Liberation from mechanical ventilation

中山醫學大學附醫院
胸腔內科/呼吸治療科
王耀震

Weaning, liberation, discontinuing

- As soon as the inciting factors causing respiratory failure starts to improve, weaning may be initiated.
- Beginning with the day of intubation.
- All patients should be evaluated at least daily.
- The gradual process of transition from full ventilatory support to spontaneous breathing, including removal of endotracheal tube.
- Liberation or discontinuing ventilatory support. (overall process).
- Liberation from mechanical ventilation is a three-step process.

Egan's fundamentals of respiratory care 12th edition

Outline

Readiness testing

Objective clinical criteria
Physiological tests

Weaning

Spontaneous breathing trials
SBT

Extubation

Airway patency
Airway protection

Classification of the patients

Simple weaning	Successful extubation after 1 attempt
Difficult weaning	Requiring up to 3 SBT attempts within 7 days of first attempt
Prolonged weaning	Failure of > 3 SBT attempts or > 7 days of weaning after first SBT

Weaning from mechanical ventilation ERJ 2007;29:1033

Five categories

- In the vast majority of ventilated patients, removal is quick and routine.
- Need a more systematic approach to discontinuing ventilatory support, normally about 15 - 20% of patients.
- Require days to weeks to wean from ventilatory support: < 5%
- Ventilator-dependent or “unweanable” patients: < 1%
- No chance for survival in whom the ventilator is discontinued while comfort measures are provided, terminal weaning or terminal extubation.

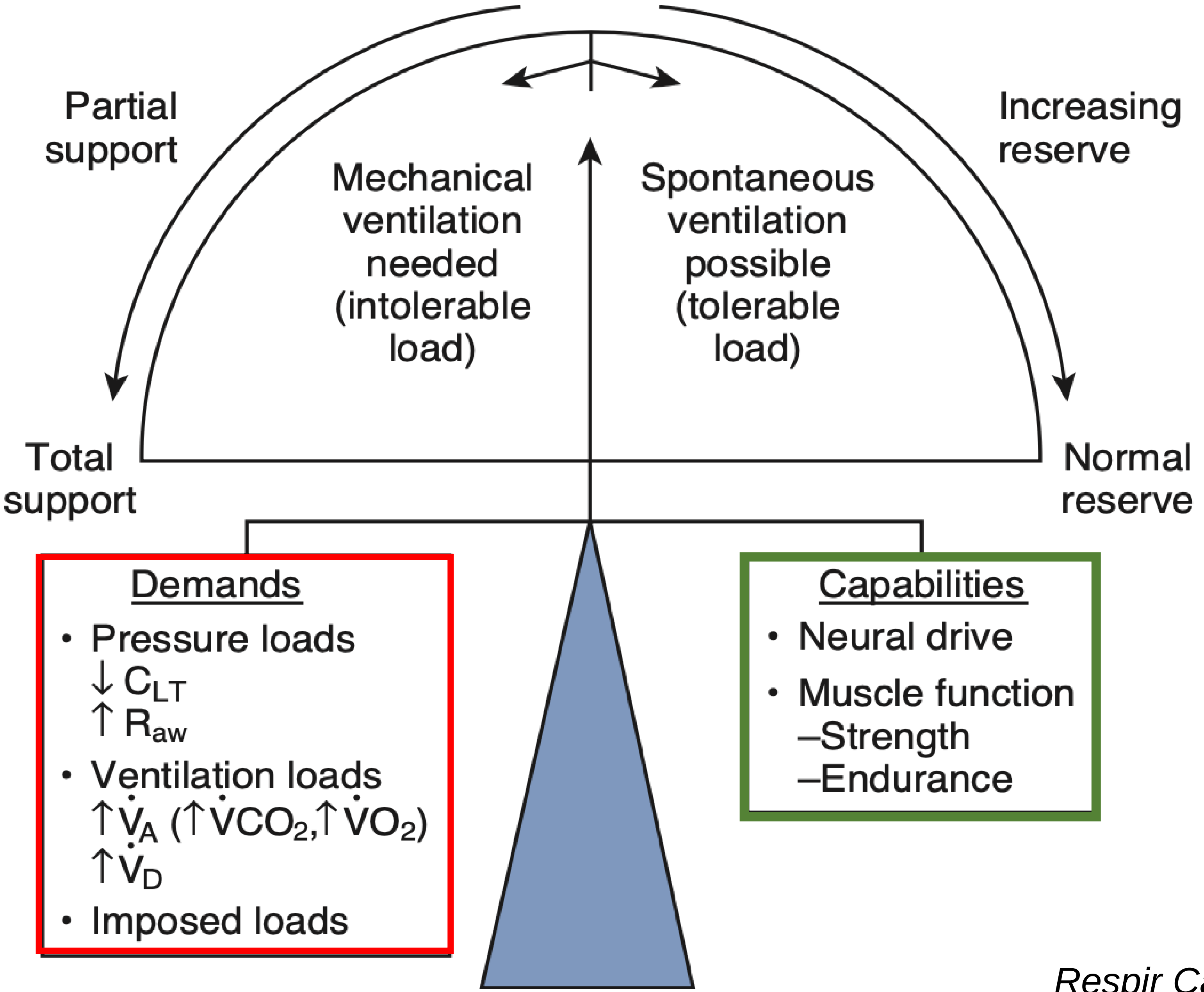
Egan’s fundamentals of respiratory care 12th edition

