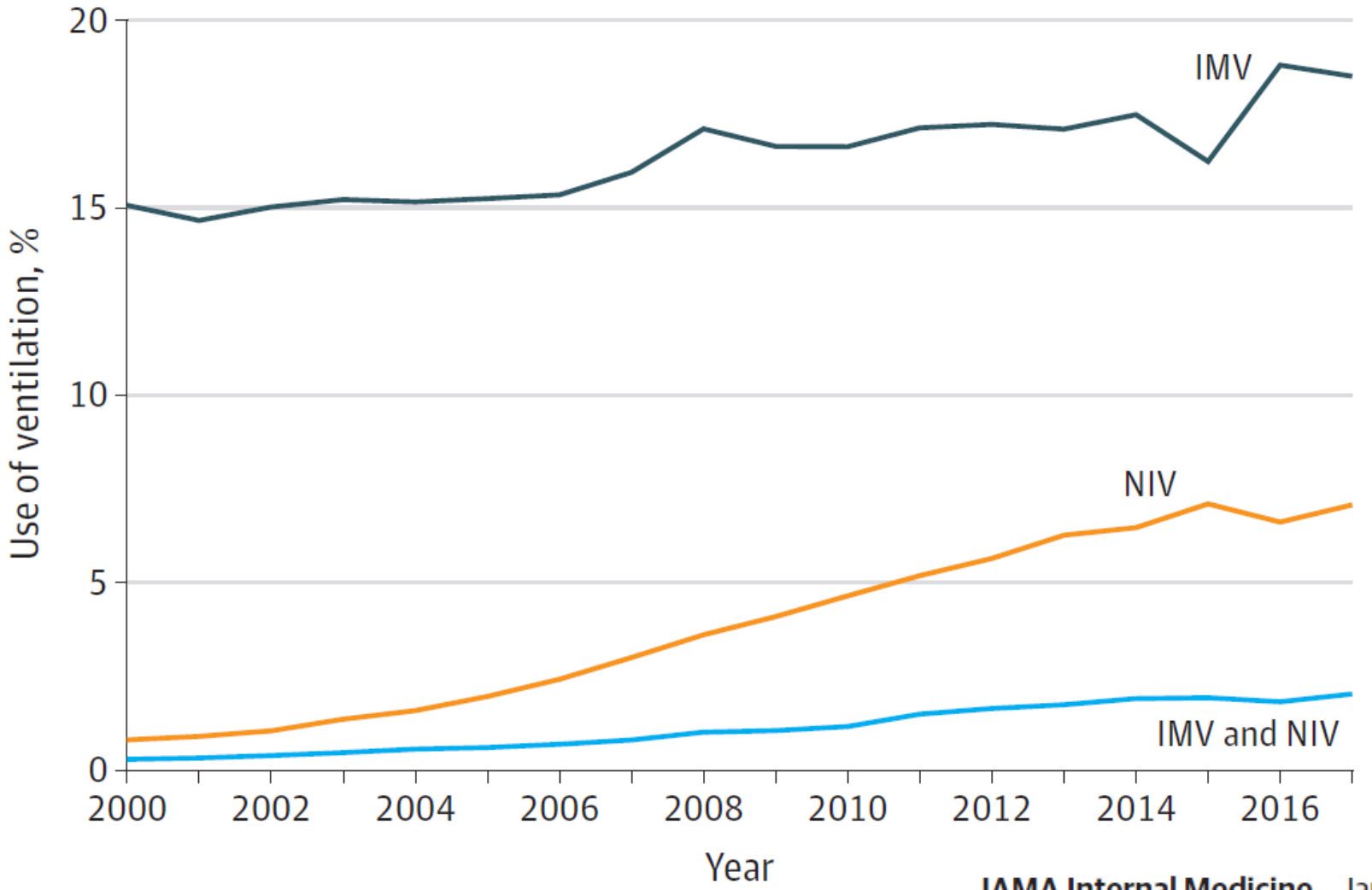
實實在在關心您健康的好厝邊

Trend of NIV and IMV during CAP hospitalization

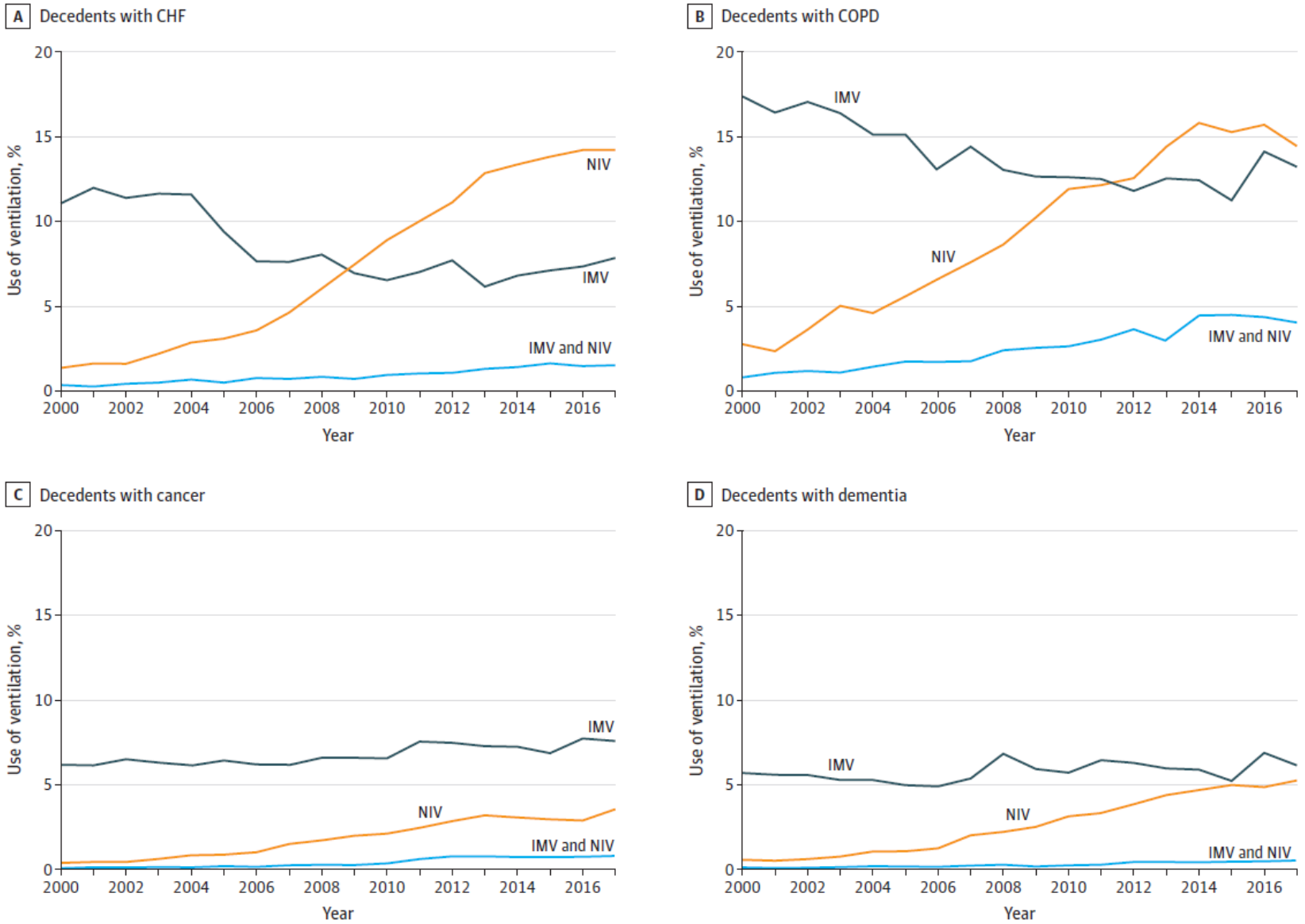


2021 Shah et al. Cureus 13(9): e17954. DOI 10.7759/cureus.17954

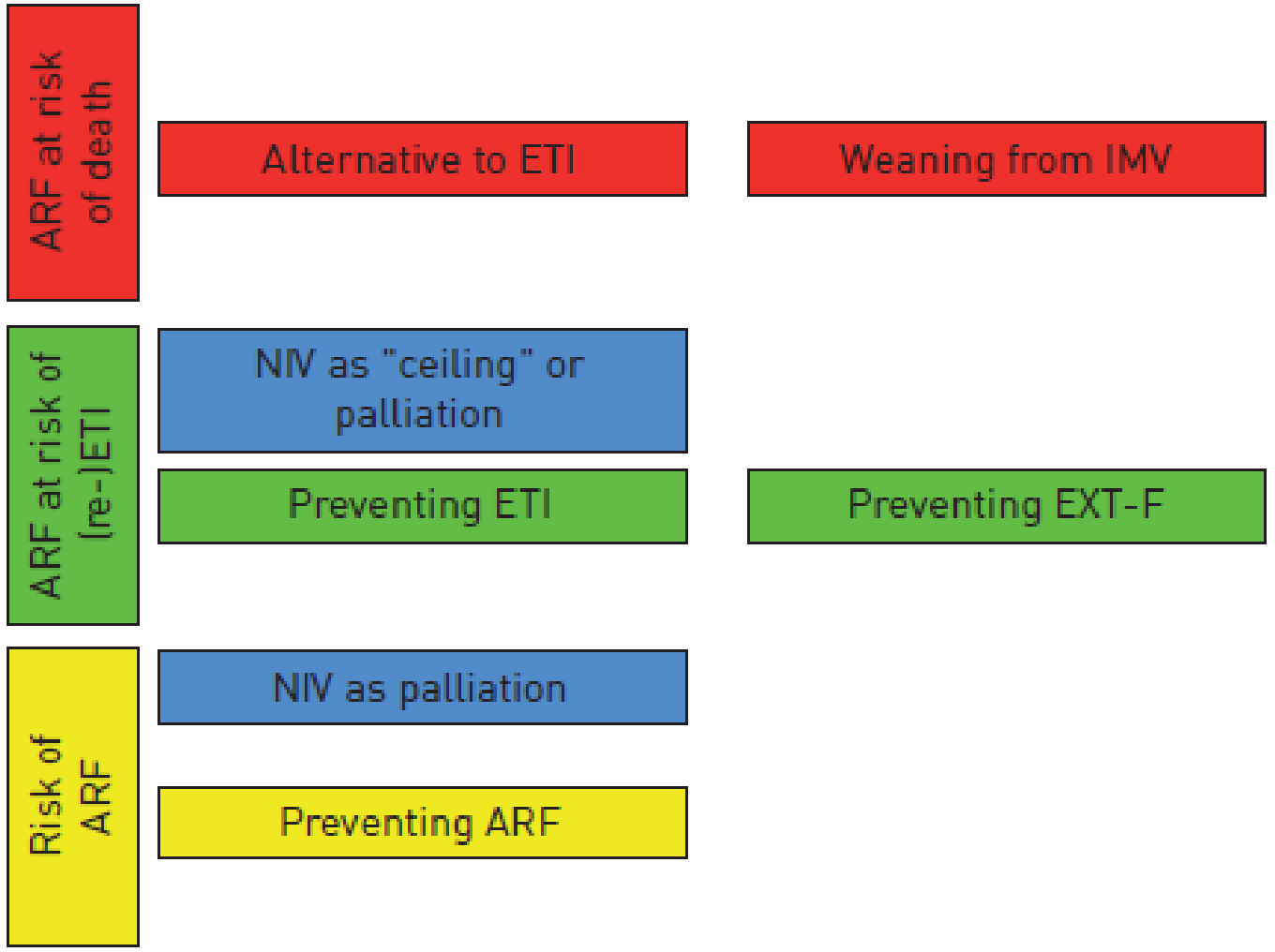
Trends in Ventilatory Support at the End of Life 2000-2017



Trends in Ventilatory Support at the End of Life by Admitting Diagnosis, 2000-2017

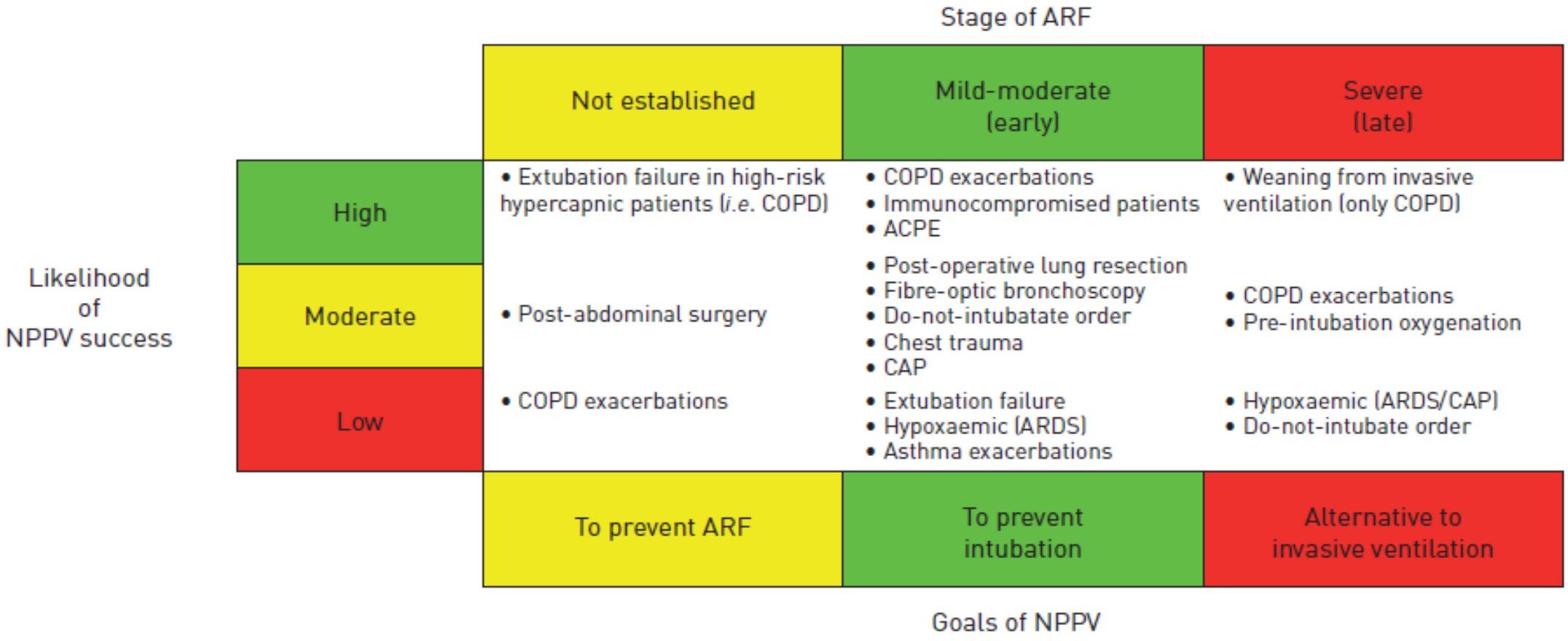


Time frames for the application of NIV in acute respiratory failure



Eur Respir Rev 2018; 27: 180029

Evidence-based indications for NIV according to the severity and time of acute respiratory failure



