Respiratory failure… What a Respiratory Therapist need to know

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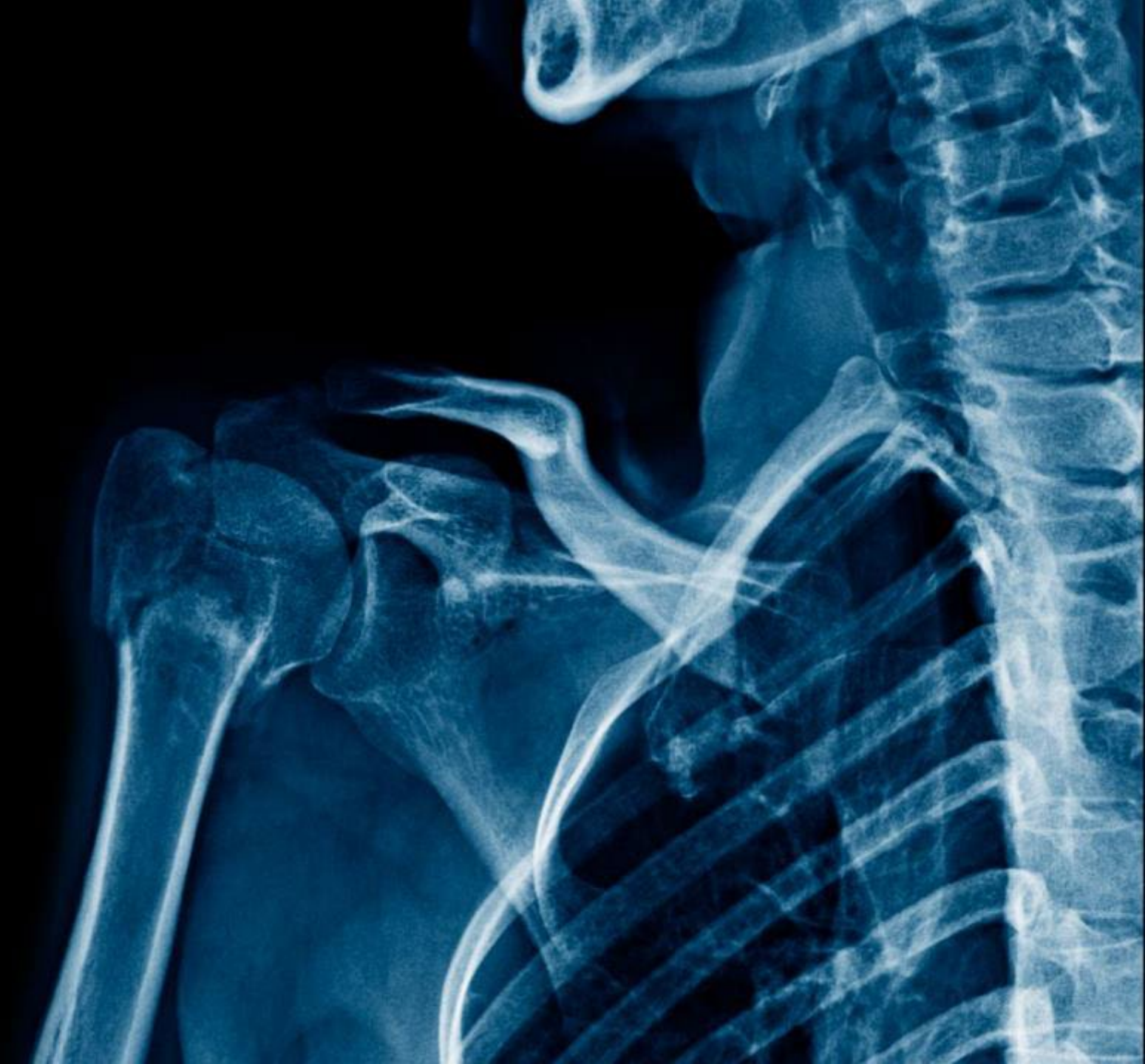


Respiratory failure

- *Defined as the inability of the respiratory system to meet the oxygenation, ventilation or metabolic needs of the body*
- *Classification:*
  - *Type 1 – Hypoxemic*
  - *Type 2 – Hypercapnic with or without hypoxemia*
- *Could be acute or chronic or acute on chronic*

Parillo JE, Dellinger RP. Critical Care Med-Principles of diagnosis and management in adult. 4th Ed.

	Hypoxemic respiratory failure	***Hypercapnic respiratory failure***
Criteria	*PaO_2< 60/ SpO_2 <90% while on FiO_2 >0.5* *Or* *PaO_2 <40 on any FiO_2*	*Acute: PaCO2> 50* *Or* *In acute on chronic: PaCO2 above baseline with concurrent serum pH<7.3*
Causes	*V/Q mismatch* *R→L shunt* *Alveolar hypoventilation* *Diffusion defect* *Inadequate FiO_2*	*Pump failure (↓drive, muscles fatigue/ ↑WOB)* *⬆ CO2 production* *R→L shunt* *⬆ Dead-space*

Hypoxic & Hypercapnic respiratory failure- criteria & etiologies

Strategies to prevent intubation

HFB VS. NIV

Figure 6. NIV vs usual care (overall) - Need for endotracheal intubation

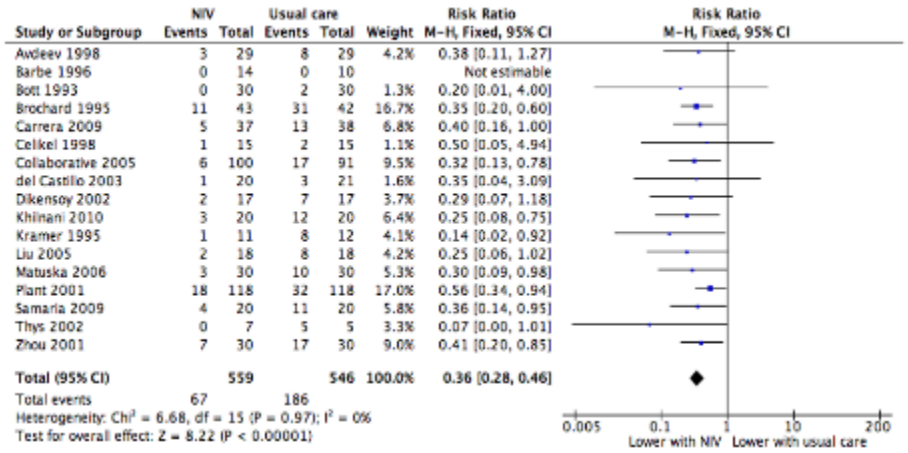
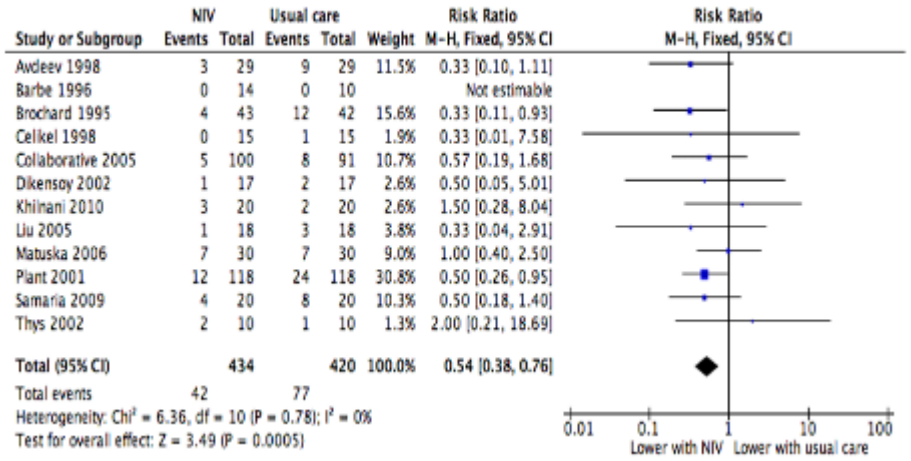


Figure 3. NIV vs usual care (overall) - Mortality



NIV in hypercapnic respiratory failure

- *Decreases intubation rate*
- *Decreases mortality*
- *Decreases respiratory rate/ WOB*
- *Increases V_T & MV*
- *Decreases ICU/ hospital LOS*

Osadnik CR, Tee VS, Carson-Chahhoud KV, Picot J, Wedzicha JA, Smith BJ. Non-invasive ventilation for the management of acute hypercapnic respiratory failure due to exacerbation of chronic obstructive pulmonary disease. Cochrane Database of Systematic Reviews 2017, Issue 7. Art. No.: CD004104. DOI: 10.1002/14651858.CD004104.pub4.

N Engl J Med 2015; 372:2185-2196

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

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

Jean-Pierre Frat, M.D., Arnaud W. Thille, M.D., Ph.D., Alain Mercat, M.D., Ph.D., Christophe Girault, M.D., Ph.D., Stéphanie Ragot, Pharm.D., Ph.D., Sébastien Perbet, M.D., Gwénael Prat, M.D., Thierry Boulain, M.D., Elise Morawiec, M.D., Alice Cottereau, M.D., Jérôme Devaquet, M.D., Saad Nseir, M.D., Ph.D., et al., for the FLORALI Study Group and the REVA Network*

RCT of 310 pts with PaO_2/FiO_2<300

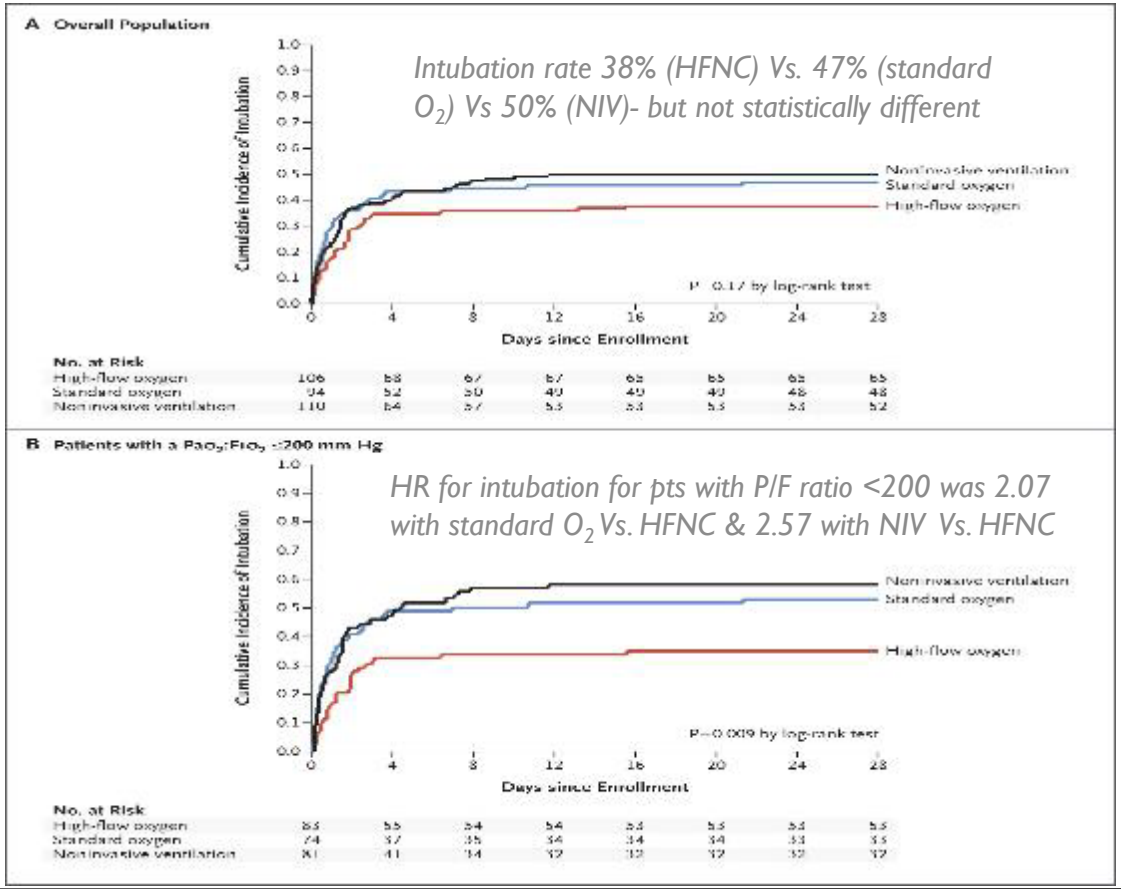
Protocol:

1:1:1 HFNC: Standard O_2: NIV

Results:

HR for death at 90 days 2.01 with standard O_2 Vs. HFNC (p=0.046) & 2.50 with NIV Vs. HFNC (p=0.006)

HFNC also had higher ventilator-free days compared to standard O_2 & NIV



Intubation rate 38% (HFNC) Vs. 47% (standard O_2) Vs 50% (NIV)- but not statistically different

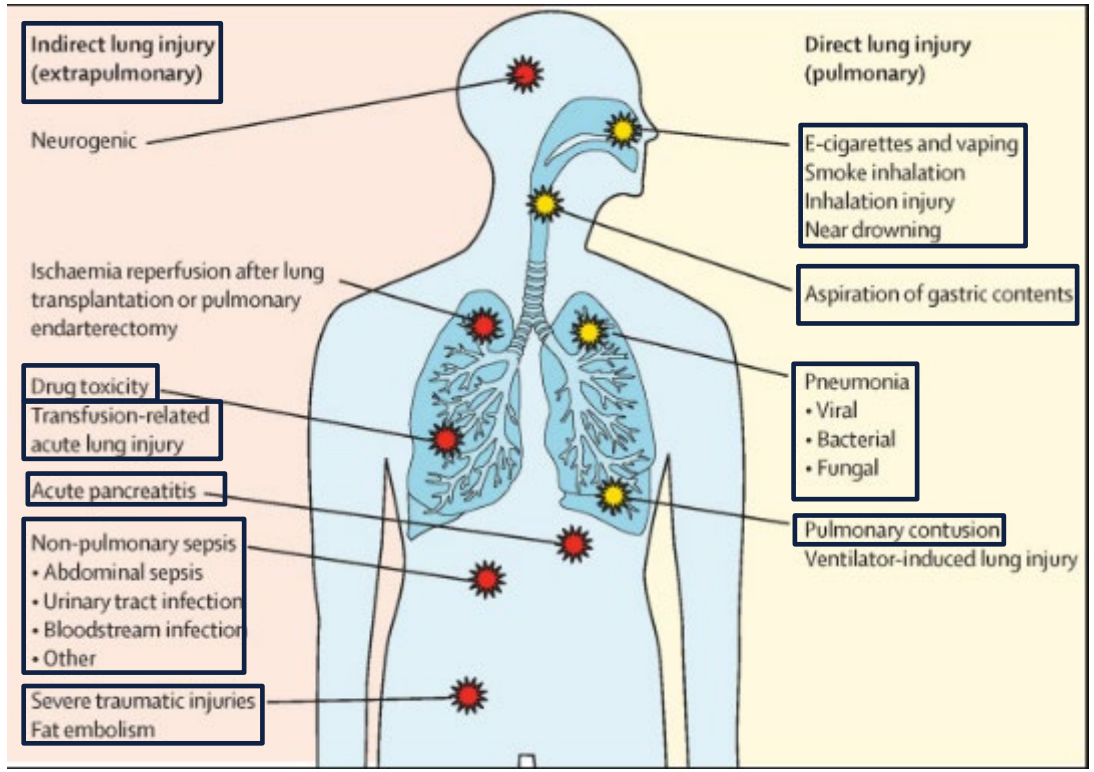
HR for intubation for pts with P/F ratio <200 was 2.07 with standard O_2 Vs. HFNC & 2.57 with NIV Vs. HFNC

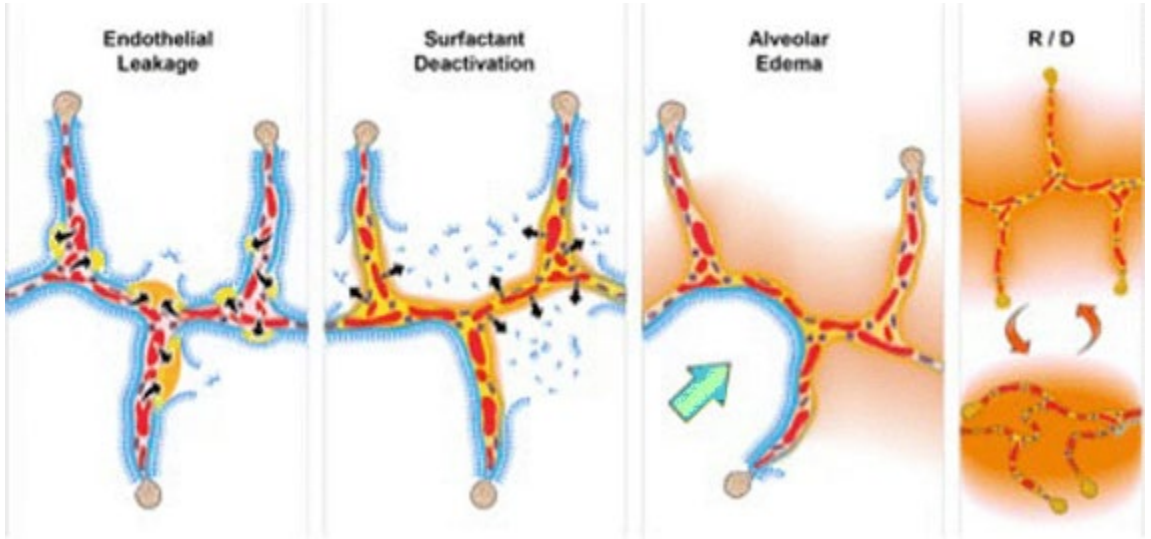
Ventilator management in ARDS

Where less is more

Acute Respiratory Distress Syndrome

Multiple different insults → *Same pathophysiologic consequence*





- *Gas-exchange problem (V/Q mismatch)*
- *Decreased compliance (Stiff lungs)*
- *Elevated pulmonary vascular resistance/R→L shunt*

Acute respiratory distress syndrome: causes, pathophysiology, and phenotypes.
The Lancets. ACUTE RESPIRATORY DISTRESS SYNDROME 2022| VOLUME 400, ISSUE 10358, P1145-1156, OCTOBER 01, 2022

ARDS- Incidence

ARDS is common

0.42 cases per ICU bed over 4 weeks
10.4% of all ICU admissions
23.4% of patients requiring MV

But…..often unrecognized

Only 51.3% mild ARDS and 78.5% of severe ARDS were clinically recognized

Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries
Bellani et al. JAMA, 2016; 315:788

