Mechanical Ventilation 2020 Guidelines

Brian W. Carlin, MD, FAARC, MAACVPR

PSRC Webinar

May, 2020

Disclosures

Brian Carlin, MD

- Speaker's bureau / Advisory panels
  - Sunovion
  - Glaxo Smith Kline
  - Monaghan
  - Theravance
  - Philips Respironics
  - Mylan

- Fiduciary positions
  - National Lung Health Education Program (NLHEP)
  - National Board for Respiratory Care (NBRC)

Objectives

- At the completion of this session, the learner will be able to:
  - Name two methods to wean a patient from mechanical ventilation
  - Develop a protocol for the use of NIV/HFNC in the appropriate patient
  - Develop a strategy for managing a patient with COVID-19 respiratory failure

Ventilatory Modalities

Ventilator Modes

- Volume control
  - Assist-control
  - Synchronized intermittent mandatory
- Pressure control
  - Pressure support
  - Pressure controlled
  - Airway pressure release

Guidelines

- Modality selection
- Weaning
- Liberation
- COVID-19

2001 Recommendations

Ely, CHEST 2001

- Recommended that consider protocols that include daily cessation and targeted sedation goals to reduce the duration of MV and of the length of stay in the ICU

2001 Recommendations

Ely, CHEST 2001

- Recommended that at least once daily SBT are performed to identify patients who are ready for liberation from the ventilator

- Recommended that when patients have passed an SBT, clinicians seriously consider prompt extubation.

Protocols for Weaning

Ely, CHEST 2001

- Patients who fail to wean on an SBT
  - Check for remediable factors
  - Use a comfortable, safe, and well-monitored ventilation mode
  - Repeat the SBT the following day

Protocols for Weaning

Ely, CHEST 2001

- Published protocols incorporating
  - Patient-specific needs
  - Clinician preferences
  - Institutional resources

2007 Recommendations

MacIntyre, CHEST 2007

- Consideration of discontinuation of MV
  - Lung injury is stable/resolving
  - Gas exchange is adequate
    - $FiO_2 < .4$- .5; PEEP < 5-8 cm H_2O
  - Hemodynamic variables stable
  - Capability to initiate spontaneous breaths

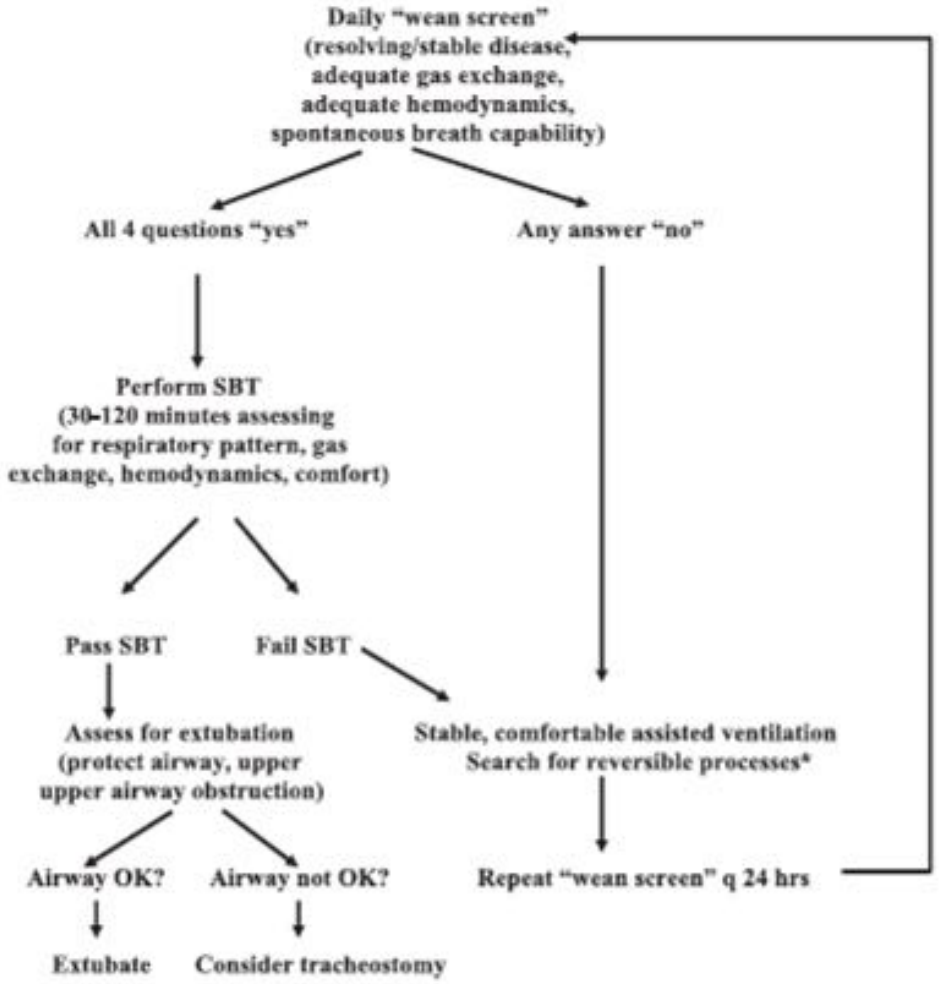
2007 Recommendations

MacIntyre, CHEST 2007

- Spontaneous breathing trial (SBT)
  - T piece
  - Pressure support (5-7 cm)
  - 30-120 minute trial
  - Integrated approach
    - Assessment of respiratory pattern
    - Hemodynamic status
    - Gas exchange
    - Patient comfort

2007 Recommendations

MacIntyre, CHEST 2007



Current Recommendations

Ouellette CHEST 2017

- For acutely hospitalized patients ventilated more than 24 h, the initial SBT should be conducted with inspiratory pressure augmentation (5-8 cm H2O) rather than without (T-piece or CPAP)
  - Conditional recommendation
  - Moderate quality of evidence

Current Recommendations

Ouellette CHEST 2017

- For acutely hospitalized patients ventilated for more than 24 hours, protocols attempting to minimize sedation should be used
  - Conditional recommendation
  - Low quality evidence

Current Recommendations

Ouellette CHEST 2017

- For patients at high risk for extubation failure who have been receiving mechanical ventilation for more than 24 h, and who have passed a SBT, we recommend extubation to preventative NIV
  - Strong recommendation
  - Moderate grade of evidence

Remediable Factors

- Correct
  - underlying reason for support
  - gas exchange abnormalities
  - electrolyte derangements
  - bronchospasm
  - malnutrition
  - positioning
  - excess secretions

Current Recommendations

Schmidt, CHEST 2017

TABLE 2] Summary of Recommendations

Recommendation	Strength of Recommendation	Certainty of Evidence (ie, Quality of Evidence)
1. For acutely hospitalized patients ventilated more than 24 h, we suggest that the initial SBT be conducted with inspiratory pressure augmentation (5-8 cm H_2O) rather than without (T-piece or CPAP)	Conditional	Moderate certainty in the evidence
2. For acutely hospitalized patients ventilated for more than 24 h, we suggest protocols attempting to minimize sedation	Conditional	Low certainty in the evidence
3. For patients at high risk for extubation failure who have been receiving mechanical ventilation for more than 24 h and who have passed an SBT, we recommend extubation to preventive NIV	Strong	Moderate certainty in the evidence
4. For acutely hospitalized patients who have been mechanically ventilated for > 24 h, we suggest protocolized rehabilitation directed toward early mobilization	Conditional	Low certainty in the evidence
5. We suggest managing acutely hospitalized patients who have been mechanically ventilated for > 24 h with a ventilator liberation protocol	Conditional	Low certainty in the evidence
6a. We suggest performing a CLT in mechanically ventilated adults who meet extubation criteria and are deemed at high risk for PES	Conditional	Very low certainty in the evidence
6b. For adults who have failed a CLT but are otherwise ready for extubation, we suggest administering systemic steroids at least 4 h before extubation; a repeated CLT is not required	Conditional	Moderate certainty in the evidence

Nursing Considerations

- Minimize use of sedatives and analgesics through continued symptom assessment
- Implement daily wakefulness and early mobility initiatives

Respiratory Therapy Considerations

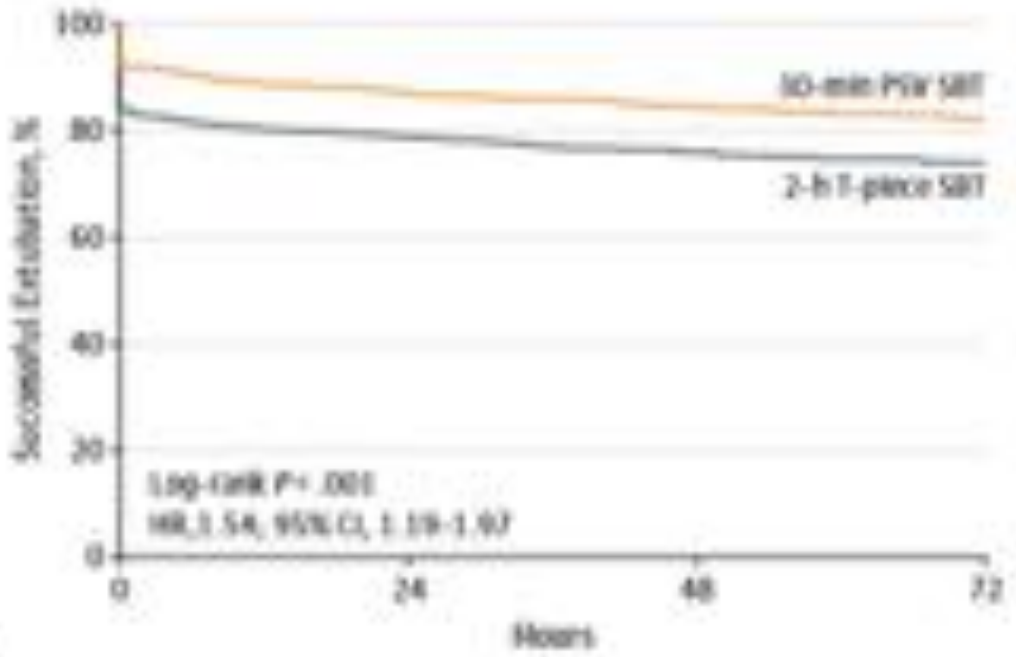
- Implement daily weaning trials
- Assess degree of secretions
- Assess mental status
- Help with mobility

Effect of Pressure Support vs T-Piece Ventilation Strategies During Spontaneous Breathing Trials on Successful Extubation Among Patients Receiving Mechanical Ventilation

C Subra, G Hernandez, A Vazquez, et al

JAMA.2019;321(22):2175-2182J

Figure 2. Probability of Successful Extubation After First SBT in Each Group



No. at risk

30-min PSV SBT	575	505	484	472
2-h T-piece SBT	578	456	438	426

PSV indicates pressure support ventilation; SBT, spontaneous breathing trial. Successful extubation was defined as remaining free of mechanical ventilation for 72 hours after first SBT.