Eur Respir Rev 2018; 27: 180029

Official ERS/ATS clinical practice guidelines: recommendations for actionable PICO questions

Clinical indication[#]	Certainty of evidence[¶]	Recommendation
Prevention of hypercapnia in COPD exacerbation	⊕⊕	Conditional recommendation against
Hypercapnia with COPD exacerbation	⊕⊕⊕⊕	Strong recommendation for
Cardiogenic pulmonary oedema	⊕⊕⊕	Strong recommendation for
Acute asthma exacerbation		No recommendation made
Immunocompromised	⊕⊕⊕	Conditional recommendation for
***De novo* respiratory failure** (without prior chronic respiratory disease)		No recommendation made
Post-operative patients	⊕⊕⊕	Conditional recommendation for
Palliative care	⊕⊕⊕	Conditional recommendation for
Trauma	⊕⊕⊕	Conditional recommendation for
Pandemic viral illness		No recommendation made
Post-extubation in high-risk patients (prophylaxis)	⊕⊕	Conditional recommendation for
Post-extubation respiratory failure	⊕⊕	Conditional recommendation against
Weaning in hypercapnic patients	⊕⊕⊕	Conditional recommendation for

[#]: all in the setting of acute respiratory failure; [¶]: certainty of effect estimates: ⊕⊕⊕⊕, high; ⊕⊕⊕, moderate; ⊕⊕, low; ⊕, very low.

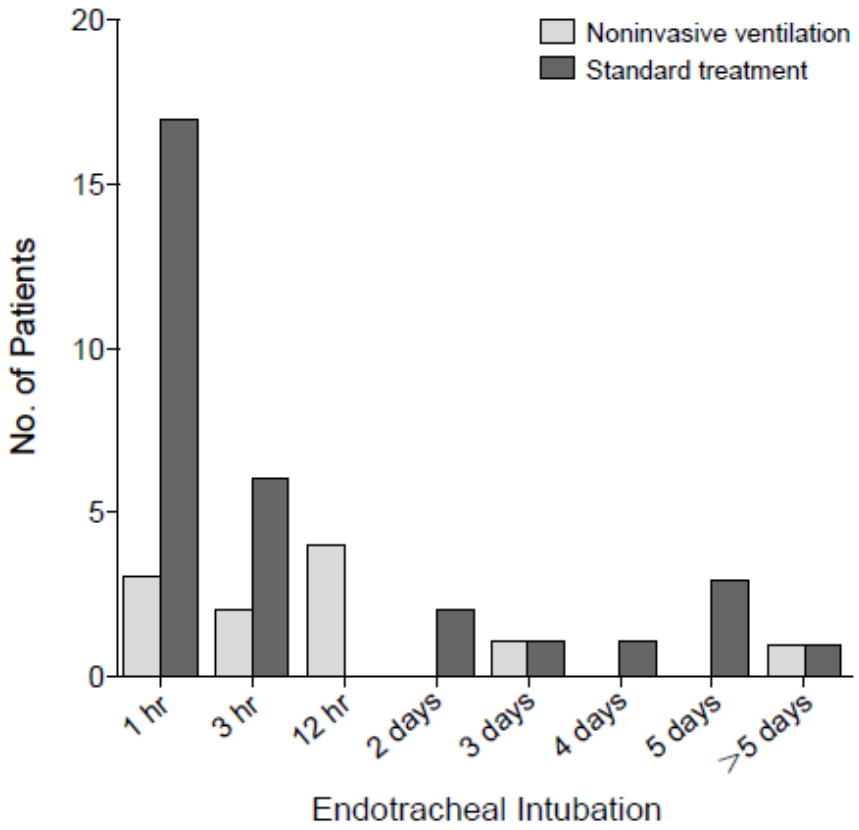
Eur Respir J 2017; 50: 1602426

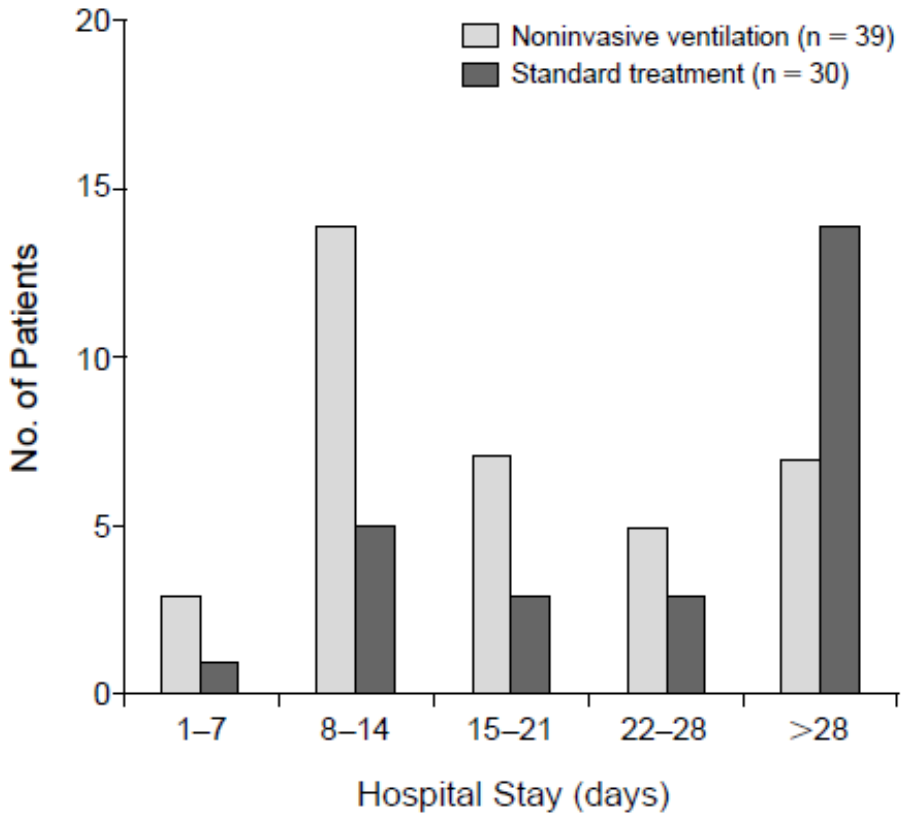
The New England
Journal of Medicine

(N Engl J Med 1995;333:817-22.)

Volume 333 SEPTEMBER 28, 1995 Number 13

NONINVASIVE VENTILATION FOR ACUTE EXACERBATIONS OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE





The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

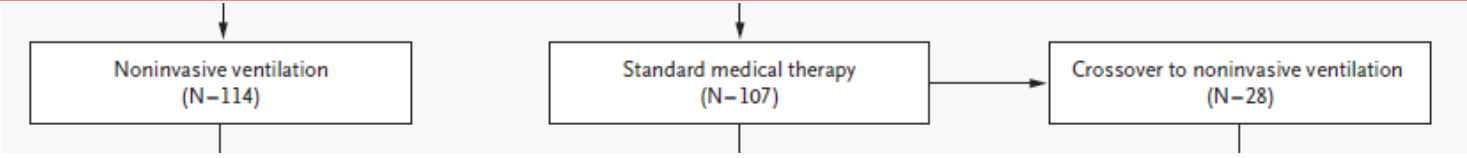
N Engl J Med 2004;350:2452-60.

Noninvasive Positive-Pressure Ventilation for Respiratory Failure after Extubation

RESULTS

A total of 221 patie…omly assigned to either noninvas…erapy (107 patients) when the tr…was no difference between the r…y group in the need for reintubat…relative risk in the noninvasive-ve…0.76 to 1.30). The rate of death …ve-ventilation group than in the s…tive risk, 1.78; 95 percent confide…ime from respiratory failure to reintubation was longer in the noninvasive-ventilation group (12 hours vs. 2 hours 30 minutes, P=0.02).

In a post hoc analysis of the 23 patients with chronic obstructive pulmonary disease who were included in the study, we observed that the rate of reintubation was lower among those who had been assigned to noninvasive ventilation (7 of 14 [50 percent]) than among those who had been assigned to standard therapy (6 of 9 [67 percent], P=0.67), but the sample was too small to allow us to draw meaningful conclusions about this subgroup. Similarly,



Noninvasive Ventilation in Acute Cardiogenic Pulmonary Edema

Variable	Standard Oxygen Treatment (N=367)	CPAP or NIPPV (N=702)	Odds Ratio (95% CI)	P Value
Death within 7 days (% of patients)	9.8	9.5	0.97 (0.63 to 1.48)	0.87
Death within 30 days (% of patients)	16.4	15.2	0.92 (0.64 to 1.31)	0.64
Intubation within 7 days (% of patients)	2.8	2.9	1.05 (0.49 to 2.27)	0.90
Admission to critical care unit (% of patients)	40.5	45.2	1.21 (0.93 to 1.57)	0.15
Myocardial infarction (% of patients)				
WHO criteria	24.9	27.0	1.12 (0.84 to 1.49)	0.46
Universal criteria	50.5	51.9	1.06 (0.82 to 1.36)	0.66
			Difference between Means (95% CI)†	
Mean length of hospital stay (days)	10.5	11.4	0.9 (−0.2 to 2.0)	0.10
Mean change at 1 hr after start of treatment‡				
Dyspnea score§	3.9	4.6	0.7 (0.2 to 1.3)	0.008
Pulse rate (beats/min)	13	16	4 (1 to 6)	0.004

N Engl J Med 2008;359:142-51.

Non-invasive positive pressure ventilation (CPAP or bilevel NPPV) for cardiogenic pulmonary oedema (Review)

Berbenetz N, Wang Y, Brown J, Godfrey C, Ahmad M, Vital FMR, Lambiase P, Banerjee A, Bakhai A, Chong M

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	of participants (studies)	Certainty of the evidence (GRADE)
	Risk with SMC	Risk with NPPV			
HOSPITAL MORTALITY follow-up: median 13 days; range 1 day - 41 days	Study population		RR 0.65 (0.51 to 0.82)	2484 (21 RCTs)	⊕⊕◯◯ LOW[a,b]
	176 per 1000	114 per 1000 (90 to 144)			
ETI RATE follow-up: median 1 day; range 0.1 day - 30 days	Study population		RR 0.49 (0.38 to 0.62)	2449 (20 RCTs)	⊕⊕⊕◯ MODERATE[c]
	154 per 1000	75 per 1000 (58 to 95)			
ACUTE MI INCIDENCE follow-up: median 3 days; range 1 day - 41 days	Study population		RR 1.03 (0.91 to 1.16)	1313 (5 RCTs)	⊕⊕⊕◯ MODERATE[d]
	421 per 1000	433 per 1000 (383 to 488)			
HOSPITAL LENGTH OF STAY	The mean HOSPITAL LENGTH OF STAY was 9.65 days	MD 0.31 days lower (1.23 lower to 0.61 higher)	-	1714 (11 RCTs)	⊕◯◯◯ VERY LOW[e,f,g]
ICU LENGTH OF STAY	This outcome could not be pooled due to high heterogeneity. There was no evidence of a difference between NPPV and SMC in 4 RCTs, and 2 RCTs reported a shorter length of stay for NPPV (1 day shorter (95% CI −1.79 to −0.21); n = 30; 4		-	587 (6 RCTs)	⊕◯◯◯ VERY LOW[h,i,j]

Cochrane Database of Systematic Reviews 2019, Issue 4. Art. No.: CD005351. DOI: 10.1002/14651858.CD005351.pub4.

Non-invasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma (Review)

Non-invasive positive pressure ventilation for treatment of respiratory failure due to severe acute exacerbations of asthma

Patient or population: patients with asthma
Settings:
Intervention: non-invasive positive pressure ventilation

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	Non-invasive positive pressure ventilation				
Mortality Follow-up: 30 days	See comment	See comment	Not estimable	86 (2 studies)	⊕○○○ **very low**[1,2,3]	Not estimable
Endotracheal intubation Follow-up: 30 days	See comment	See comment	**RR 4.48** (0.23 to 89.13)	86 (2 studies)	⊕⊕○○ **low**[1,2]	No events in control group
Length of hospital stay Follow-up: 30 days	See comment	See comment	See comment	86 (2 studies)	⊕○○○ **very low**[1,2,3]	Unable to pool data
Number of hospital admissions Follow-up: 30 days	**625 per 1000**	**175 per 1000** (56 to 525)	**RR 0.28** (0.09 to 0.84)	33 (1 study)	⊕○○○ **very low**[2,3,4]	
FEV1 (% predicted) Percentage scale from: 1% to 150%. Follow-up: 1 to 30 days	Mean FEV1 (% predicted) ranged across control groups from **35.51 L to 43.9 %**	The mean FEV1 (% predicted) in the intervention groups was **14.02 % higher** (7.73 to 20.32 higher)	**MD 14.02** (7.73 to 20.32)	66 (2 studies)	⊕⊕○○ **low**[2,5]	

Cochrane Database of Systematic Reviews 2012, Issue 12.