BERLIN definition of ARDS

Acute onset: ≤ *1 week from insult or new/worsening symptoms*

Chest Imaging: *bilateral, not explained by alternative etiologies*

Origin of edema: *not fully explained by cardiac/fluid overload*

- If no ARDS risk factor, need objective assessment

Hypoxia: *PaO_2/FiO_2 ratio <300 while on PEEP ≥ 5 cm H_2O*

- *Mild: 201-300 mm Hg*
- *Moderate: 101-200 mm Hg*
- *Severe: ≤ 100 mm Hg*

ARDS-Net JAMA. 2012;307:2526

Treatment of ARDS

- **Improve gas exchange by reducing shunt fraction**
  - Lung-protective ventilation
  - Prone positioning
  - Negative fluid balance
  - Pulmonary vasodilators
- **Increase O2 delivery**
  - Improve cardiac filling
  - Inotropes
  - Maintain adequate Hgb
- **Decreased O2 consumption**
  - Mechanical ventilation
  - Sedation/ Paralysis
  - Avoidance of fever
- **Avoidance of further injury**
  - Lung-protective ventilation
  - Prone positioning
  - Judicious transfusion

Lung-protective ventilator strategy

Lower Tidal Volume

4-8 mL/Kg of IBW

Adequate PEEP-

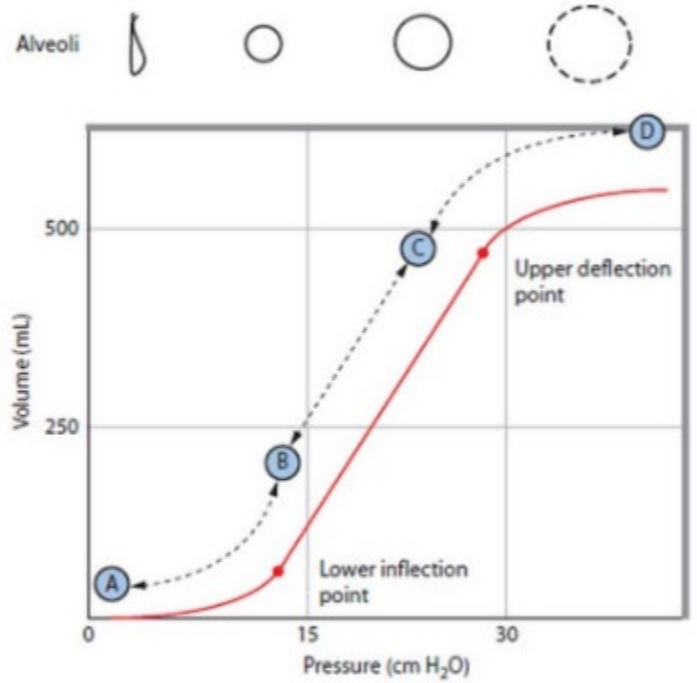
How much is enough?

Limit Pplat <30 cm of H_2O

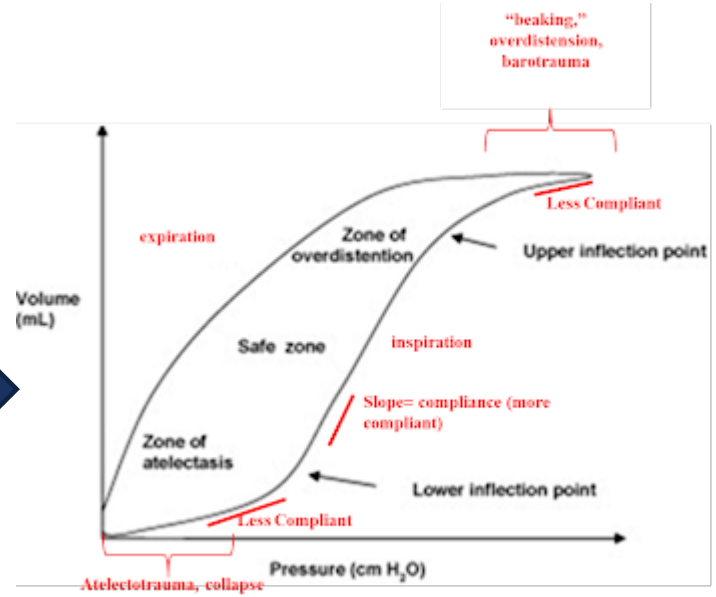
Lower Driving Pressure

<15 cm of H_2O

How could ventilation strategy protect lung?



Source: Jesse B. Hall, Gregory A. Schmidt, John P. Kress: *Principles of Critical Care*, 4th Edition: www.accessmedicine.com



Ideally ventilation should happen between upper and lower deflection point

Prevent atelectrauma

- *Adequate PEEP*

Prevent over-distention

- *Lower tidal volume*

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Ventilation with Lower Tidal Volumes as Compared with Traditional Tidal Volumes for Acute Lung Injury and the Acute Respiratory Distress Syndrome

The Acute Respiratory Distress Syndrome Network*

N Engl J Med 2000; 342:1301-1308

861 patients with ALI/ARDS

Higher (12 mL/Kg IBW) Vs. Lower tidal-volume (6 mL/Kg IBW)

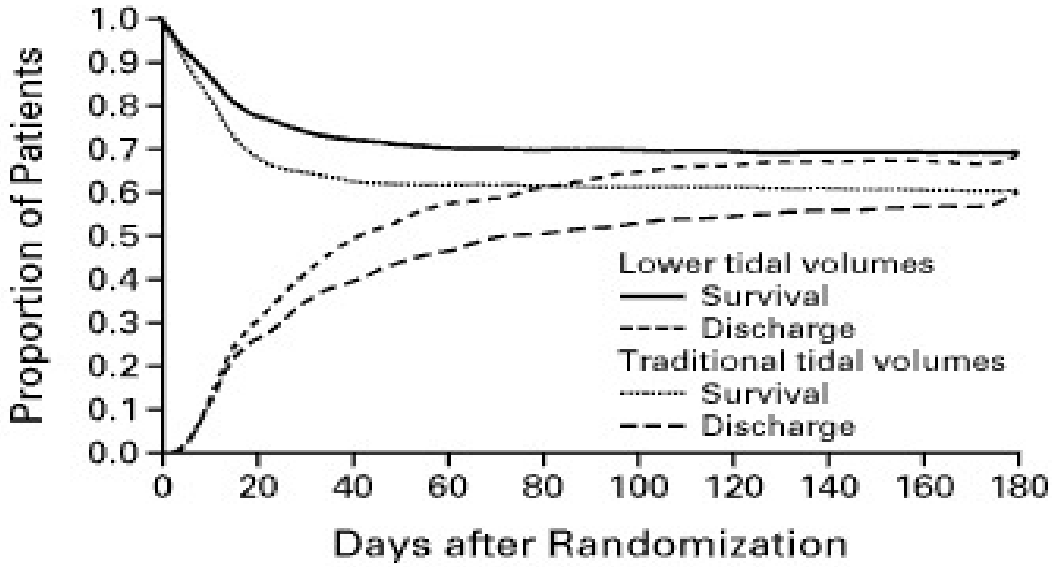


TABLE 4. MAIN OUTCOME VARIABLES.*

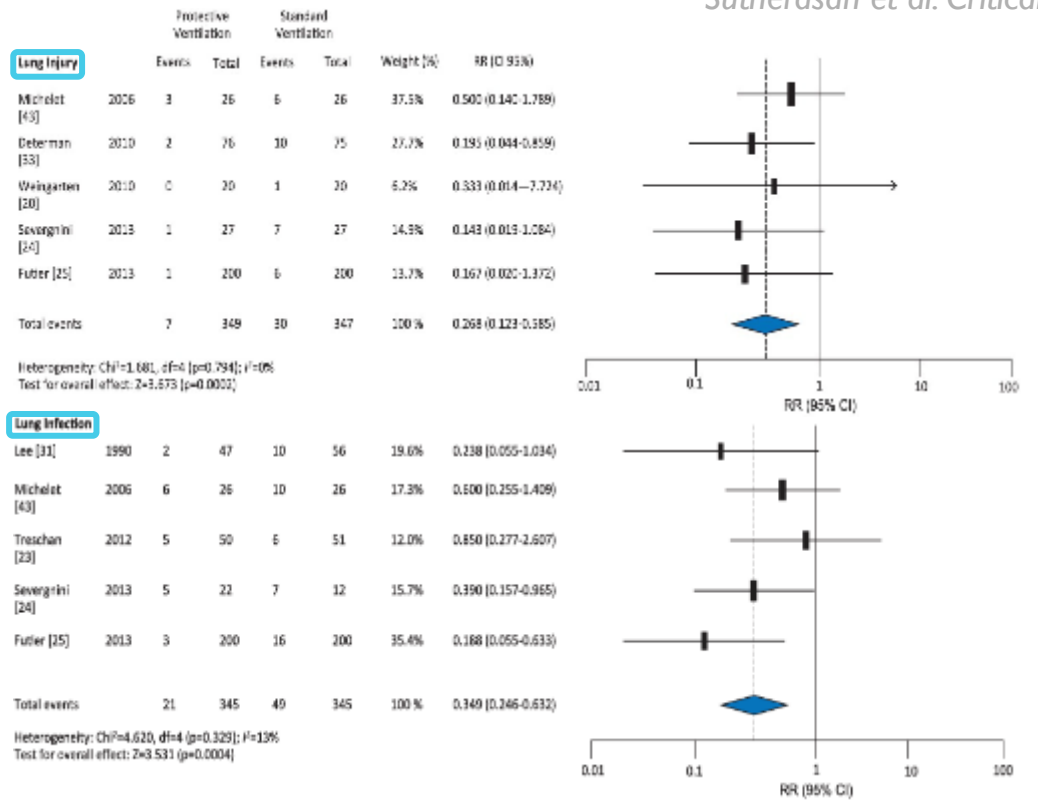
VARIABLE	GROUP RECEIVING LOWER TIDAL VOLUMES	GROUP RECEIVING TRADITIONAL TIDAL VOLUMES	P VALUE
Death before discharge home and breathing without assistance (%)	31.0	39.8	0.007
Breathing without assistance by day 28 (%)	65.7	55.0	<0.001
No. of ventilator-free days, days 1 to 28	12±11	10±11	0.007
Barotrauma, days 1 to 28 (%)	10	11	0.43
No. of days without failure of nonpulmonary organs or systems, days 1 to 28	15±11	12±11	0.006

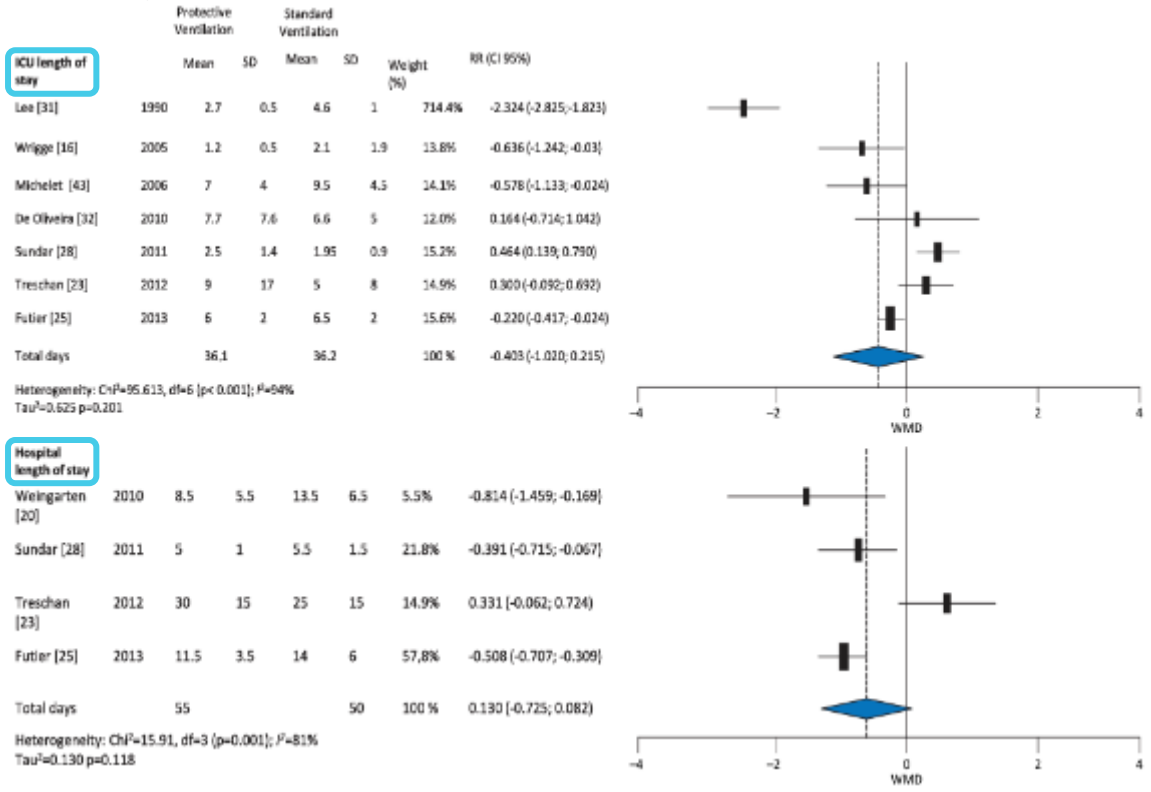
REVIEW

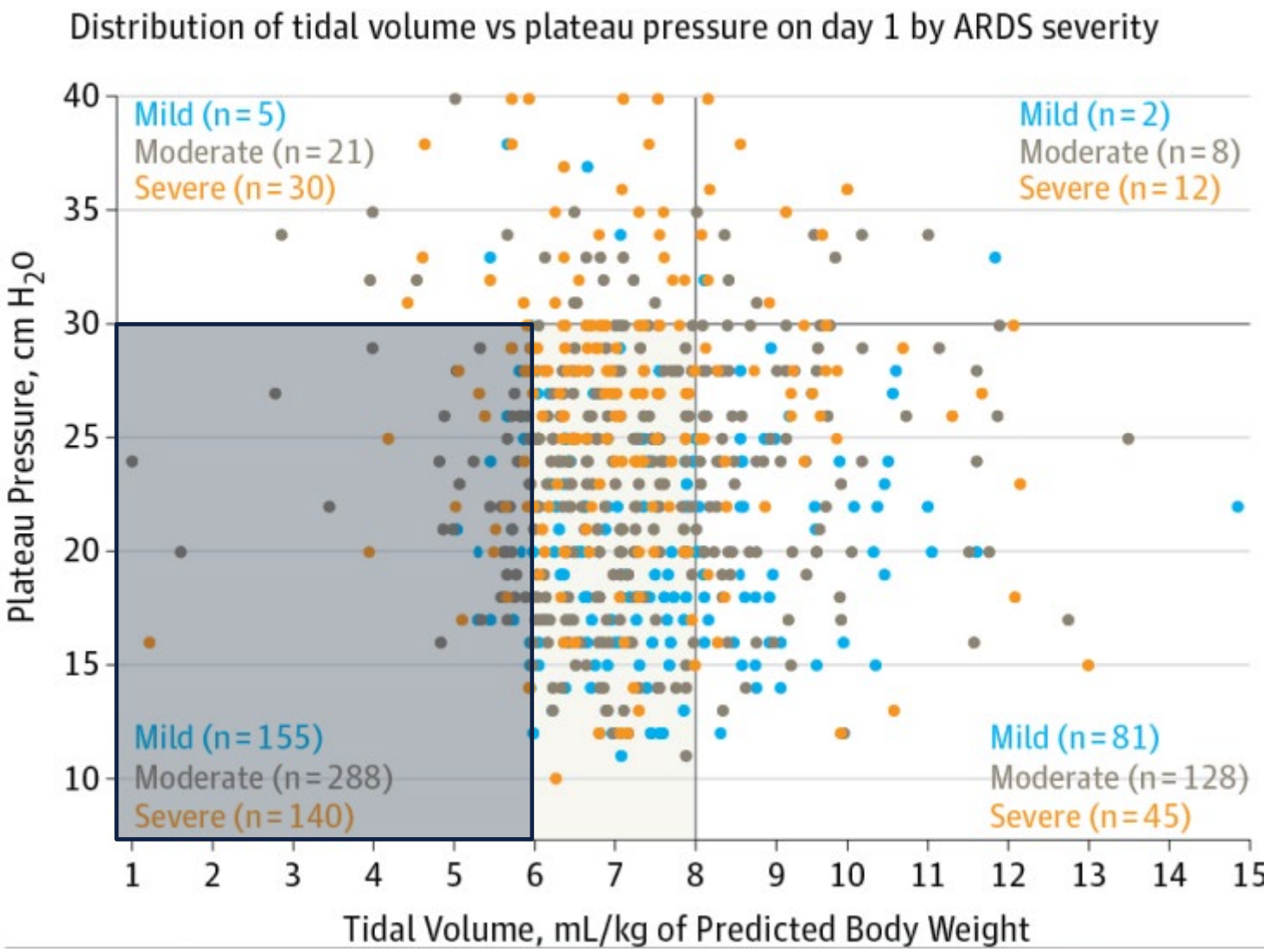
CRITICAL CARE

Protective mechanical ventilation in the non-injured lung: review and meta-analysis

Sutherasan et al. Critical Care 2014, 18:211







Current practice of mechanical ventilation in ARDS

Epidemiology, Patterns of Care, and Mortality for Patients With Acute Respiratory Distress Syndrome in Intensive Care Units in 50 Countries
Bellani et al. JAMA, 2016; 315:788

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Higher versus Lower Positive End-Expiratory Pressures in Patients with the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute ARDS Clinical Trials Network[A]

N Engl J Med 2004; 351:327-336

RCT of 549 patients with ALI/ARDS

Mean PEEP of 8.3 cm H_2O in the lower-PEEP group Vs. 13.2 cm H_2O in the higher-PEEP group

