Non-Invasive Support

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Management of

HYPOXEMIA in COVID-19 Pneumonia

: A case approach

A Rational Critical Care Management

LIVE Webinar
10 มิถุนายน 2563
18.00 - 19.30 น.

From Oxygen Therapy to Mechanical Ventilation

Before Intubation

อ. นพ. สัณฐิติ โมรากุล

รพ.รามาธิบดี

After Intubation

ผศ. พิเศษ พญ. ณับผลิกา กองพลพรหม

ผู้ช่วยศาสตราจารย์พิเศษ ภาควิชาอายุรศาสตร์
คณะแพทยศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

Refractory Hypoxemia

พ.อ. นพ. ครรชิต ปิยะเวชวิรัช

อาจารย์ที่ปรึกษา แผนกโรคปอดและเวชบำบัดวิกฤติ
รพ.พระมงกุฎเกล้า

ลงทะเบียนฟรี

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สมาคมเวชบำบัดวิกฤตแห่งประเทศไทย
THE THAI SOCIETY OF CRITICAL CARE MEDICINE

Live Webinar

Respiratory Support in COVID-19 Patients

วันอาทิตย์ที่ 2 พฤษภาคม 2564
เวลา 15.00 ถึง 17.00 น.

Moderator

พ.อ. นพ.ครรชิต ปิยะเวชวิรัตน์

- **Assessment**
  อ.พญ.นิษฐา เอื้ออารีมิตร
- **Non-Invasive Support**
  ผศ.นพ.สัณฐิติ โมรากุล
- **Post Intubation**
  พล.ท. นพ.อดิศร วงษา

ลงทะเบียนฟรี

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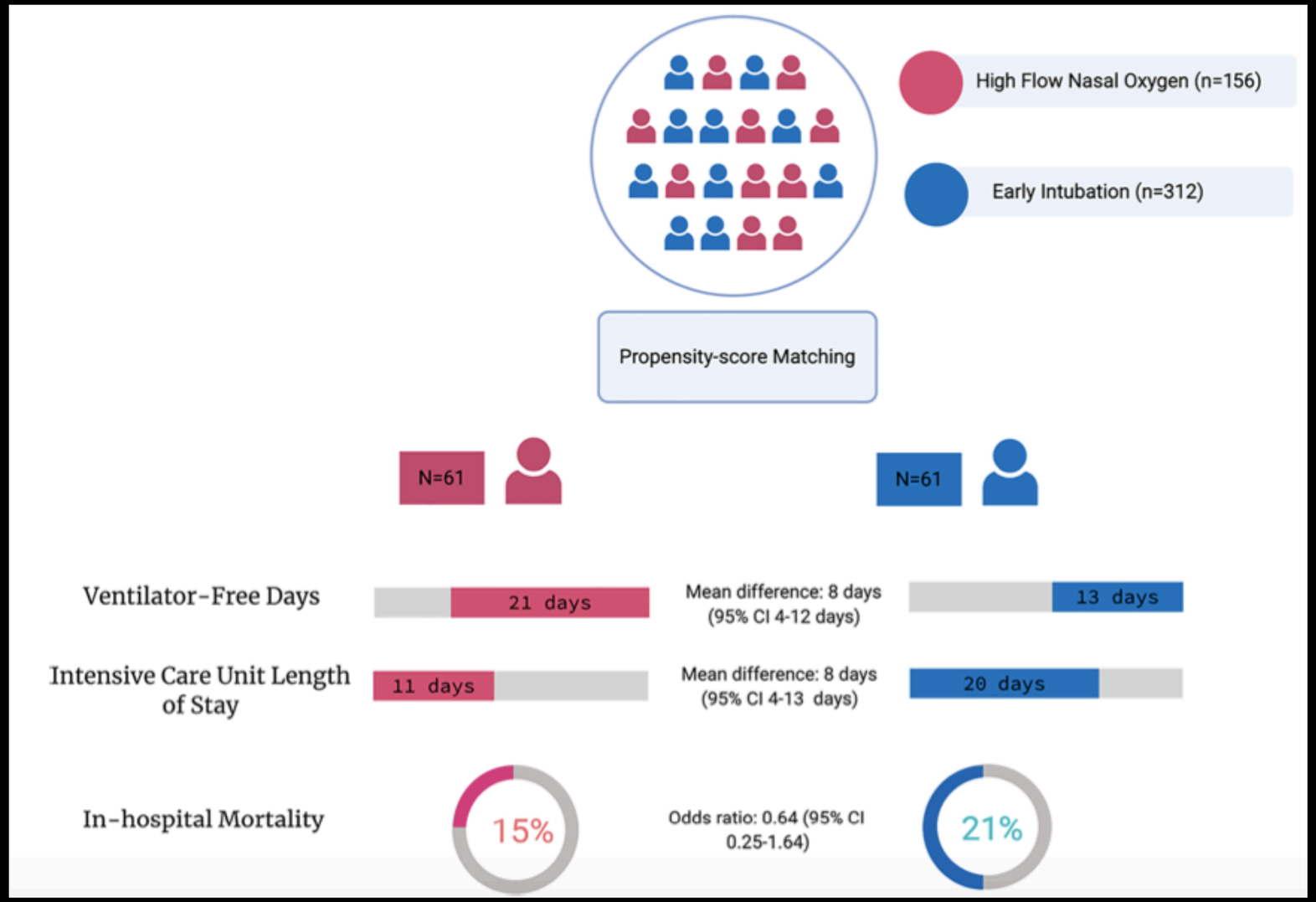
From 1st wave to 3rd wave of the COVID-19 pandemic

- Early intubation was preferred in early pandemic
- Non-invasive respiratory support are more attractive now
    - Conventional oxygen therapy
    - HFNC
    - CPAP and NIV
    - Awake-proning

High-flow nasal oxygen in patients with COVID-19-associated acute respiratory failure



A multicentre cohort study using a prospectively collected database of patients with COVID-19 associated acute respiratory failure admitted to 36 Spanish ICU

Mellado-Artigas et al. Crit Care Feb (2021) 25:58

From 1st wave to 3rd wave of the COVID-19 pandemic

- A key treatment goal is to avoid, where possible, the need for invasive mechanical ventilation
- Non-invasive respiratory support strategies are attractive treatment options
  - might cause harm to patients through **delays to tracheal intubation** or exacerbation of lung injury
  - might cause **harm to health-care workers** through nosocomial infection

Non-invasive respiratory support strategies in COVID-19. Lancet Respir Med 2021

	Organisation	Guideline	Overview of non-invasive respiratory strategies*		
			HFNO	CPAP	BIPAP/NIV
GLOBAL					
	World Health Organization	Clinical management of COVID 19 (May 2020) https://www.who.int/publications/i/item/clinical-management-of-covid-19	Conditional recommendation	Conditional recommendation	Conditional recommendation
	Surviving Sepsis Campaign	Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19) (January 2021) https://journals.lww.com/ccmjournal/Abstract/9000/Surviving_Sepsis_Campaign_Guidelines_on_the.95371.aspx	Weak recommendation	Not specifically mentioned	Weak recommendation
UK					
	NHS England~	Guidance for the role and use of non-invasive respiratory support in adult patients with COVID-19 (November 2020) https://www.nice.org.uk/Media/Default/About/COVID-19/Specialty-guides/specialty-guide-NIV-respiratory-support-and-coronavirus.pdf; https://www.nice.org.uk/guidance/ng191/chapter/Recommendations	Does not support	Supports	Only for hypercapnic acute-on-chronic ventilatory failure
	British Thoracic Society/Intensive Care Society	Respiratory care in patients with Acute Hypoxaemic Respiratory Failure associated with COVID-19 (January 2021) https://www.brit-thoracic.org.uk/covid-19/covid-19-information-for-the-respiratory-community/	Supports (trial enrolment suggested#)	Supports (trial enrolment suggested#)	Not specifically mentioned
	Faculty of Intensive Care Medicine/Intensive Care Society/Association of Anaesthetists/Royal College of Anaesthetists	Clinical guide for the management of critical care for adults with COVID-19 during the coronavirus pandemic (October 2020) https://icmanaesthesiacovid-19.org/clinical-guide-for-the-management-of-critical-care-for-adults-with-covid-19-during-the-coronavirus-pandemic	Supports in the context of trial enrolment#	Supports	Consider for hypercapnic acute-on-chronic ventilatory failure