Subra, JAMA 2019

PROTOCOLIZED WEANING

Protocolized Weaning

Perkins, JAMA 2018

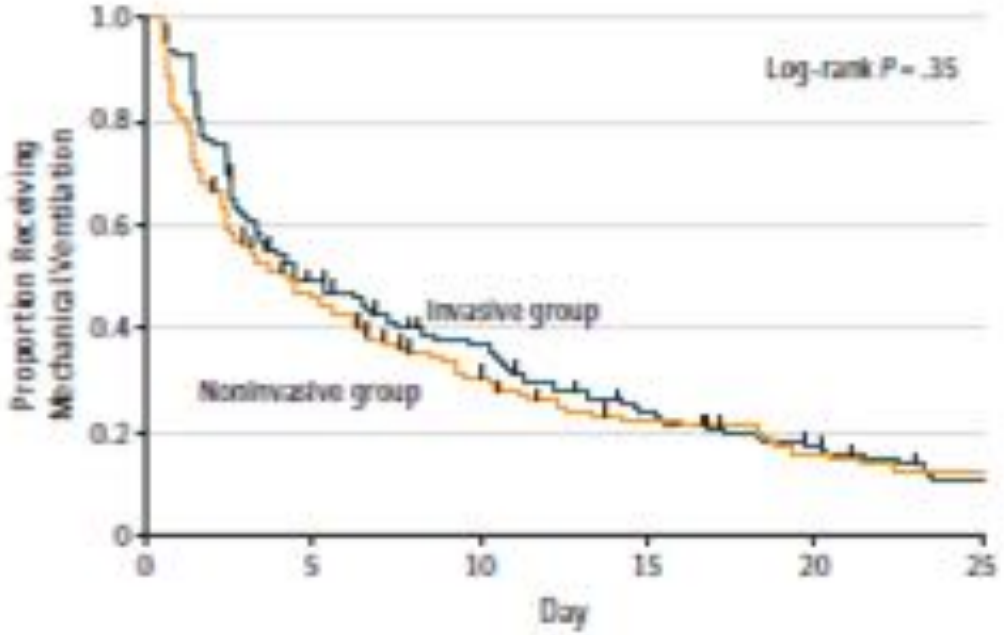
- Randomized, allocation-controlled, open-label, multicenter
- 2013-2016
- 41 ICUs (United Kingdom)
- 48 hrs of ventilation, failed SBT

Protocolized Weaning

Perkins, JAMA 2018

- Extubation to NIV (n=182)
- Standard weaning (n=182)
- Outcome
  - Primary
    - Successful liberation
  - Secondary
    - Duration of MV
    - Reintubation
    - Tracheostomy rate

Figure 2. Time to Liberation From Mechanical Ventilation by Treatment Group

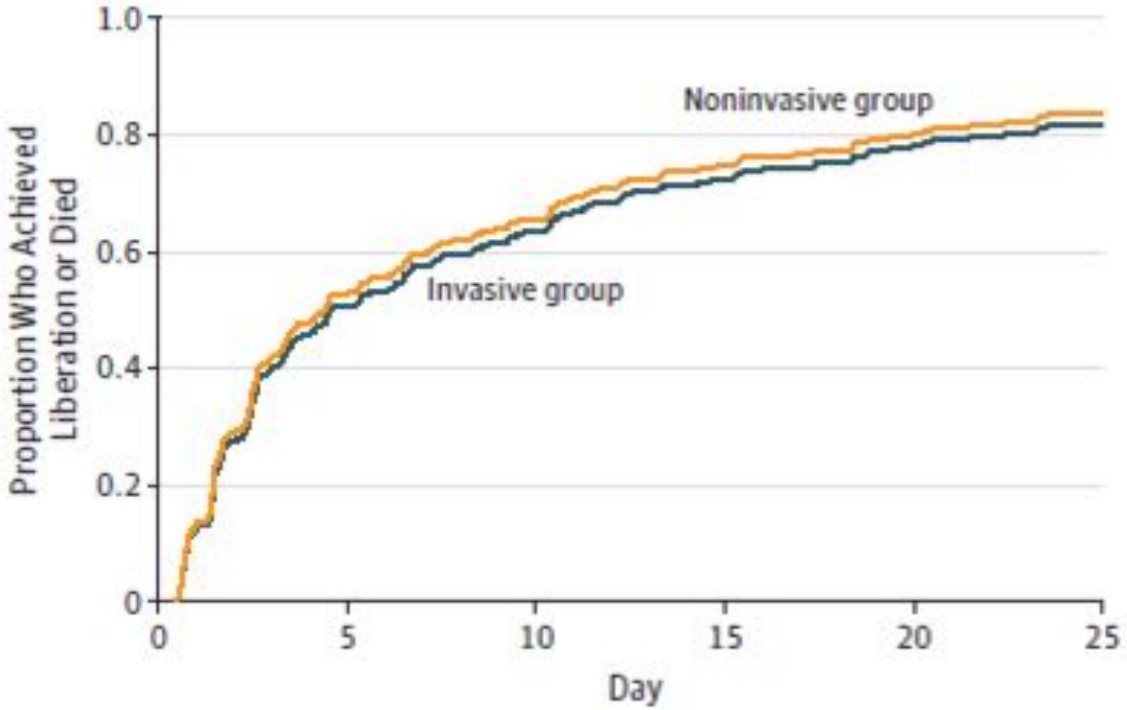


No. at risk						
Invasive group	182	86	61	37	24	12
Noninvasive group	182	79	48	32	21	17

Hash marks indicate each censoring time. Median time to liberation from ventilation was 4.5 days (95% CI, 3.46-7.25 days) in the invasive group and 4.3 days (95% CI, 2.63-5.58 days) in the noninvasive group.

Perkins, JAMA 2018

Figure 3. Cumulative Incidence of Liberation From Ventilation or Death by Treatment Group



No. at risk						
Invasive group	182	86	61	37	24	12
Noninvasive group	182	79	48	32	21	17

Perkins, JAMA 2018

EXTUBATION GUIDELINES

Guidelines for Extubation

Quintard, Ann Inten Care 2019

- Recommend a SBT in patients ventilated more than 48 h
- SBT is inadequate as the sole means for detecting all patients at risk for extubation failure

Guidelines for Extubation

Quintard, Ann Inten Care 2019

- If the leak volume is low or nil, corticosteroids should probably be prescribed to prevent extubation failure
  - Grade 2
  - Strong agreement

- Once corticosteroid therapy is decided, it should be started at least 6 h before extubation
  - Grade 1
  - Strong agreement

Guidelines for Extubation

Quintard, Ann Inten Care 2019

- High flow oxygen via a nasal cannula
  - cardiothoracic surgery
  - hypoxemic patients
  - at risk for reintubation
- Noninvasive ventilation
  - Acute postoperative respiratory failure

Guidelines for Extubation

Quintard, Ann Inten Care 2019

- Treatment from a physiotherapist probably required before and after extubation
  - Grade 2
  - Strong agreement
- A physiotherapist should probably attend endotracheal extubation
  - Grade 2
  - Strong agreement

Guidelines for Extubation

Quintard, Ann Inten Care 2019

- A cuff leak test should probably be performed to predict the occurrence of laryngeal edema
  - Grade 2
  - Strong agreement

- Measures to prevent and treat laryngeal pathology should probably be implemented during mechanical ventilation
  - Grade 1
  - Strong agreement

NEWER CONSIDERATSIONS IN LIBERATION FROM MECHANICAL VENTILATORY SUPPORT

NONINVASIVE VENTILATION

AND

HEATED HIGH FLOW NASAL CANNULA

GUIDELINES FOR NIV USE AFTER EXTUBATION

NIV for Respiratory Failure

Rochwerg, ERJ 2017

- NIV be used to facilitate weaning from mechanical ventilation in patients with hypercapneic respiratory failure
  - Conditional recommendation
  - Moderate certainty of evidence
  - No recommendation for hypoxemic patients

NIV for Respiratory Failure

Rochwerg, ERJ 2017

- NIV be used to prevent post-extubation respiratory failure in high-risk patients (not low risk patients) post-extubation
  - Conditional recommendation
  - Low certainty of evidence

NIV for Respiratory Failure

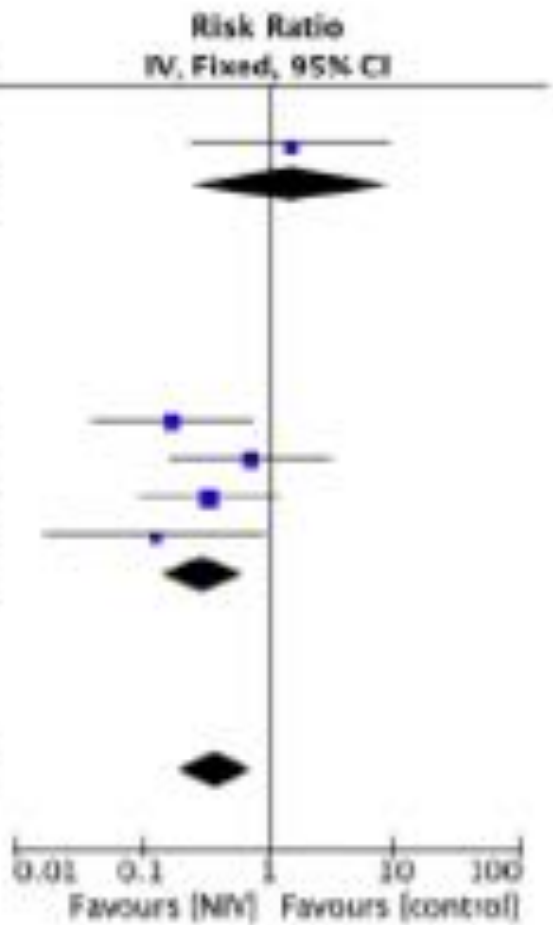
Rochwerg, ERJ 2017

- NIV should not be used in the treatment of patients with established post-extubation respiratory failure
  - Conditional recommendation
  - Low certainty of evidence
  - May actually increase mortality

Question #10a: Should NIV be used in the prevention of respiratory failure post extubation?