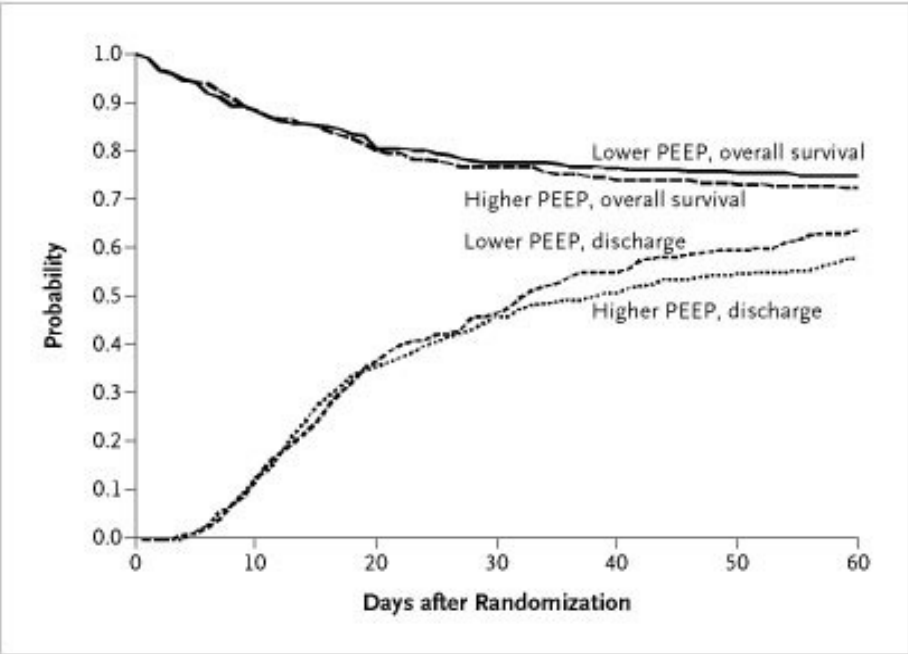


Table 4. Main Outcome Variables.*

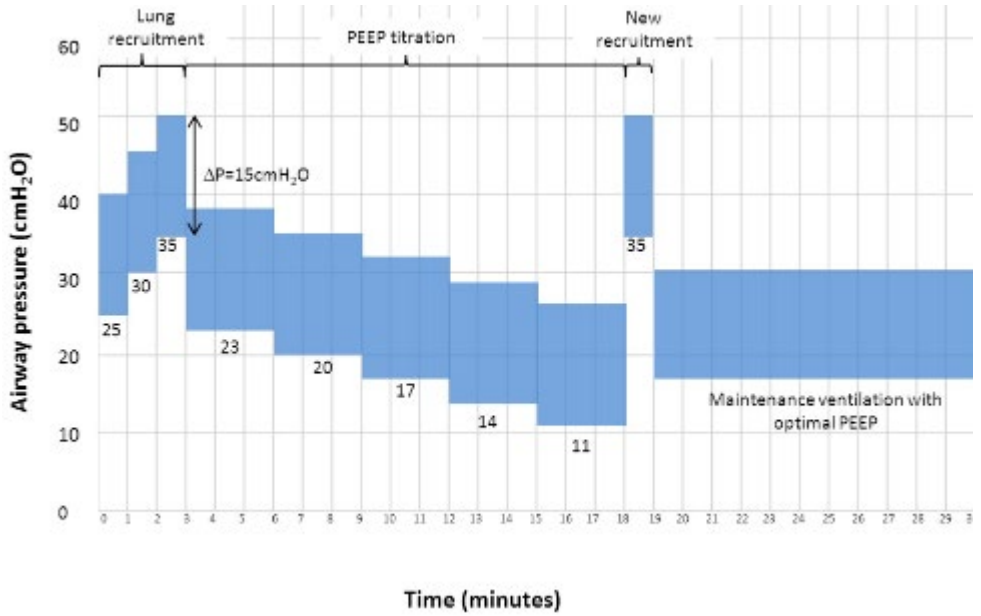
Outcome	Lower-PEEP Group	Higher-PEEP Group	P Value
Death before discharge home (%)†			
Unadjusted	24.9	27.5	0.48
Adjusted for differences in baseline covariates	27.5	25.1	0.47
Breathing without assistance by day 28 (%)	72.8	72.3	0.89
No. of ventilator-free days from day 1 to day 28‡	14.5±10.4	13.8±10.6	0.50
No. of days not spent in intensive care unit from day 1 to day 28	12.2±10.4	12.3±10.3	0.83
Barotrauma (%)§	10	11	0.51
No. of days without failure of circulatory, coagulation, hepatic, and renal organs from day 1 to day 28	16±11	16±11	0.82

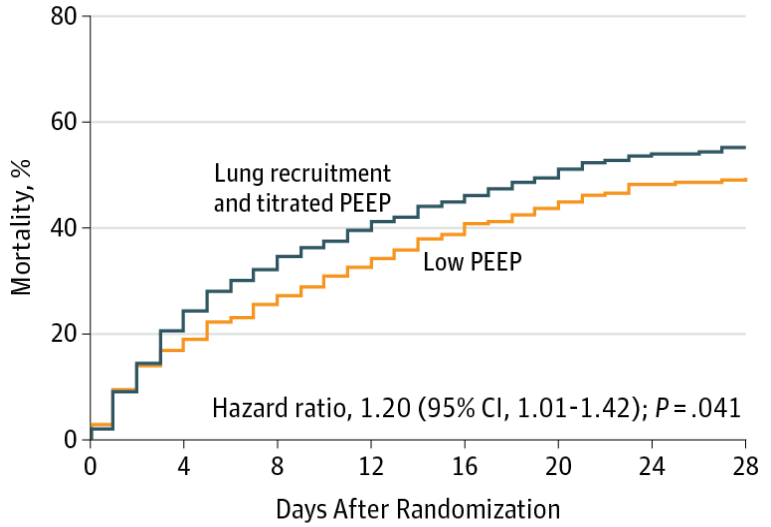
JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

Effect of Lung Recruitment and Titrated Positive End-Expiratory Pressure (PEEP) vs Low PEEP on Mortality in Patients With Acute Respiratory Distress Syndrome
A Randomized Clinical Trial

Writing Group for the Alveolar Recruitment for Acute Respiratory Distress Syndrome Trial (ART) Investigators

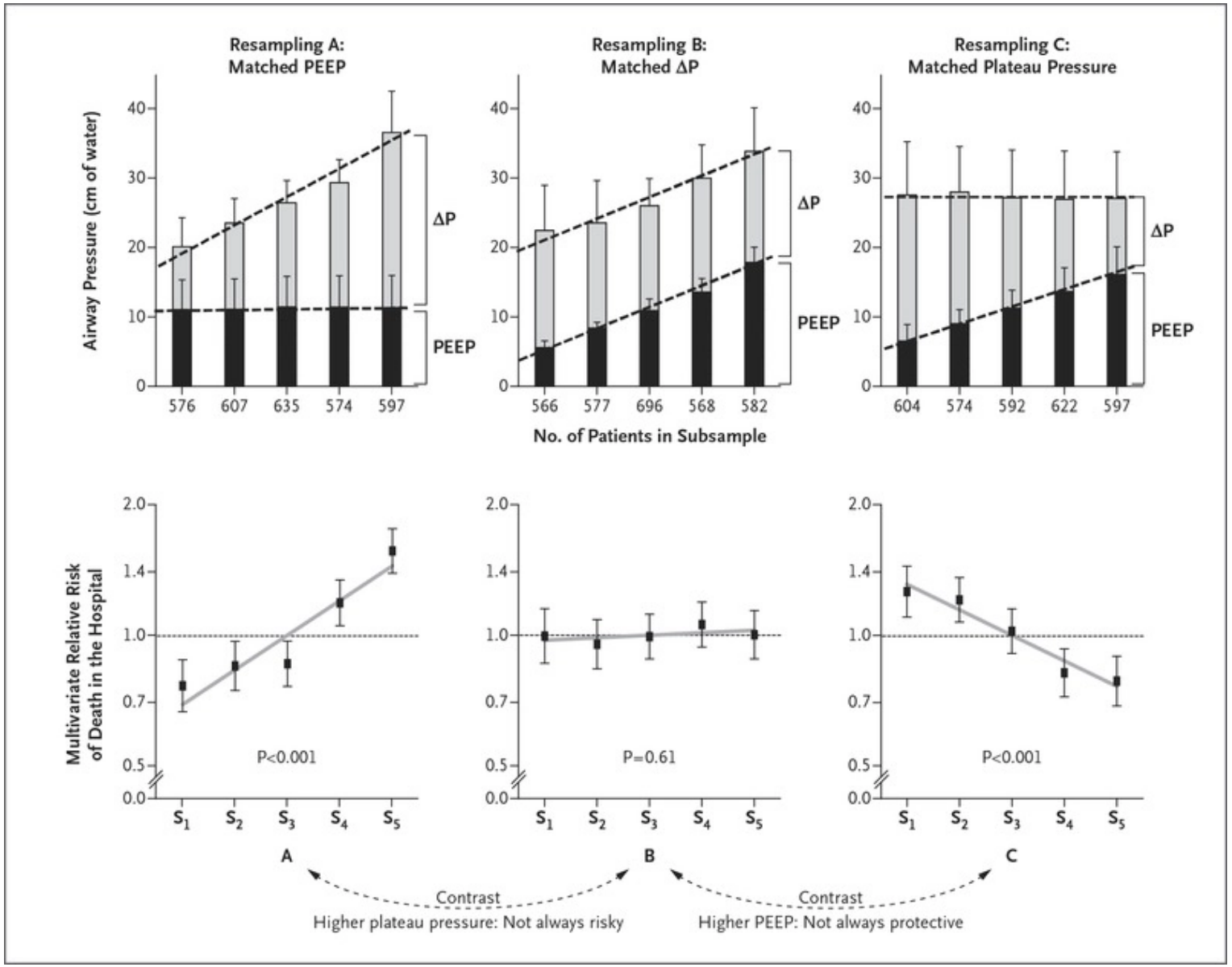
RCT of 1013 patients with P/F ratio <200
ARDS-Net Vs. recruitment & titrated PEEP





No. at risk								
Lung recruitment and titrated PEEP	501	397	340	303	276	254	233	225
Low PEEP	509	423	378	343	312	286	264	260

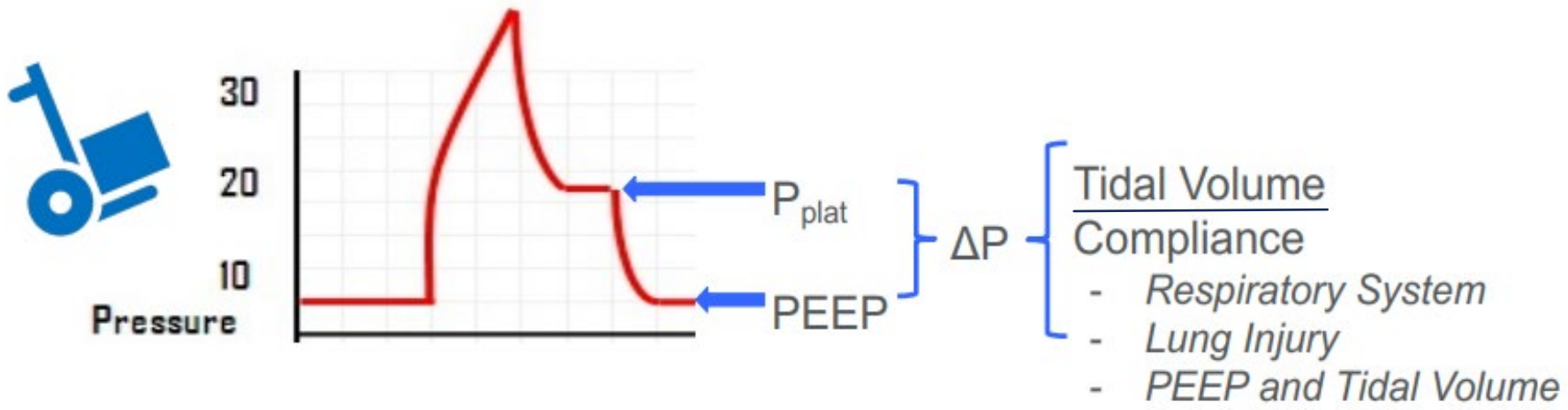
JAMA. 2017;318(14):1335-1345. doi:10.1001/jama.2017.14171



Which pressure matters most in ARDS ?

Amato MBP et al. N Engl J Med 2015; 372:747-755

What is Driving pressure (ΔP)?



- *$\Delta P = V_T$/Lung compliance*
- *Independent predictor of survival*

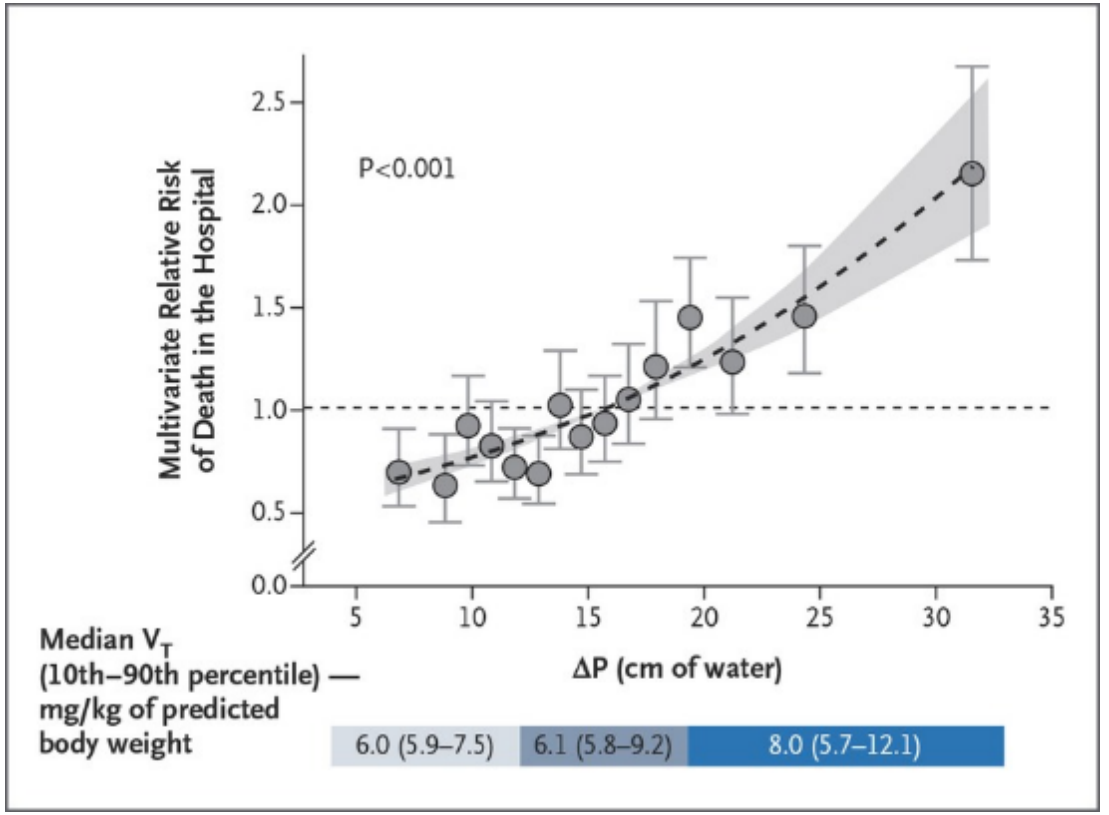
The NEW ENGLAND JOURNAL of MEDICINE

SPECIAL ARTICLE

Driving Pressure and Survival in the Acute Respiratory Distress Syndrome

Marcelo B.P. Amato, M.D., Maureen O. Meade, M.D., Arthur S. Slutsky, M.D., Laurent Brochard, M.D., Eduardo L.V. Costa, M.D., David A. Schoenfeld, Ph.D., Thomas E. Stewart, M.D., Matthias Briel, M.D., Daniel Talmor, M.D., M.P.H., Alain Mercat, M.D., Jean-Christophe M. Richard, M.D., Carlos R.R. Carvalho, M.D., et al.

N Engl J Med 2015; 372:747-755



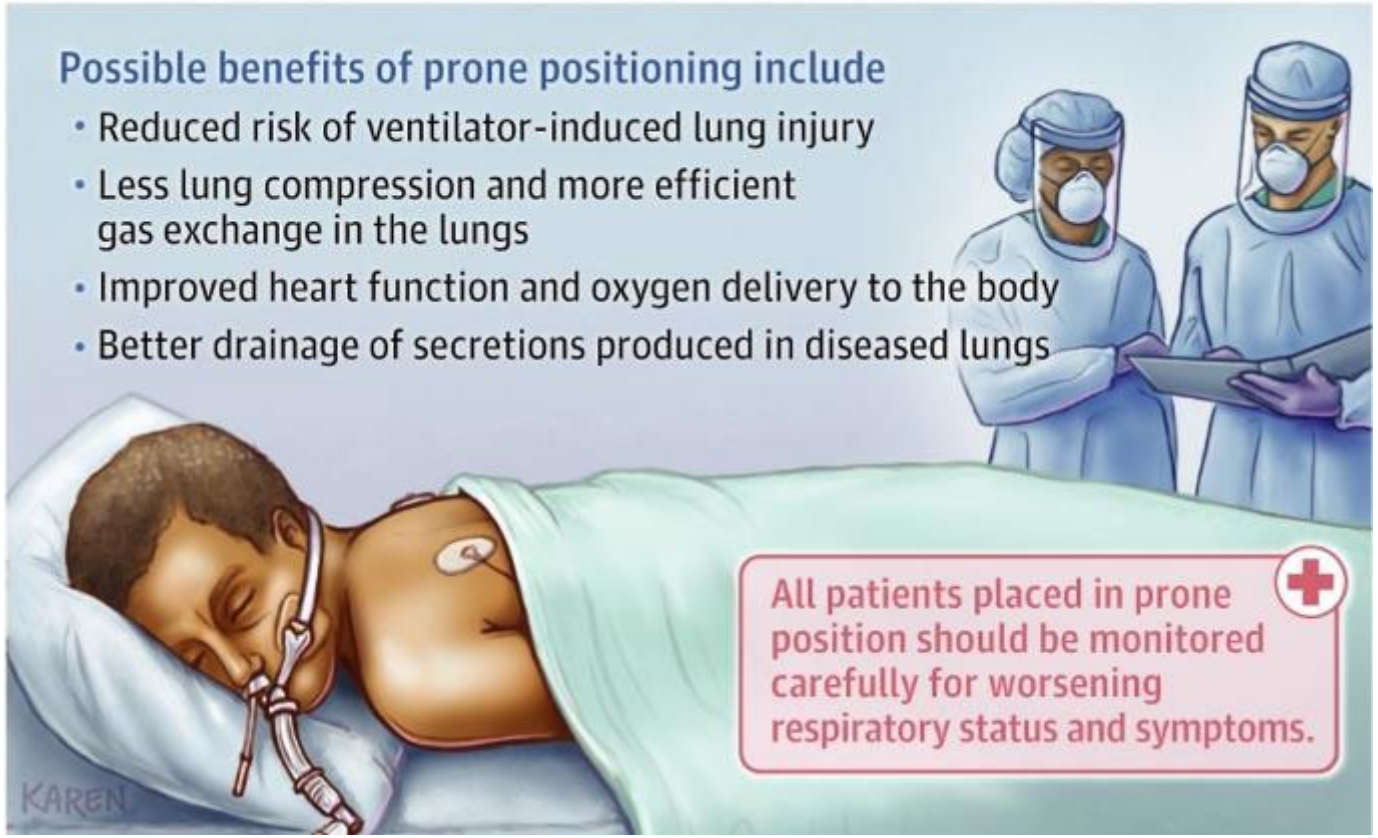
How do we know we are protecting lung?