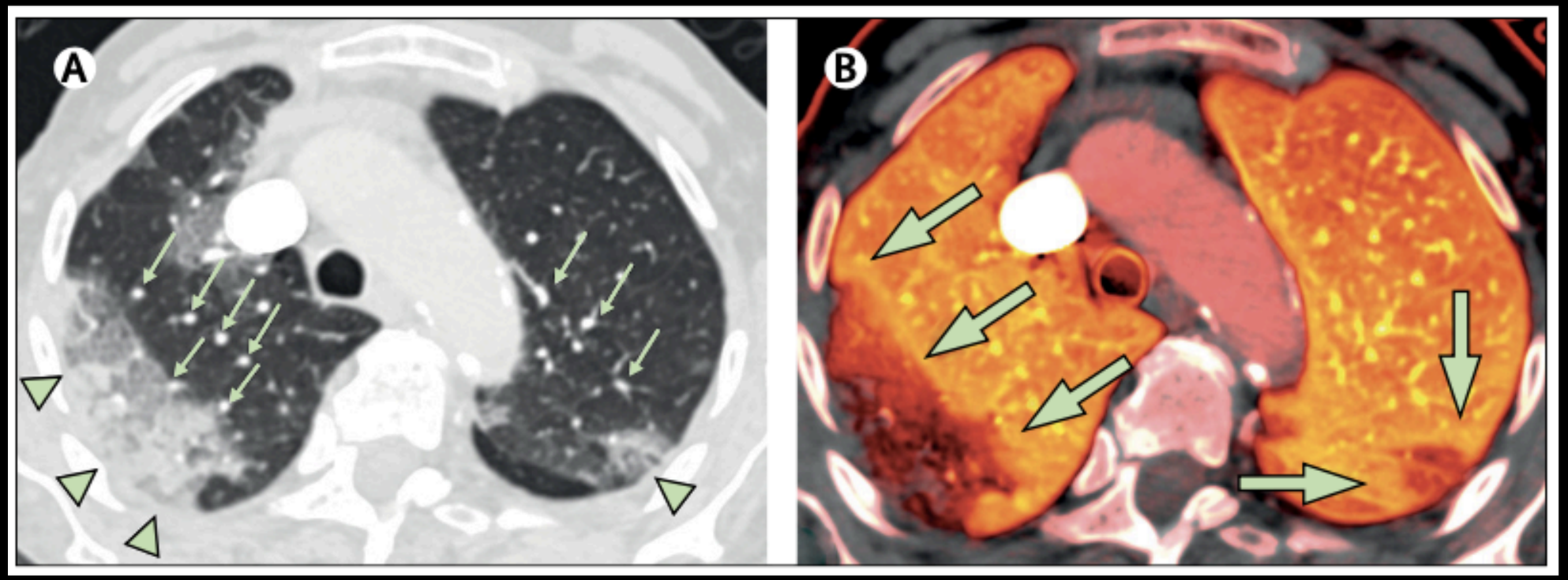
EUROPE					
	Italian Thoracic Society/Italian Respiratory Society	Managing the respiratory care of patients with COVID-19 (March 2020) https://ers.app.box.com/s/j09ysr2kdhmkcu1ulm8y8dxnosm6yi0h	Supports	Supports	Supports
	Societe de Pneumologie de Langue Francaise	Procedure for pulmonary management of non-ICU patients hospitalized in the context of the COVID-19 pandemic (April 2020) https://splf.fr/covid-19-docs-english-version/	Conditional recommendation	Conditional recommendation	Conditional recommendation
	Irish Thoracic Society	Respiratory Management of Patients with COVID-19 (January 2021) https://irishthoracicsociety.com/wp-content/uploads/2020/03/Respiratory-Mgt-Guideline-V2-Jan-2021.20.01.pdf	Supports	Supports	Only for hypercapnic acute-on-chronic ventilatory failure
	German Respiratory Society	Position statement for the State-of-the-Art Application of Respiratory Support in Patients with COVID-19 (June 2020) https://www.karger.com/Article/FullText/509104 German recommendations for critically ill patients with COVID-19 (April 2020) https://link.springer.com/article/10.1007/s00063-020-00689-w	Conditional recommendation	Conditional recommendation	Conditional recommendation
AUSTRALIA/NEW ZEALAND					
	Australia and New Zealand Intensive Care Society/National COVID-19 Clinical Evidence Taskforce	COVID-19 Guidelines (January 2021 https://www.anzics.com.au/coronavirus-guidelines/ https://covid19evidence.net.au; https://www.anzics.com.au/coronavirus-guidelines/	;	Not specifically mentioned	Conditional recommendation

Causes of Hypoxemia in COVID-19

- Intrapulmonary shunting
- Loss of lung perfusion regulation
- Intravascular microthrombi
- Impaired diffusion capacity
- Preservation of lung mechanics

The pathophysiology of ‘happy’ hypoxemia in COVID-19. Dhont et al. Respiratory Research (2020) 21:198

Hypoxemia related to COVID-19: vascular and perfusion abnormalities on dual-energy CT



Pulmonary vascular dilation might be due to failure of HPV from inflammatory proceed

V/Q missmatch

Shunt

Lang M, et al. Lancet Infect Dis 2020

Hypoxemia related to COVID-19

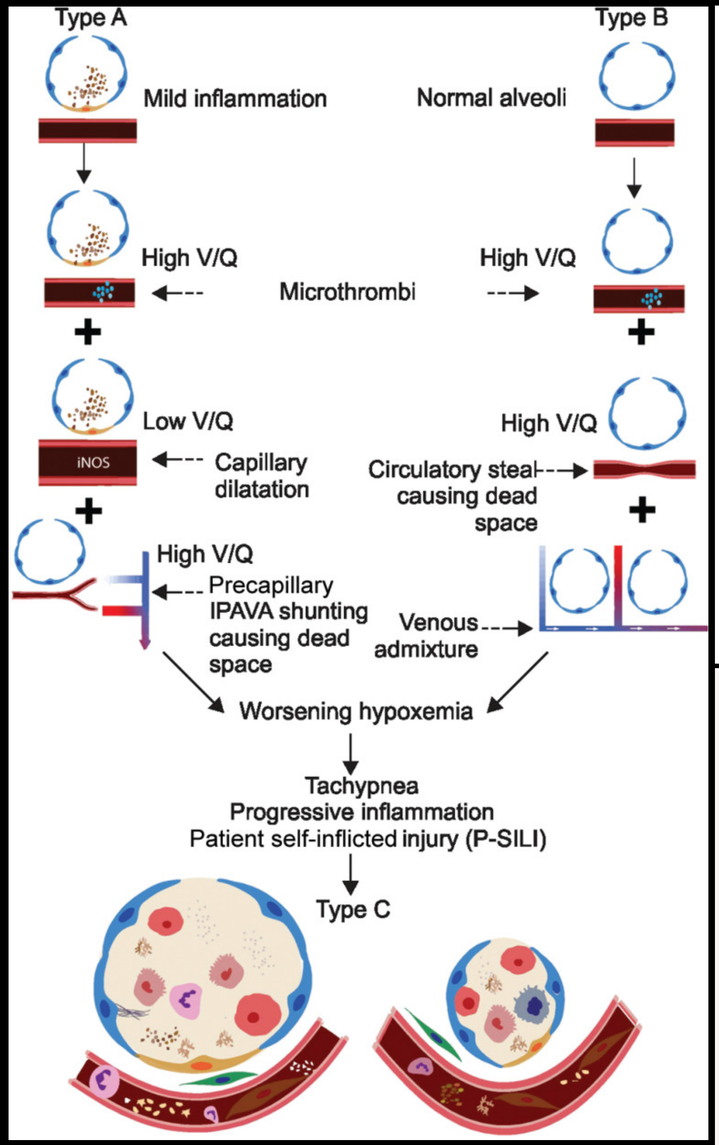
- Some patients with COVID19 and acute hypoxemic respiratory failure have preserved lung compliance
- Can’t be explain with
  - Diffuse alveolar damage (DAD)
  - Peripheral ground glass opacities with or without consolidation
- Microvascular thrombi as a possible explanation for the severe hypoxaemia related to COVID19
  - elevated D-dimer levels
  - cutaneous changes in their extremities suggesting thrombotic microangiopathy