Non-invasive positive pressure ventilation for acute asthma in children (Review)

Non-invasive positive pressure ventilation for children with acute asthma

Patient or population: children with acute asthma
Setting: hospital
Intervention: non-invasive ventilation as add-on therapy to standard care
Comparison: standard care

Korang SK, Feinberg J, Wetterslev J, Jakobsen JC.
Non-invasive positive pressure ventilation for acute asthma in children.
Cochrane Database of Systematic Reviews 2016, Issue 9. Art. No.: CD012067.

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	No. of participants (studies)	Quality of the evidence (GRADE)	Comments
	Risk with standard care	Risk with non-invasive ventilation as add-on therapy to standard care				
Mortality	Study population		not estimable	16 (1 RCT)	⊕◯◯◯ **very low**[a]	No deaths were seen.
	0 per 1000	0 per 1000				
Serious adverse events	Study population		not estimable	35 (2 RCTs)	⊕◯◯◯ **very low**[a]	No serious adverse events were reported
	not pooled	not pooled				
Asthma symptom score at the acute phase	not estimable	not pooled	-	35 (2 RCTs)	⊕◯◯◯ **very low**[a]	Basnet 2012: Children in NPPV group had an improvement in their mean CAS from 7 (median, 7; interquartile range, 6 to 8) at baseline to 1.6 (median,2;interquartile range, 2 to 2.8) at 24 hours vs mean CAS from 6.9 (median, 7; interquartile

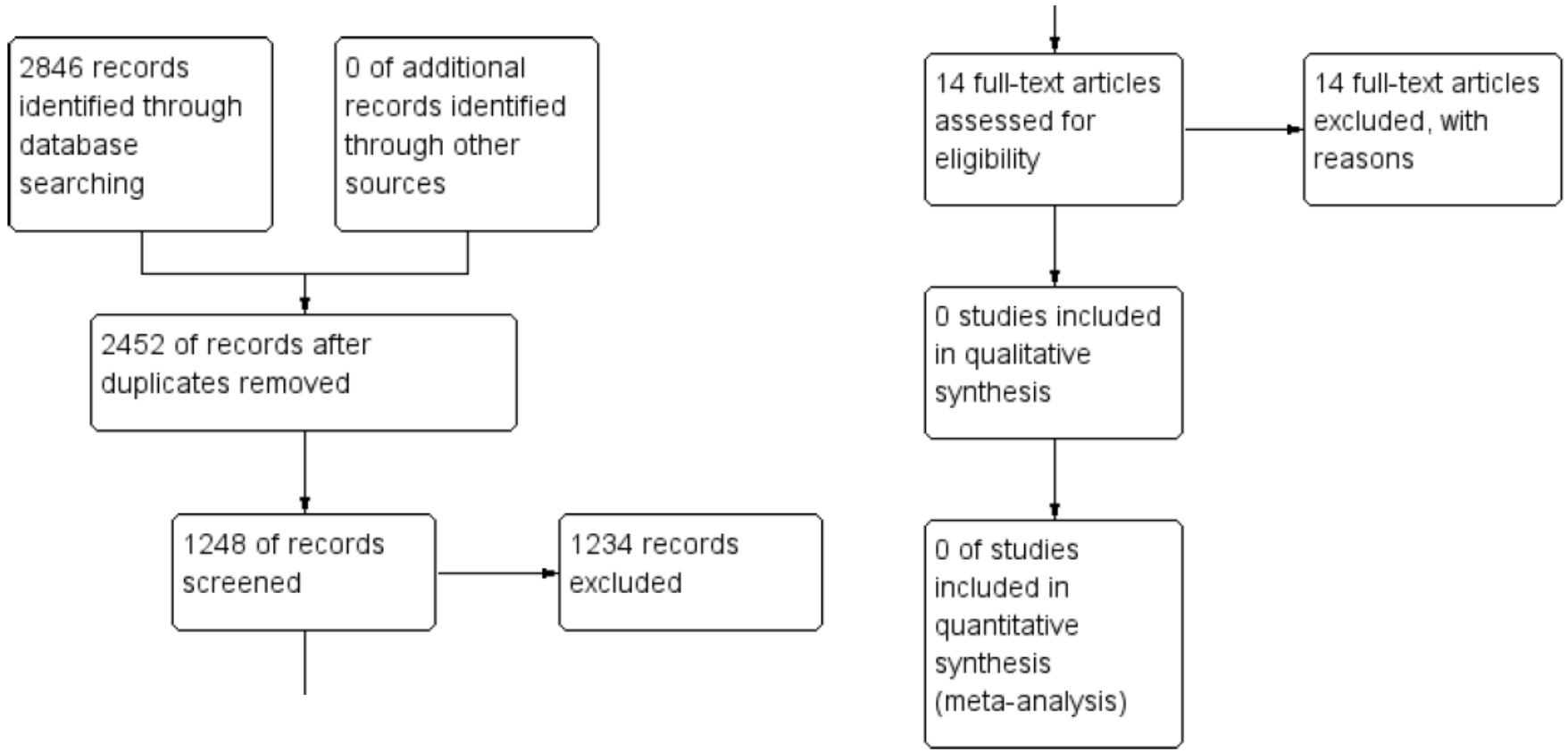
Non-invasive positive pressure ventilation for prevention of complications after pulmonary resection in lung cancer patients (Review)

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	NIPPV versus no NIPPV				
Pulmonary complications	254 per 1000	277 per 1000 (183 to 421)	RR 1.03 (0.72 to 1.47)	238 (4 studies)	⊕⊕◯◯ low[1,2]	
Rate of intubation	Study population		RR 0.55 (0.25 to 1.2)	69 (2 studies)	⊕⊕⊕◯ moderate[2]	
	371 per 1000	204 per 1000 (93 to 446)				
	Moderate					
	296 per 1000	163 per 1000 (74 to 355)				
Mortality	115 per 1000	54 per 1000 (20 to 152)	RR 0.60 (0.24 to 1.53)	151 (4 studies)	⊕⊕⊕◯ moderate[2]	
Length of intensive care unit stay		The mean length of intensive care unit stay in the intervention groups was 0.75 lower (3.93 lower to 2.43		69 (2 studies)	⊕⊕◯◯ low[3,4]	

Cochrane Database of Systematic Reviews 2019, Issue 3. Art. No.: CD010355.

Invasive versus non-invasive ventilation for acute respiratory failure in neuromuscular disease and chest wall disorders (Review)

Luo F, Annane D, Orlikowski D, He L, Yang M, Zhou M, Liu GJ



Cochrane Database of Systematic Reviews 2017, Issue 12.

Evidence-based Utilization of Noninvasive Ventilation and Patient Outcomes

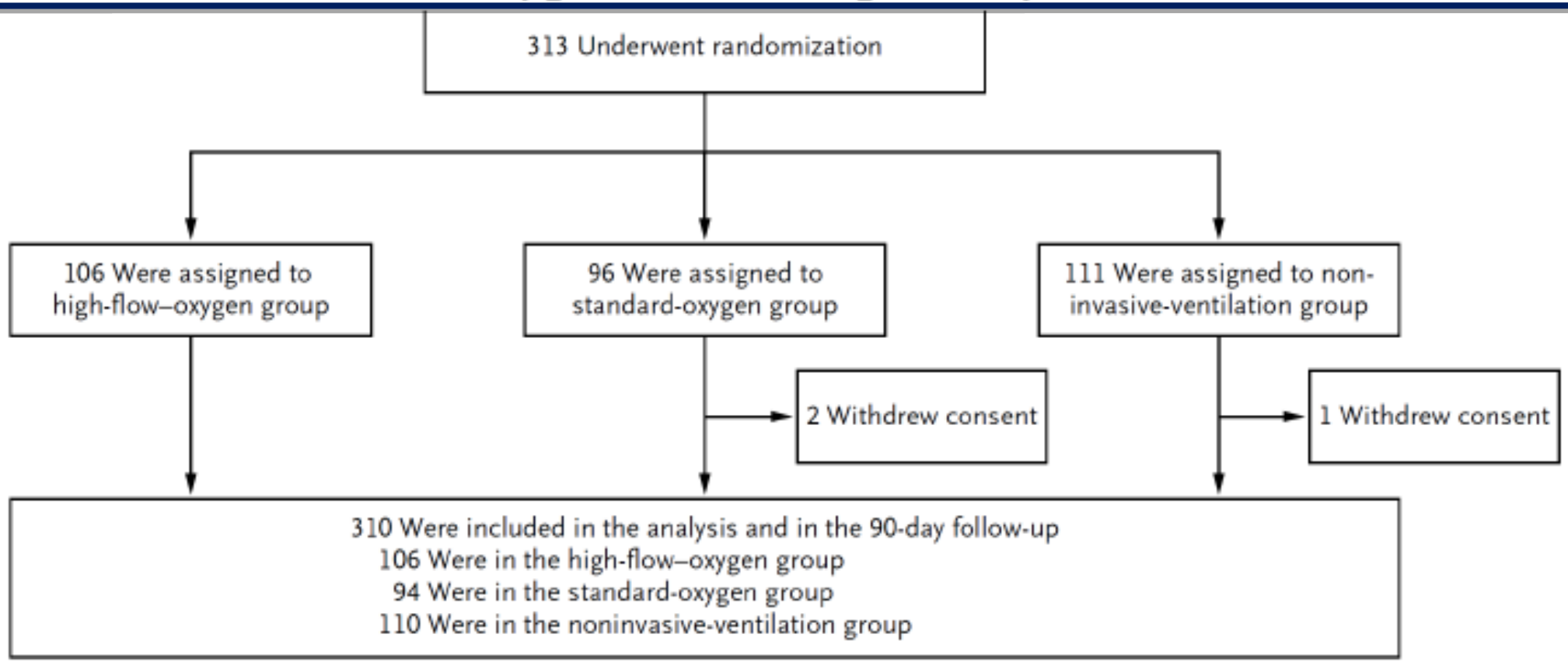
Anuj B. Mehta[1,2,3], Ivor S. Douglas[2,3], and Allan J. Walkey[4,5]

Table 1. Etiology of respiratory failure treated with noninvasive ventilation

Condition	Patients Receiving NIV (*n* = *22,706*) %
Pneumonia	26.1
COPD	15.0
HF	15.0
Nonpneumonia sepsis	4.6
Asthma	3.6
Other*	35.6