- *Stress Index can be of help.*
- *The pattern of change in airway pressure with volume-control ventilation using a constant inspiratory flow rate (square wave pattern)*
- *Provides clues as to the likelihood of overinflation.*
- *A concave upward contour of airway pressure vs time suggests overinflation is present, because proportionally higher pressure is required to complete lung inflation.*

Stress Index

Red line concave upward tracing. Stress index slightly >1.0.

Red line concave downward tracing. Stress index slightly <1.0.



Prone positioning

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Prone Positioning in Severe Acute Respiratory Distress Syndrome

Claude Guérin, M.D., Ph.D., Jean Reignier, M.D., Ph.D., Jean-Christophe Richard, M.D., Ph.D., Pascal Beuret, M.D., Arnaud Gacouin, M.D., Thierry Boulain, M.D., Emmanuelle Mercier, M.D., Michel Badet, M.D., Alain Mercat, M.D., Ph.D., Olivier Baudin, M.D., Marc Clavel, M.D., Delphine Chatellier, M.D., et al., for the PROSEVA Study Group*

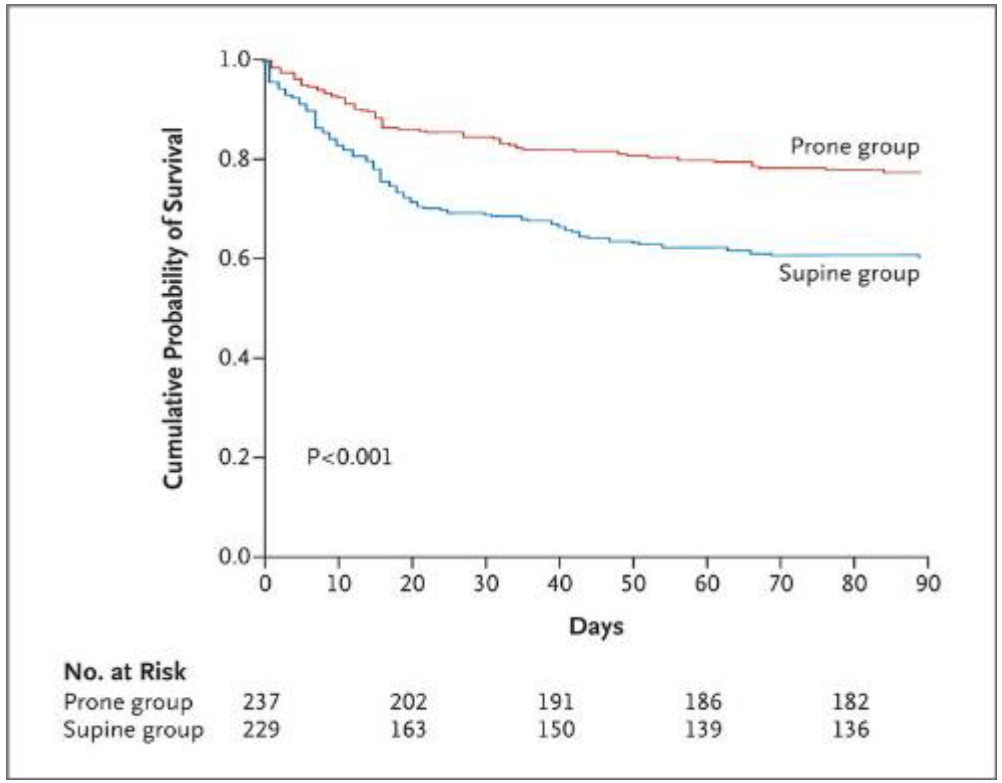
N Engl J Med 2013; 368:2159-2168

RCT of 466 patients

Eligibility Criteria:
severe ARDS (P/F<150 mm Hg) AND FiO2 >0.6, PEEP >5 cm of H_2O, V_T ~ 6 ml/Kg of IBW

Protocol:
Proned for at-least 16 hours using regular hospital bed

Result:
28-day mortality: 16% Vs. 32.8%



Initial ACURASYS trial showed improvement in adjusted 90-day mortality in patients with severe ARDS.

Despite that, neuro-muscular blockers (NMB) were not adopted widely, perhaps due to poor confidence in the validity of the results and persistent concerns regarding adverse effects of NMBs.

Is paralytics the answer?

Trial

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Early Neuromuscular Blockade in the Acute Respiratory Distress Syndrome

The National Heart, Lung, and Blood Institute PETAL Clinical Trials Network*

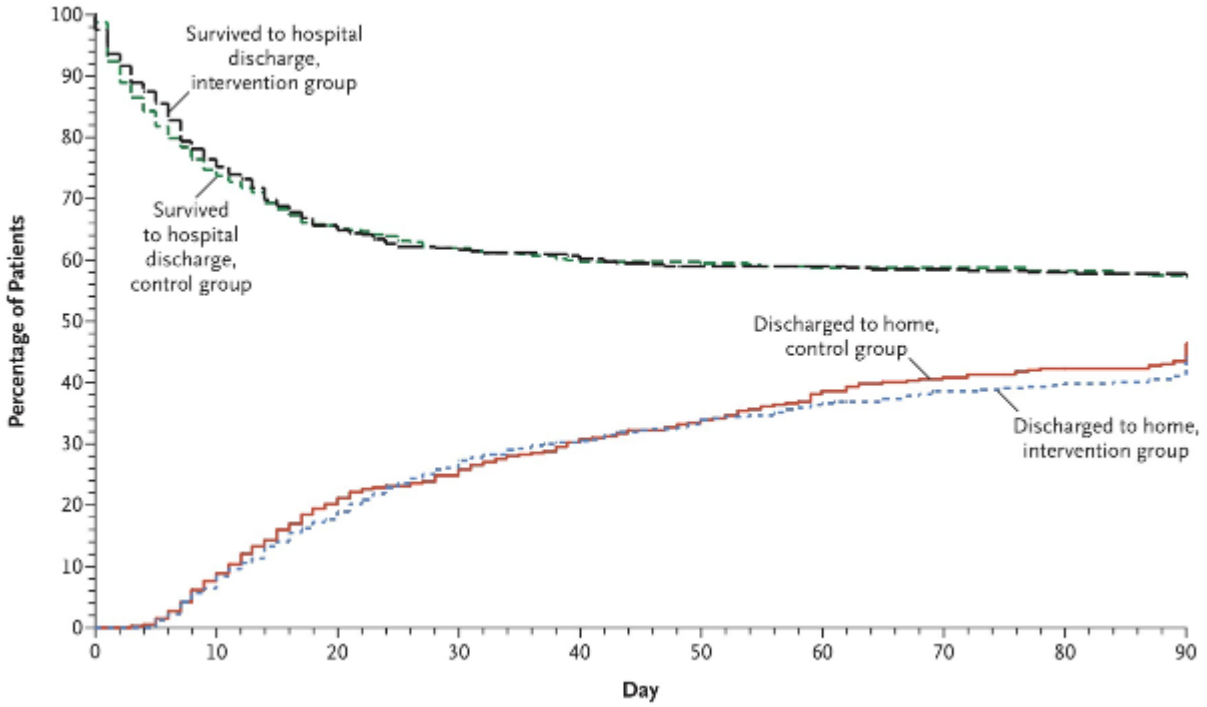
N Engl J Med 2019; 380:1997-2008

RCT of 1006 patients

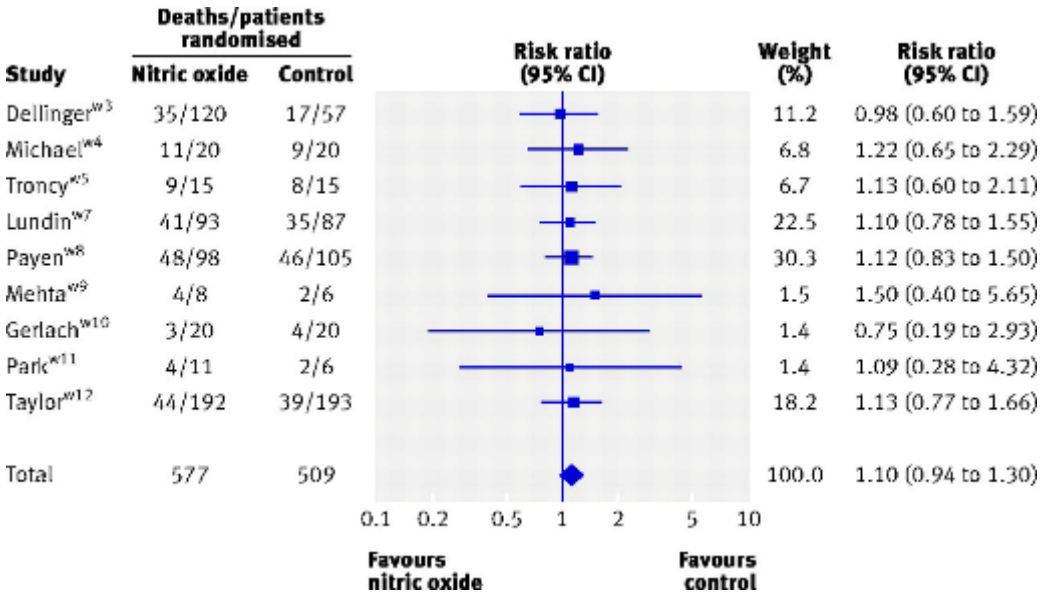
Eligibility Criteria:
severe ARDS (P/F<150 mm Hg) AND PEEP ≥8 cm of H2O

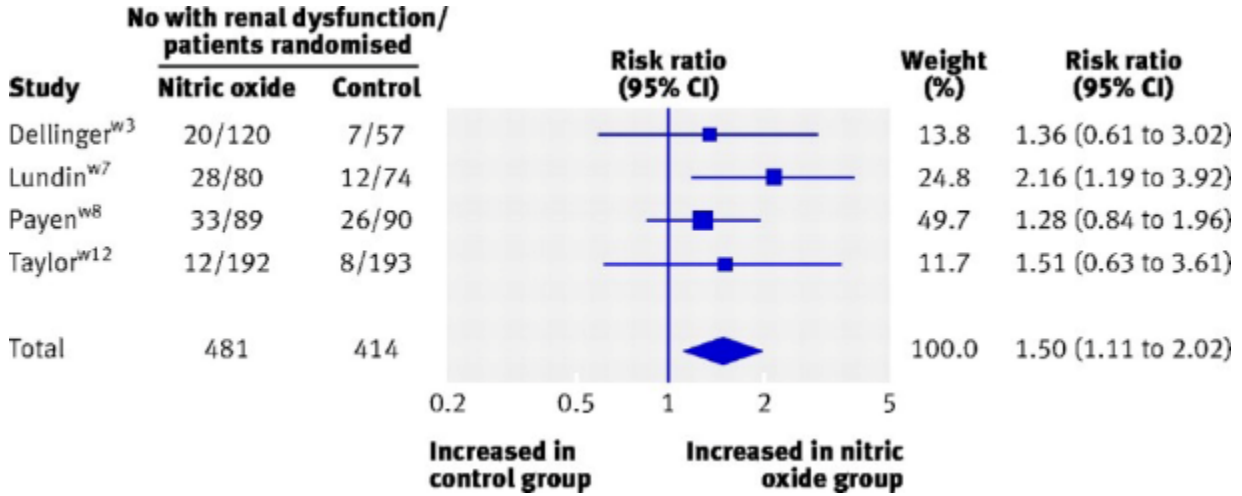
Protocol: 48-hr cisatracurium drip along with deep sedation Vs. lighter sedation only

Result:
90-day mortality: 42.5% Vs. 42.8%



Inhaled pulmonary vasodilator





No definitive mortality benefit & increases risk of renal dysfunction

Used as salvage therapy in severe hypoxemia by improving V/Q mismatch

Adhikari NKJ, et.al: BMJ 2007; 334:757

Inhaled Epoprostenol Titration schedule

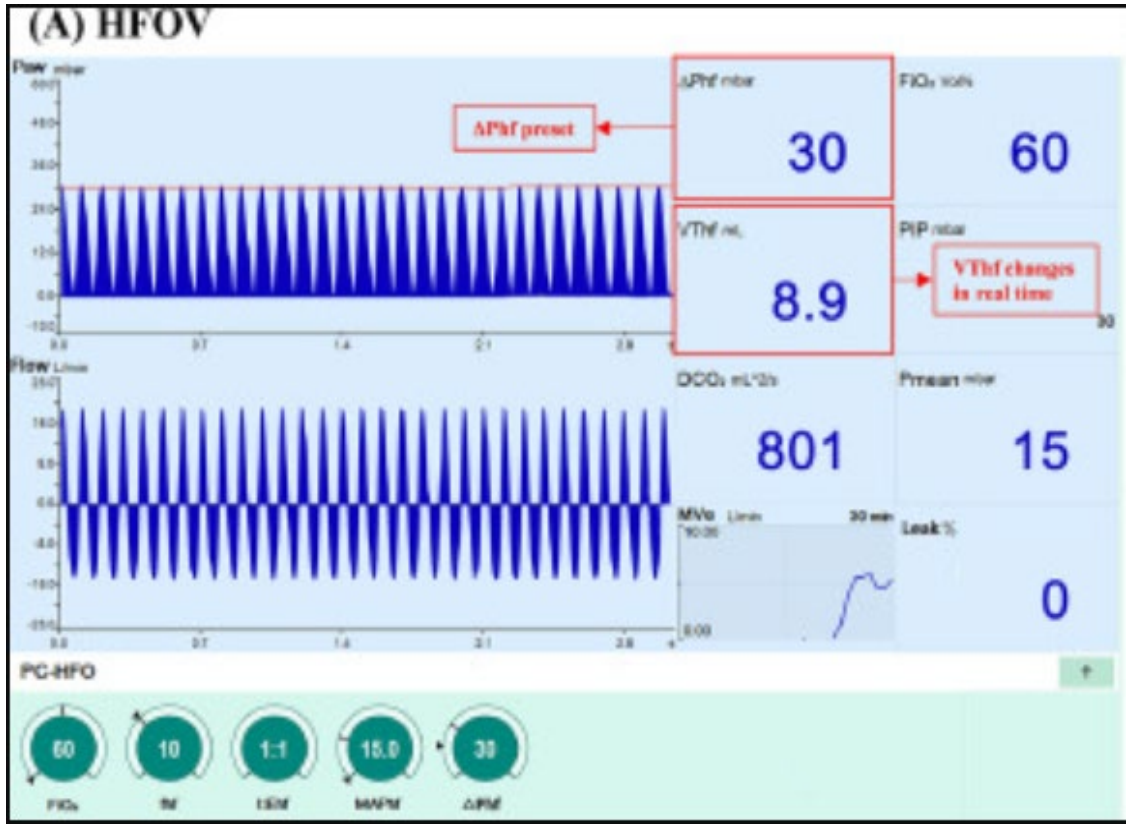
Fixed-Dose Aerosolized Epoprostenol	Weight-based Aerosolized Epoprostenol (70 kg)	
	Epoprostenol (30,000 ng/mL)	Normal Saline
Initial Dose 20,000 ng/mL (1mg/50 mL)	Dose: 50 ng/kg/min	
	7 mL/hr	1 mL/hr
10,000 ng/mL (0.5 mg/50 mL)	Dose: 25 ng/kg/min	
	3.5 mL/hr	4.5 mL/hr
5,000 ng/mL (0.25 mg/50 mL)	Dose: 12.5 ng/kg/min	
	1.8 mL/hr	6.2 mL/hr
2,500 ng/mL (0.125 mg/50 mL)	Dose: 6.25 ng/kg/min	
	0.9 mL/hr	0.1 mL/hr
	Dose: 3.13 ng/kg/min	
	0.4 mL/hr	7.6 mL/hr
• Avoids calculation errors. • Dose delivered can only be changed by changing concentration of supply.	• Provides a wide range of dose titrations using a single concentration.	
• Can wean if stable to next lower dose as tolerated by the partial arterial oxygen pressure to fraction of inspired oxygen ratio or mean pulmonary artery pressures (if available) as often as every 4 hours. • For more rapid titration must also purge previous concentration in infusion tubing. • May discontinue/pause nebulization at any point to assess effect on indices of oxygenation.		