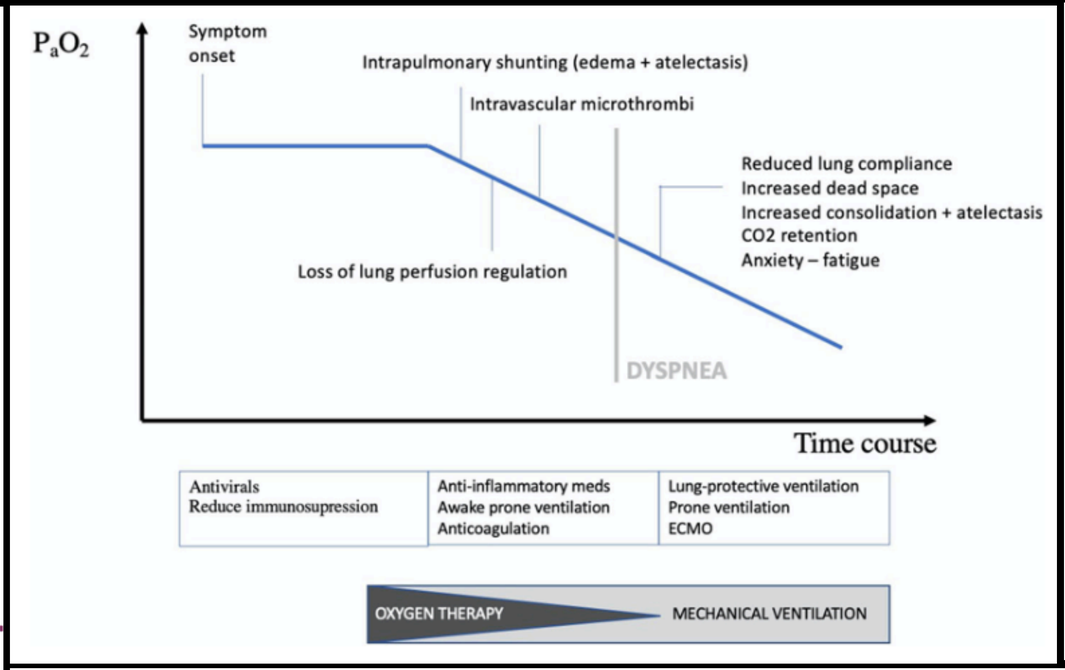
Lang M, et al. Lancet Infect Dis 2020

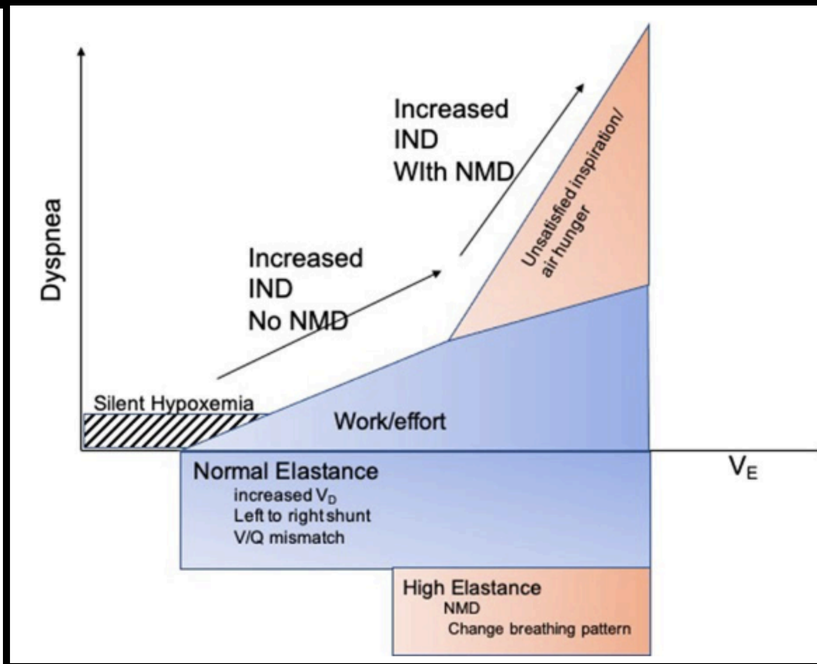
Pulmonary Vascular Endothelialitis, Thrombosis, and Angiogenesis in Covid-19

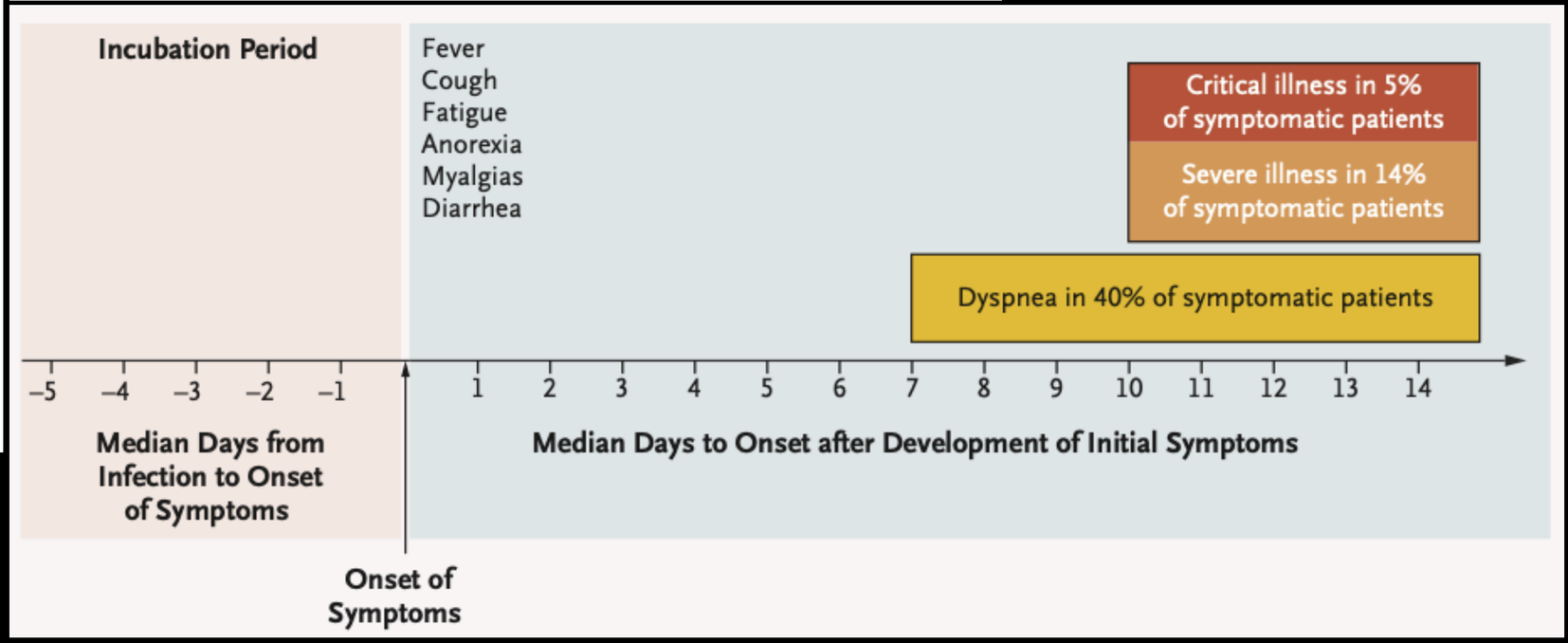
- Examined 7 lungs obtained during autopsy from patients who died from Covid-19
- DAD with distinctive vascular features
  - severe endothelial injury, intracellular virus and disrupted cell membranes
- Histologic analysis of pulmonary vessels
  - widespread thrombosis with microangiopathy
  - alveolar capillary microthrombi were 9 times
  - new vessel growth — predominantly through a mechanism of intussusceptive angiogenesis — was 2.7 time

Ackermann M, et al. nejm may 2020


Type A
Type B
Mild inflammation
Normal alveoli
High V/Q
Microthrombi
High V/Q
Low V/Q
iNOS
Capillary dilatation
High V/Q
Circulatory steal causing dead space
High V/Q
Precapillary IPAVA shunting causing dead space
Venous admixture
Worsening hypoxemia
Tachypnea
Progressive inflammation
Patient self-inflicted injury (P-SILI)
Type C