Mortality

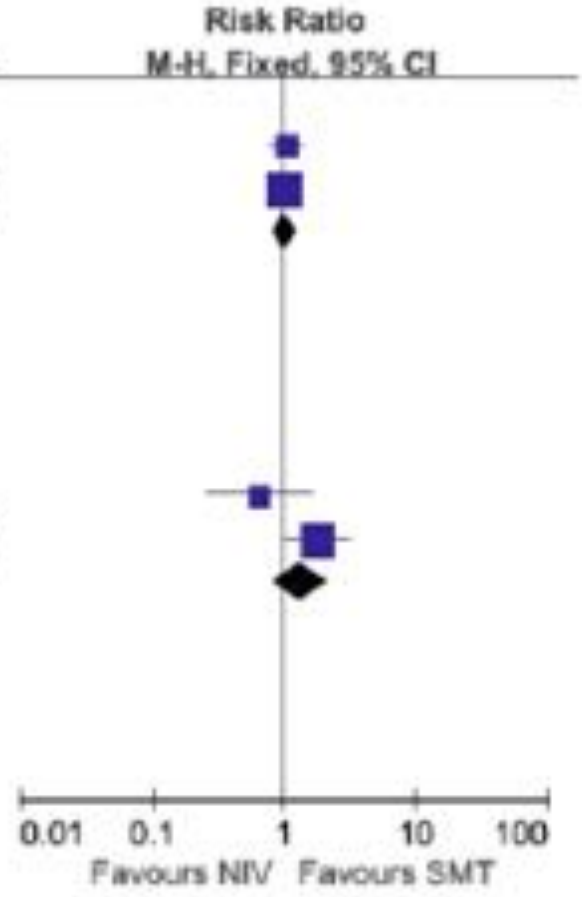
Study or Subgroup	NIV Events	NIV Total	Control Events	Control Total	Weight	Risk Ratio IV, Fixed, 95% CI
1.2.1 Unselected Patients						
Su 2012	3	202	2	204	14.7%	1.51 [0.26, 8.97]
Subtotal (95% CI)		**202**		**204**	**14.7%**	**1.51 [0.26, 8.97]**
Total events	3		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.46 (P = 0.65)						
1.2.2 At Risk Patients						
Ferrer 2006	2	29	12	83	21.6%	0.18 [0.04, 0.76]
Ferrer 2009	3	54	4	52	22.1%	0.72 [0.17, 3.07]
Nava 2005	3	48	9	49	29.9%	0.34 [0.10, 1.18]
Ornico 2013	1	20	7	18	11.6%	0.13 [0.02, 0.95]
Subtotal (95% CI)		**201**		**202**	**85.3%**	**0.31 [0.15, 0.64]**
Total events	9		12			
Heterogeneity: Chi^2 = 2.66, df = 3 (P = 0.45); I^2 = 0%						
Test for overall effect: Z = 3.15 (P = 0.002)						
Total (95% CI)		**403**		**406**	**100.0%**	**0.39 [0.20, 0.76]**
Total events	12		34			
Heterogeneity: Chi^2 = 5.31, df = 4 (P = 0.26); I^2 = 25%						
Test for overall effect: Z = 2.73 (P = 0.006)						
Test for subgroup differences: Chi^2 = 2.65, df = 1 (P = 0.10), I^2 = 62.3%						



Question #10b: Should NIV be used in the treatment of respiratory failure post extubation?

Mortality & Re-intubation

Study or Subgroup	NIV group Events	Total	SMT group Events	Total	Weight	Risk Ratio M-H, Fixed, 95% CI	Year
1.1.1 reintubation							
Keenan 2002	28	39	29	42	34.7%	1.04 [0.78, 1.38]	2002
Esteban 2004	55	114	51	107	65.3%	1.01 [0.77, 1.33]	2004
Subtotal (95% CI)		153		149	100.0%	1.02 [0.83, 1.25]	
Total events	83		80				
Heterogeneity: Chi² = 0.02, df = 1 (P = 0.89); I² = 0%							
Test for overall effect: Z = 0.21 (P = 0.84)							
1.1.2 ICU mortality							
Keenan 2002	6	39	10	42	38.4%	0.65 [0.26, 1.61]	2002
Esteban 2004	28	114	15	107	61.6%	1.75 [0.99, 3.09]	2004
Subtotal (95% CI)		153		149	100.0%	1.33 [0.83, 2.13]	
Total events	34		25				
Heterogeneity: Chi² = 3.30, df = 1 (P = 0.07); I² = 70%							
Test for overall effect: Z = 1.18 (P = 0.24)							



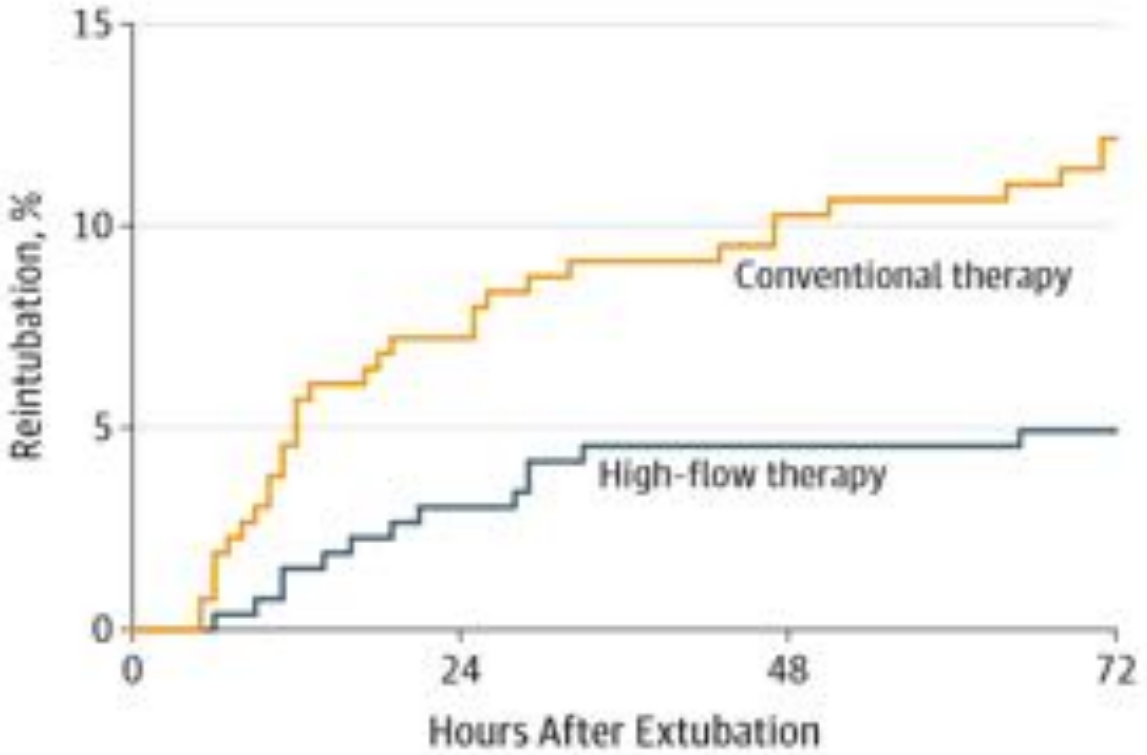
Rochwerg, ERJ 2017

Effect of Post-Extubation High-Flow Nasal Cannula vs Conventional Oxygen Therapy on Reintubation in Low-Risk Patients: A Randomized Clinical Trial

G Hernandez, C Vaquero, P Gonzalez, et al

JAMA 2016;315(13):1354-1361

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

Hernandez, JAMA 2016

Post-Extubation HFNC

Hernandez, JAMA 2016

- Results

NNT (HFNC) 14

(95% CI, 8-40)

Post-Extubation HFNC

Hernandez, JAMA 2016

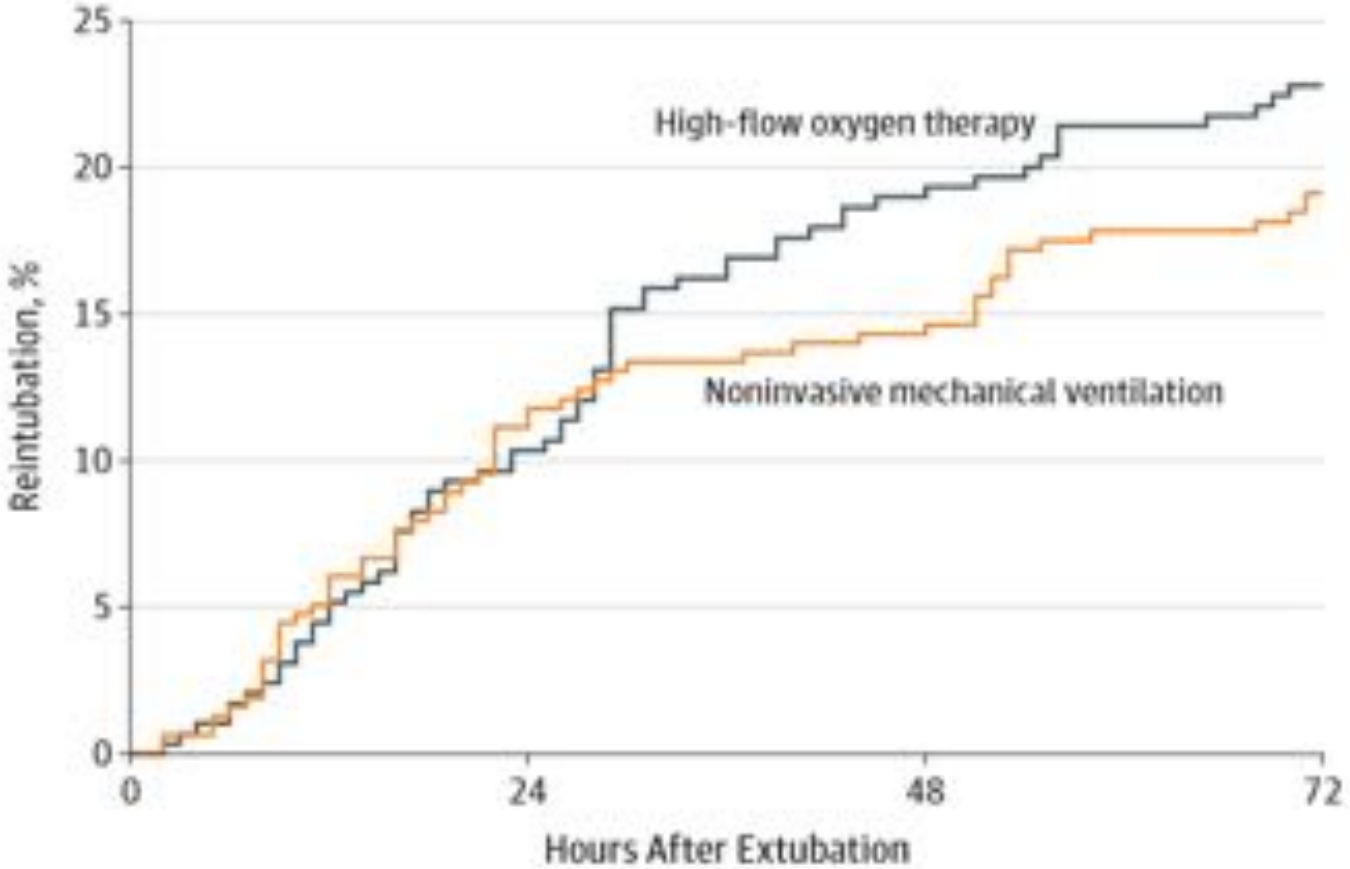
- Results
  - Time to reintubation not different
  - All tolerated HFNC
  - No adverse events reported