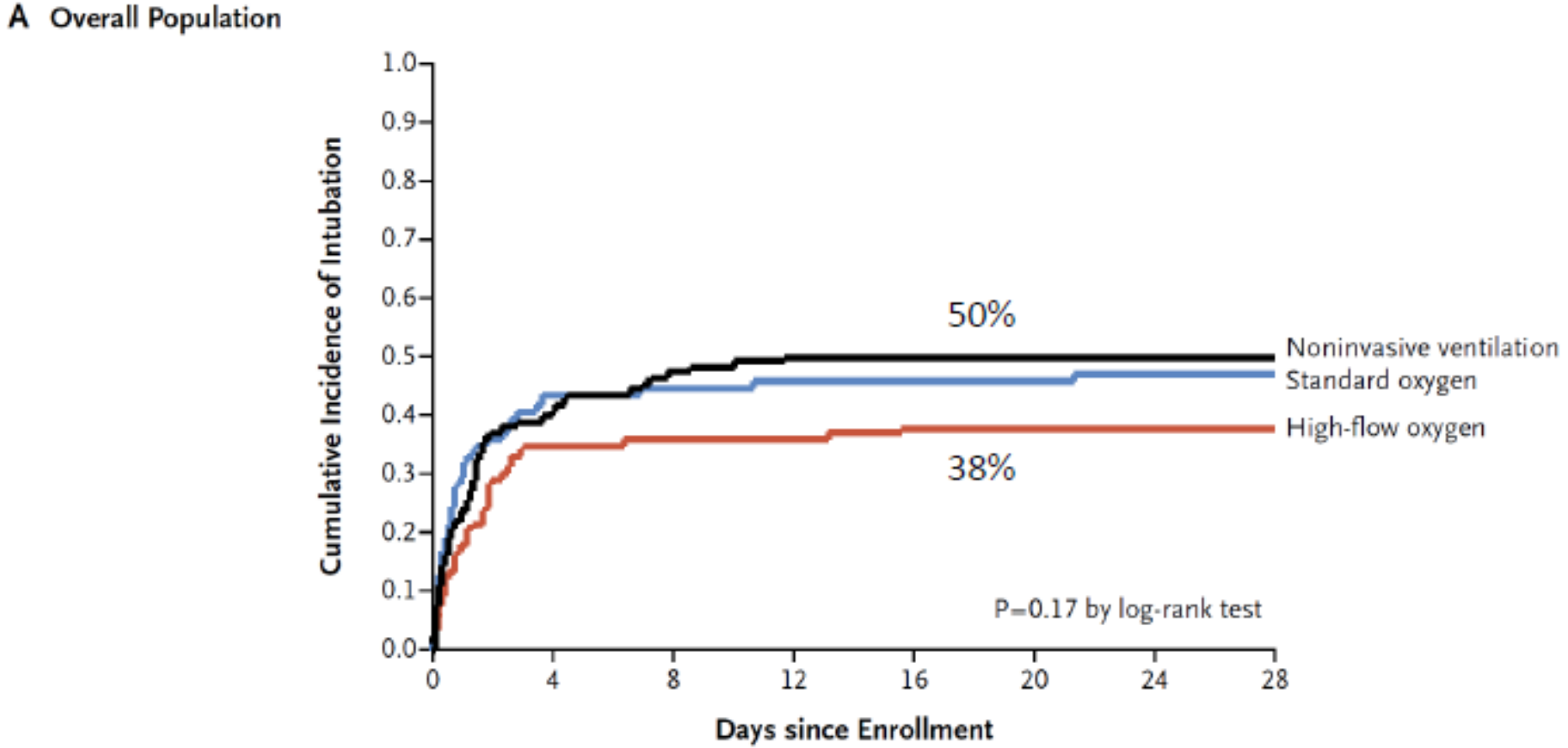
ORIGINAL ARTICLE

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



N Engl J Med 2015; 372:2185-2196

Cumulation of intubation rates

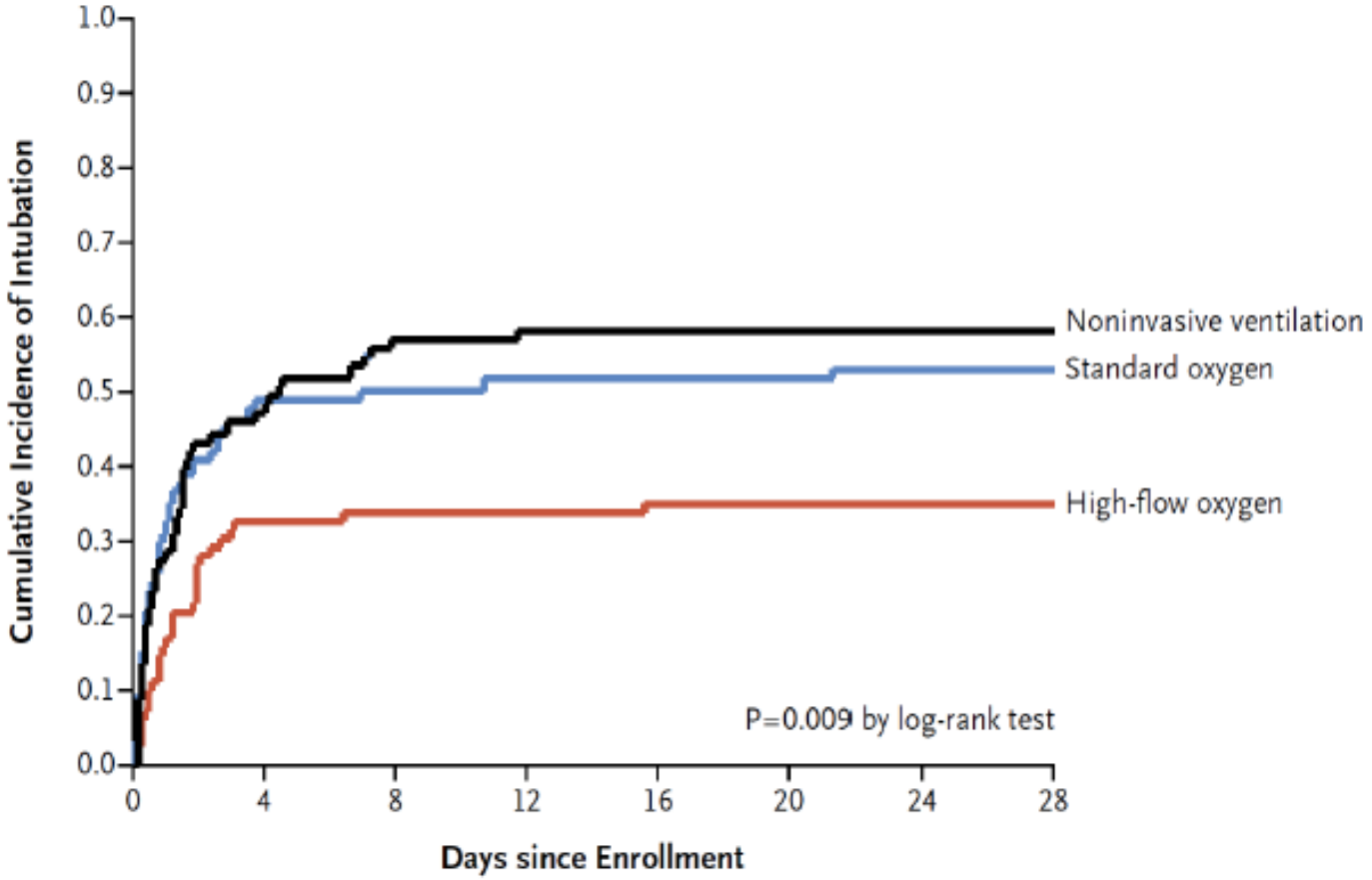


No. at Risk								
High-flow oxygen	106	68	67	67	65	65	65	65
Standard oxygen	94	52	50	49	49	49	48	48
Noninvasive ventilation	110	64	57	53	53	53	53	52

N Engl J Med 2015; 372:2185-2196

Cumulation of intubation rates

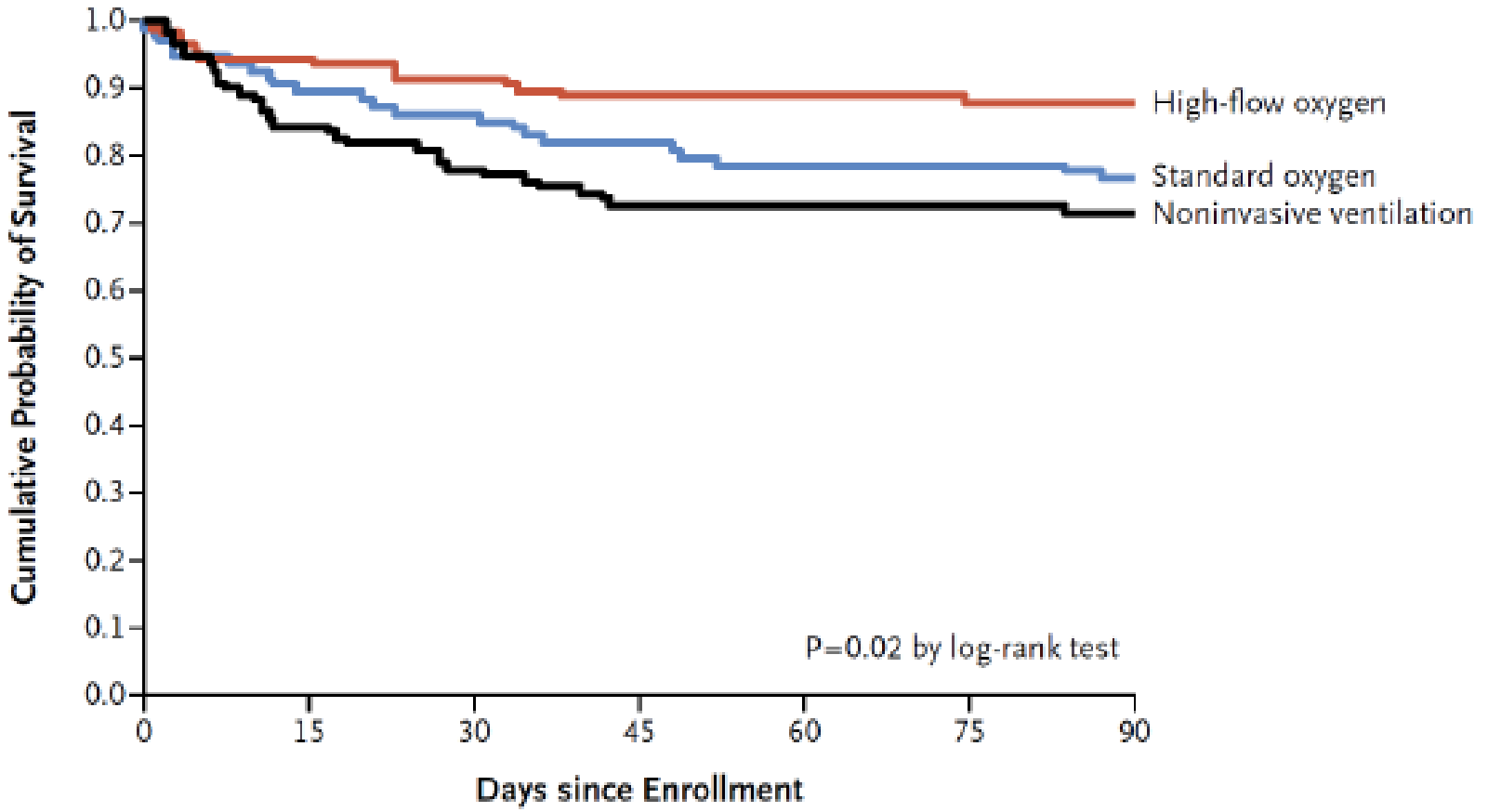
B Patients with a Pao_2:FIO_2 ≤200 mm Hg



No. at Risk								
High-flow oxygen	83	55	54	54	53	53	53	53
Standard oxygen	74	37	35	34	34	34	33	33
Noninvasive ventilation	81	41	34	32	32	32	32	32

N Engl J Med 2015; 372:2185-2196

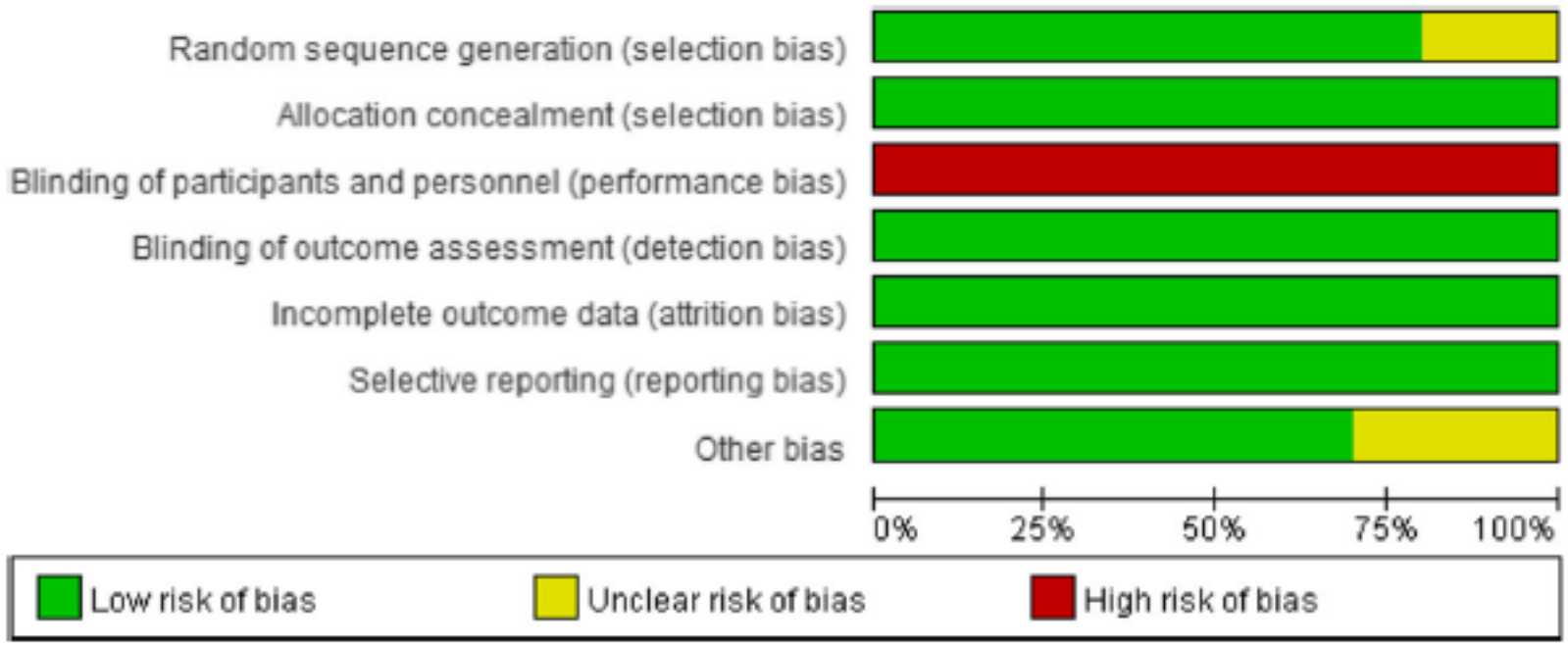
Cumulation of survival rates at day 90



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

N Engl J Med 2015; 372:2185-2196

High-flow nasal cannula oxygen therapy is superior to conventional oxygen therapy but not to noninvasive mechanical ventilation on intubation rate: a systematic review and meta-analysis



Zhao *et al. Critical Care* (2017) 21:184

Comparison of intubation rates

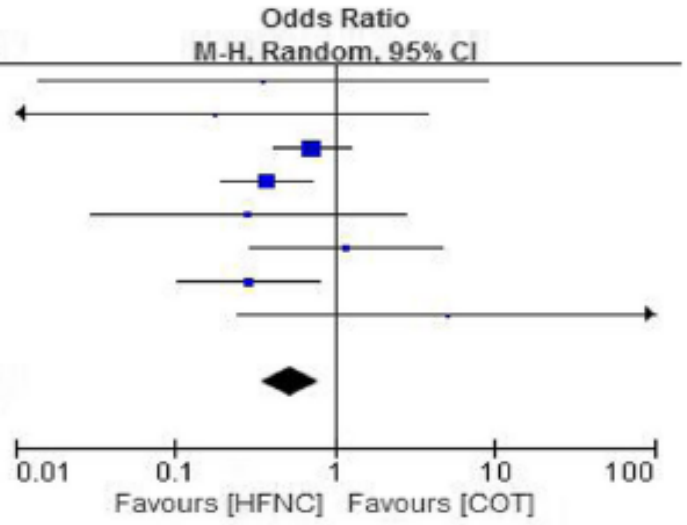
HFNC versus COT

a

Study or Subgroup	HFNC Events	HFNC Total	COT Events	COT Total	Weight	Odds Ratio M-H, Random, 95% CI
Bell, N.2015	0	48	1	52	1.7%	0.35 [0.01, 8.90]
Corley, A.2015	0	81	2	74	1.9%	0.18 [0.01, 3.77]
Frat, J. P.2015	40	106	44	96	38.4%	0.72 [0.41, 1.26]
Hernandez, G.2016	13	264	32	263	29.8%	0.37 [0.19, 0.73]
Jones, P. G.2015	1	172	3	150	3.3%	0.29 [0.03, 2.78]
Lemiale, V.2015	5	53	4	49	8.6%	1.17 [0.30, 4.64]
Maggiore, S. M.2014	6	53	16	52	14.5%	0.29 [0.10, 0.81]
Parke, R.2013	2	170	0	171	1.9%	5.09 [0.24, 106.79]
Total (95% CI)		**947**		**907**	**100.0%**	**0.52 [0.34, 0.79]**
Total events	67		102			