P_aO_2
Symptom onset
Intrapulmonary shunting (edema + atelectasis)
Intravascular microthrombi
Reduced lung compliance
Increased dead space
Increased consolidation + atelectasis
CO2 retention
Anxiety – fatigue
Loss of lung perfusion regulation
DYSPNEA
Time course
Antivirals
Reduce immunosupression
Anti-inflammatory meds
Awake prone ventilation
Anticoagulation
Lung-protective ventilation
Prone ventilation
ECMO
OXYGEN THERAPY
MECHANICAL VENTILATION


Dyspnea
Increased IND WIth NMD
Unsatisfied inspiration/ air hunger
Increased IND No NMD
Silent Hypoxemia
Work/effort
Normal Elastance
increased V_D
Left to right shunt
V/Q mismatch
High Elastance
NMD
Change breathing pattern
V_E


Incubation Period
Fever
Cough
Fatigue
Anorexia
Myalgias
Diarrhea
Critical illness in 5% of symptomatic patients
Severe illness in 14% of symptomatic patients
Dyspnea in 40% of symptomatic patients
−5 −4 −3 −2 −1 1 2 3 4 5 6 7 8 9 10 11 12 13 14
Median Days from Infection to Onset of Symptoms
Median Days to Onset after Development of Initial Symptoms
Onset of Symptoms

Clinical Case (1)

- 58 year old man with HT and DLP
- From symptoms onset (fever, no cough, no dyspnea)
  - Day 7 : swab ⊕
  - Day 8: hospital admission, CXR progression
    - Darunavir/Ritonavir, HCQ, Favipiravir
    - Nasal canula 5 l/min $SpO_2 > 95\%$

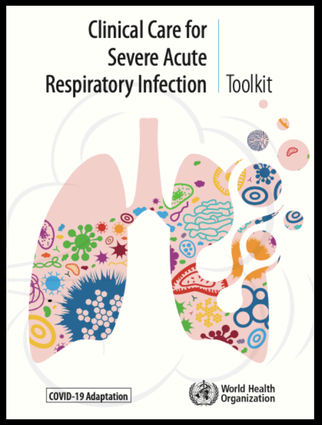
Surviving Sepsis Campaign Guidelines on the Management of Adults With Coronavirus Disease 2019 (COVID-19) in the ICU: First Update

Critical Care Medicine: March 2021

• In adults with COVID-19, we suggest starting supplemental oxygen if the peripheral SpO_2 is < 92%, and recommend starting supplemental oxygen if SpO_2 is < 90%	STRONG
• In adults with COVID-19 and acute hypoxemic respiratory failure on oxygen, we recommend that SpO_2 be maintained no higher than 96%	STRONG
• For adults with COVID-19 and acute hypoxemic respiratory failure despite conventional oxygen therapy, we suggest using HFNC over conventional oxygen therapy	WEAK

Clinical management of COVID 19

WHO May 2020

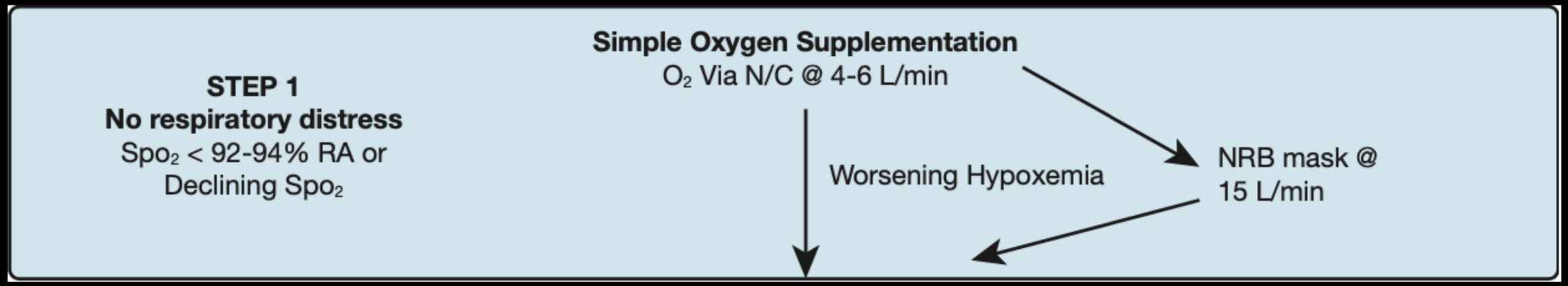


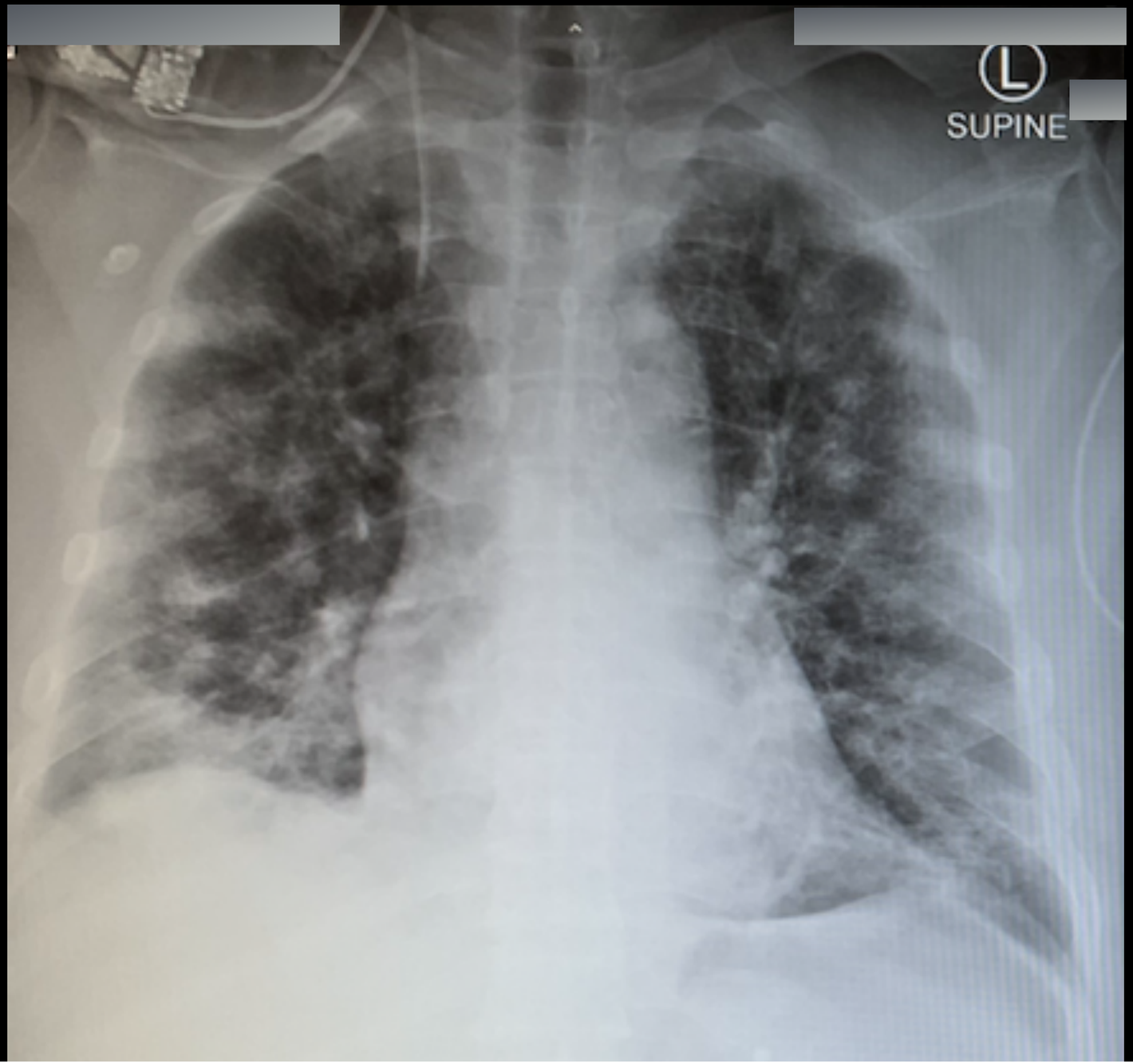
We recommend immediate administration of supplemental oxygen therapy to any patient with emergency signs during resuscitation to target SpO_2 ≥ 94% and to any patient without emergency signs and hypoxaemia (i.e. stable hypoxaemic patient) to target SpO_2 > 90% or ≥ 92–95% in pregnant women.