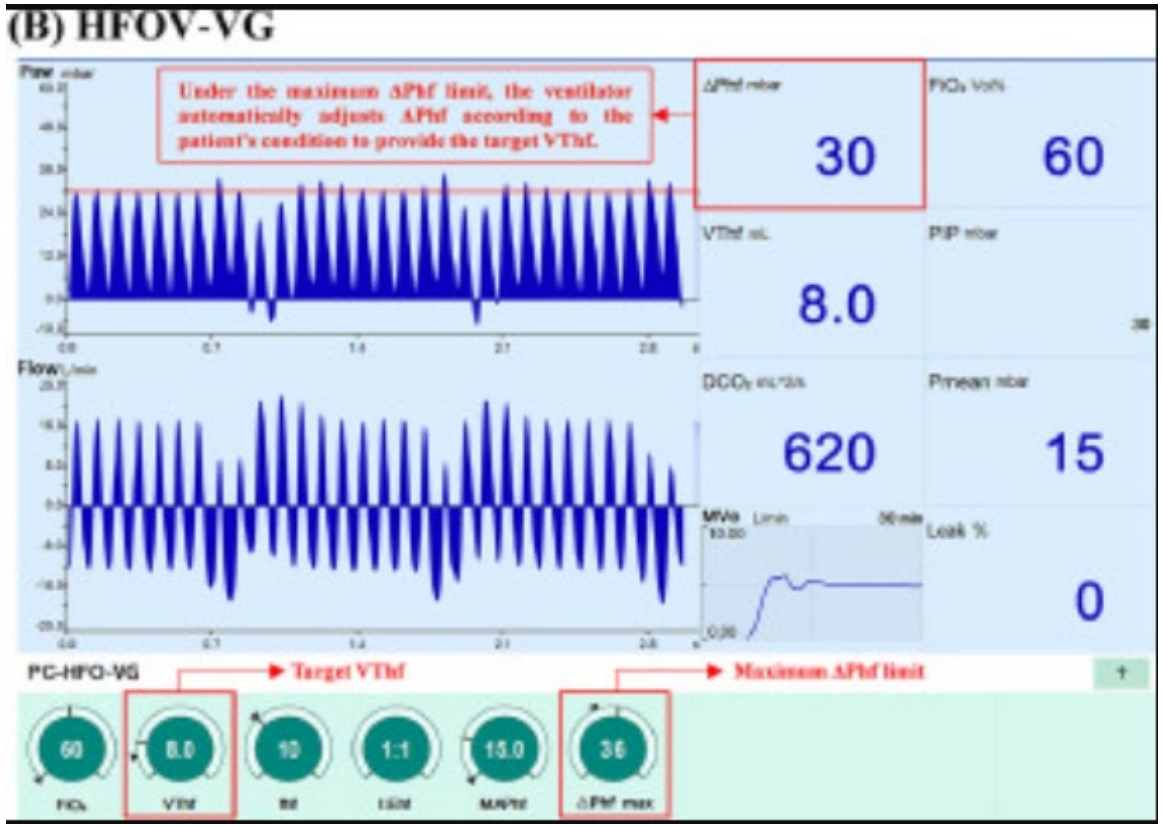
Dzierba AL et al. Pharmacotherapy. 2014 Mar;34(3):279-90 doi: 10.1002/phar.1365

Fancy ventilator modes

- *High-frequency Oscillatory ventilation*
- *Inverse ratio ventilation*
- *Airway Pressure Release Ventilation (APRV)*
- *Neurally Adjusted Ventilatory Assist (NAVA)*

High frequency oscillatory ventilation





The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

High-Frequency Oscillation in Early Acute Respiratory Distress Syndrome

Niall D. Ferguson, M.D., Deborah J. Cook, M.D., Gordon H. Guyatt, M.D., Sangeeta Mehta, M.D., Lori Hand, R.R.T., Peggy Austin, C.C.R.A., Qi Zhou, Ph.D., Andrea Matte, R.R.T., Stephen D. Walter, Ph.D., Francois Lamontagne, M.D., John T. Granton, M.D., Yaseen M. Arabi, M.D., et al., for the OSCILLATE Trial Investigators and the Canadian Critical Care Trials Group*

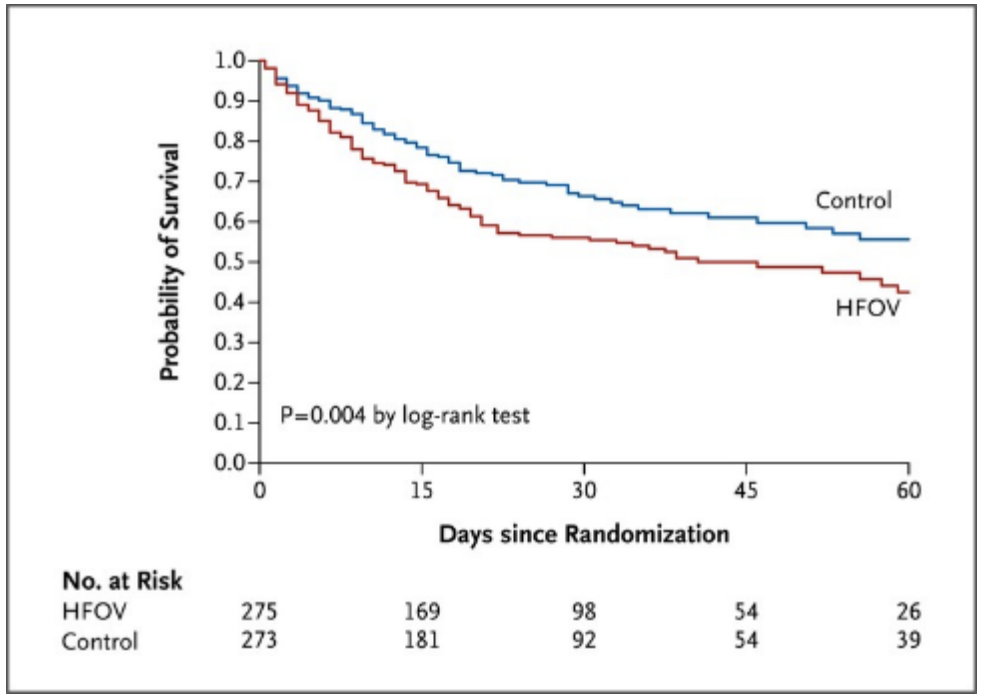
N Engl J Med 2013; 368:795-805

RCT of 548 patients

Eligibility Criteria:
Moderate-to-severe ARDS (P/F<200) AND FiO_2 ≥0.5 cm of H2O

Protocol: *HFOV targeting lung recruitment Vs. low V_T and high-PEEP strategy*

Result:
In hospital mortality: 47% Vs. 35%
(RR of death with HFOV, 1.33; 95% CI, 1.09-1.64; p=0.005).

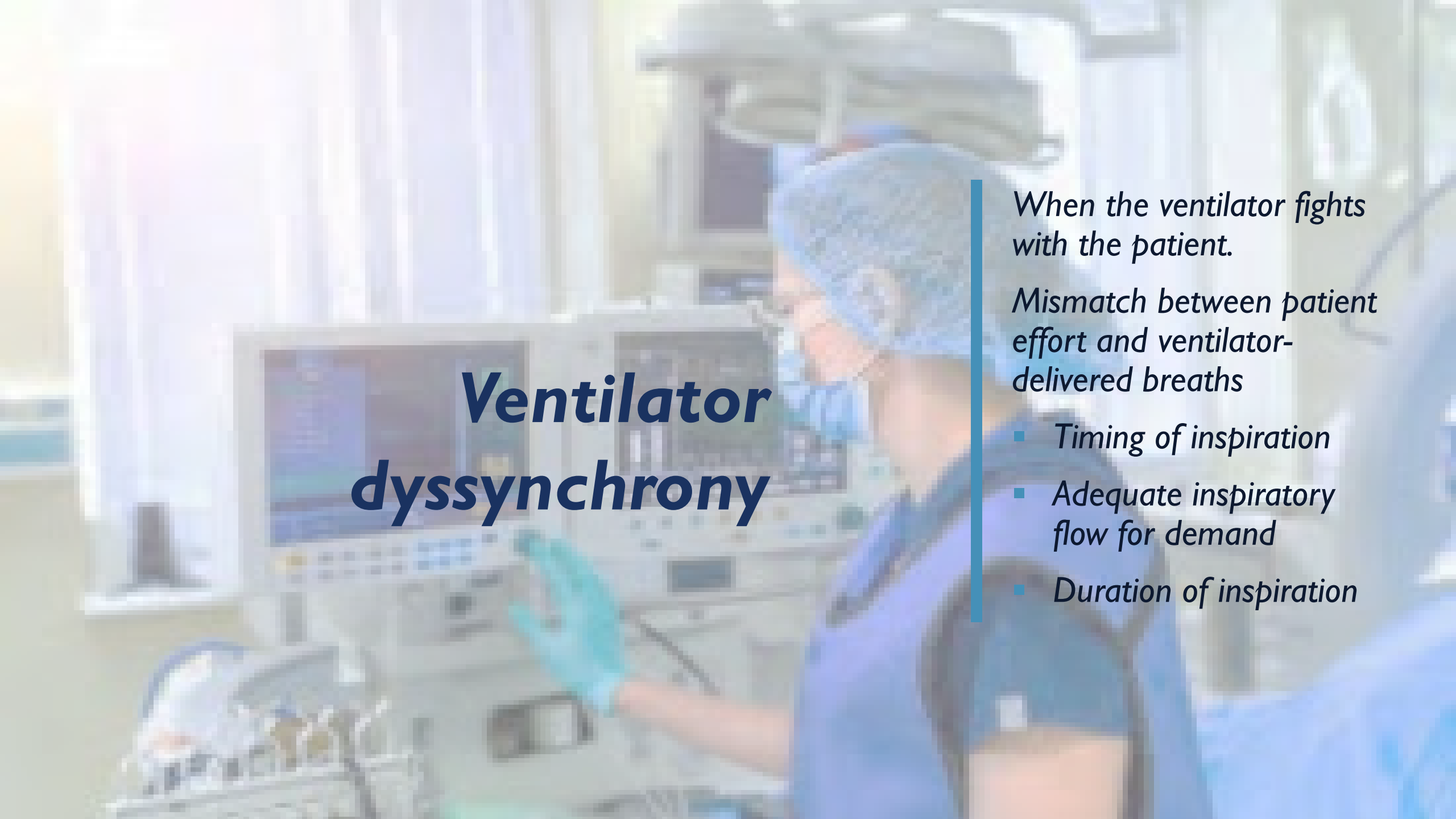


Airway Pressure Release Ventilation (APRV)

- *Pressure-controlled*
- *Time cycled*
- *Machine-triggered*
- *Spontaneous breathing under continuous positive breathing pressure with brief pressure relief times*

- ***APRV tends to increase vent days, ICU LOS, VAP***
- ***Worsened mortality in ARDS***

Maxwell RA, et.al: J Trauma 2010; 69:501
Ganesan SL, AJRCCM 2018; 198:1199



Ventilator dyssynchrony

When the ventilator fights with the patient.

Mismatch between patient effort and ventilator-delivered breaths

- *Timing of inspiration*
- *Adequate inspiratory flow for demand*
- *Duration of inspiration*

Patient-ventilator asynchrony during assisted mechanical ventilation

Arnaud W Thille 1, Pablo Rodriguez, Belen Cabello, François Lellouche, Laurent Brochard

Intensive Care Med (2006) 32:1515–1522
DOI 10.1007/s00134-006-0301-8

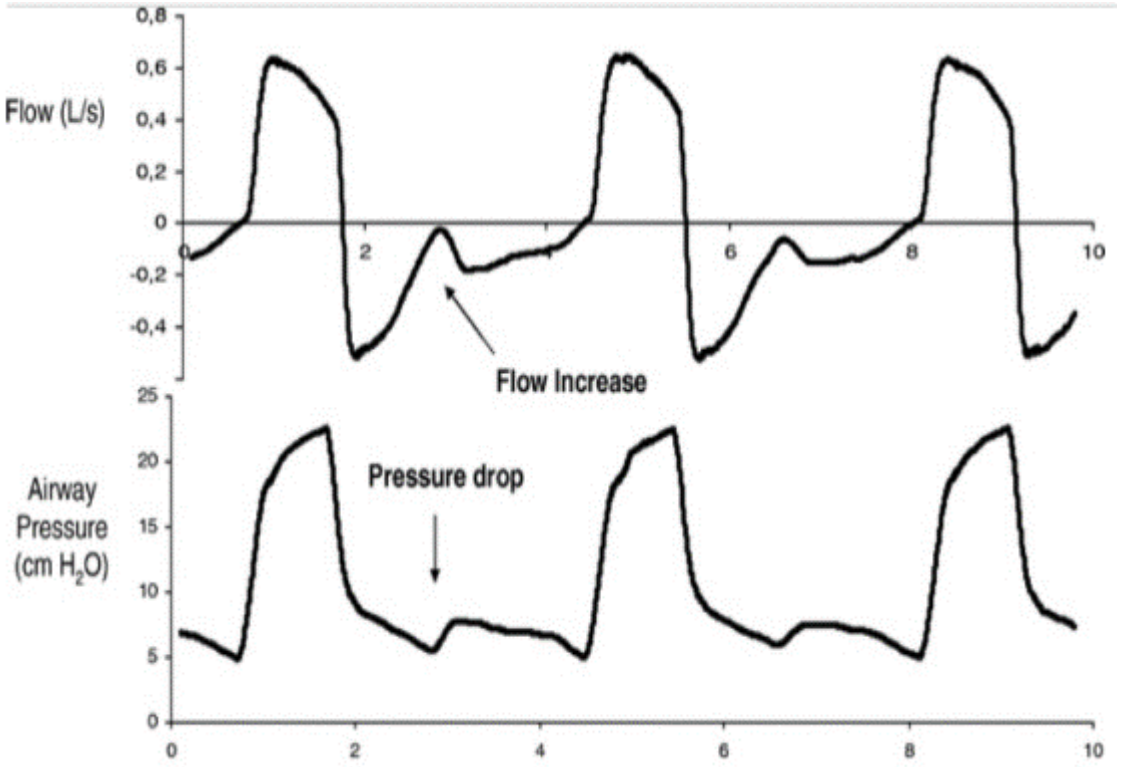
62 consecutive mechanically vented patients followed prospectively

Result:

- 24% had an asynchrony index >10% of respiratory efforts

- Ineffective triggering and double-triggering were the two main asynchrony patterns
- Higher degree of asynchrony associated with a longer duration of mechanical ventilation [7.5 days vs. 25.5 days]

Ineffective Triggering- *when an inspiratory effort does not trigger a ventilator breath*

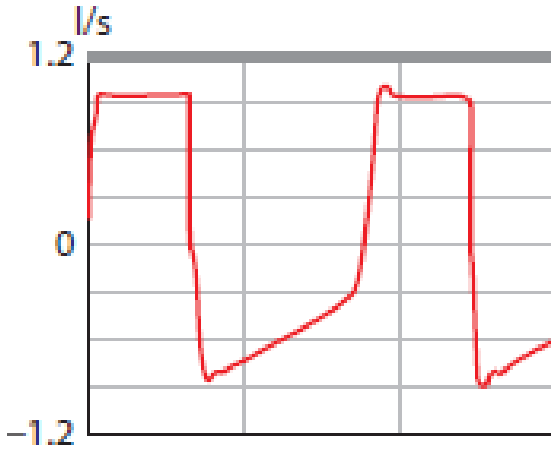


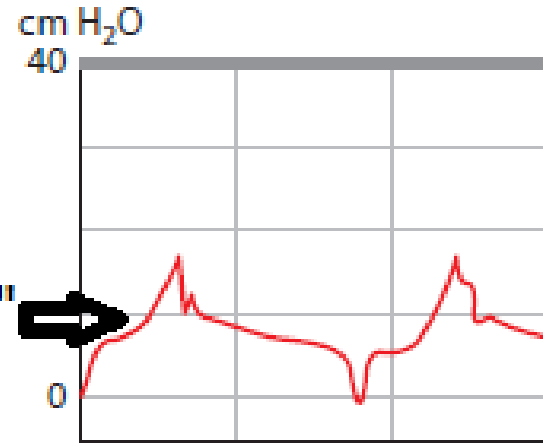
Thille A, Brochard L. (2007) Promoting Patient Ventilator Synchrony. *Clin Pulm Med*

Ineffective Triggering- Management Strategies

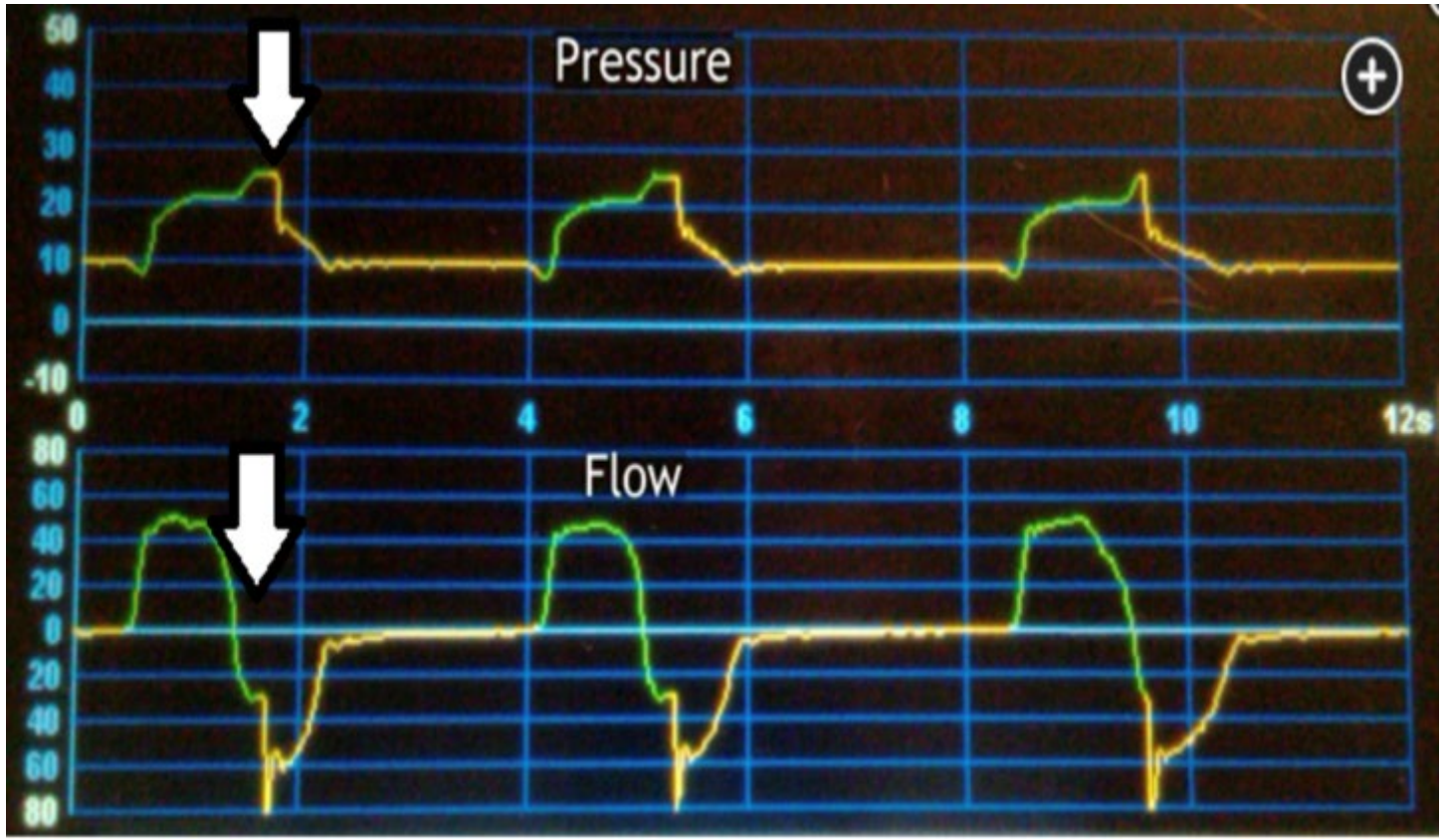
- *Increase trigger sensitivity*
- *Increase applied PEEP*
  - *Set around 75-80% of total PEEP*
- *Decrease tidal volume, increase flow rate*
- *Bronchodilators, steroids*