Effect of Post-Extubation High-Flow Nasal Cannula vs Noninvasive Positive Pressure Ventilation on Reintubation and Post-Extubation Respiratory Failure in High Risk Patients: A Randomized Clinical Trial

G Hernandez, C Vaquero, P Gonzalez, et al

JAMA 2016; 316(15):1565-1574

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



No. at risk				
High-flow oxygen therapy	290	260	234	223
Noninvasive mechanical ventilation	314	279	269	253

Hernandez, JAMA 2016

Post-Extubation HFNC v. NIV

Hernandez, JAMA 2016

- Results

Adverse events (requiring therapy withdrawal)

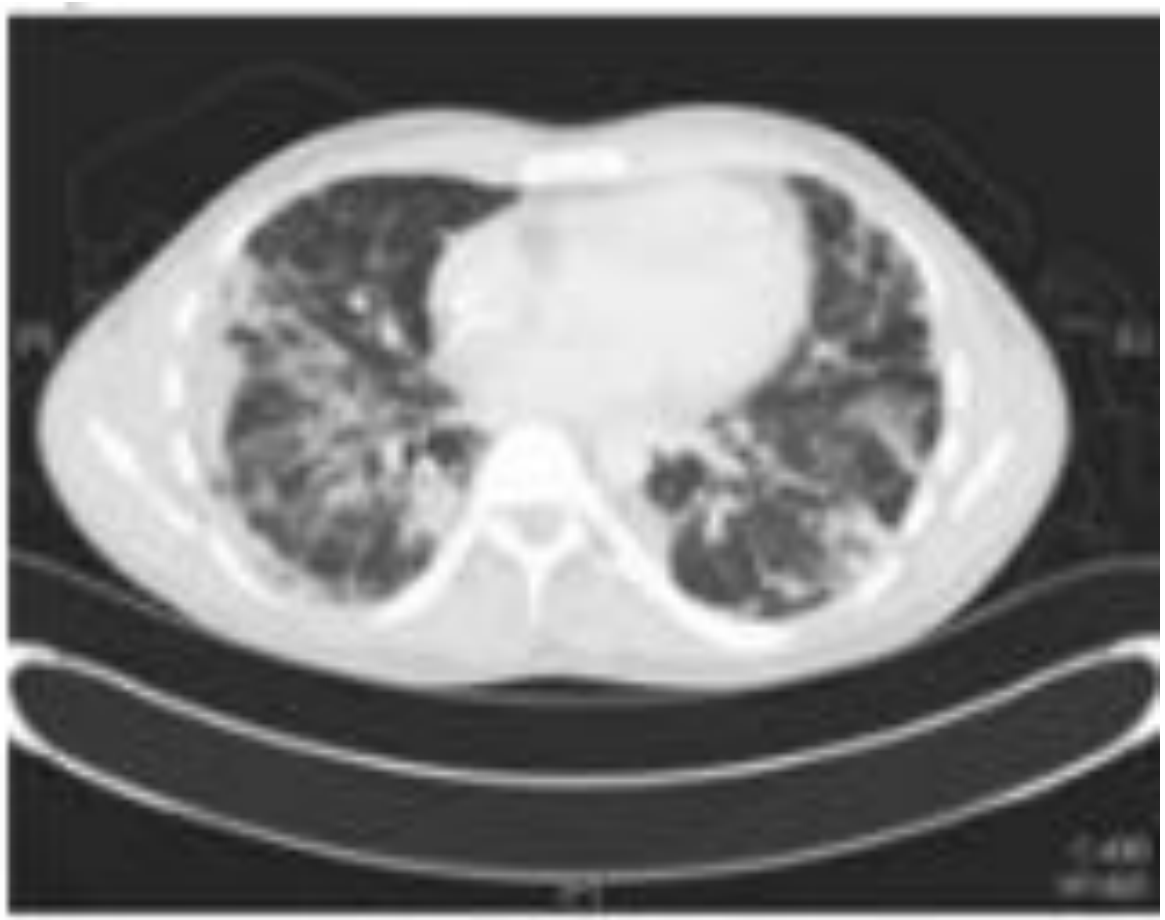
HFNC	0%
NIV	42.9%

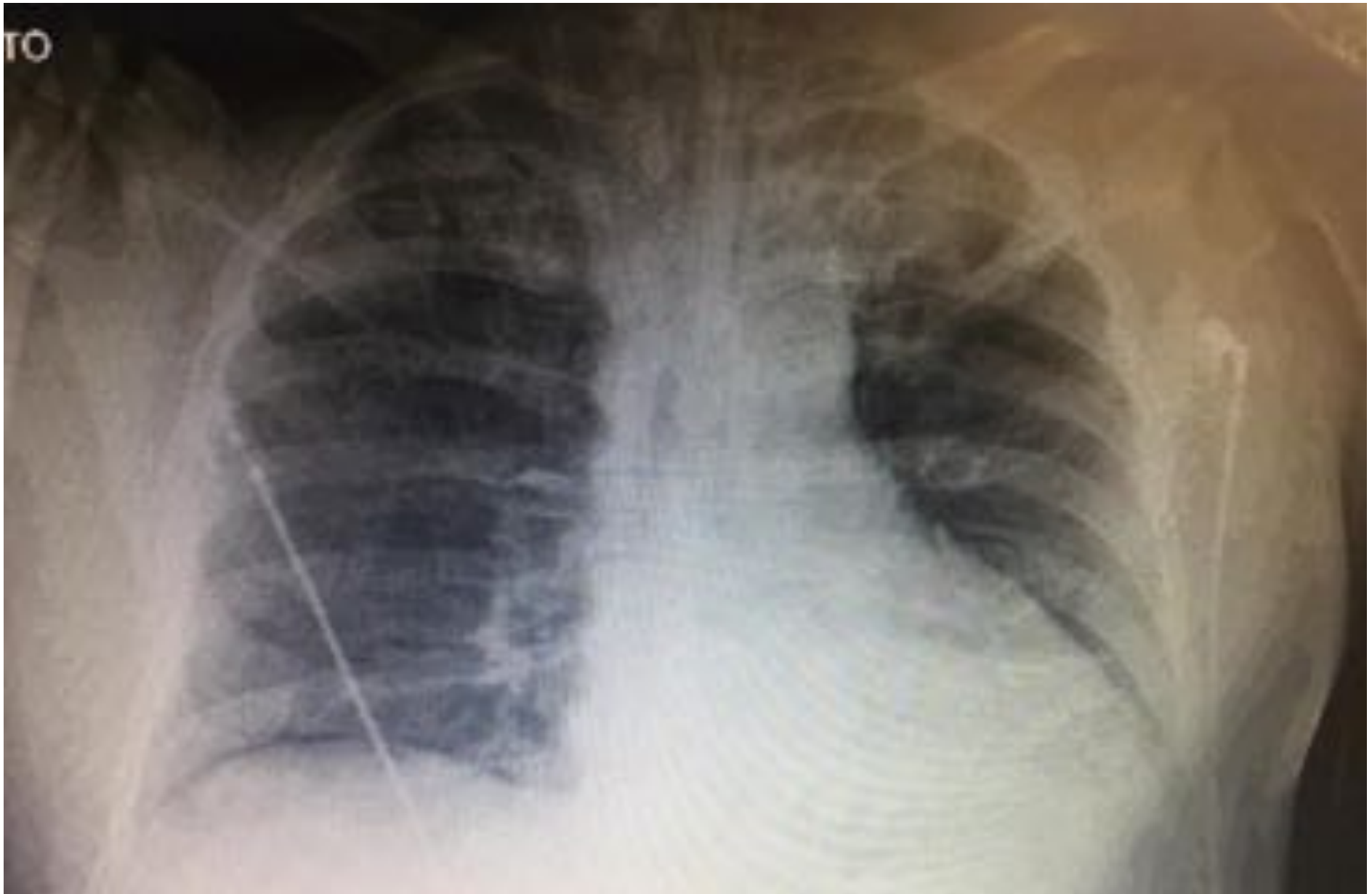
$P < .001$

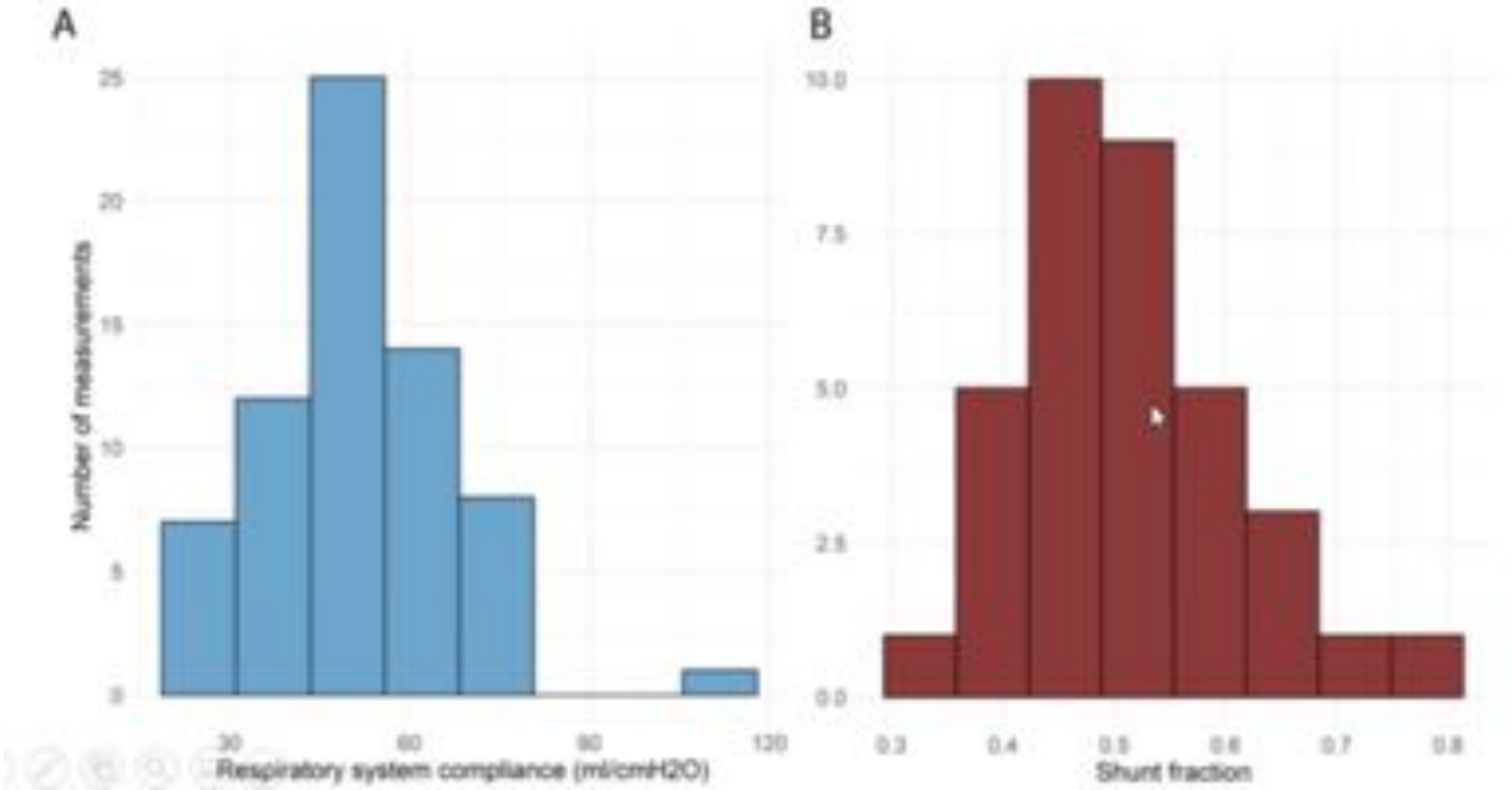
COVID 19 Respiratory Failure