- Adults with emergency signs should receive emergency airway management and oxygen therapy during resuscitation to target SpO_2 ≥ 94%
- Once the patient is stable, target > 90% SpO_2 in non-pregnant adults and ≥ 92–95% in pregnant women
- Appropriate delivery devices (nasal cannula for rates up to 5 L/min; Venturi mask for flow rates 6–10 L/min; and face mask with reservoir bag for flow rates 10–15 L/min)

High-Flow, Noninvasive Ventilation and Awake (Nonintubation) Proning in Patients With Coronavirus Disease 2019 With Respiratory Failure

CHEST November 2020; 158(5):1992-2002





Multi-focal patchy consolidations both lungs with minimal bilateral pleural effusion

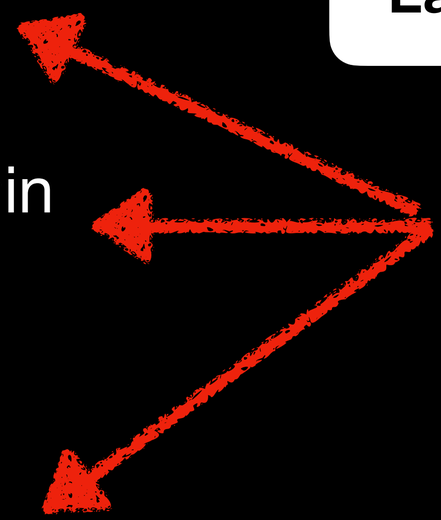
Clinical Case (1)

- **Day 9: ICU admission**
  - Nasal canula 5 l/min SpO_2 89-92%, RR 30 /min
  - Mask with bag 10 l/min SpO_2 100%, RR 24-28 /min
- **Day 12:**
  - Mask with bag 10 l/min SpO_2 95% RR 25-30/min