Flow-Dyssynchrony

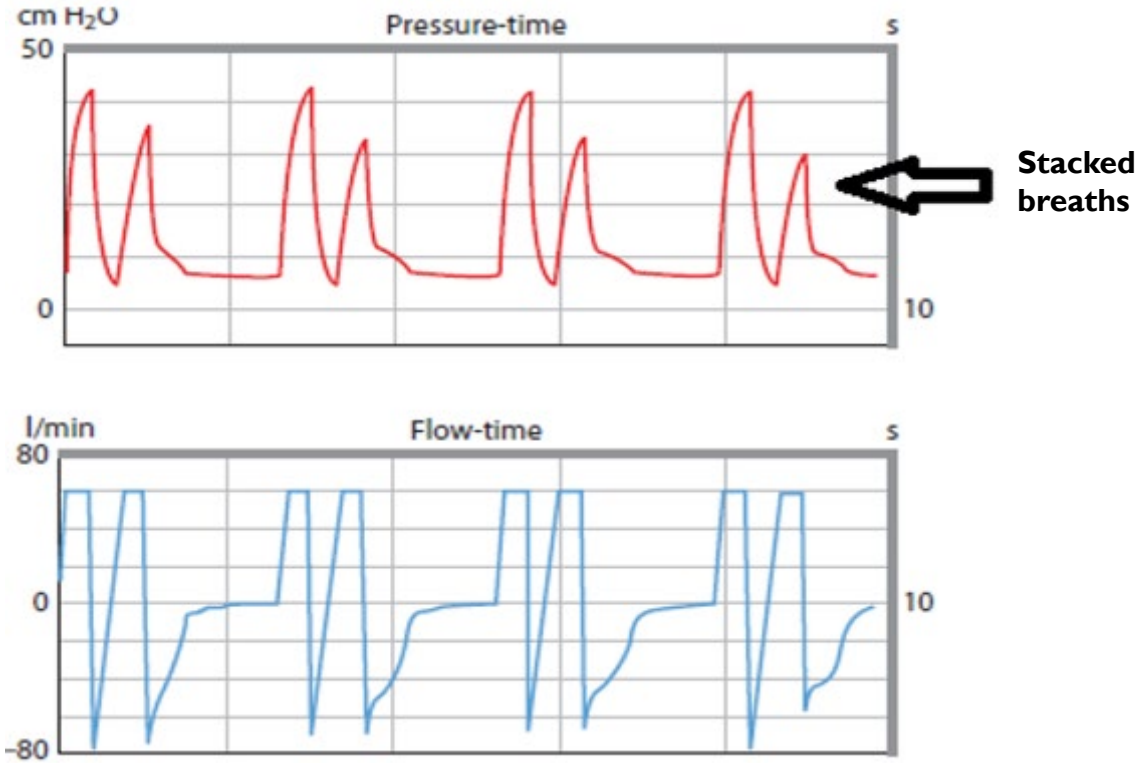


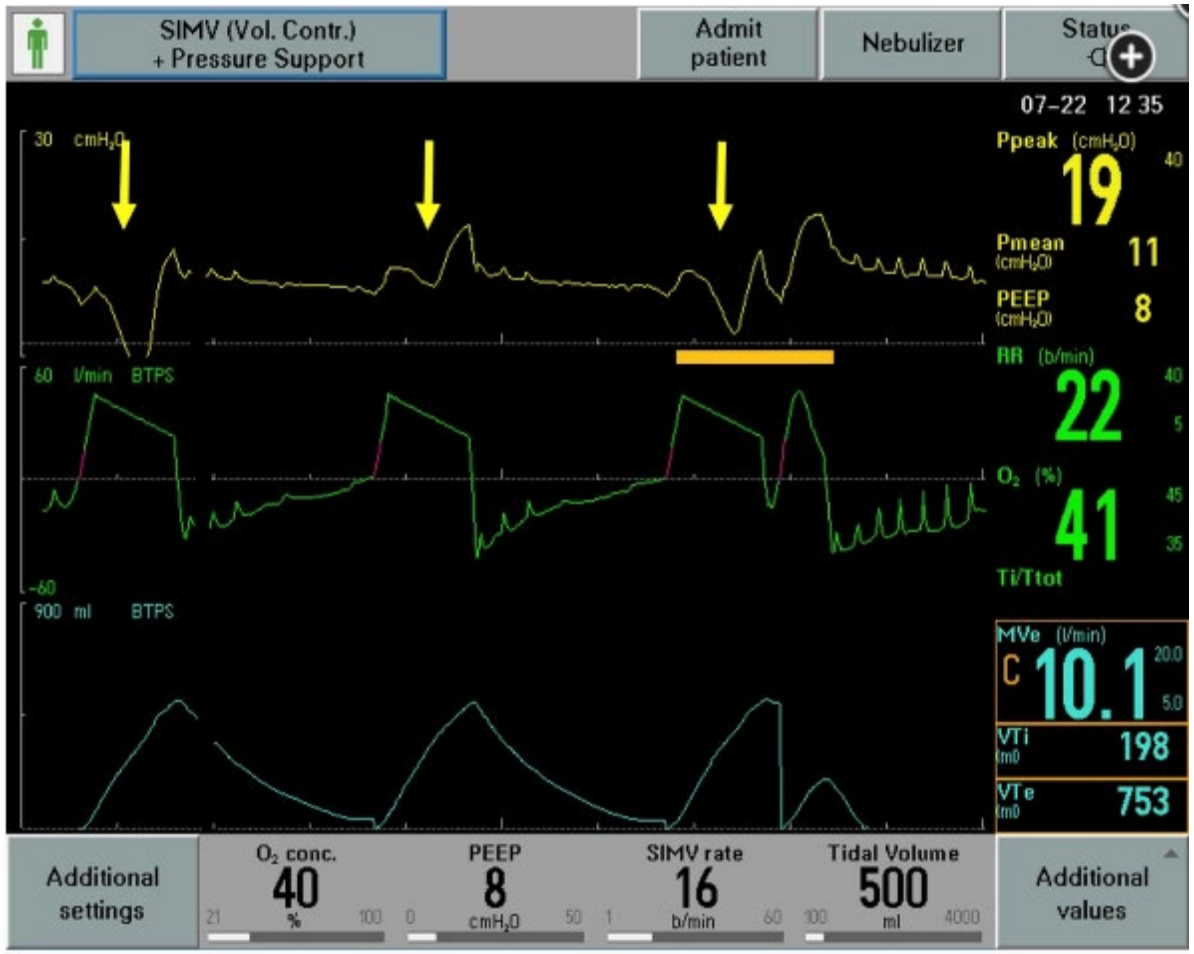


"Scalloping"



Double Triggering



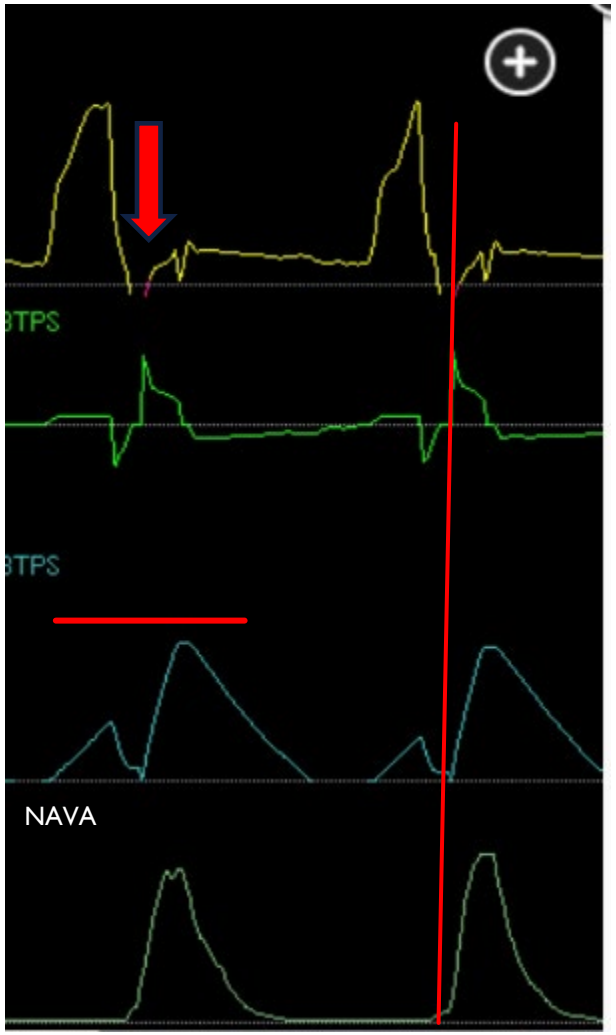


It is thought that the passive mechanical thoracic insufflation triggers a patient-initiated breath as a reflex action when patient's respiratory muscle activity is strong enough to trigger a second (stacked)breath

Double Triggering- Management Strategies

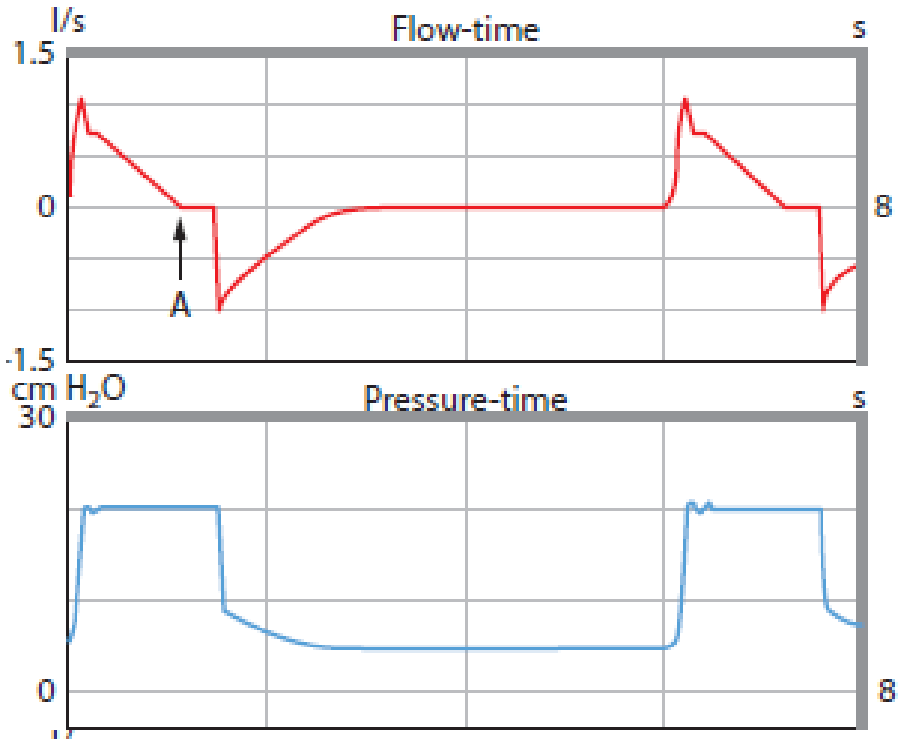
- *Management Strategies*
  - *If PC mode*
    - *can increase I-time or pressure*
  - *If VC mode*
    - *I-time can be increased by increasing tidal volume and decreasing flow rate*
      - *In patient with high respiratory drive, decreasing flow rate may increase inspiratory effort*
    - *May need sedation*

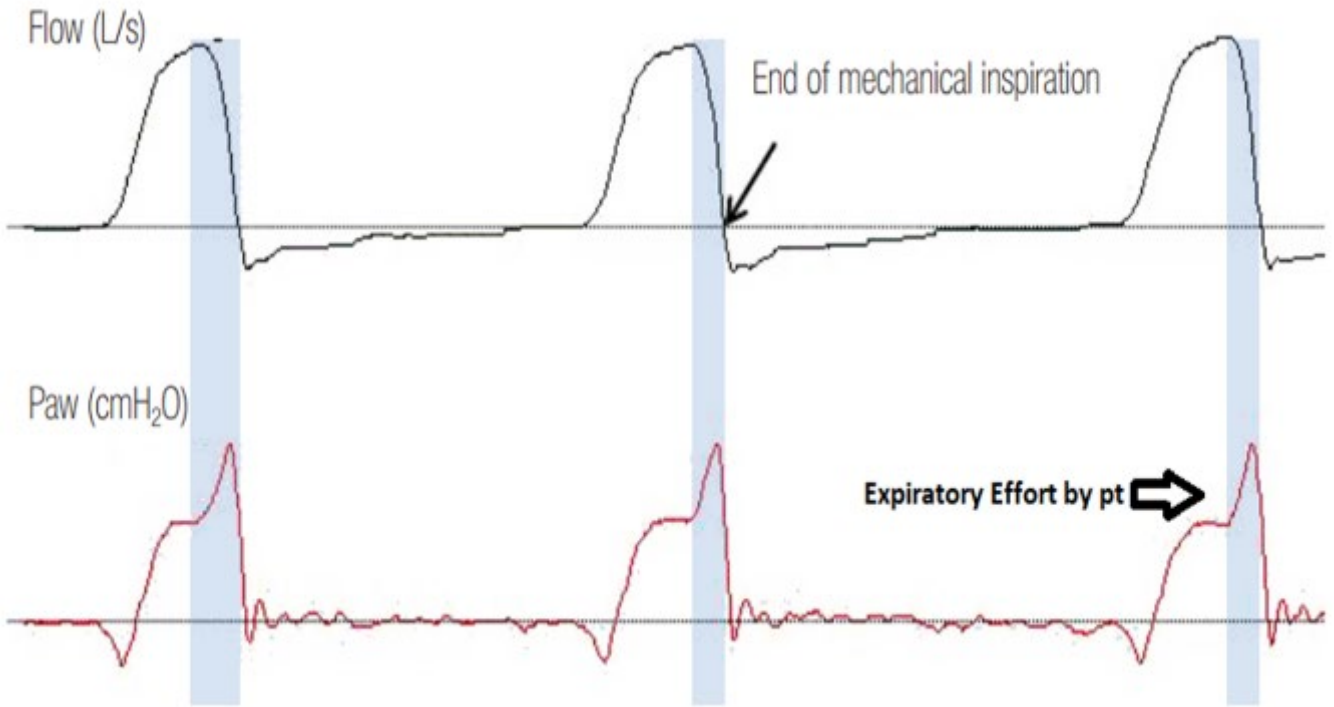
Reverse triggering



- Stacked breaths of 2 distinct paired tidal volumes
- 1st breath is a time-triggered mandatory (controlled) breath, and the second breath is the result of diaphragmatic electrical activity.
- As demonstrated with the NAVA catheter- the diaphragmatic contraction starts clearly after the first breath is being delivered.

Delayed Cycling





Antonogiannaki, E, et.al. (2017). Patient-Ventilator Dyssynchrony. Korean Journal of Critical Care Medicine.

Ventilator liberation

Importance of daily SAT / SBT

How to assess readiness for SBT?

Evidence for some reversal of the cause for respiratory failure

Adequate oxygenation

- PaO2/FiO2 ratio > 150 to 200
- PEEP: 5-8cmH_2O
- FiO2 < 0.6
- pH >7.25

Hemodynamic stability

- Absence of active myocardial ischemia
- No clinically significant hypotension

The capability to initiate an inspiratory effort

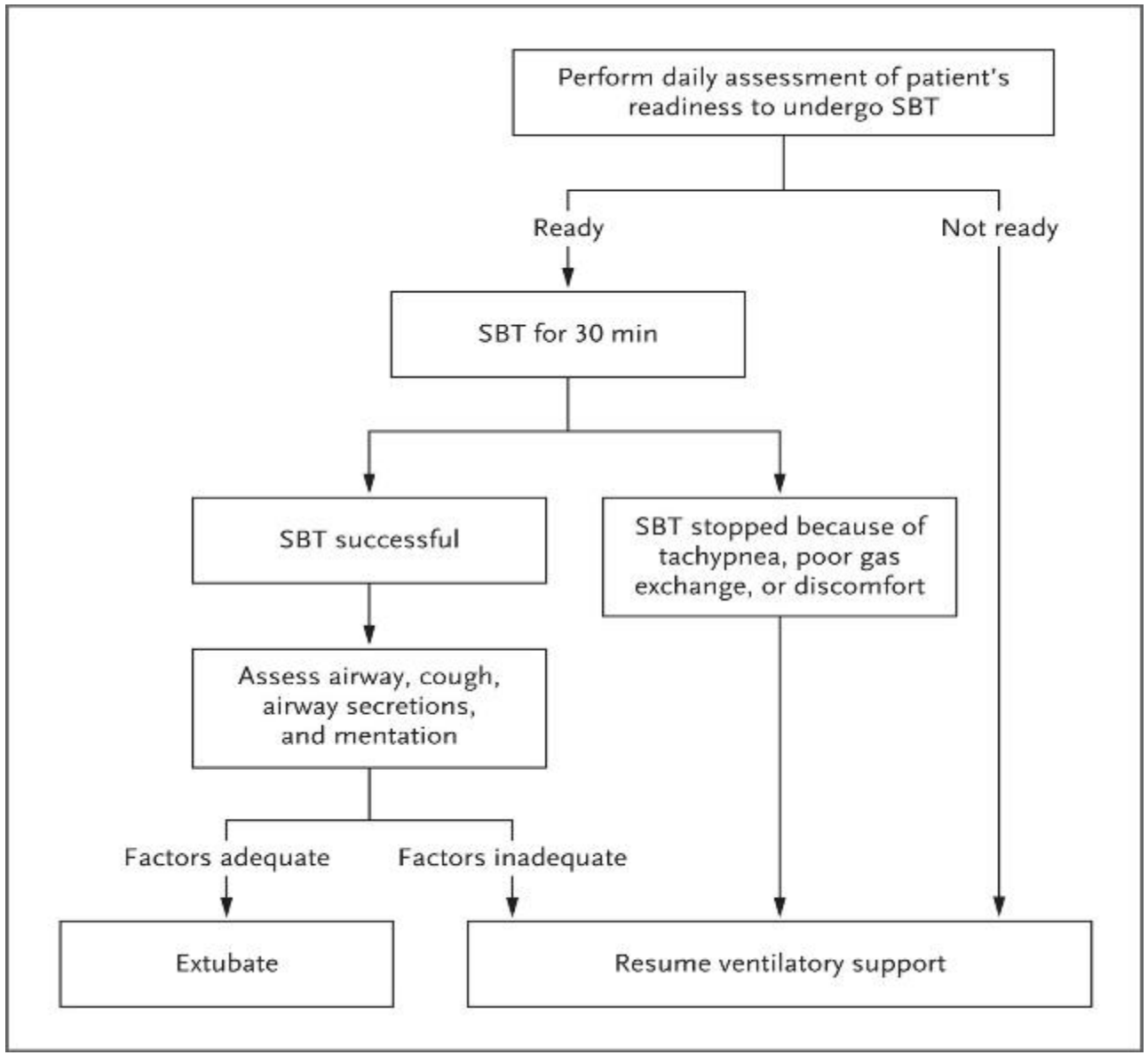
These "clinical assessments" are not enough to make decisions on the discontinuation of support.