Heterogeneity: Tau² = 0.04; Chi² = 7.73, df = 7 (P = 0.36); I² = 9%

Test for overall effect: Z = 3.04 (P = 0.002)



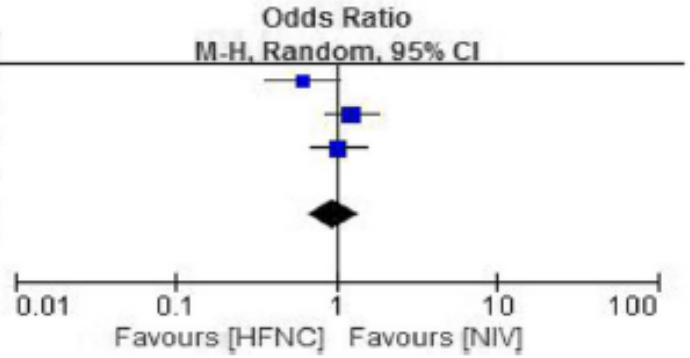
HFNC versus NIV

b

Study or Subgroup	HFNC Events	HFNC Total	NIV Events	NIV Total	Weight	Odds Ratio M-H, Random, 95% CI
Frat, J. P.2015	40	106	55	111	26.7%	0.62 [0.36, 1.06]
Hernandez, G.2016	66	290	60	314	36.7%	1.25 [0.84, 1.85]
Stéphan, F.2015	58	414	57	416	36.6%	1.03 [0.69, 1.52]
Total (95% CI)		**810**		**841**	**100.0%**	**0.96 [0.66, 1.39]**
Total events	164		172			

Heterogeneity: Tau² = 0.06; Chi² = 4.29, df = 2 (P = 0.12); I² = 53%

Test for overall effect: Z = 0.20 (P = 0.84)



Zhao *et al. Critical Care* (2017) 21:184

Effect on the rate of escalation of respiratory support and Mortality

HFNC versus NIV

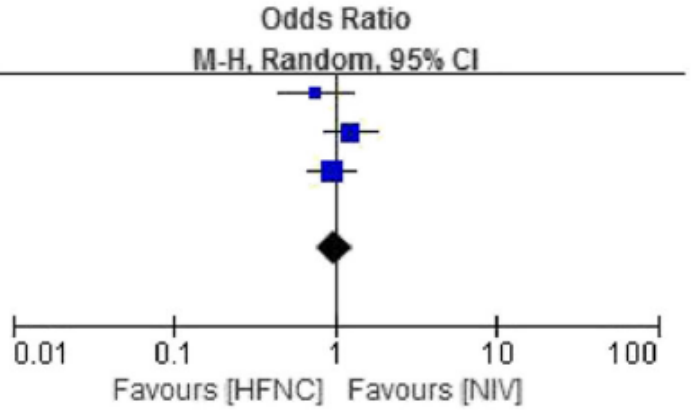
Effect on the rate of escalation of respiratory support

a

Study or Subgroup	HFNC Events	HFNC Total	NIV Events	NIV Total	Weight	Odds Ratio M-H, Random, 95% CI
Frat, J. P.2015	45	106	55	111	20.3%	0.75 [0.44, 1.28]
Hernandez, G.2016	66	290	60	314	34.5%	1.25 [0.84, 1.85]
Stéphan, F.2015	87	414	91	416	45.2%	0.95 [0.68, 1.32]
Total (95% CI)		**810**		**841**	**100.0%**	**1.00 [0.77, 1.28]**
Total events	198		206			

Heterogeneity: $Tau^2 = 0.01$; $Chi^2 = 2.40$, $df = 2$ ($P = 0.30$); $I^2 = 17\%$

Test for overall effect: $Z = 0.04$ ($P = 0.97$)



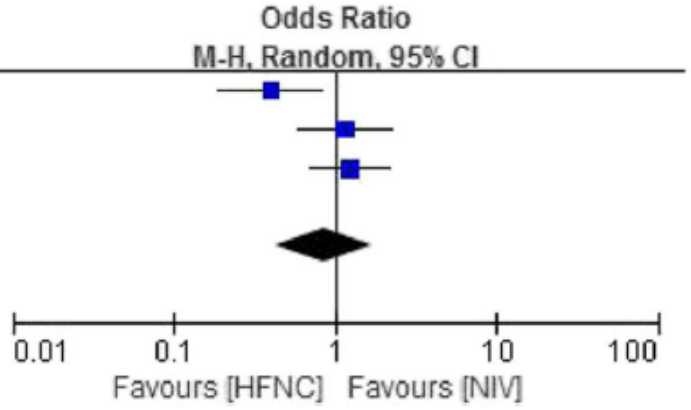
Effect on mortality

b

Study or Subgroup	HFNC Events	HFNC Total	NIV Events	NIV Total	Weight	Odds Ratio M-H, Random, 95% CI
Frat, J. P.2015	12	106	27	111	30.7%	0.40 [0.19, 0.83]
Hernandez, G.2016	19	290	18	314	33.1%	1.15 [0.59, 2.24]
Stéphan, F.2015	28	414	23	416	36.2%	1.24 [0.70, 2.19]
Total (95% CI)		**810**		**841**	**100.0%**	**0.85 [0.43, 1.68]**
Total events	59		68			

Heterogeneity: $Tau^2 = 0.25$; $Chi^2 = 6.43$, $df = 2$ ($P = 0.04$); $I^2 = 69\%$

Test for overall effect: $Z = 0.46$ ($P = 0.65$)



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[Intervention Review]

High-flow nasal cannulae for respiratory support in adult intensive care patients

Sharon R Lewis[1], Philip E Baker[2], Roses Parker[3], Andrew F Smith[4]

Conclusion

HFNC may lead to less treatment failure when compared to standard oxygen therapy, but probably makes little or no difference when compared to NIV or NIPPV. For most other review outcomes, we found no reliable evidence of a difference in effect. However, we identified another 51 ongoing trials and we plan to include these in future updates of the review. When these trials are incorporated, we may reach different conclusions about whether HFNC is helpful for breathing support in adult ICU patients.

HFNC compared to NIPPV or NIV for respiratory support in adult intensive care patients

Population: adults in the ICU, requiring respiratory support
Setting: ICUs. In this review, these ICUs were in: Belgium, China, France, Saudi Arabia, and Spain
Intervention: oxygen delivered via HFNC, initiated after extubation from invasive mechanical ventilation or without prior use of invasive mechanical ventilation
Comparison: oxygen delivered via NIV or NIPPV (using BiPAP)

Outcomes	Anticipated absolute effects* (95% CI)		Relative effect (95% CI)	Number of participants (studies)	Certainty of the evidence (GRADE)	Comments
	Risk with NIPPV or NIV	Risk with HFNC				
Treatment failure (escalation of respiratory therapy to NIV, NIPPV or invasive ventilation) Measured up to 28 days	Study population 202 per 1000	198 per 1000 (158 to 247)	RR 0.98 (0.78 to 1.22)	1758 (5 studies)	⨁⨁◯◯ **Low** [a]	We conducted subgroup analysis and found no evidence of a difference in treatment failure when used post-extubation (RR 1.12, 95% CI 0.89 to 1.41; 3 studies, 1472 participants) and without prior use of mechanical ventilation (RR 0.77, 95% CI 0.58 to 1.03; 2 studies, 286 participants)
In-hospital mortality (up to 90 days; included studies reported in-hospital mortality, and mortality up to 28 days and up to ICU discharge)	Study population 136 per 1000	126 per 1000 (87 to 179)	RR 0.92 (0.64 to 1.31)	1758 (5 studies)	⨁⨁◯◯ **Low**[a]	-

義大醫院 E-DA HOSPITAL I-SHOU UNIVERSITY

Cochrane Database of Systematic Reviews 2021, Issue 3. Art. No.: CD010172.

HFNC compared to NIPPV or NIV for respiratory support in adult intensive care patients

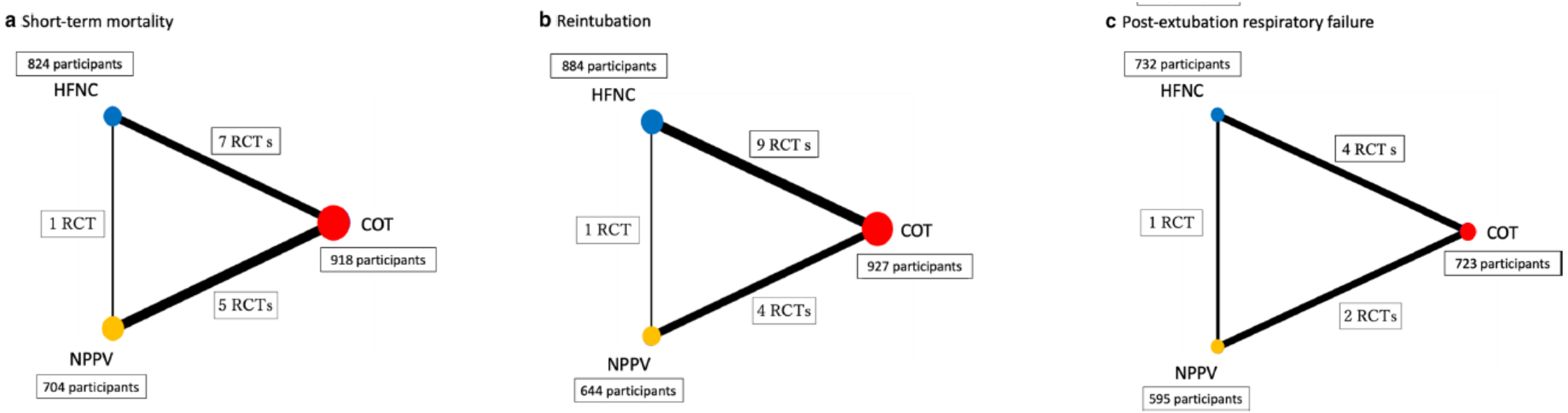
Adverse events Respiratory infection (pneumonia)	Study population for pneumonia 159 per 1000	81 per 1000 (27 to 241)	RR 0.51 (0.17 to 1.52)	1750 (3 studies)	⊕⊖⊖⊖ **Very low** [b]	-
Barotrauma (pneumothorax)	Study population for barotrauma 17 per 1000	19 per 1000 (7 to 53)	RR 1.15 (0.42 to 3.14)	830 (1 study)	⊕⊖⊖⊖ **Low** [c]	-
Nasal mucosa or skin trauma	Study population for nasal mucosa or skin trauma -	-	-	-	-	No studies reported this outcome
Length of ICU stay	9.9 days	MD 0.72 days lower (2.85 days lower to 1.42 days higher)	-	246 (2 studies)	⊕⊕⊖⊖ **Low** [d]	In addition, 2 studies reported median lengths of ICU stay which we did not combine in analysis; these studies reported little or no difference in median lengths of ICU stay
Respiratory effects: PaO_2/FiO_2 ratio up to 24 hours after initiation of therapy	228.9 mmHg	MD 58.1 mmHg lower (71.68 mmHg lower to 44.51 mmHg lower)	-	1086 (3 studies)	⊕⊕⊖⊖ **Low**[e]	-
Comfort (short-term effect) Measured up to 24 hours, scales were standardized to allow comparison; higher numbers indicate more comfort	6.06	MD 1.33 higher (0.74 higher to 1.92 higher)	-	258 (2 studies)	⊕⊖⊖⊖ **Very low** [f]	In addition, 1 study reported improved comfort with HFNC (RR 1.30, 95% CI 1.10 to 1.53; 1 study, 168 participants), and 1 study (830 participants) reported little or no difference between types of respiratory support, with comfort rated as 'poor', 'acceptable' or 'good'.
Comfort (long-term effect) Measured at more than 24 hours	-	-	-	-	⊕⊖⊖⊖ **Very low** [g]	1 study (304 participants) reported little or no difference between types of respiratory support, with comfort rated as 'poor', 'acceptable' or 'good'.

Cochrane Database of Systematic Reviews 2021, Issue 3. Art. No.: CD010172.

RESEARCH Open Access

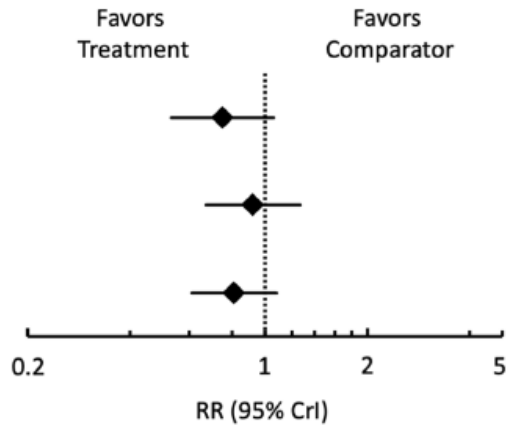
Post-extubation oxygenation strategies in acute respiratory failure: a systematic review and network meta-analysis

Hideto Yasuda[1,2*], Hiromu Okano[3], Takuya Mayumi[4], Chihiro Narita[5], Yu Onodera[6], Masaki Nakane[7] and Nobuaki Shime[8]



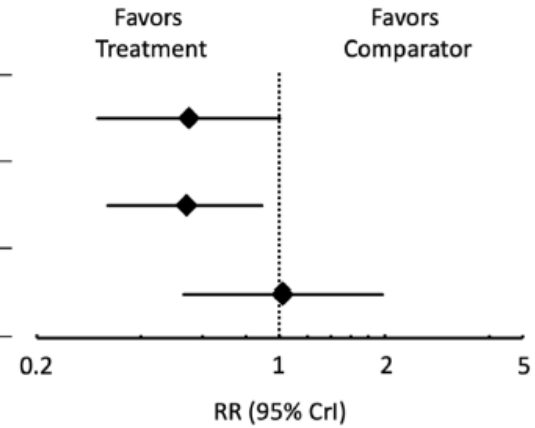
a Short-term mortality

Treatment	Comparator	RR (95% CrI)
NPPV	COT	0.75 (0.53-1.06)
HFNC	COT	0.92 (0.67-1.27)
NPPV	HFNC	0.81 (0.61-1.08)