S/F ~ 225

S/F > 100

S/F <100



Early Intubation

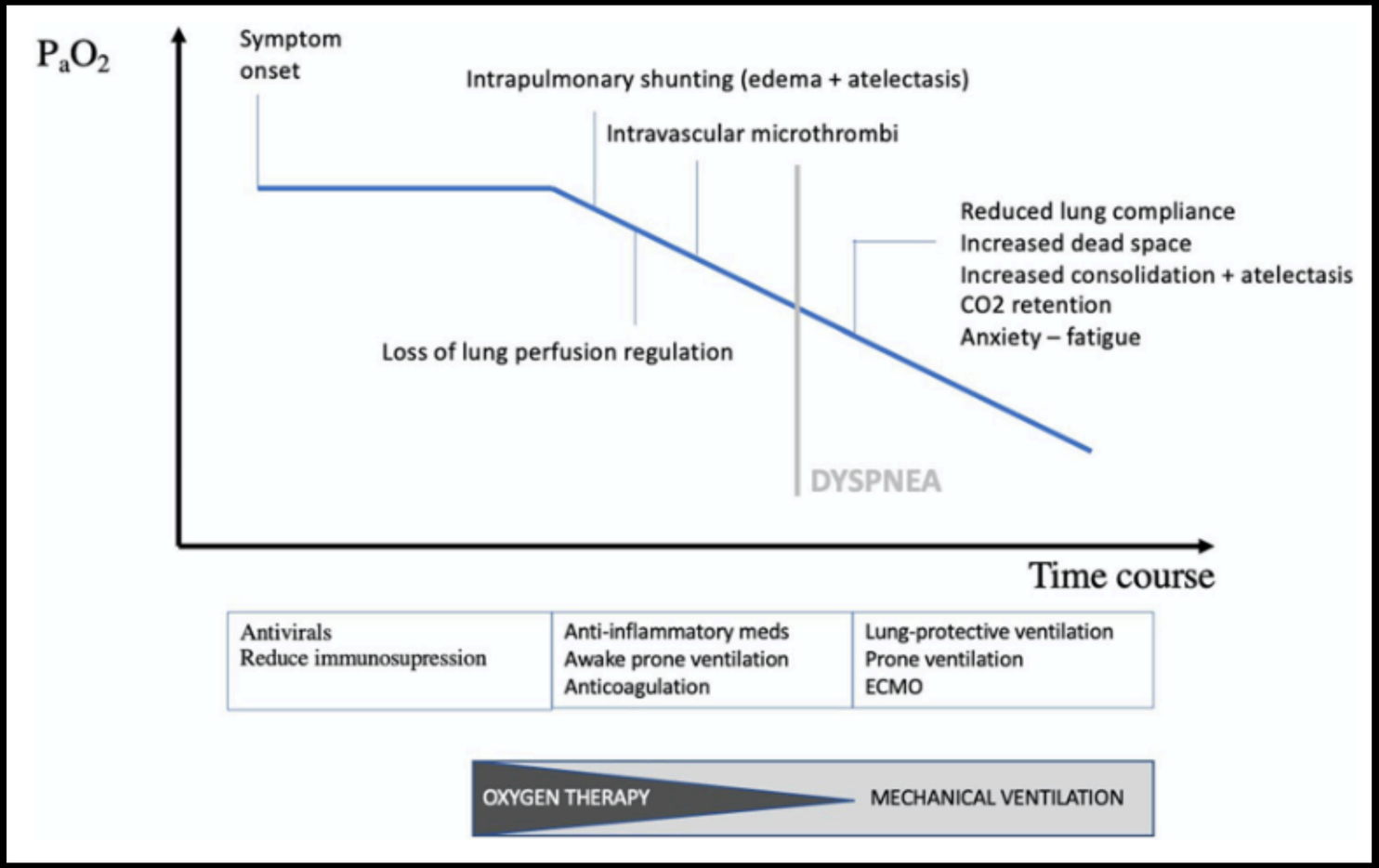
HFNC

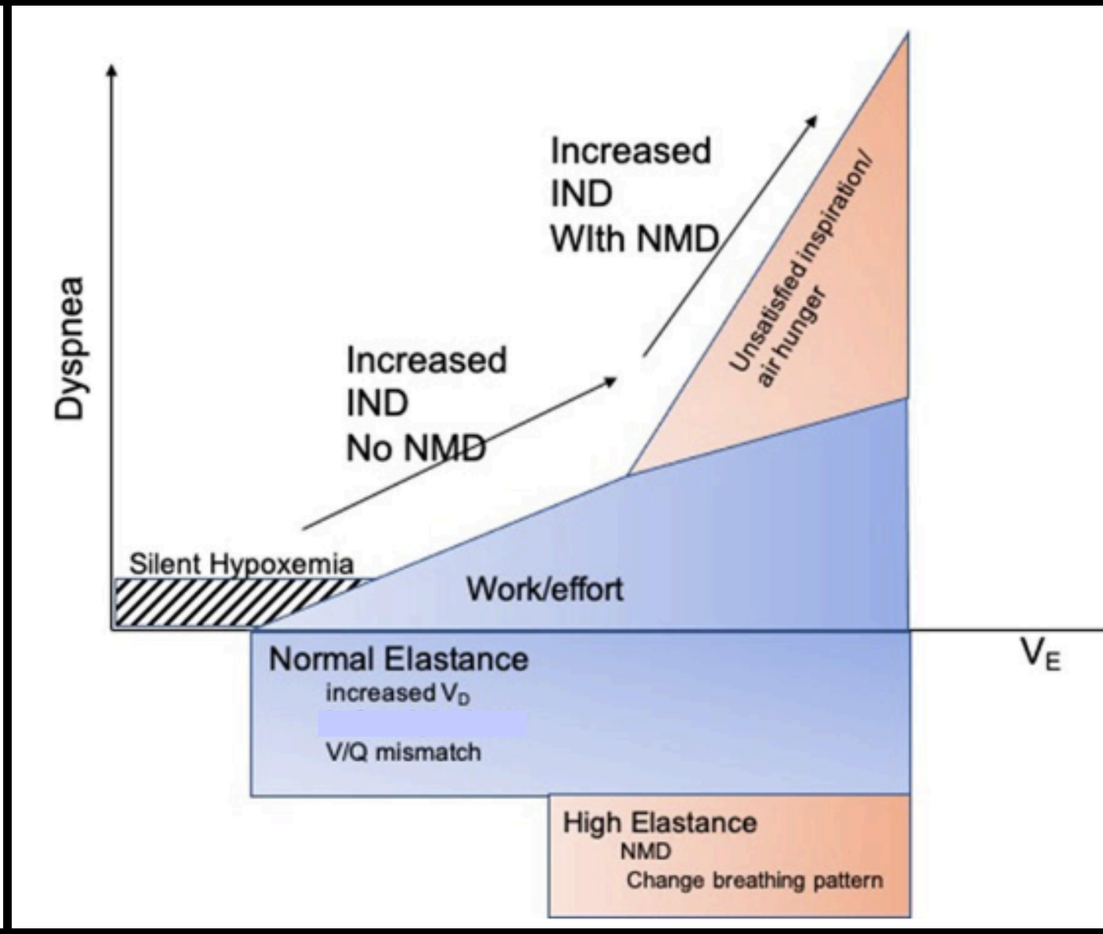
NIV

Self-proning

$SpO_2 < 92\%$

COT keep SpO_2 92-96%





Dhont et al. Respiratory Research (2020) 21:198

Advantages to HFNC

- More Reliable Oxygen Delivery
  - HFNC can better meet the inspiratory demands of patients with respiratory distress and respiratory failure
- HFNC Can Reduce Dead Space and Increase End Expiratory Lung Volumes (EELV)
  - clearance of dead space from the nasal cavities, posterior oropharynx, and proximal trachea
  - reduce rebreathing of CO_2 and improve the efficiency of ventilation
  - Despite these limitations of open mouth breathing and variable pressure during the respiratory cycle, application of high flow rates increases EELV on EIT

Suffredini DA. Journal of Intensive Care Medicine 2021, Vol. 36(1) 9-17

Advantages to HFNC

- HFNC Improves Compliance and Work of Breathing in Patients with Respiratory Failure
  - decreased work of breathing measured by the PTP and respiratory rate, decreased inspiratory effort measured by esophageal manometry and increased dynamic respiratory system compliance after receiving HFNC at 40 LPM for 20 minutes
  - HFNC is Comfortable and Well Tolerated

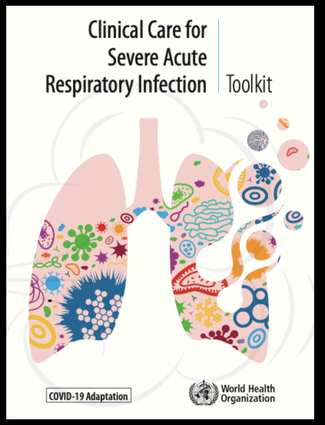
Suffredini DA. Journal of Intensive Care Medicine 2021, Vol. 36(1) 9-17

Surviving Sepsis Campaign Guidelines on the Management of Adults With Coronavirus Disease 2019 (COVID-19) in the ICU: First Update

Critical Care Medicine: March 2021

- For adults with COVID-19 and acute hypoxemic respiratory failure despite conventional oxygen therapy, **we suggest using HFNC over conventional oxygen therapy.** — WEAK
- In adults with COVID-19 and acute hypoxemic respiratory failure, **we suggest using HFNC over NIPPV.** — WEAK
- In adults with COVID-19 receiving NIPPV or HFNC, we recommend **close monitoring for worsening of respiratory status and early intubation in a controlled setting if worsening occurs.** — BEST PRACTICE MANAGEMENT

Clinical management of COVID 19



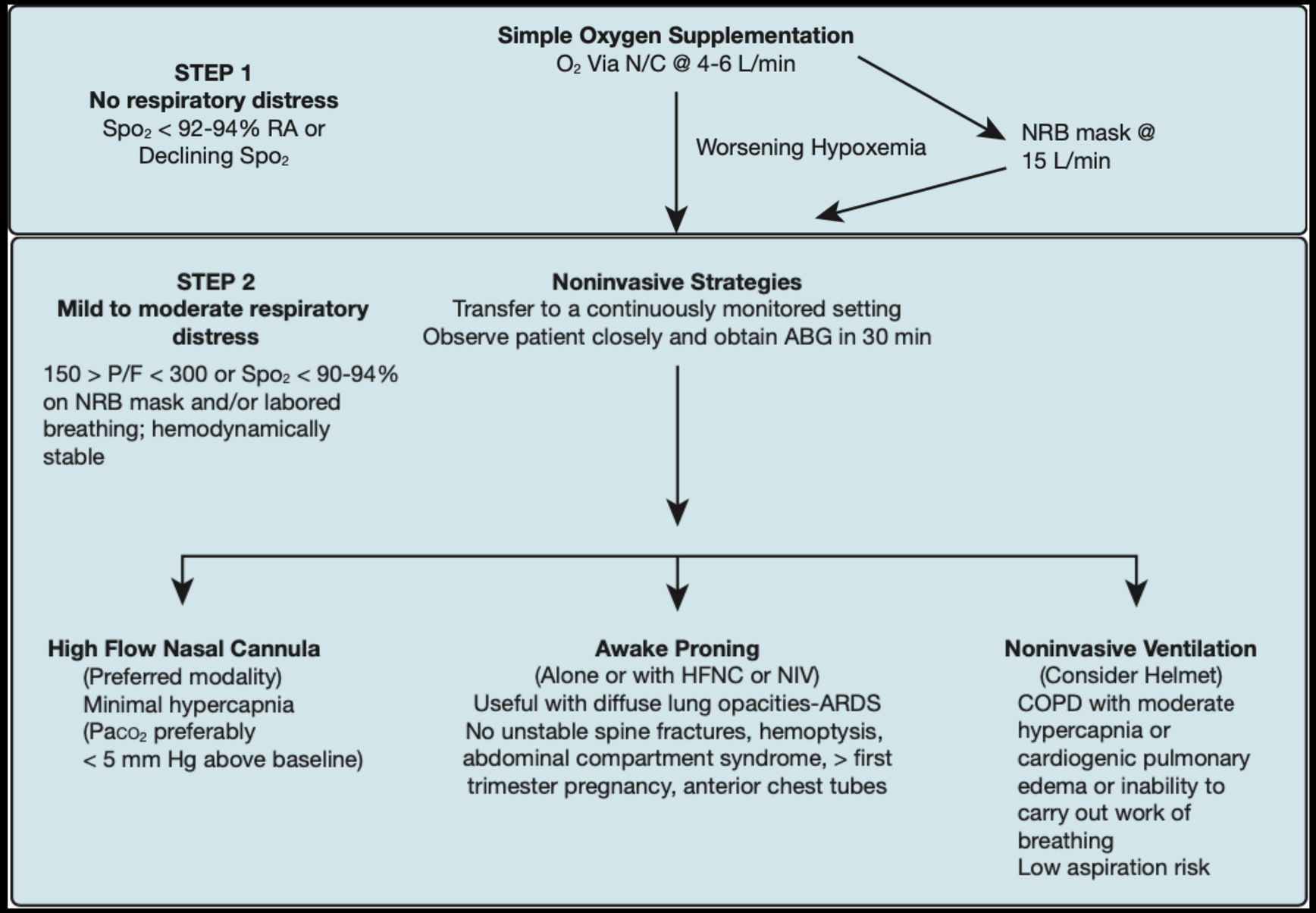
WHO May 2020

The following recommendations pertain to adult and paediatric patients with mild ARDS who are treated with non-invasive or HFNO systems.

In selected patients with COVID-19 and mild ARDS, a trial of HFNO, non-invasive ventilation – continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP) may be used. Refer to Table 6.3 for definitions of mild, moderate and severe ARDS.