Evaluation of Systems to Determine Etiology of Respiratory Failure

- Neurologic factors
- Respiratory factors and ventilatory muscle function
- Metabolic factors
- Cardiovascular factors
- Psychological factors

Chest 120(6 Suppl):438S-444S, 2001

Evidence-Based Guidelines for Weaning and Discontinuing Ventilatory Support



Respir Care 40:244–259, 1995

Clinical criteria

- Improvement in the underlying cause of respiratory failure
- Adequate oxygenation
- Acid-base balance (Arterial pH > 7.25)
- Hemodynamic stability
- Ability to take spontaneous respiration

UpToDate®

Weaning from mechanical ventilation: Readines

Adequate oxygenation

- $P_aO_2/F_iO_2 \geq$ 150-200mmHg
- SPO_2 90% while receiving $FiO_2 \leq$ 40% and PEEP $\leq 5cmH_2O$
- For chronic hypoxemia → $P_aO_2/F_iO_2 \geq$ 120mmHg
- Higher F_iO_2 (50%) may be acceptable in significant underlying lung disease.
- Higher PEEP (8 cmH_2O) may be acceptable to avoid atelectasis (obesity, abdominal distention, narrow ETT < 7mm)
- Normal Hb level, adequate cardiac output and tissue perfusion are assumed.

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Weaning from mechanical ventilation: Readiness t

PaO_2/F_iO_2 and SPO_2/F_iO_2

PaO_2/FiO_2	≥ 300	200	150	< 100
SpO_2/FiO_2	315	235	190	150
FiO_2	0.30	0.40	0.50	0.60
SpO_2 (%)	> 94	94	95	< 90

Leasa *et al. Crit Care* (2021) 25:22

Hemodynamic stability

- Hemodynamic stable without myocardial ischemia
- Mean arterial pressure consistently > 60mmHg
- Systolic pressure > 90mmHg and < 180mmHg
- Use of vasopressors only in low and stable dose (dopamine < 5mcg/kg/min)

UpToDate®

Weaning from mechanical ventilation: Readiness tes

Metabolic factors

- Nutrition should be adequate.
- 1.5-2.0 times resting energy expenditure.
- Protein intake should be 1-1.5g/kg per day.
- Avoid excessive carbohydrate → CO_2 production.
- Avoid amino acid formulations (arginine/lysine) → metabolic acidosis.

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Metabolic factors

- **Hypokalemia**
- **Hypocalcemia**
- **Hypophosphatemia**
- **Hypomagnesemia**

  Malnourished patients and those with chronic alcoholism
- **Hypothyroidism**

  Impaired respiratory muscle function.

  Blunts the central response to hypercapnia and hypoxemia

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Additional or optional requirement

- Hemoglobin level ≥ 7g/dL
- Core temperature ≤ 38.5C
- Mental status awake and alert or easily arousable GCS ≥ 8
- RASS (Richmond agitation-sedation scale) -2 to +1
- As many as 47% of patients who spend >5 days in an ICU experience psychogenic disturbance

Respir Care. 1995;40:277– 281.