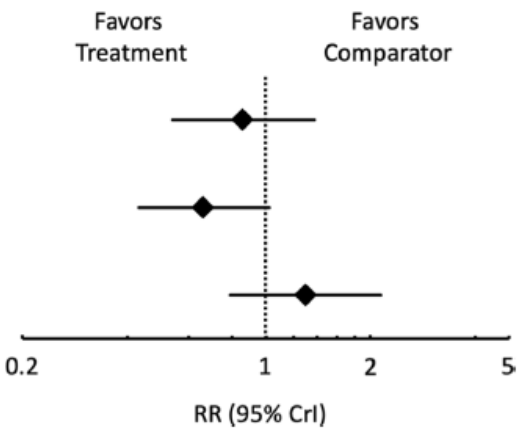
b Reintubation

Treatment	Comparator	RR (95% CrI)
NPPV	COT	0.55 (0.30-1.00)
HFNC	COT	0.54 (0.32-0.89)
NPPV	HFNC	1.02 (0.53-1.97)



c Post-extubation respiratory failure

Treatment	Comparator	RR (95% CrI)
NPPV	COT	0.86 (0.54-1.38)
HFNC	COT	0.66 (0.43-1.02)
NPPV	HFNC	1.30 (0.79-2.14)



Yasuda *et al. Crit Care* (2021) 25:135

SYSTEMATIC REVIEW

Noninvasive respiratory support following extubation in critically ill adults: a systematic review and network meta-analysis

Shannon M. Fernando[1,2*], Alexandre Tran[1,3,4], Behnam Sadeghirad[5,6], Karen E. A. Burns[6,7,8],

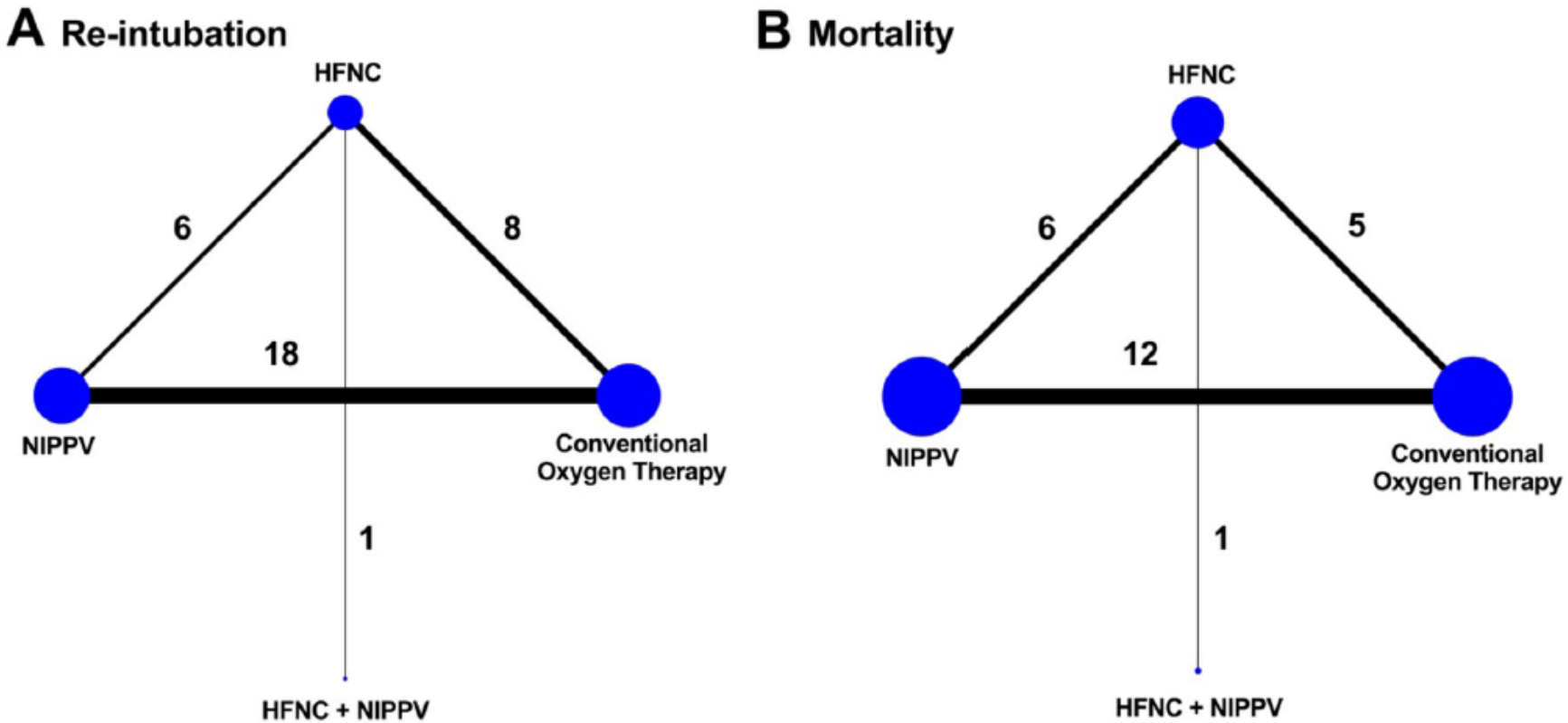


Table 2 Network and absolute estimates evaluating the efficacy of the interventions for prevention of reintubation in critically ill adults

Comparison	Network odds ratio (95% CI)	Absolute risk difference (95% CI)	Number needed to treat	GRADE
NIPPV vs conventional oxygen	0.65 (0.52–0.82)	− 5.18 (− 8.09 to − 2.26)	20 (13 to 45)	Moderate[a]
HFNC vs conventional oxygen	0.63 (0.45–0.87)	− 3.84 (− 6.7 to − 0.98)	26 (15 to 102)	Moderate[a]
NIPPV vs HFNC	1.04 (0.78–1.38)	− 1.34 (− 4.4 to 1.72)	N/A	Low[a,b]
HFNC + NIPPV vs conventional oxygen	0.38 (0.19–0.74)	− 10.25 (− 18.49 to − 2.01)	10 (6 to 50)	Moderate[a]
HFNC + NIPPV vs NIPPV	0.58 (0.3–1.11)	− 5.07 (− 13.38 to 3.24)	N/A	Low[a,b]
HFNC + NIPPV vs HFNC	0.6 (0.33–1.08)	− 6.41 (− 14.13 to 1.31)	N/A	Low[a,b]

Table 3 Network estimates evaluating the efficacy of the interventions for prevention of short-term all-cause mortality in critically ill adults

Comparison	Network odds ratio (95% CI)	Absolute risk difference (95% CI)	GRADE
NIPPV vs conventional oxygen	0.8 (0.61–1.04)	− 1.65 (− 3.81 to 0.5)	Moderate[b]
HFNC vs conventional oxygen	0.9 (0.66–1.24)	− 0.29 (− 1.58 to 1.01)	Low[a]
NIPPV vs HFNC	0.89 (0.69–1.13)	− 1.37 (− 3.47 to 0.72)	Moderate[b]
HFNC + NIPPV vs conventional oxygen	0.95 (0.56–1.62)	0.41 (− 5.36 to 6.18)	Low[a]
HFNC + NIPPV vs NIPPV	1.19 (0.73–1.95)	2.07 (− 3.93 to 8.07)	Low[a]
HFNC + NIPPV vs HFNC	1.05 (0.69–1.62)	0.7 (− 4.93 to 6.33)	Low[a]

Predictors of Intubation in Patients With Acute Hypoxemic Respiratory Failure Treated With a Noninvasive Oxygenation Strategy*

Multivariate Logistic Regression Analyses of Factors Associated With Intubation

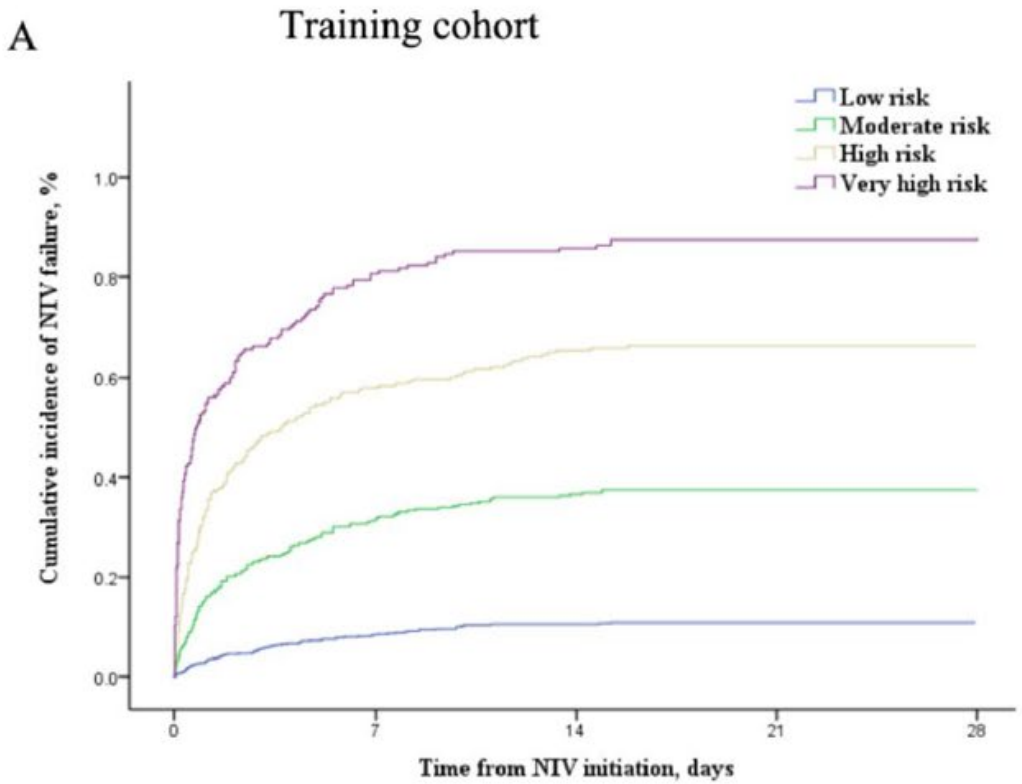
Risk Factors	OR (95% CI)	*p*
In patients treated with conventional O_2 therapy by nonrebreathing mask[a]		
Respiratory rate ≥ 30 breaths/min at H1	2.76 (1.13–6.75)	0.03
In patients treated with high-flow nasal cannula oxygen therapy[a]		
Heart rate at H1 (per beat/min)	1.03 (1.01–1.06)	< 0.01
In patients treated with noninvasive ventilation[ab]		
Tidal volume > 9 mL/kg of predicted body weight at H1	3.14 (1.22–8.06)	0.02
Pao_2/Fio_2 ≤ 200 mm Hg at H1	4.26 (1.62–11.16)	0.003

1 hour after non-invasive O2 therapy is important!

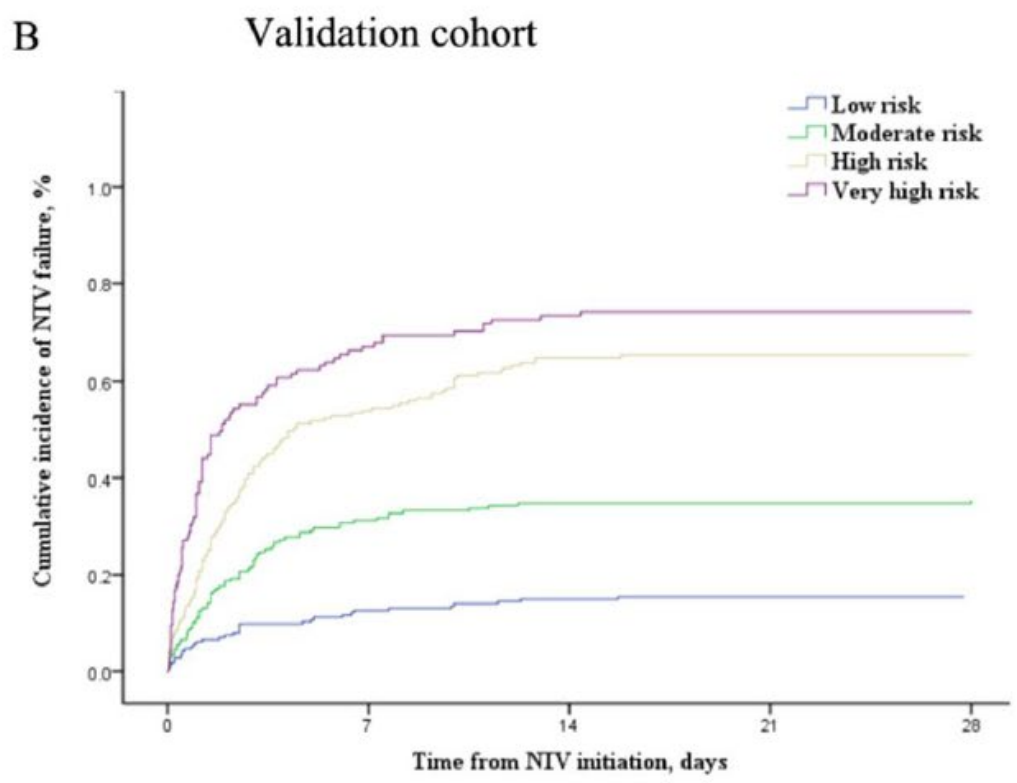
Crit Care Med 2018; 46:208–215

An updated HACOR score for predicting the failure of noninvasive ventilation: a multicenter prospective observational study

Jun Duan[1*†], Lijuan Chen[2†], Xiaoyi Liu[3†], Suha Bozbay[4†], Yuliang Liu[1†], Ke Wang[5†], Antonio M. Esquinas[6],



Number of patients					
Low risk	700	641	626	624	623
Moderate risk	338	232	214	211	209
High risk	238	100	82	80	79
Very high risk	175	34	25	22	20



Number of patients					
Low risk	214	187	182	181	181
Moderate risk	198	136	129	129	129
High risk	191	88	67	66	64
Very high risk	125	41	33	32	31

Points for each variable in the original HACOR score 1-2 hours after NIV application