COVID-19 Respiratory Failure

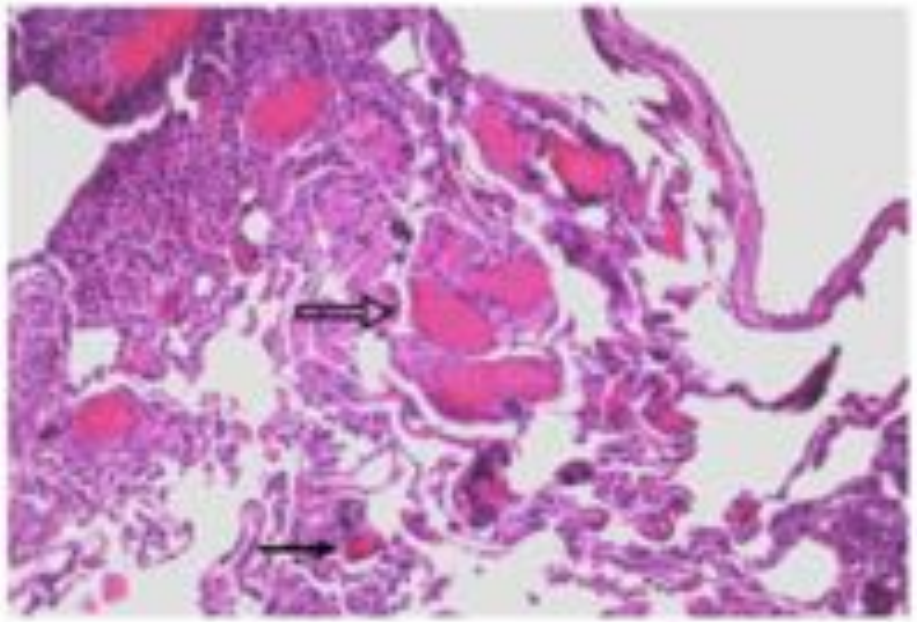
- Severe hypoxemia
- Isocapnia
- Quite good compliance (40-60 ml/cmH2O)
- Prolonged course
- Secondary infection
- Thromboembolic complications
- Cardiac failure
- Hyper-inflammation



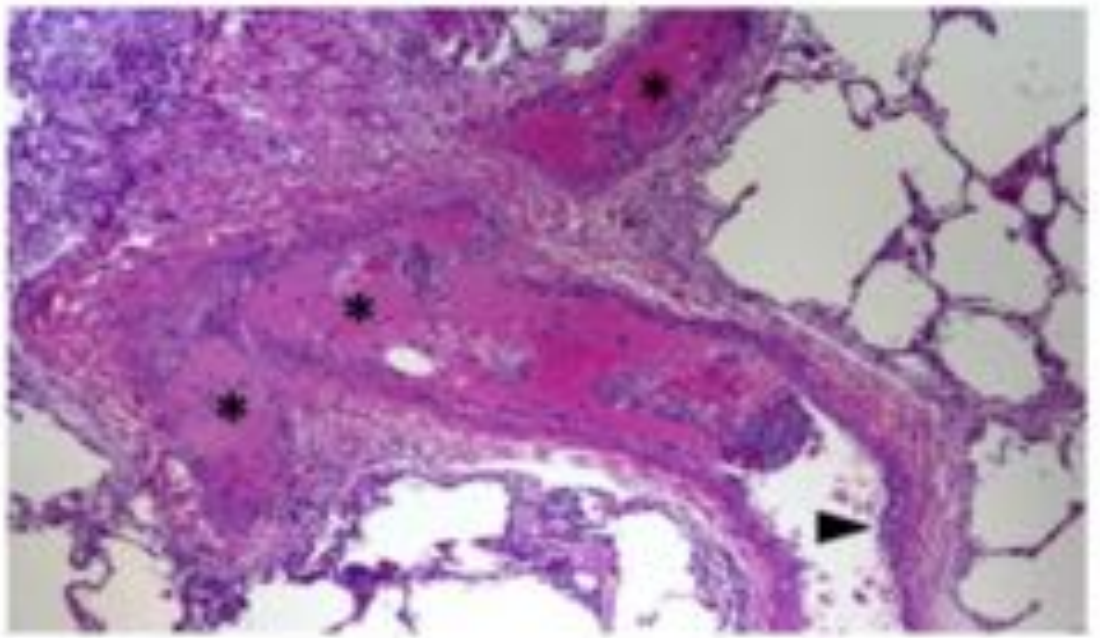

TO


A
B
Number of measurements
25
20
15
10
5
0
30
60
90
120
Respiratory system compliance (ml/cmH2O)
10.0
7.5
5.0
2.5
0.0
0.3
0.4
0.5
0.6
0.7
0.8
Shunt fraction

B



C



Mechanical Ventilation

- Protective strategies (ARDS protocol)
- Avoid thoracoabdominal dyssynchrony
- Adequate sedation/paralysis

Noninvasive Strategies

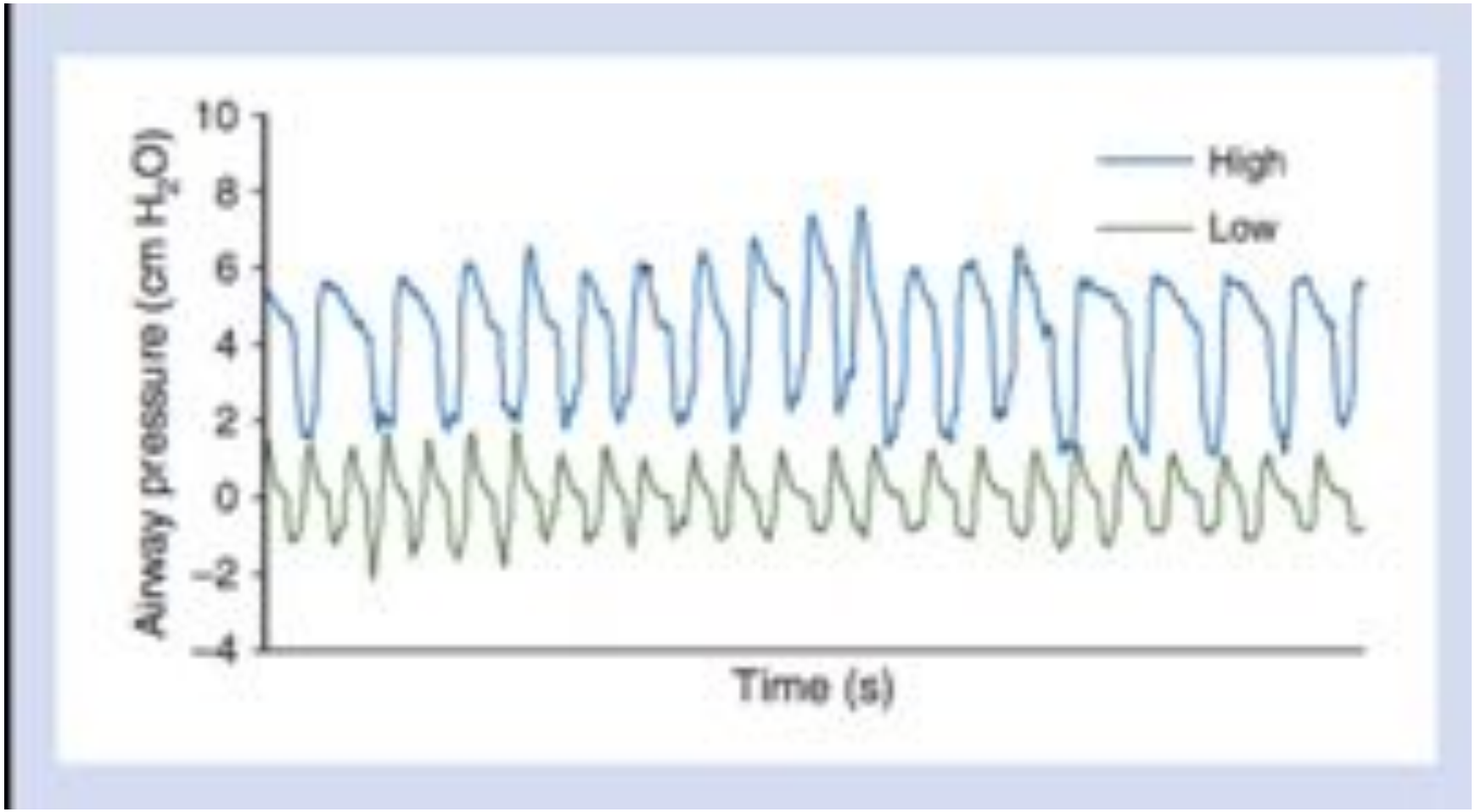
- Prone positioning
- Noninvasive ventilation
- Heated high flow nasal cannula