- Hemodynamic instability, multiorgan failure or abnormal mental status should not receive HFNO or NIV
- Capable of performing ETT in case the patient acutely deteriorates or does not improve after a short trial (about 1 hour)
- Adult HFNO systems can deliver 60 L/min of gas flow and FiO2 up to 1.0
- Patients with hypercapnia should generally not receive HFNO

High-Flow, Noninvasive Ventilation and Awake (Nonintubation) Proning in Patients With Coronavirus Disease 2019 With Respiratory Failure



CHEST November 2020;
158(5):1992-2002

An Index Combining Respiratory Rate and Oxygenation to Predict Outcome of Nasal High-Flow Therapy

- To validate the diagnostic accuracy of ROX index for determining HFNC outcome (need or not for intubation).
  - ROX defined as the ratio of SpO_2/FIO_2 to respiratory rate
- 191 patients treated with HFNC in the validation cohort
  - 35.6% required intubation
- ROX ≥ 4.88 measured after HFNC initiation was consistently associated with a lower risk for intubation
  - 2 hours HR 0.434 (0.264–0.715); P = 0.001
  - 6 hours HR 0.304 (0.182–0.509); P < 0.001
  - 12 hours HR 0.291 (0.161–0.524); P< 0.001

Roca O, et al. Am J Respir Crit Care Med. 2019; 199(11):1368–1376

An Index Combining Respiratory Rate and Oxygenation to Predict Outcome of Nasal High-Flow Therapy

- Most intubations occur between the 12th and the 24th hour
- Monitoring the ROX index over time with a special focus from the 12th hour
- If the ROX ≥4.88: high chance of success
- Gray zone obviously exists between 3.85 and 4.88
- if the ROX <3.85: intubation should be discussed

Roca O, et al. Am J Respir Crit Care Med. 2019; 199(11):1368–1376

ROX Index to Guide Management of COVID-19 Pneumonia

	Value
Total	108
Age, years Median (IQR)	62 (53 – 68)
Gender Male, n (%)	82 (76)
Number of co-morbidities Median (IQR)	1 (0-2)
HFNC only, n (%)	69 (64%)
CPAP only, n (%)	18 (17%)
CPAP and HFNC, n (%)	21 (19%)

P/F ratio at admission (n=73) Median (IQR)	112.5 (75.3 – 266.7)
ROX index at admission (n=90) Median (IQR)	9.6 (4.3 – 17.0)
Do not intubate order at admission, n (%)	19 (21%)
Mechanical ventilation, n (%)	49 (54%)
Mortality, n (%)	33 (37%)

ANNALS ATS Articles in Press. Published February 26, 2021

ROX Index to Guide Management of COVID-19 Pneumonia

	N	AUROC	Sensitivity, %	Specificity, %
RR ≥30 respirations/min				
0h	88	0.64 (0.52 – 0.76)	36.5 (24.7 – 49.6)	84.0 (63.9 – 95.5)
2h	79	0.58 (0.47 – 0.68)	35.2 (22.7 – 49.4)	80.0 (59.3 – 93.2)
12h	57	0.53 (0.44 – 0.67)	28.6 (14.6 – 46.3)	77.3 (54.6 – 92.2)
ROX index <4.88				
0h	88	0.72 (0.60 – 0.84)	76.2 (63.8 – 86.0)	60.0 (38.7 – 78.9)
2h	82	0.78 (0.67 – 0.90)	54.4 (40.7 – 67.6)	88.0 (68.8 – 97.5)
12h	62	0.82 (0.70 – 0.94)	60.0 (43.3 – 75.1)	86.4 (65.1 – 97.1)

ANNALSATS Articles in Press. Published February 26, 2021

High-flow nasal cannula in COVID-19: Outcomes of application and examination of the ROX index to predict success

- The need for ETT after HFNC was generally based on the presence of hypoxemia
  - Failure to maintain an SpO_2 >88% despite maximal FiO_2 by the HFNC
  - RR >35 breaths/min with associated respiratory distress
- The diagnostic accuracy of a ROX index at 12 hours was the best
  - AUC 0.78; 95% CI: 0.72-0.84
  - ROX > 3.67 had a sensitivity of 84.1%, specificity of 49.4%

Respiratory Care. December 2020, respcare.08631

Application of high-flow nasal cannula in hypoxemic patients with COVID-19: a retrospective cohort study

- The best cutoff point for the ROX index at 24h was estimated to be 6.10
- A ROX index > 6.10 at 24h after HFNC onset
- a sensitivity of 90.8%, a specificity of 78.1%
- a positive predictive value of 89.4%, a negative predictive value of 80.6%

https://assets.researchsquare.com/files/rs-34561/v1/9382381f-070b-49a1-8ea6- fdfb81359421.pdf.

Application of high-flow nasal cannula in hypoxemic patients with COVID-19: a retrospective cohort study

Characteristics		Outcome of HFNC treatment		*p* value
	All patients (*n* = 105)	Success (*n* = 65)	Failure (*n* = 40)	
Baseline characteristics				
Age (years)	64.0±11.3	59.5±10.9	71.3±7.6	□0.001
Sex, male	51(48.6%)	26(40.0%)	25(62.5%)	0.025
Smoking, current or former	11(10.5%)	7(10.8%)	4(10.0%)	0.901
Comorbidities	60(57.1%)	35(53.8%)	25(62.5%)	0.384
Lab tests at admission				
LYM (× 10^9/L; normal range 1.1−3.2)	0.63(0.43-0.80)	0.62(0.49-0.79)	0.70(0.36-0.80)	0.777
D-D (ug/ml; normal range 0.0−0.5)	0.67(0.42-4.19)	0.62(0.42-1.78)	1.04(0.46-5.00)	0.056
CRP (mg/L; normal range 0.0−5.0)	46.8(28.2-83.5)	45.6(30.4-83.5)	39.3(23.4-85.4)	0.946
PaO_2/FiO_2 at HFNC application	116.0(102.1-132.0)	116.0(102.7-128.0)	112.8(100.5-138.5)	0.722

Variables	Time (hour)	HFNC success	HFNC failure	*P*
RR	2	24(22-26)	25(23-27)	0.138
	6	22(21-24)	24(23-26)	0.001
	12	22(20-25)	25(24-25)	0.002
	24	21(20-23)	25(25-28)	□0.001
SpO_2/FiO_2	2	153.2(135.6-194.9)	158.3(139.8-170.0)	0.157
	6	158.6(135.3-215.3)	123.8(116.7-157.9)	□0.001
	12	179.6(136.1-206.5)	127.0(115.3-161.7)	□0.001
	24	182.7(142.8-202.1)	126.4(116.0-153.8)	□0.001
PaO_2/FiO_2	2	116.7(93.8-143.8)	111.1(100.0-125.0)	0.141
	6	115.4(100.8-164.3)	95.3(83.5-120.3)	□0.001
	12	130.0(104.6-168.8)	90.7(76.9-106.3)	□0.001
	24	145.0(107.2-167.3)	85.2(72.9-110.9)	□0.001
ROX index	2	6.8(5.6-7.8)	6.4(4.9-7.6)	0.074
	6	6.7(5.9-9.5)	5.0(4.6-6.5)	□0.001
	12	7.9(6.1-9.1)	5.0(4.4-7.3)	□0.001
	24	7.8(6.6-10.0)	4.8(4.4-6.0)	□0.001

Use of Prone Positioning in Nonintubated Patients With COVID-19 and Hypoxemic ARF

- To evaluate the feasibility, efficacy, and tolerance of PP in awake patients with COVID-19
- Confirmed COVID-19 who equired oxygen supplementation and had chest CT findings suggestive posterior lesions
- Result
  - 63% tolerated it for more than 3 hours
  - 25% were responders to PP
  - 3/24 (12.5%) were persistent responders

Research letter, Elharrar X, et al. JAMA May 1, 2020

Surviving Sepsis Campaign Guidelines on the Management of Adults With Coronavirus Disease 2019 (COVID-19) in the ICU: First Update

Critical Care Medicine: March 2021

- There is insufficient evidence to issue a recommendation on the use of awake prone positioning in nonintubated adults with severe COVID-19
  - No recommendation
  - Uncertainty about the balance between benefit and harm
  - Awaiting the results of ongoing RCTs

Surviving Sepsis Campaign Guidelines on the Management of Adults With Coronavirus Disease 2019 (COVID-19) in the ICU: First Update

Critical Care Medicine: March 2021

- A systematic review that summarized the evidence on awake prone positioning, including 35 observational studies
  - 29 of these studies included COVID-19 patients
  - All reports showed an improvement in oxygenation while in prone position
  - Magnitude of improvement was imprecise
  - Improvements in oxygenation were lost once patients reverted to the supine position

Awake prone positioning for COVID-19 hypoxemic respiratory failure: a rapid review. J Crit Care 2021; 61:63–70

Effect of Helmet NIV vs HFNC on Days Free of Respiratory Support in Patients With COVID-19 and Moderate to Severe Hypoxemic Respiratory Failure: The HENIVOT Randomized Clinical Trial