Variable	Category	Points
Heart rate, beats/min	<120	0
	≥121	1
pH (**A**cidosis)	≥7.35	0
	7.30–7.34	2
	7.25–7.29	3
	<7.25	4
GCS (**C**onsciousness)	15	0
	13–14	2
	11–12	5
	≤10	10
PaO_2/FiO_2 (**O**xygenation), mmHg	≥201	0
	176–200	2
	151–175	3
	126–150	4
	101–125	5
	≤100	6
Respiratory rate, breaths/min	≤30	0
	31–35	1
	36–40	2
	41–45	3
	≥46	4

Duan *et al. Critical Care* (2022) 26:196

Basic score for predicting NIV failure in the training cohort

Variable	Regression coefficient β per unit increase	Weight $(\beta/\beta_{reference}) \times 0.5$	**Assigned points**
Pneumonia	0.90	0.90/0.19 × 0.5 = 2.37	**2.5**
CPE	–1.59	–1.59/0.19 × 0.5 = –4.18	**–4**
Presence of pulmonary ARDS	1.11	1.11/0.19 × 0.5 = 2.932	**3**
Presence of immunosuppression	0.54	0.54/0.19 × 0.5 = 1.42	**1.5**
Presence of septic shock	0.96	0.96/0.19 × 0.5 = 2.53	**2.5**
SOFA score	0.19	0.19/0.19 × 0.5 = 0.5	**0.5 × SOFA**

Fig. 3 Cumulative incidence of NIV failure in patients at low, moderate, high, and very high risk for NIV failure when the updated HACOR score is assessed after 1–2 h of NIV. Patients with updated HACOR scores of ≤ 7, 7.5–10.5, 11–14, and > 14, respectively, were classified as being at low, moderate, high, and very high risk for NIV failure. NIV = noninvasive ventilation, HACOR = heart rate, acidosis, consciousness, oxygenation, and respiratory rate

Predictive power for NIV failure of the updated HACOR score

Cutoff value	SE	SP	PPV	NPV	+LR	−LR
Training cohort						
After 1–2 h of NIV, $N=1451$						
>7	84.9%	67.3%	59.8%	88.6%	2.59	0.22
>10.5	59.9%	89.6%	76.8%	79.6%	5.76	0.45
>14	29.5%	97.9%	89.1%	70.8%	14.31	0.72
After 12 h of NIV, $N=1133$						
>7	84.0%	71.2%	58.5%	90.2%	2.92	0.22
>10.5	55.0%	91.8%	76.3%	80.9%	6.67	0.49
>14	20.9%	99.5%	95.1%	72.2%	39.86	0.80
After 24 h of NIV, $N=942$						
>7	77.9%	73.5%	56.6%	88.2%	2.94	0.30
>10.5	51.7%	93.4%	77.7%	81.3%	7.84	0.52
>14	21.0%	99.2%	92.4%	73.9%	27.4	0.80
Validation cohort						
After 1–2 h of NIV, $N=728$						
>7	89.9%	45.3%	57.4%	84.6%	1.64	0.22
>10.5	67.7%	76.5%	70.3%	74.3%	2.88	0.42
>14	29.0%	92.5%	76.0%	61.4%	3.86	0.77
After 12 h of NIV, $N=633$						
>7	90.5%	51.2%	56.7%	88.4%	1.85	0.19
>10.5	60.3%	79.0%	66.9%	73.8%	2.87	0.50
>14	27.5%	95.2%	80.0%	65.0%	5.66	0.76
After 24 h of NIV, $N=552$						
>7	90.5%	53.2%	56.3%	89.3%	1.93	0.18
>10.5	66.1%	78.3%	67.0%	77.5%	3.04	0.43
>14	23.5%	95.2%	76.5%	65.1%	4.87	0.80

Sullivan *et al. Journal of Intensive Care* (2022) 10:3
https://doi.org/10.1186/s40560-021-00593-1

Journal of Intensive Care

REVIEW Open Access

Noninvasive respiratory support for COVID-19 patients: when, for whom, and how?

Zachary P. Sullivan, Luca Zazzeron, Lorenzo Berra, Dean R. Hess, Edward A. Bittner and Marvin G. Chang*

Table 1 Indications for NIV and HFNC in the setting of Acute Respiratory Failure

Indications for NIV in the Setting of Acute Respiratory Failure
1) Known patient history of OSA, COPD, congestive heart failure, or cardiogenic pulmonary edema [46, 47]
2) Hypercapnic respiratory failure
3) Dyspnea or staccato speech [48, 49]
Indications for HFNC in the Setting of Acute Respiratory Failure
1) $PaO_2 < 65$ or $SpO_2 < 90\%$ on supplemental oxygen [48]
2) RR > 25 [49]
3) Mild ARDS as defined by $PaO_2/FiO_2 < 300$ but > 200 [24, 49]

Table 2 Contraindication to Non-invasive Ventilation (NIV)

Contraindications to NIV
1) Cardiac and respiratory arrest
2) Encephalopathy or altered mentation [37]
3) Severe hypoxaemia on admission defined as $PaO_2/FiO_2 < 150$ [50]
4) Pneumothorax, pleural effusion, or pulmonary embolism [49]
5) Active upper gastrointestinal bleed, emesis, or aspiration risk [37]
6) Recent facial trauma or facial surgery [37]
7) Hemodynamic instability as defined by vasopressor use [37, 51]
8) Multiorgan dysfunction or failure [51]
9) SOFA score > 5 is predictive of NIV failure [51, 52]
10) Poorly controlled respiratory secretions [37, 39, 53]
11) CXR/CT showing evidence of bilateral, multilobar involvement [39, 51–53]

Table 3 Appropriate monitoring of Noninvasive Respiratory Support (NIRS)

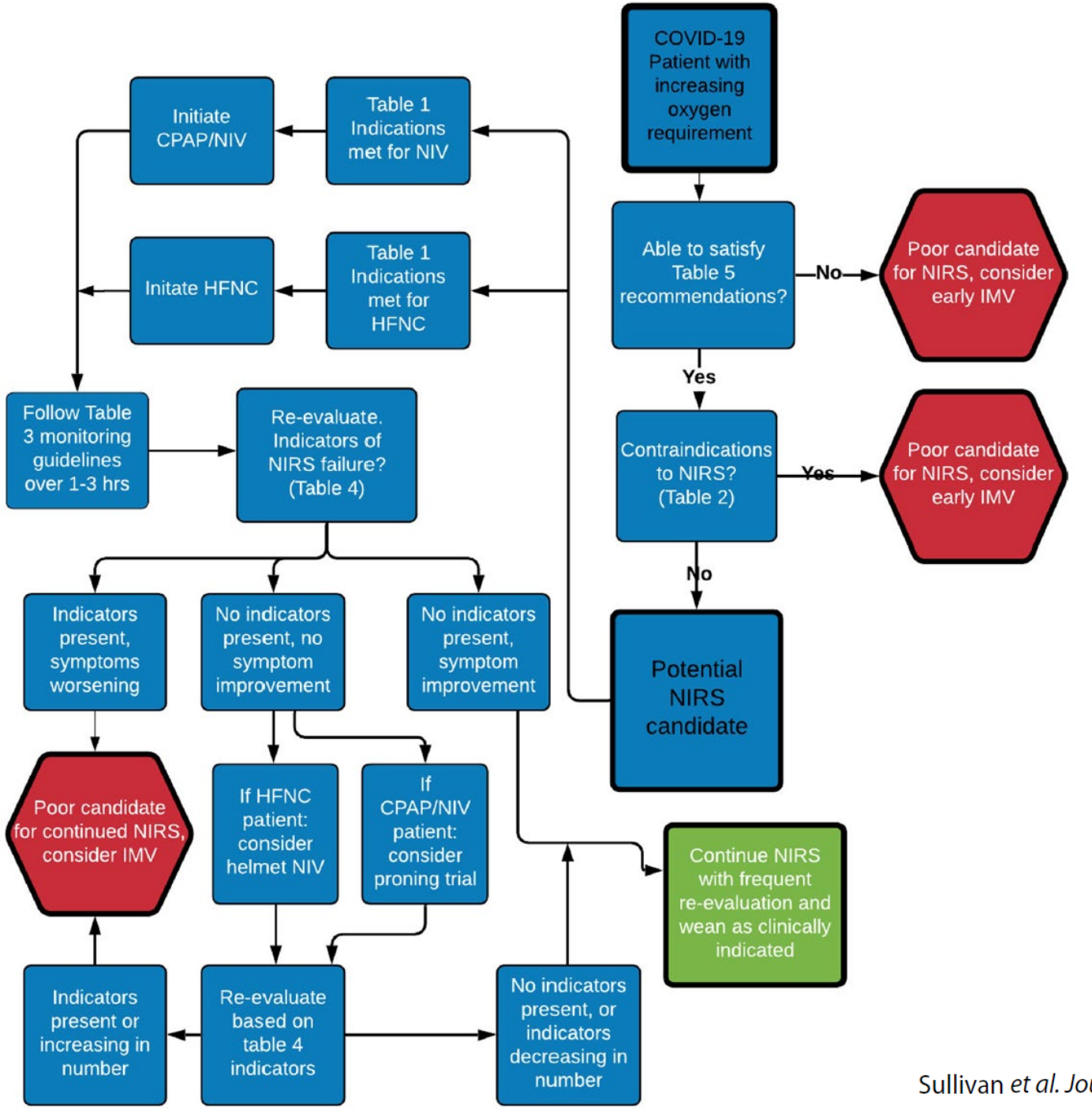
Appropriate Monitoring of Noninvasive Respiratory Support
1) Hourly lab assessment (for 3 h)
a) ABG including PaO_2, $PaCO_2$, bicarbonate, lactate, and base excess
b) PaO_2/FiO_2 (target $PaO_2/FiO_2 > 300$) [24, 50]
c) Subjective improvement or worsening of dyspnea [4]
2) Continuous monitoring (for 3 h):
a) Heart rate and respiratory rate trends [4, 24]
b) Pulse oximetry and FiO_2 requirement
c) Tidal volume measurement if utilizing CPAP or NIV [21, 43, 54]

Table 4 Primary and Secondary Indicators of Noninvasive Respiratory (NIRS) failure

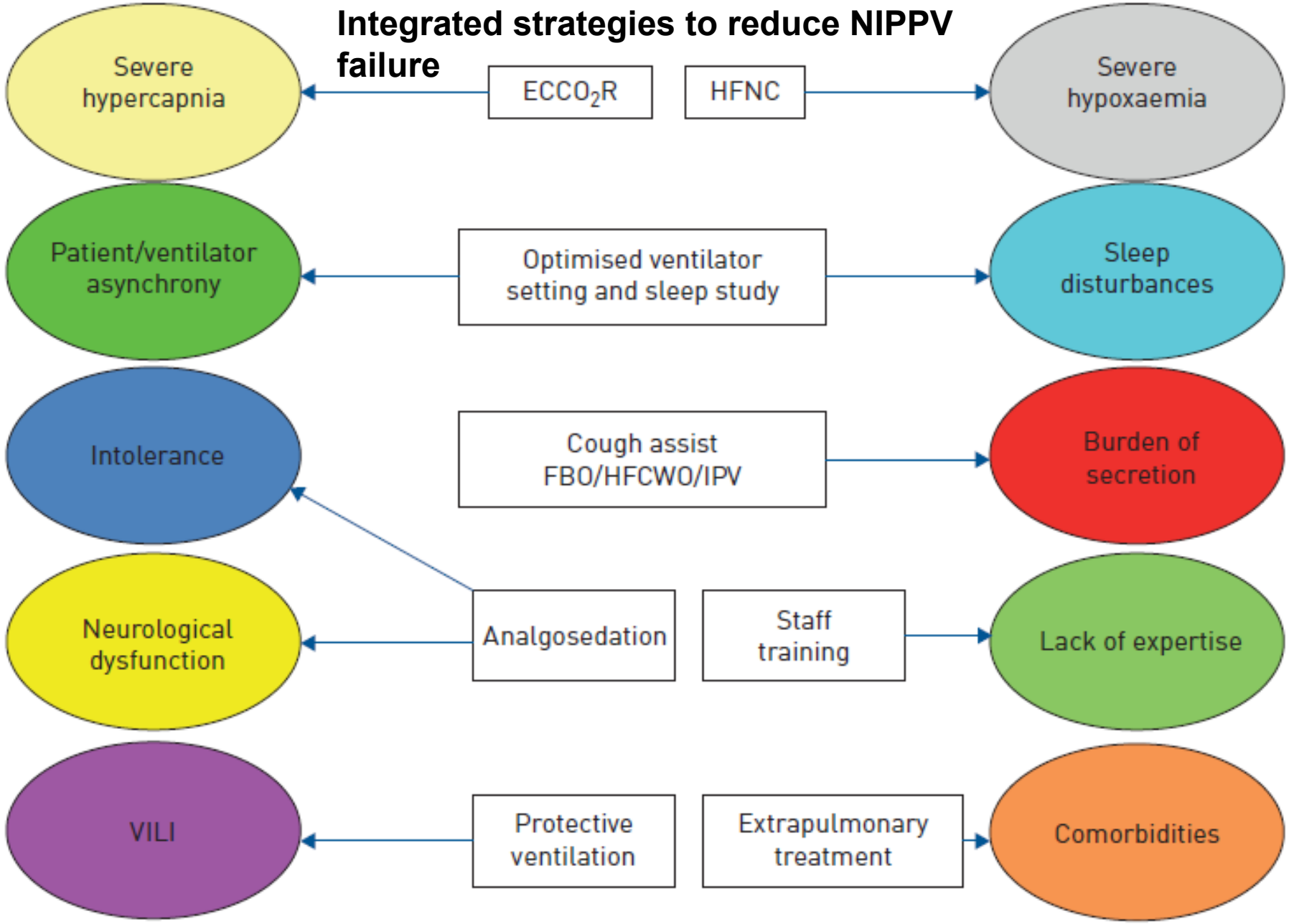
Primary Indicators of Noninvasive Respiratory Support Failure
1) $PaO_2/FiO_2 < 150$ or inability to improve PaO_2/FiO_2 after 1 h of NIV [39, 50, 55]
2) Worsening/unimproved dyspnea or tachypnea > 25 after 1 h of NIV [24, 39, 53, 56]
3) Failure to maintain PaO_2 of 60 on FiO_2 of 0.6 [39, 53]
4) $SpO_2/FiO_2 < 196$ [35]
5) Tidal volume of > 9 ml/kg predicted body weight [21, 43, 54]
6) ROX value less than 2.85 at 2 h, less than 3.47 at 6 h, or less than 3.85 at 12 h predict HFNC failure [57]
7) pH < 7.25 or $PaCO_2 > 75$ after 2 h of NIV [42]
Secondary Indicators of Noninvasive Respiratory Support Failure
1) SAPS II > 35, APACHE II > 17, or rising SOFA score [39, 51, 52, 55]
2) High peak pressure requirement [39, 53]
3) Worsening bronchorrhea [39, 53]
4) Intolerance of mask [39, 53]