One survey of 121 of intensivists using clinical judgment to assess the potential for discontinuation found a sensitivity of only 35% and a specificity of 79%

2 RCT showed intensivist did not recognize that discontinuation was feasible in almost $^2/_3$ of the subjects

Evidence-based guidelines for weaning and discontinuing ventilatory support.
Chest. 2001 Dec (6 Suppl):375S-95S

Ventilator liberation



McConville JF et al. NEJM 2012;367:2233-39

SBT- which mode and for how long?

Which Mode?

- RCT of 1135 mechanically vented pts.
  - 2-hour T-piece Vs. 30-minute PSV 8 cm H_2O
- Vent. liberation:
  - T-piece 74% liberated
  - PSV 82.3% liberated

How Long?

- 30 min vs. 120 min SBT
  - 88% vs. 85% passed
  - Reintubation rate: 13.5% vs. 13.4%

Esteban AJRCCM 1999;159:512
Subira JAMA 2019; 321:2175

Efficacy and safety of a paired sedation and ventilator weaning protocol for mechanically ventilated patients in intensive care (Awakening and Breathing Controlled trial): a randomised controlled trial

Lancet, 2008-01-12, Volume 371, Issue 9607, Pages 126-134

Timothy D Girard, John P Kress, Barry D Fuchs, Jason W W Thomason, William D Schweickert, Brenda T Pun, Darren B Taichman, Jan G Dunn, Anne S Pohlman, Paul A Kinniry, James C Jackson, Angelo E Canonico, Richard W Light, Ayumi K Shintani, Jennifer L Thompson, Sharon M Gordon, Jesse B Hall, Robert S Dittus, Gordon R Bernard, E Wesley Ely

336 mechanically vented patients in 4 tertiary care hospital ICU

Usual Care + SBT
Vs.
paired SAT + SBT

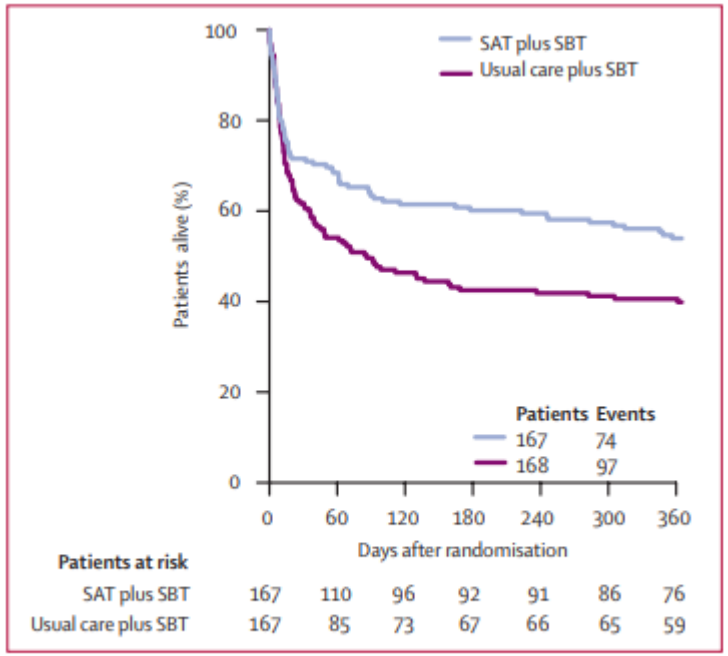


Figure 4: **Survival at 1 year**
Events indicate the number of deaths in each group in the year after enrolment.

	Intervention group (n=167)	Control group (n=168)	p value
Ventilator-free days*			
Mean	14·7 (0·9)	11·6 (0·9)	0·02
Median	20·0 (0 to 26·0)	8·1 (0 to 24·3)	
Time to discharge (days)			
From intensive care	9·1 (5·1 to 17·8)	12·9 (6·0 to 24·2)	0·01
From hospital	14·9 (8·9 to 26·8)	19·2 (10·3 to NA)†	0·04
28-day mortality	47 (28%)	58 (35%)	0·21
1-year mortality	74 (44%)	97 (58%)	0·01
Duration of brain dysfunction (days)			
Coma	2 (0 to 4)	3 (1 to 7)	0·002
Delirium	2 (0 to 5)	2 (0 to 6)	0·50
RASS at first successful SBT	−1 (−3 to 0)	−2·5 (−4 to 0)	0·0001
Complications			
Any self-extubation	16 (10%)	6 (4%)	0·03
Self-extubation requiring reintubation‡	5 (3%)	3 (2%)	0·47
Reintubation‡	23 (14%)	21 (13%)	0·73
Tracheostomy	21 (13%)	34 (20%)	0·06

Data are mean (SD), n (%), or median (IQR). RASS=Richmond agitation-sedation scale. SAT=spontaneous awakening trial. SBT=spontaneous breathing trial. *Ventilator-free days from study day 1 to 28. †Greater than 25% of patients in the SBT group remained in the hospital at study day 28. ‡Reintubation within 48 hours of extubation.

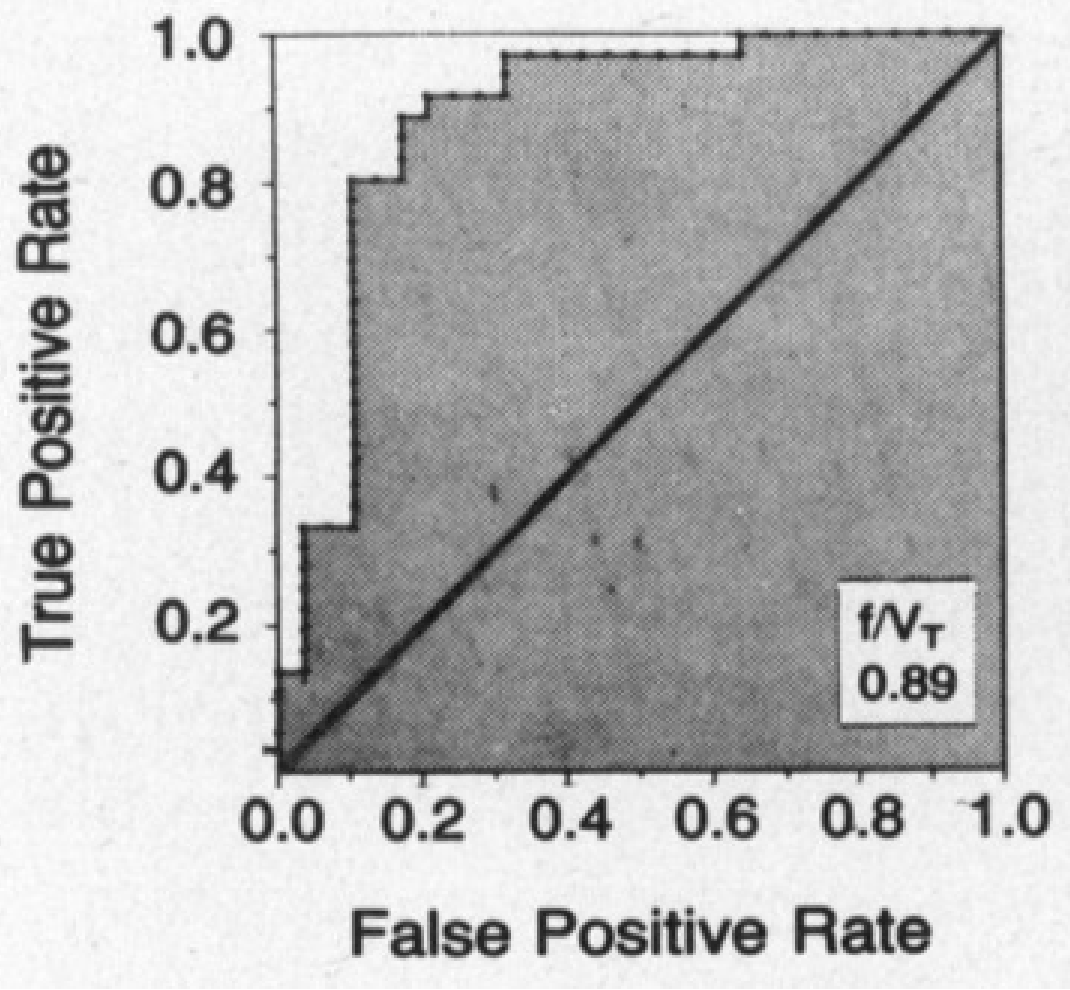
Table 3: **Main outcomes**

After passing 30 min of SAT & SBT…

- *Bedside evaluation:*
  - *Absence of a good cough (Peak cough flow ≤ 60L/min)*
  - *Need for frequent suctioning (Respiratory secretions > 2.5 mL/h)*
  - *Can't complete 4 simple commands*
- *All 3 present: Relative risk for re-intubation is 23 (~100% failure)*
- *None present: 3% failure rate*

Salam: Intensive Care Med 30:1334; 2004
Frutos-Vivar Chest 2006;130:1664

RSBI (Rapid Shallow Breathing Index)



- *One-minute of spontaneous breathing with T-piece with 0/0 PS*
- *Medical ICU patients*
- *f/V_T or RR/V_T <105*
  - *PPV 78%*
  - *NPV 95%*

Yang KL, et al. N Engl J Med. 1991;324(21):1145

Cuff leak

- *Airflow around the ETT after the cuff of the ETT is deflated*
- *Absence may indicate presence of laryngeal edema & risk for post-extubation stridor*
- *Measurement*
  - *Qualitatively*
  - *Quantitatively: Cuff leak volume <110 mL/ 12-24% of V_T*
- *Risk factors: Female, elderly, small sized patient, traumatic intubation, Large ETT, prolonged intubation etc..*
- *Imperfect predictor of post-extubation stridor (sensitivity 15-85%, specificity 70-99%)*
- *In absence of cuff leak and **in presence** of risk-factor, give steroid 6-8 hours before re-assessing*

Girard TD et al. Am J Respir Crit Care Med. 2017 Jan 1;195(1):120-133.

Extubation failure

Don’t be afraid to fail

Implications of Extubation Delay in Brain-Injured Patients Meeting Standard Weaning Criteria

WILLIAM M. COPLIN, DAVID J. PIERSON, KATHY D. COOLEY, DAVID W. NEWELL, and GORDON D. RUBENFELD

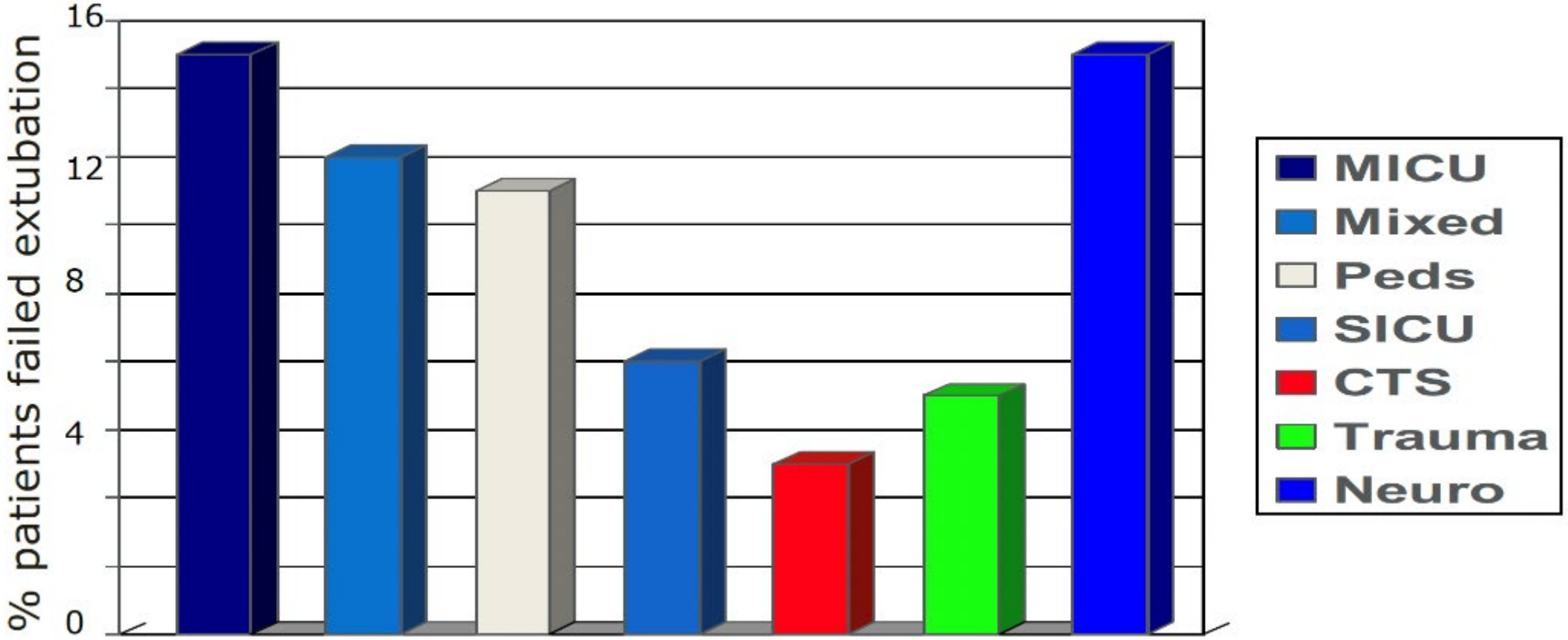
Division of Pulmonary and Critical Care Medicine and the Departments of Neurology, Neurological Surgery, and Respiratory Care, Harborview Medical Center, University of Washington, Seattle, Washington

	No Delay	Extubation Delay	p Value
Factor, n (%)	99 (73%)	37 (27%)	
Pneumonia, n (%)	21 (21.2%)	14 (37.8%)	0.048
Intensive care unit length of stay, d	3 (1–15)	8 (3–22)	< 0.001
Hospital length of stay, d	11 (1–39)	17 (3–61)	0.009
Cost, $ (range)	41,824	70,881	< 0.001
	(6,576–165,994)	(27,051–193,109)	
Mortality, n (%)	12 (12.1%)	10 (27.0%)	0.04
Tracheotomy, n (%)	4 (4.0%)	0 (0.0%)	0.6

Coplin AJRCCM 2000;161:1530

Extubation failure rate

Metanalysis of 6 studies- Total ~3500 patients



Epstein SK. Respir Care. 2009;54:198

Effect of Postextubation High-Flow Nasal Oxygen With Noninvasive Ventilation vs High-Flow Nasal Oxygen Alone on Reintubation Among Patients at High Risk of Extubation Failure

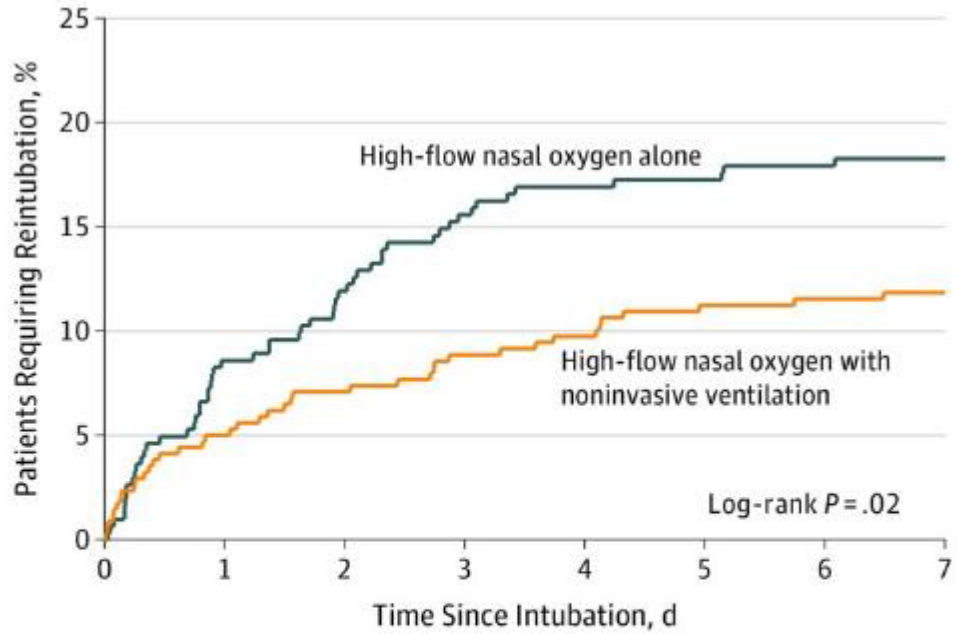
Thiellie AW et al.