- Multicenter randomized clinical trial in 4 intensive care units (ICUs) in Italy
- 109 patients with COVID-19 and moderate to severe hypoxemic respiratory failure (PF ratio < ?200)
  - Helmet NIV (PEEP 10-12 cmH_2O; pressure support 10-12 cm H_2O) for at least 48 hours eventually followed by HFNC (n = 54)
  - High-flow oxygen alone (60 L/min) (n = 55)
- The primary outcome was the number of days free of respiratory support within 28 days after enrollment

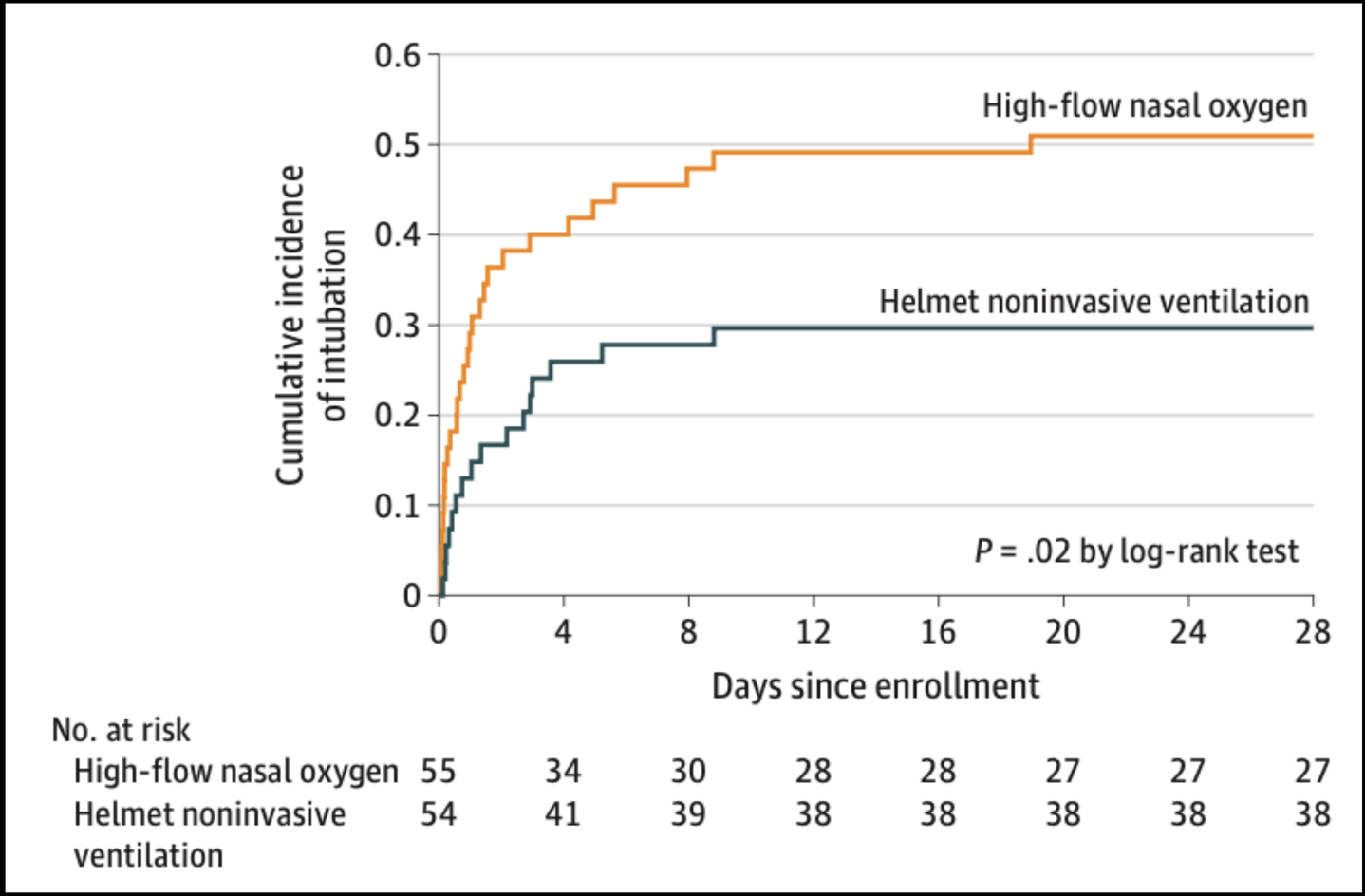
JAMA. doi:10.1001/jama.2021.4682 Published online March 25, 2021.

Effect of Helmet NIV vs HFNC on Days Free of Respiratory Support in Patients With COVID-19 and Moderate to Severe Hypoxemic Respiratory Failure: The HENIVOT Randomized Clinical Trial

Outcome	No. (%)		Absolute or mean difference (95% CI)[b]	Odds ratio (95% CI)	*P* value[c]
	Helmet noninvasive ventilation (n = 54)[a]	High-flow nasal oxygen (n = 55)[a]			
Primary outcome					
Respiratory support-free days, median (IQR)[d]	20 (0 to 25)	18 (0 to 22)	2 (−2 to 6)		.26
Secondary outcomes					
Intubation within 28 d from enrollment	16 (30)	28 (51)	−21 (−38 to −3)	0.41 (0.18 to 0.89)	.03
Intubation within 28 d from enrollment, after adjudication of intubation criteria by external experts	15 (28)	28 (51)	−23 (−39 to −5)	0.37 (0.17 to 0.82)	.02
Invasive ventilation-free days, median (IQR)					
28 d	28 (13 to 28)	25 (4 to 28)	3 (0 to 7)		.04
60 d	60 (43 to 60)	57 (19 to 60)	6 (−3 to 15)		.07
Mortality					
28 d	8 (15)	10 (18)	−3 (−17 to 11)	0.78 (0.28 to 2.16)	.80
60 d	13 (24)	12 (22)	2 (−13 to 18)	1.14 (0.46 to 2.78)	.82

JAMA. doi:10.1001/jama.2021.4682 Published online March 25, 2021.

Effect of Helmet NIV vs HFNC on Days Free of Respiratory Support in Patients With COVID-19 and Moderate to Severe Hypoxemic Respiratory Failure: The HENIVOT Randomized Clinical Trial



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. doi:10.1001/jama.2021.4682 Published online March 25, 2021.

Surviving Sepsis Campaign Guidelines on the Management of Adults With Coronavirus Disease 2019 (COVID-19) in the ICU: First Update

Critical Care Medicine: March 2021

• In adults with COVID-19 and acute hypoxemic respiratory failure, we suggest using HFNC over NIPPV.	WEAK
• In adults with COVID-19 and acute hypoxemic respiratory failure, if HFNC is not available and there is no urgent indication for ETT, we suggest a trial of NIPPV with close monitoring and short-interval assessment for worsening of respiratory failure.	WEAK
• We were not able to make a recommendation regarding the use of helmet NIPPV compared with mask NIPPV. It is an option, but we are not certain about its safety or efficacy in COVID-19.	NO RECOMMENDATION
• In adults with COVID-19 receiving NIPPV or HFNC, we recommend close monitoring for wors- ening of respiratory status and early intubation in a controlled setting if worsening occurs.	BEST PRACTICE MANAGEMENT

STEP 1
No respiratory distress
Spo_2 < 92-94% RA or
Declining Spo_2

Simple Oxygen Supplementation
O_2 Via N/C @ 4-6 L/min

Worsening Hypoxemia

NRB mask @
15 L/min

High Flow Nasal Cannula
(Preferred modality)
Minimal hypercapnia
($Paco_2$ preferably
< 5 mm Hg above baseline)

PaO_2/FiO_2	≥ 300	200	150	< 100
SpO_2/FiO_2	315	235	190	150

Awake Proning
(Alone or with HFNC or NIV)
Useful with diffuse lung opacities-ARDS
No unstable spine fractures, hemoptysis, abdominal compartment syndrome, > first trimester pregnancy, anterior chest tubes

PaO_2/FiO_2	≥ 300	200	150	< 100
SpO_2/FiO_2	315	235	190	150

Noninvasive Ventilation
(Consider Helmet)
COPD with moderate hypercapnia or cardiogenic pulmonary edema or inability to carry out work of breathing
Low aspiration risk

PaO_2/FiO_2	≥ 300	200	150	< 100
SpO_2/FiO_2	315	235	190	150

Invasive Mechanical Ventilation
(Unless carries a Do Not Intubate order)
ARDS net guidelines

Modify from CHEST November 2020; 158(5):1992-2002