Table 5 Safety considerations for Noninvasive Respiratory Support (NIRS) in COVID patients

Safety Considerations for Noninvasive Respiratory Support in COVID patients
1) Isolated negative pressure environment (room, hood, tent) [44]
a) Preferably with anteroom and private bathroom
2) Full contact, droplet, and airborne isolation precautions [44]
3) Full PPE that includes PAPR or N-95, gown, gloves, and face/eye shield [4]
4) Escalation of care to ICU for rapidly increasing O_2 requirement or patients on NIV
5) NIV with helmet and tight air cushion or unvented oronasal mask [9]
a) Dual limb circuit over single limb circuits when utilizing CPAP or NIV
6) For single limb circuit, filter over leak port
7) Viral–bacterial filter between mask and exhalation port [4]
8) Staffing that allows for close monitoring to assess for deterioration
9) Sterile equipment nearby in preparation for emergent intubation in the event of rapid deterioration
10) Daily monitoring of HCW for symptoms[1]


COVID-19 Patient with increasing oxygen requirement
Able to satisfy Table 5 recommendations?
No
Poor candidate for NIRS, consider early IMV
Yes
Contraindications to NIRS? (Table 2)
Yes
Poor candidate for NIRS, consider early IMV
No
Potential NIRS candidate
Table 1 Indications met for NIV
Initiate CPAP/NIV
Table 1 Indications met for HFNC
Initate HFNC
Follow Table 3 monitoring guidelines over 1-3 hrs
Re-evaluate. Indicators of NIRS failure? (Table 4)
Indicators present, symptoms worsening
No indicators present, no symptom improvement
No indicators present, symptom improvement
Poor candidate for continued NIRS, consider IMV
If HFNC patient: consider helmet NIV
If CPAP/NIV patient: consider proning trial
Continue NIRS with frequent re-evaluation and wean as clinically indicated
Indicators present or increasing in number
Re-evaluate based on table 4 indicators
No indicators present, or indicators decreasing in number

Integrated strategies to reduce NIPPV failure



Eur Respir Rev 2018; 27: 180029

BTS/ICS guideline for the ventilatory management of acute hypercapnic respiratory failure in adults

Indications for NIV

COPD
pH <7.35
pCO2 >6.5
RR>23
If persisting after bronchodilators and controlled oxygen therapy

Neuromuscular disease
Respiratory illness with RR > 20 if usual VC <1L even if pCO2< 6.5
Or
pH < 7.35 and pCO2> 6.5

Obesity
pH <7.35, pCO2>6.5, RR>23
Or
Daytime pCO2> 6.0 and somnolent

Contraindications for NIV

Absolute
Severe facial deformity
Facial burns
Fixed upper airway obstruction

Relative
pH<7.15
(pH<7.25 and additional adverse feature)
GCS <8
Confusion/agitation
Cognitive impairment (warrants enhanced observation)

Indications for referral to ICU
AHRF with impending respiratory arrest

NIV failing to augment chest wall movement or reduce pCO2

Inability to maintain Sao2 > 85-88% on NIV

Need for IV sedation or adverse features indicating need for closer monitoring and/or possible difficult intubation as in OHS, DMD.

NIV SETUP

Mask
Full face mask (or own if home user of NIV)

Initial Pressure settings
EPAP: 3 (or higher if OSA known/expected)

IPAP in COPD/OHS/KS 15 (20 if pH <7.25)

Up titrate IPAP over 10-30 mins to IPAP 20—30 to achieve adequate augmentation of chest/abdo movement and slow RR

IPAP should not exceed 30 or EPAP 8* without expert review

IPAP in NM 10 (or 5 above usual setting)

Backup rate
Backup Rate of 16-20. Set appropriate inspiratory time

I:E ratio
COPD 1:2 to 1.3
OHS, NM & CWD 1:1

Inspiratory time
0.8-1.2s COPD
1.2-1.5s OHS, NM & CWD

Use NIV for as much time as possible in 1st 24 hours.
Taper depending on tolerance & ABGs over next 48-72 hours

SEEK AND TREAT REVERSIBLE CAUSES OF AHRF

NIV Monitoring

Oxygenation

Aim 88-92% in all patients

Note: Home style ventilators CANNOT provide > 50% inspired oxygen.

If high oxygen need or rapid desaturation on disconnection from NIV consider IMV.

Red flags
pH <7.25 on optimal NIV
RR persisting > 25
New onset confusion or patient distress

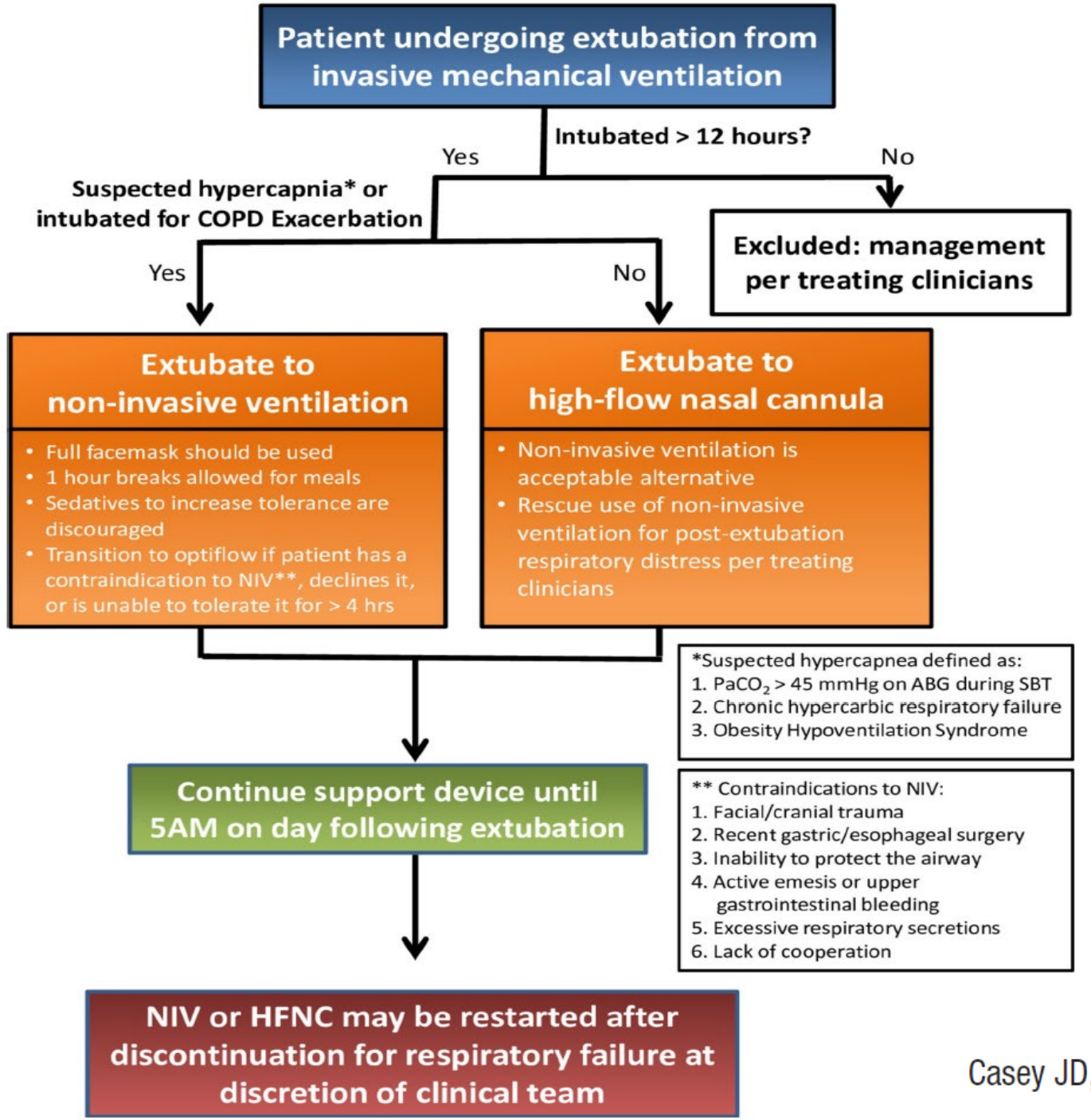
Actions
Check synchronisation, mask fit, exhalation port : give physiotherapy/bronchodilators, consider anxiolytic

CONSIDER IMV

NIV Not indicated
Asthma/Pneumonia
Refer to ICU for consideration IMV if increasing respiratory rate/distress
or
pH <7.35 and pCO2 >6.5

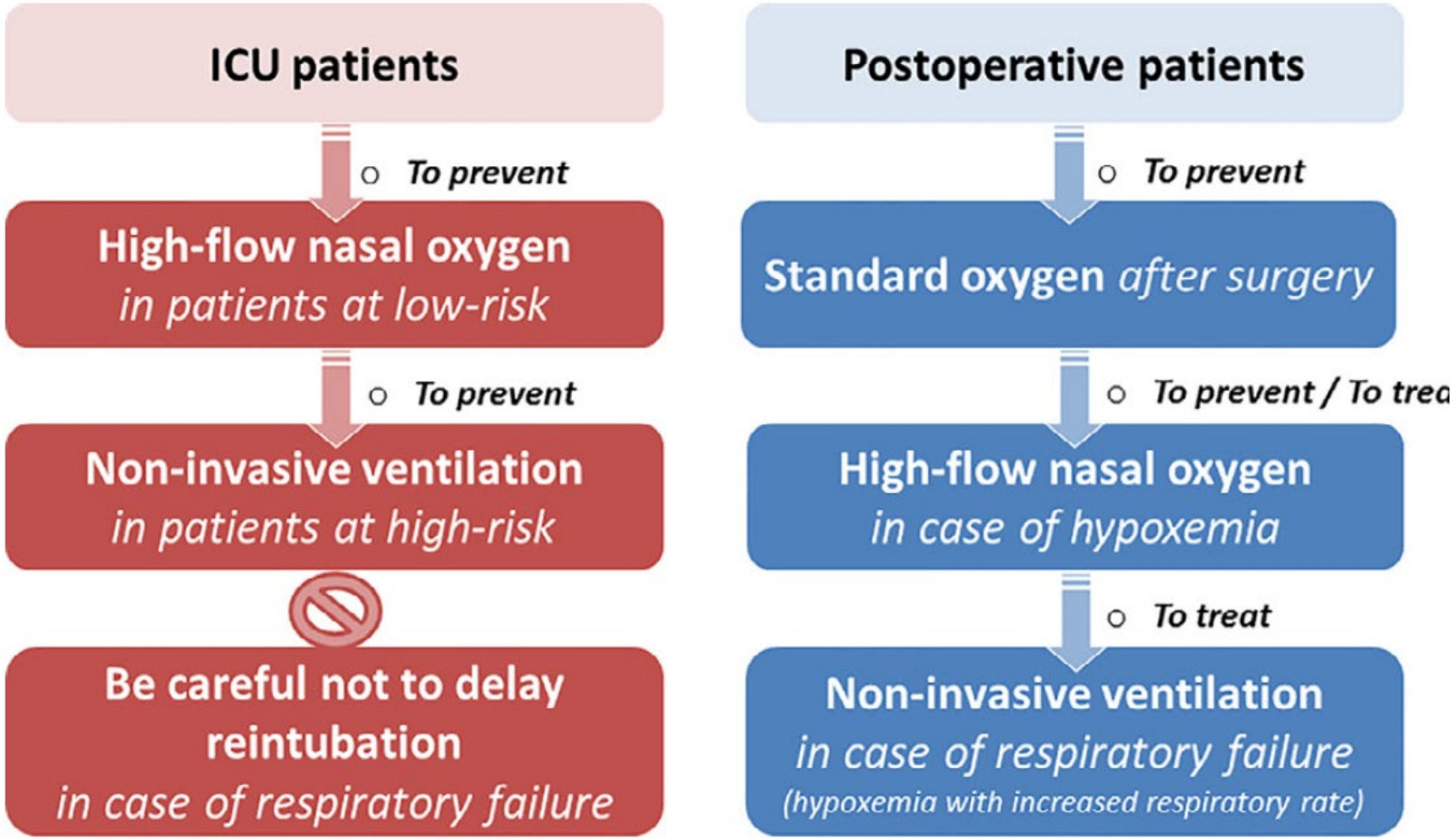
*** Possible need for EPAP > 8**
Severe OHS (BMI >35), lung recruitment eg hypoxia in severe kyphoscolios, oppose intrinsic PEEP in severe airflow obstruction or to maintain adequate PS when high EPAP required

Davidson AC, *et al. Thorax* 2016;**71**:ii1–ii35.



Casey JD, *et al. BMJ Open* 2019;**9**:e030476.

Proposal of management of oxygenation strategies to prevent or treat respiratory failure in patients extubated in ICUs



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Summary

- NIPPV and HFNC are widely used in the critical care area and it is the first-line intervention for certain forms of ARF
- Explore the results of clinical studies on NIPPV and HFNC is very important to avoid drawbacks and to reduce the rate of failure during its application.
- Understanding principle of functioning of ventilator and modes will lead the operator to choose the best approach for patients.

謝謝聆聽!