A Randomized Clinical Trial

RCT of 641 patients

Protocol: HFNC + NIV Vs. HFNC alone

Results: Reintubation rate 18.2 Vs. 11.8%



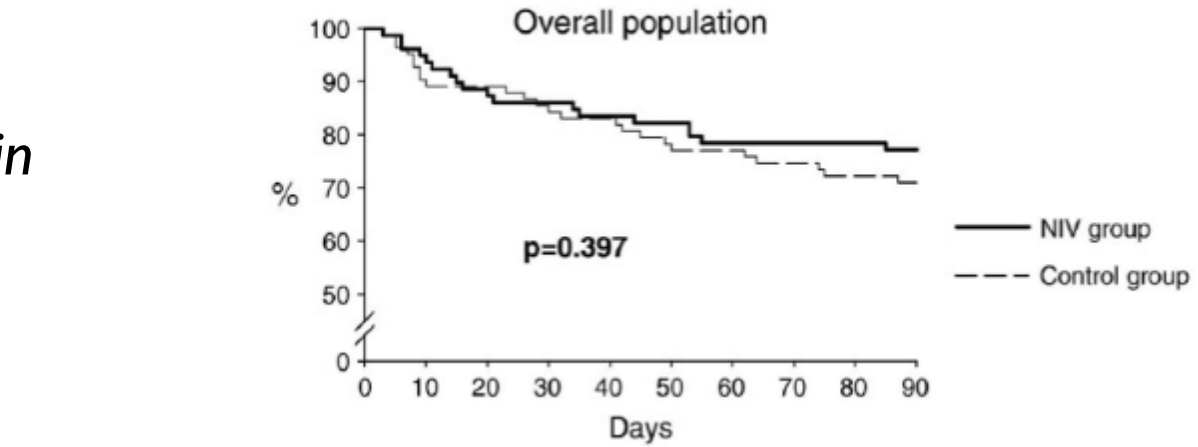
No. at risk

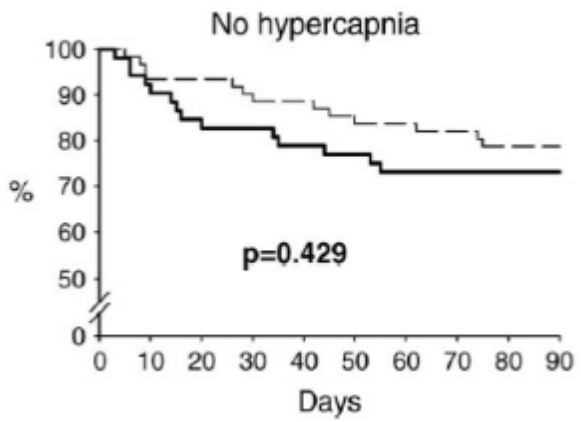
High-flow nasal oxygen								
Alone	302	276	265	253	248	246	244	243
With noninvasive ventilation	339	321	314	308	305	294	292	291

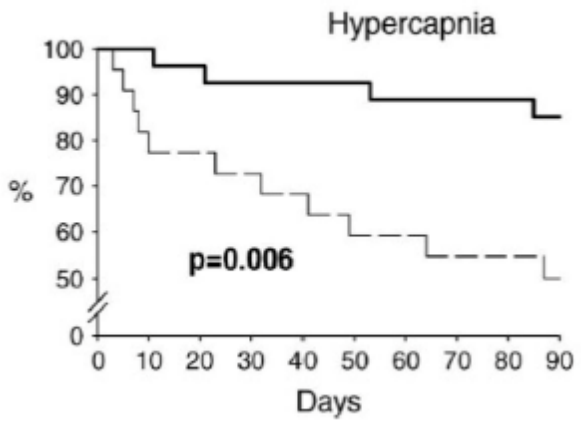
JAMA. 2019 Oct 15;322(15):1465–1475.

NIV to prevent extubation failure in high-risk cases

NIV may be used as a prophylactic measure in high-risk extubation to PREVENT respiratory failure







Ferrer M et al, AJRCCM 2006;173:164-170

NIV in post-extubation RESPIRATORY FAILURE

Table 2. Outcomes for the Study Groups*

Outcomes	NPPV (n = 39)	Standard Therapy (n = 42)	*P* Value
Reintubation, No. (%)	28 (72)	29 (69)	.79
Pneumonia, No. (%)	16 (41)	17 (40)	.61
Duration of ventilation†			
Mean (SD)	8.4 (7.4)	17.5 (28.0)	.11
Median (range)	6.7 (0.5-28.6)	8.9 (2.0-146.7)	.12
ICU length of stay			
Mean (SD)	15.1 (10.9)	19.4 (25.0)	.32
Median (range)	11.9 (3.6-41.7)	10.8 (2.3-152.7)	.72
Hospital length of stay			
Mean (SD)	32.2 (25.4)	29.8 (28.4)	.69
Median (range)	19 (6-111)	22 (4-162)	.51
ICU survival, No. (%)	33 (85)	32 (76)	.34
Hospital survival, No. (%)	27 (69)	29 (69)	.99

*NPPV indicates noninvasive positive pressure ventilation; ICU, intensive care unit.
†Duration of mechanical ventilation includes only time using conventional ventilator.

Table 4. Reasons for Reintubation, as Defined in the Protocol Guidelines, According to Study Group.

Reason	Non-invasive Ventilation (N=55)	Standard Medical Therapy (N=51)	P Value
	no. (%)		
Lack of improvement in signs of muscle fatigue	25 (45)	23 (45)	0.97
Hypoxemia	9 (16)	15 (29)	0.11
Copious secretions	5 (9)	6 (12)	0.65
Lack of improvement in pH or partial pressure of carbon dioxide	8 (15)	3 (6)	0.13
Changes in mental status	4 (7)	2 (4)	0.45
Hypotension	4 (7)	2 (4)	0.45

Keenan SP, et al, JAMA 2002;287:3238-3244
Esteban A et al, NEJM 2004;350:2452-60

Independent Effects of Etiology of Failure and Time to Reintubation on Outcome for Patients Failing Extubation

SCOTT K. EPSTEIN and RONALD L. CIUBOTARU

Pulmonary and Critical Care Division, Department of Medicine, Tupper Research Institute, New England Medical Center, Tufts University School of Medicine, Boston, Massachusetts

Am J Respir Crit Care Med. 1998 Aug;158(2):489-93

TIME TO REINTUBATION

Time to Reintubation* (*h*)	Patients† (*n*)	Patients† (%)	Deaths‡ (*n*)	Deaths‡ (%)
0–12	25	33	6	24
13–24	18	25	7	39
25–48	18	25	9	50
49–72	13	17	9	69

doi: 10.1164/ajrccm.158.2.9711045

Take Home Message

- *NIV decreases intubation rate in hypercapnic respiratory failure. Use HFNC for hypoxic ones.*
- *Lung protective ventilator strategy- low V_T , adequate PEEP, maintain Pplat <30, Driving pressure <15*
- *Proning improves survival in ARDS*
- *Early paralytics have no mortality benefit; may be used in severe hypoxemia/ ventilator dyssynchrony*
- *APRV & iEPO could be used as salvage therapy for refractory hypoxemia in ARDS*
- *Be aware of different types of ventilator dyssynchrony- try to adjust ventilator as per patient's need*
- *Daily paired SAT + SBT decreases mortality, reduces ICU/hospital LOS*
- *Weaning parameters are not perfect; trust your clinical judgement. Steroid before extubation without cuff leak*
- *Avoid extubation delay; 12-15% extubation failure rate in medical or mixed ICU is acceptable*
- *Extubate patients with baseline hypercapnia to NIV; may consider HFNC for low-risk patients; but once patient is in respiratory distress- don't delay reintubation*

Thank You

NIV recommendation in obstructive lung disease

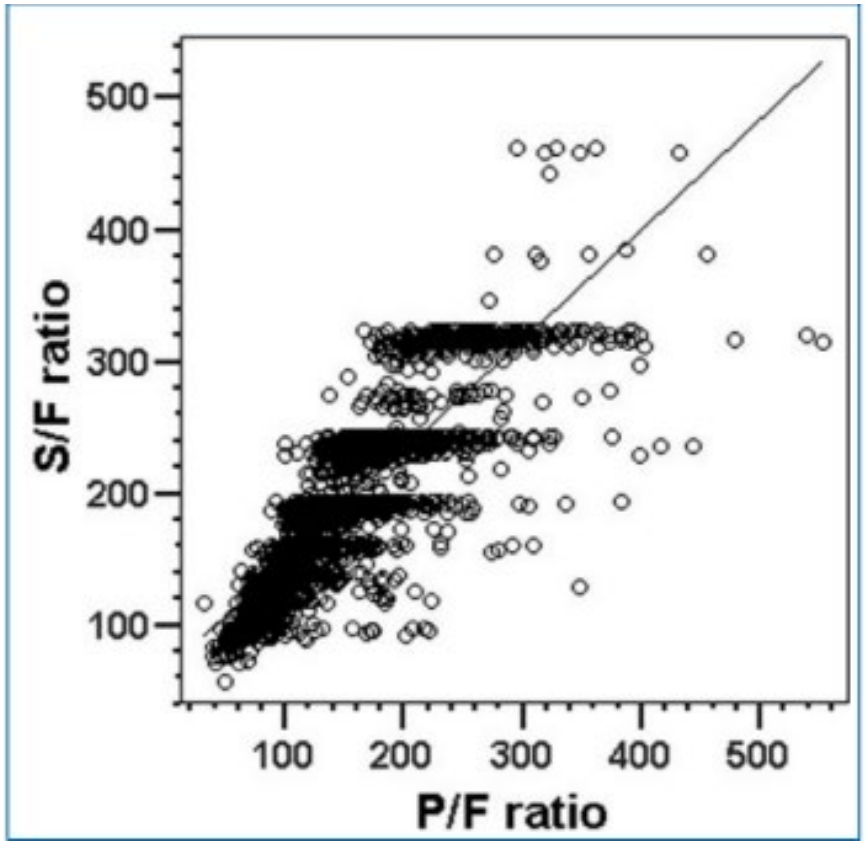
For asthma: *short trial (≤2h) reasonable but do not delay intubation, monitor closely*

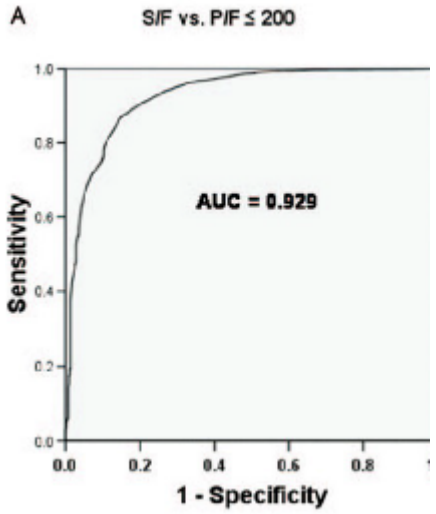
For COPD: *Preferred initial mode of ventilatory support*

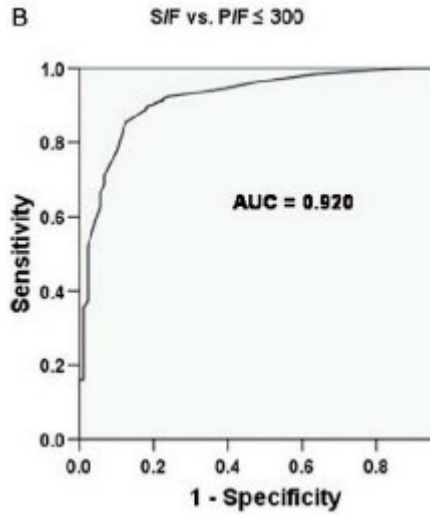
- *Indications:*
  - *Severe dyspnea / increased work of breathing*
  - *Respiratory Acidosis (pH < 7.35 with PaCO2 > 45mmHg)*
- *Contraindications:*
  - *Impaired mental status/aspiration risk*
  - *Anatomic contraindications*

Lim WJ, et al. Cochrane Database Syst Rev. 2012.
Ram FS, et al. Cochrane Database Syst Rev. 2004.

Can SpO_2/FiO_2 replace PaO_2/FiO_2?



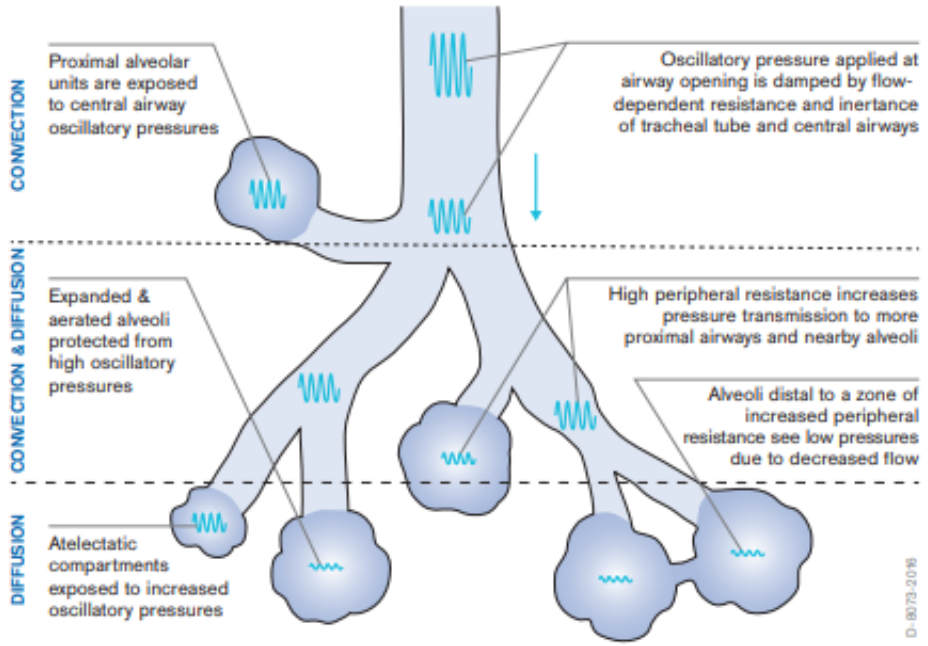


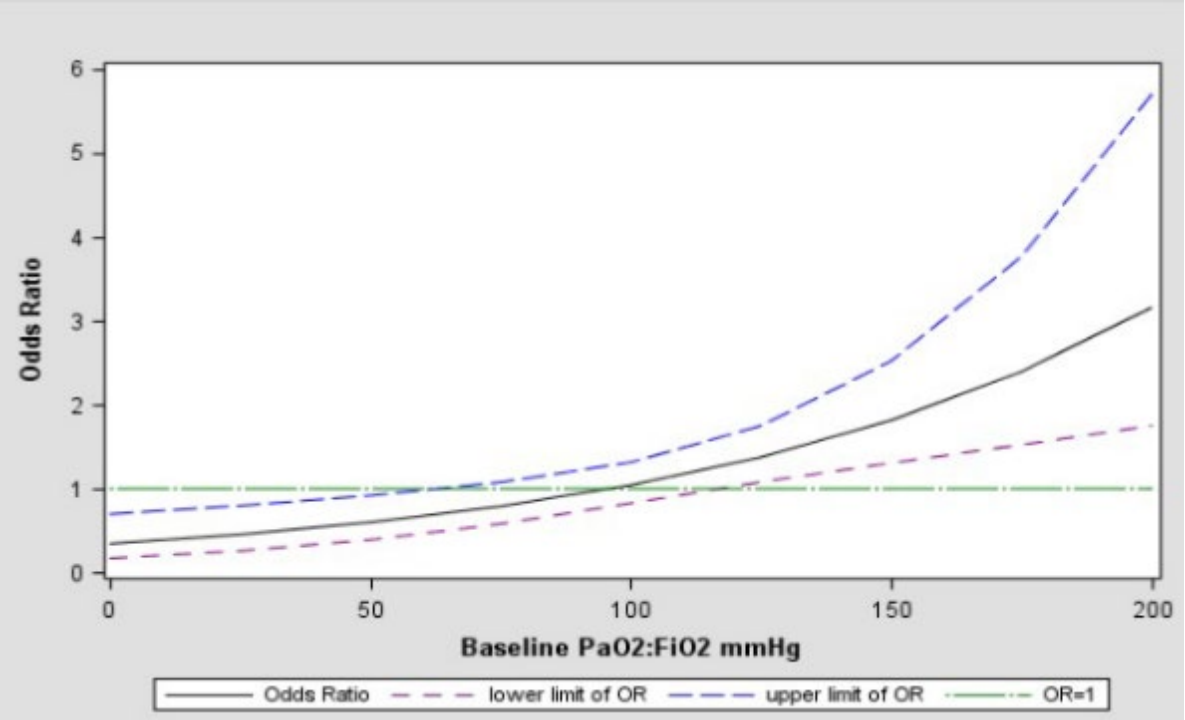


PaO_2/FiO_2	SpO_2/FiO_2
200 →	235
300 →	315

Rice TW. CHEST, 2007;132:410

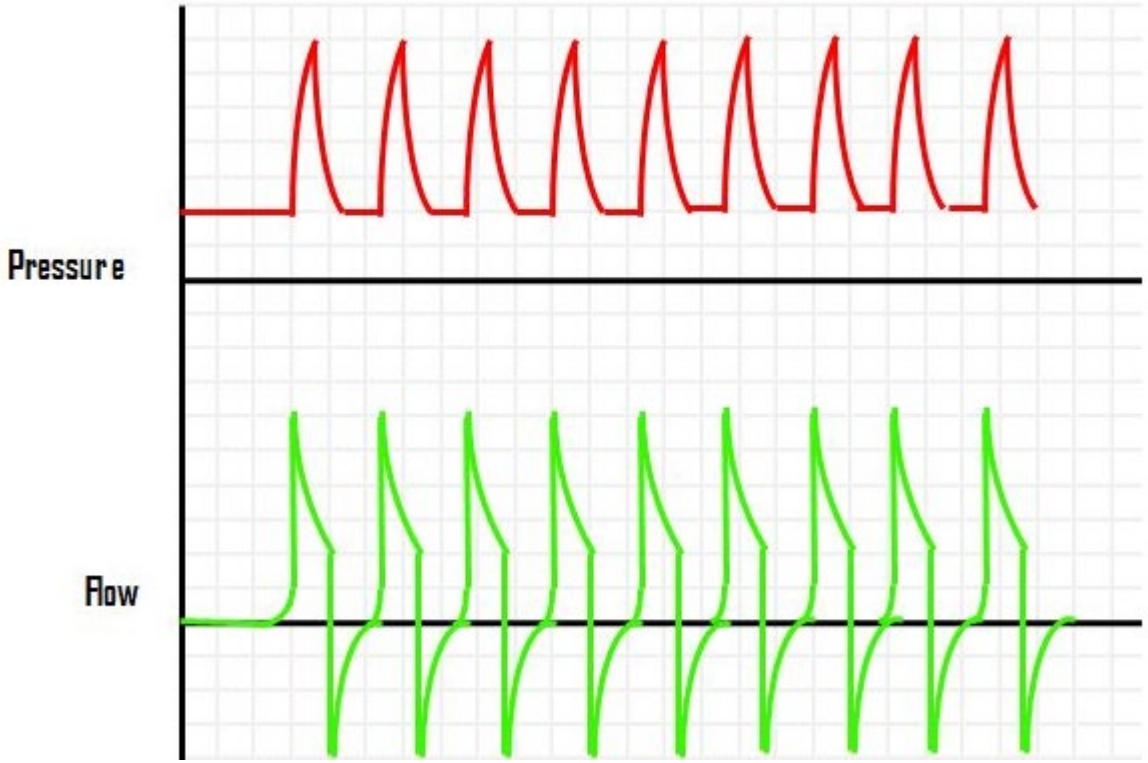
High frequency oscillatory ventilation





Metanalysis of 3 trials including 1552 subjects
Overall P/F = 114
Mortality depended on severity of hypoxemia
HFOV increases mortality for most patients, but may improve survival with severe hypoxemia (P/F <100)

Auto-triggering



- Ventilator delivers a breath in absence of patient effort
- Etiologies
  - Trigger sensitivity too high
  - Water condensation in the circuit
  - Cardiac oscillations
  - Leak from circuit
  - Air leak from chest tube

Yartsev, A. (2013)