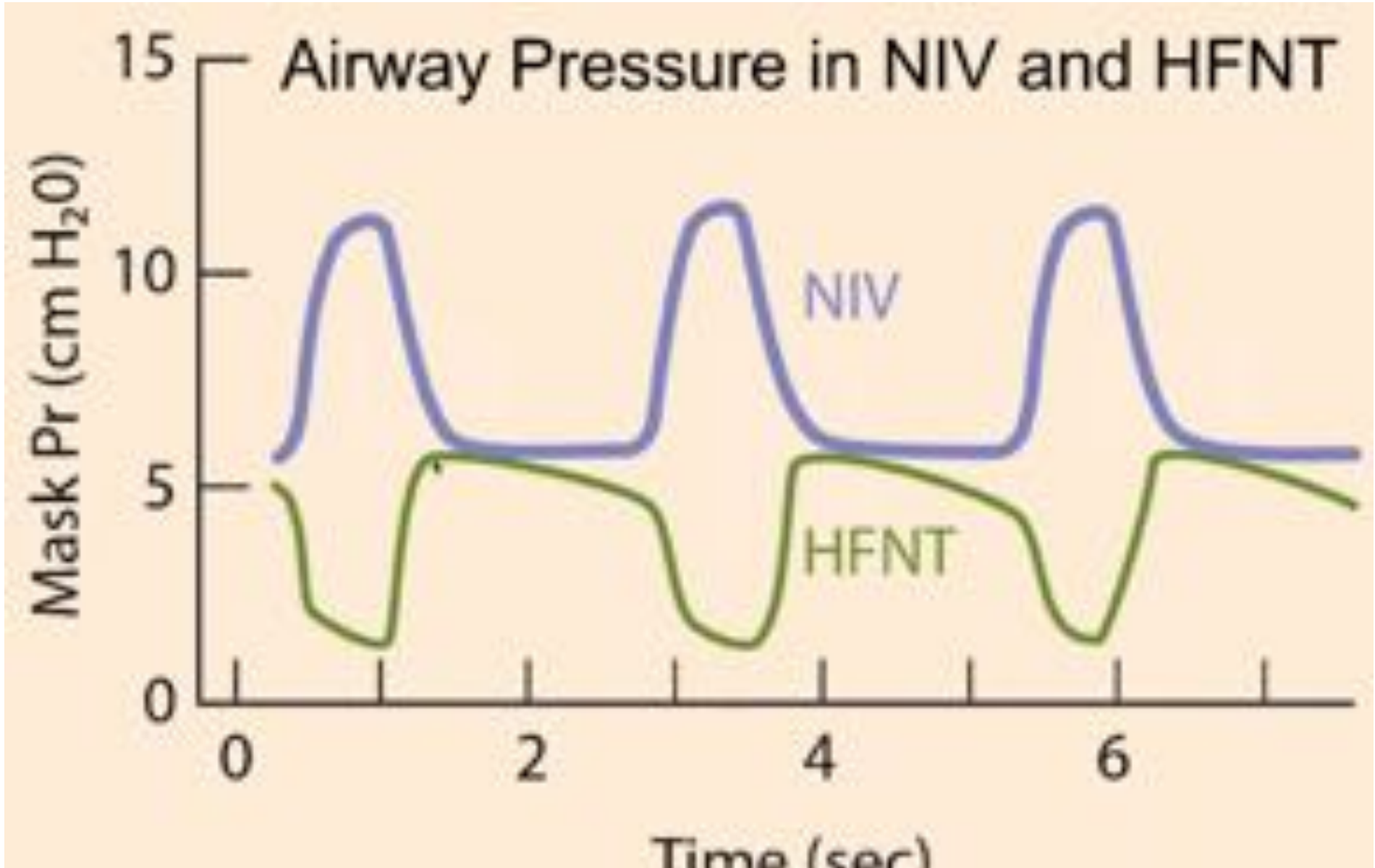
Guidelines
HFNC v. NIV

	HFNC	**NIV**
SCCM	Suggest	Suggest
WHO	Selected	Selected
ANZICS	Recommended	Not routine
NY Presbyterian	Selected	Recommend against
MGH	Not routine	Not routine
Tufts	Option	Not routine

Technical Aspects
HFNC v. NIV

	HFNC	**NIV**
Heat	31-37 degrees	Variable
Humidity	Saturated	Variable
Pressure	Variable	Present (I/E)
Flow	Continuous	Variable
Circuit	Single-heated	Single/double
Oxygen	Blender (0.21-1)	Bleed-in or blender


Airway pressure (cm H_2O)
10
8
6
4
2
0
−2
−4
High
Low
Time (s)


Airway Pressure in NIV and HFNT
Mask Pr (cm H_2O)
15
10
5
0
NIV
HFNT
0
2
4
6
Time (sec)

HFNC Advantages

- Well tolerated
- Secretion hydration / mobilization
- Better oxygenation (than standard oxygen therapy)
- Lowered work of breathing
- May avoid intubation
- Good for palliation

Aerosol Generating Procedures

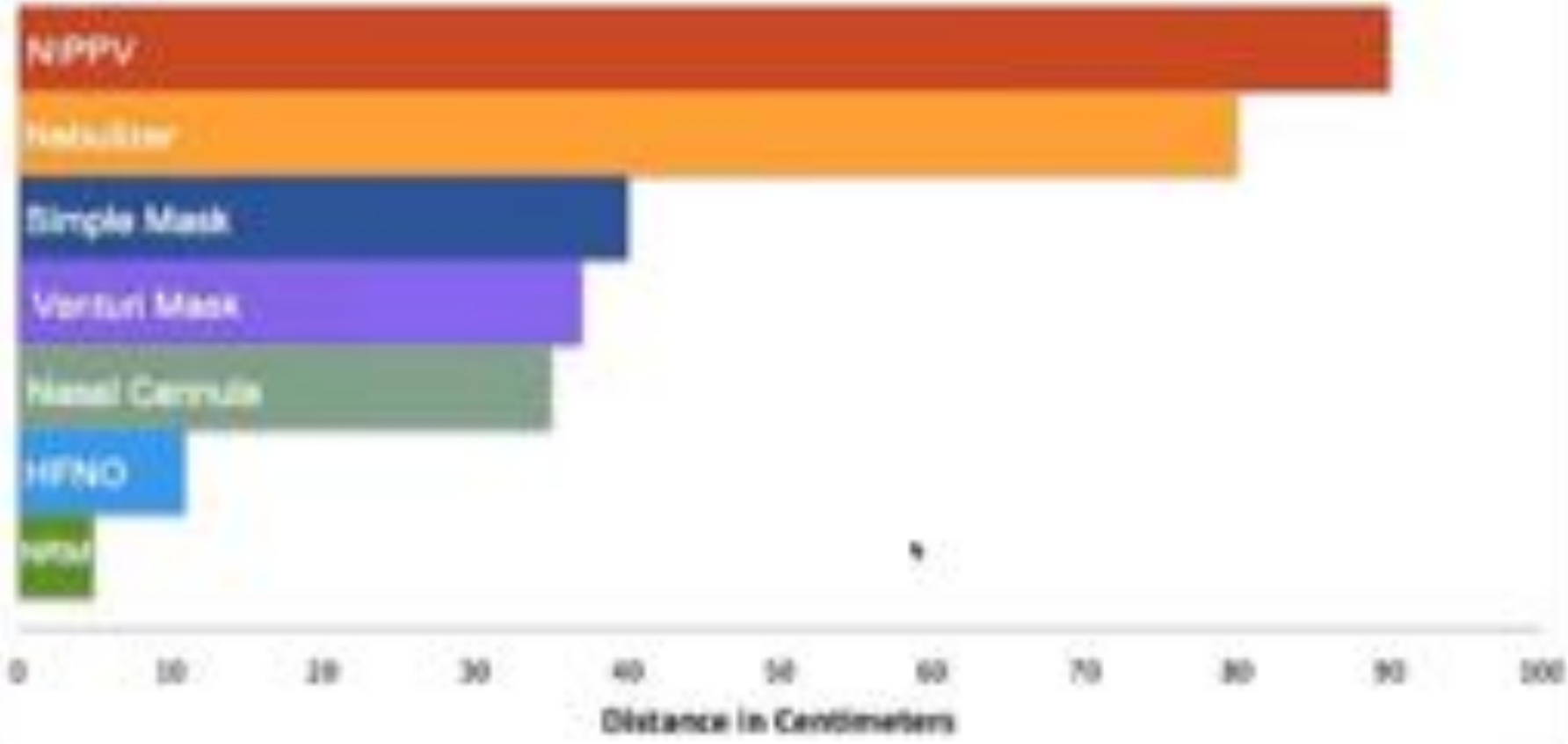
Meta-analysis of Risk of AGPs

(10 studies, low quality)

Procedure	Odds Ratio
Intubation	6.6
Tracheotomy	4.2
Bronchoscopy	3.3
Noninvasive ventilation	3.1
Bagging before ventilation	2.8
High Flow Nasal Cannula	0.4

Tran K et al, PlosOne 2012

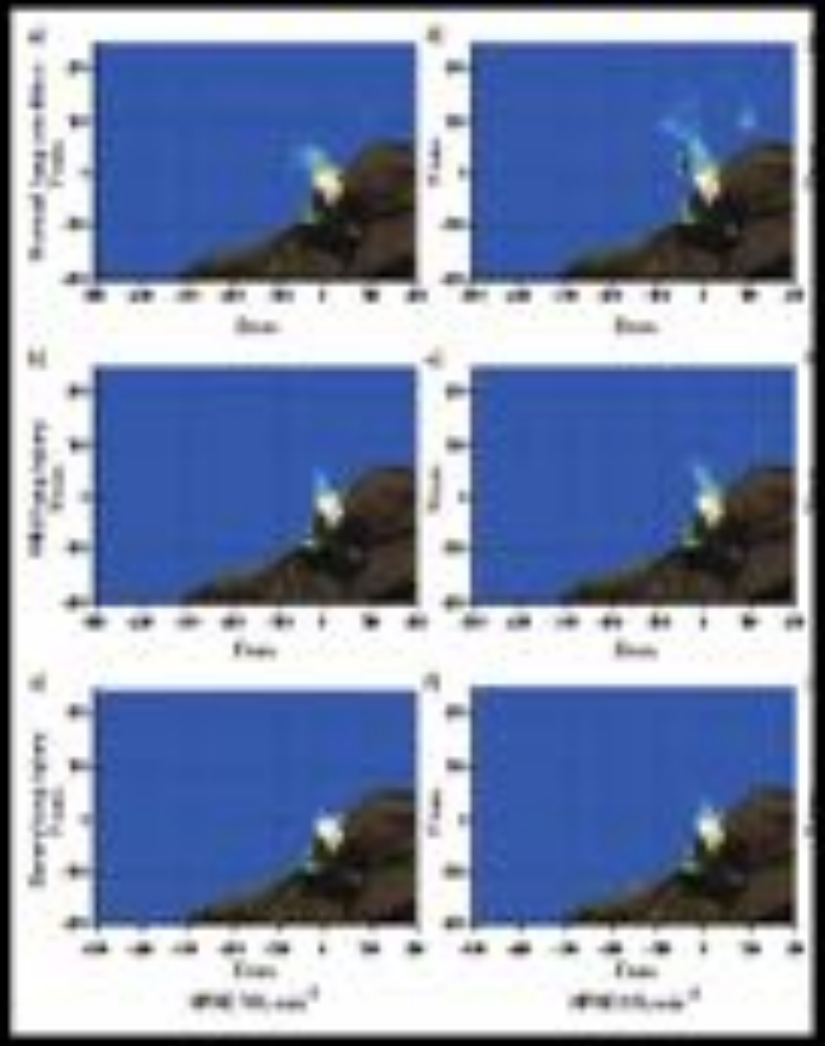
Figure 1. Comparison of aerosol dispersion differences (cm) using various treatment modalities.

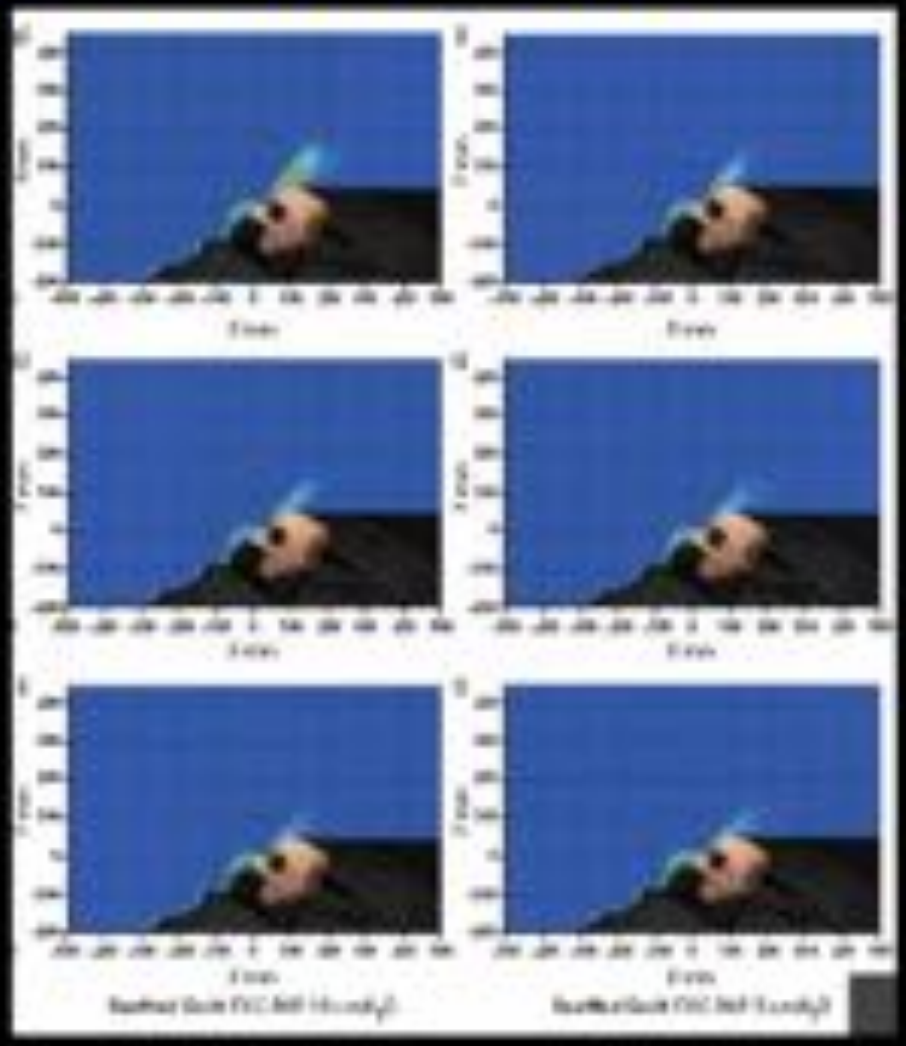


*Fericli M et al, ERJ 2020

**Leung CCH J Hosp Infection 2018

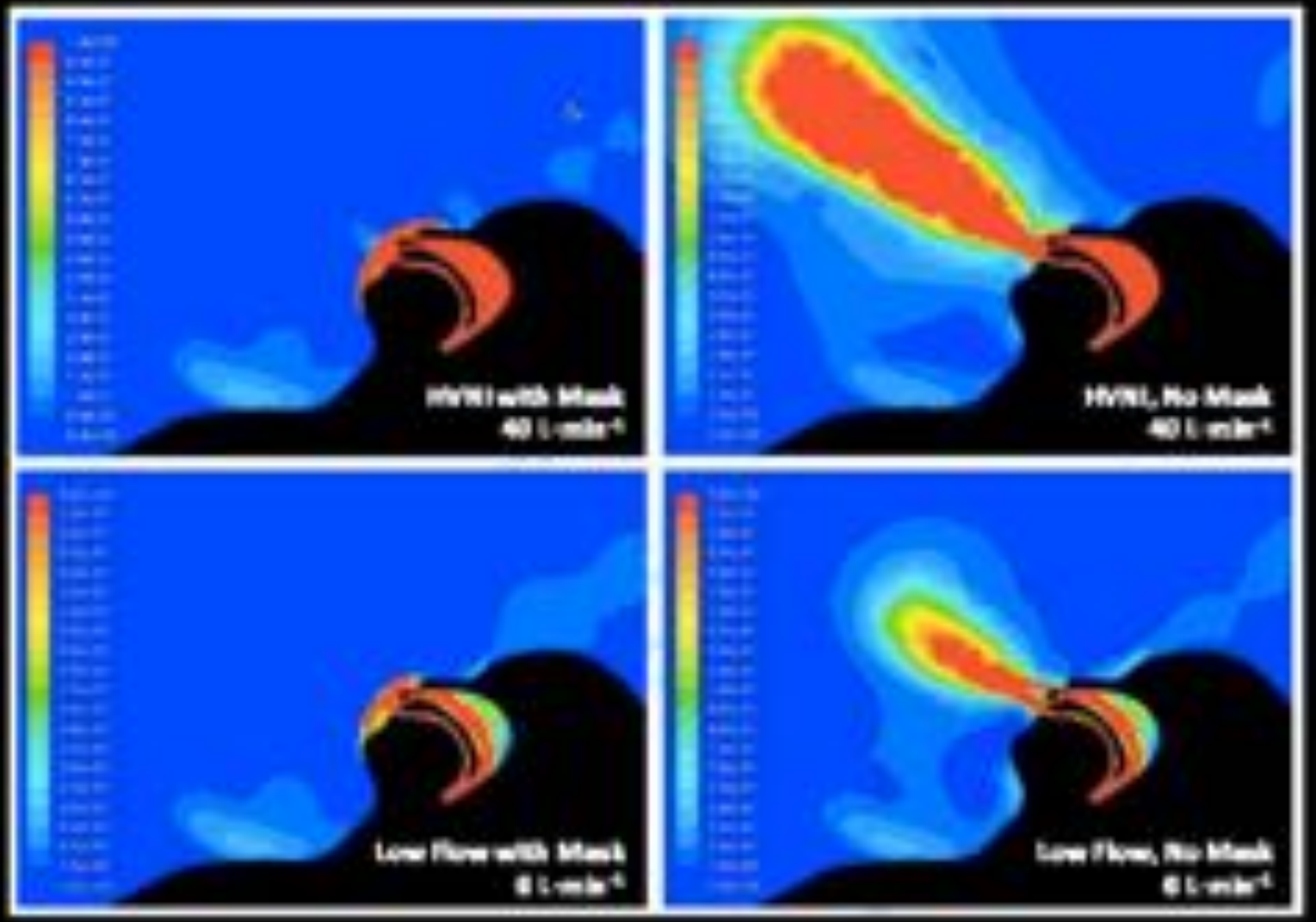
Dispersion with HFNC v CPAP



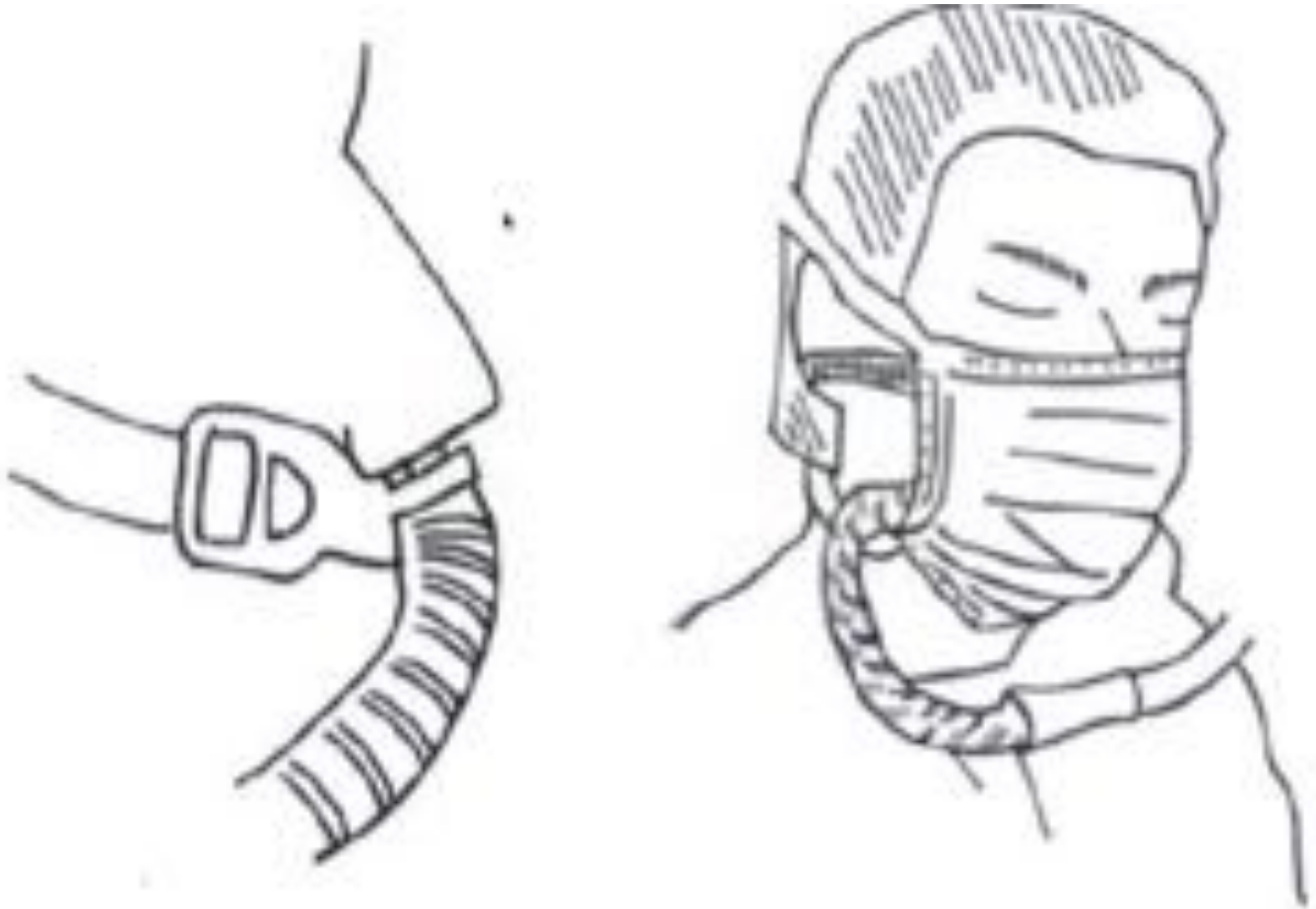


Hui DS et al ERJ 2019

High Velocity Nasal Insufflation



Scott L et al. Chest in press



COVID 19 and HFNC Patient Selection

- Oxygen up to 6 lpm not working
- Steady improvement
- 1-2 hr checkpoint
- Post-extubation
- DNI/DNR patients

COVID 19 and NIV Patient Selection

- On NIV or CPAP at home
- COPD exacerbation
- Cardiopulmonary edema
- Post-extubation
- DNI/DNR

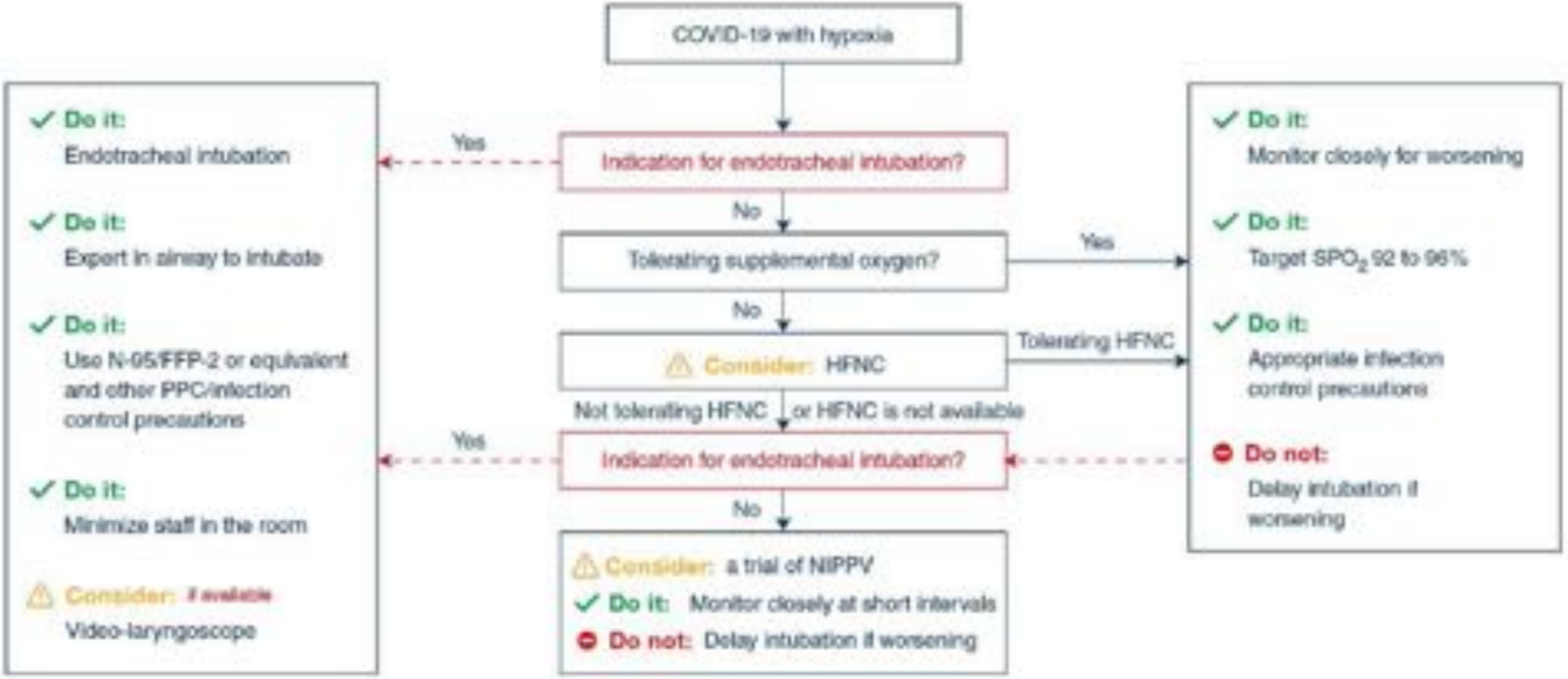
COVID 19 Respiratory Failure

- Predictors of NHF failure
  - RR > 30/min early during use
  - Failure to improve SpO2
  - Thoracoabdominal dyssynchrony
  - Vasopressor medications
  - SOFA score

COVID 19 and Invasive Ventilation

- Default mode
- Avoid emergency intubations
- Intubation team (assigned)
- Outcomes really not that good
  - China 60-97% mortality
  - Seattle 10-30% make it home (so far)

SCCM Guidelines 2020



Mechanical Ventilation COVID-19

- Start supplemental oxygen if SpO2 < 90%.
- Maintain no higher than 96%
- Failure of conventional oxygen therapy
  - HFNC over NIPPV
  - Close monitoring

- Mechanical ventilation
  - Low tidal volume ventilation
  - Plateau pressure target < 30 cm
  - Use higher PEEP strategy

Mechanical Ventilation COVID-19

- Moderate to severe ARDS
  - Prone positioning
  - 12-18 hrs
  - NMBA on as needed basis (compared to infusion)

- Worsening condition
  - Inhaled pulmonary vasodilator
  - Lung recruitment maneuvers
  - Do not use incremental PEEP maneuvers
  - ECMO support

COVID 19
Management of Respiratory Failure

- Negative pressure room, 12 air exchanges/hr
- Tier 2 PPE
- Droplet mask over HFNC prongs
- HFNC flow at 40-60 lpm
- Use dual limb circuit ventilator or exhalation viral/bacterial filters

Time period	Objective	Respiratory support options	Rationale
Before intubation	Adequate gas exchange Avoid P-SILI	Supplemental oxygen, CPAP, NIV, HFNC Awake prone positioning, Target nonvigorous breathing	Powerful respiratory effort can cause reinforcing lung and vascular stress, resulting in injury
During mechanical ventilation	Avoid pulmonary deterioration and VILI vortex	Minimize PEEP, frequency and tidal volume Adjust to acceptable gas exchange Maintain fluid balance Reduce O_2 demand Consider ECMO	Minimize transpulmonary and vascular stresses
After intubation	Minimize pulmonary stress Optimize O_2 Avoid VILI vortex	Type L[a]: use lower PEEP (<10 cm H_2O) Use more liberal tidal volume (7-9 mL/kg) as needed Reduce O_2 demand Consider prone positioning	Lower tidal volumes are unnecessary Higher PEEP is ineffective, creates dead space, and adversely redirects blood flow
	Reduce and evenly distribute lung and vascular stresses Optimize O_2 Avoid VILI vortex	Type H[a]: use higher PEEP (<15 cm H_2O) Lower tidal volume (5-7 mL/kg) Reduce O_2 demand Implement prone positioning	More closely behaves and responds like typical ARDS
Weaning phase	Avoid reversion to previously worsened pulmonary state by causing VILI and	Make transitions cautiously Avoid abrupt changes Spontaneous trials only at the very end of the weaning process	Strong spontaneous efforts raise O_2 demand, increase edema, and promote P-SILI

Marini, JAMA 2020

COVID 19
Timing to Tracheostomy

- Mortality high in these patients
- Appropriate PPE
- Later tracheostomy (14-21 days)
- reduction in viral load
- PEEP < 12, FiO2 < 60%
- Post-trach

THE FUTURE

The Future

- Improved methods for detection of pneumonia
- Improvement in patient selection for oxygenation
- Improvement in treatment strategies

The Future

- Movement away from “silo-ing of care”
- Development of better protocols
- Engagement of medical personnel
  - physicians
  - advanced practice providers
  - nurses
  - physical/occupational/speech therapists

Artificial Intelligence

- Earlier detection of weaning failures
- Smarter methods to wean
- Improved protocols
- Artificial intelligence

Respiratory Therapy

- You will always have critically ill patients who require mechanical ventilation
- You are at the cornerstone of this therapy
- You are in the perfect position to effect change


amazon

BASE YOUR STRATEGY ON THINGS THAT WON'T CHANGE.

Jeff Bezos

Base your strategy on things that won't change.

Success is going to require talented experts, a beginner's mind, and a long-term orientation.

Jeff Bezos

THANK YOU !

bwcmd@yahoo.com