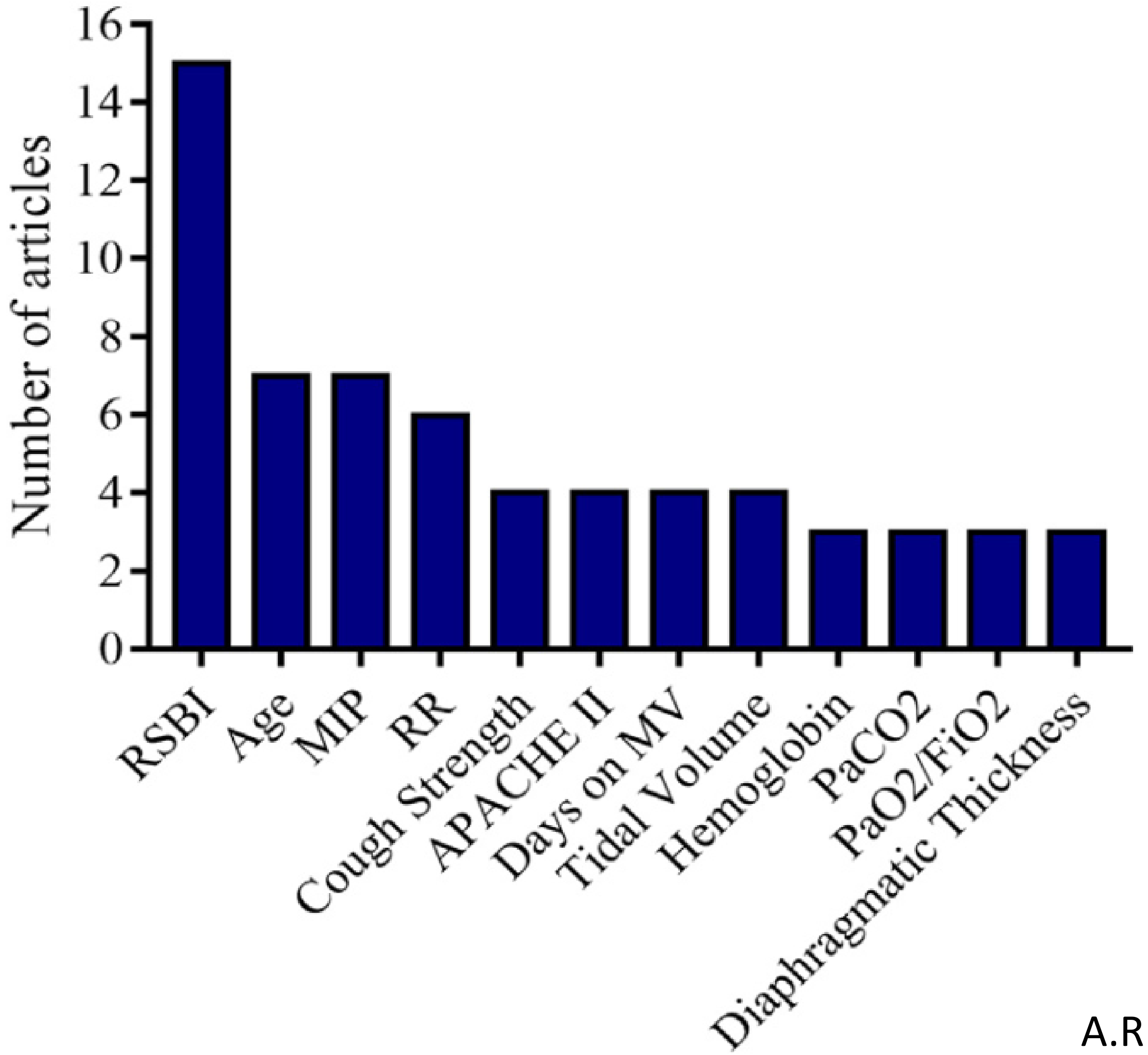
Outline

Readiness testing	**Weaning**	**Extubation**
Objective clinical criteria Physiological tests	Spontaneous breathing trials SBT	Airway patency Airway protection

Requirements of an Ideal Weaning Index

- Assessment of the pathophysiological determinants of weaning outcome and psychological problems.
- Accurately evaluate physiological function as it relates to the degree of abnormality present.
- Ease of measurement and reproducible measurements.
- Minimum patient cooperation.
- High positive and negative predictive values.

Predictive factors of weaning from mechanical ventilation and extubation outcome: A systematic review



RSBI was the most frequently studied

RSBI was an important measurement tool in deciding whether to wean/extubate

A.R. Baptistella et al. / Journal of Critical Care 48 (2018) 56–62

RSBI (rapid shallow breathing index)

- RSBI < 105 (RR per minute ÷ V_T per liter) is a good predictor for weaning.
  20 % may have false-positive results.
- RSBI of 80 is associated with 95% probability of successful liberation.

Chest. 1992;102:1829–1832

- RSBI around 50 → successfully extubation.
- RSBI around 80 → failed in the extubation.
- A discrepancy in the ideal RSBI score to predict weaning or extubation success.
- The most appropriate moment to measure RSBI ?

Journal of Critical Care 48 (2018) 56–62

RSBI (rapid shallow breathing index) in predicting extubation outcome

- RSBI measured at 30 to 60 min of SBT predicted the weaning outcome more effectively.
- RSBI at 120 min was significantly higher in patients with extubation failure and trial failure.
- When RSBI was measured every 30 min during 2 h of SBT.

  Initial RSBI was similar in extubation success and failure groups.

  RSBI remained unchanged or decreased in the success group.

  RSBI increased in the extubation failure group.

Journal of Critical Care 48 (2018) 56–62

Weaning parameters in elderly patients

- An important difference between the age and weaning.
- With age split into quartiles (≤42, 43–54, 55–62, and 63+ years), the percentages of successful attempts decrease with increasing age (91%, 91%, 87%, and 84%, respectively)
- Age > 65 is a negative predictor of weaning and extubation success.
- The longer the duration (in days) of IMV, the lower the chance of success in weaning and extubating.
- The age + MV days >100 or more predicted a poor outcome.

JAMA 1993;269:1025–9

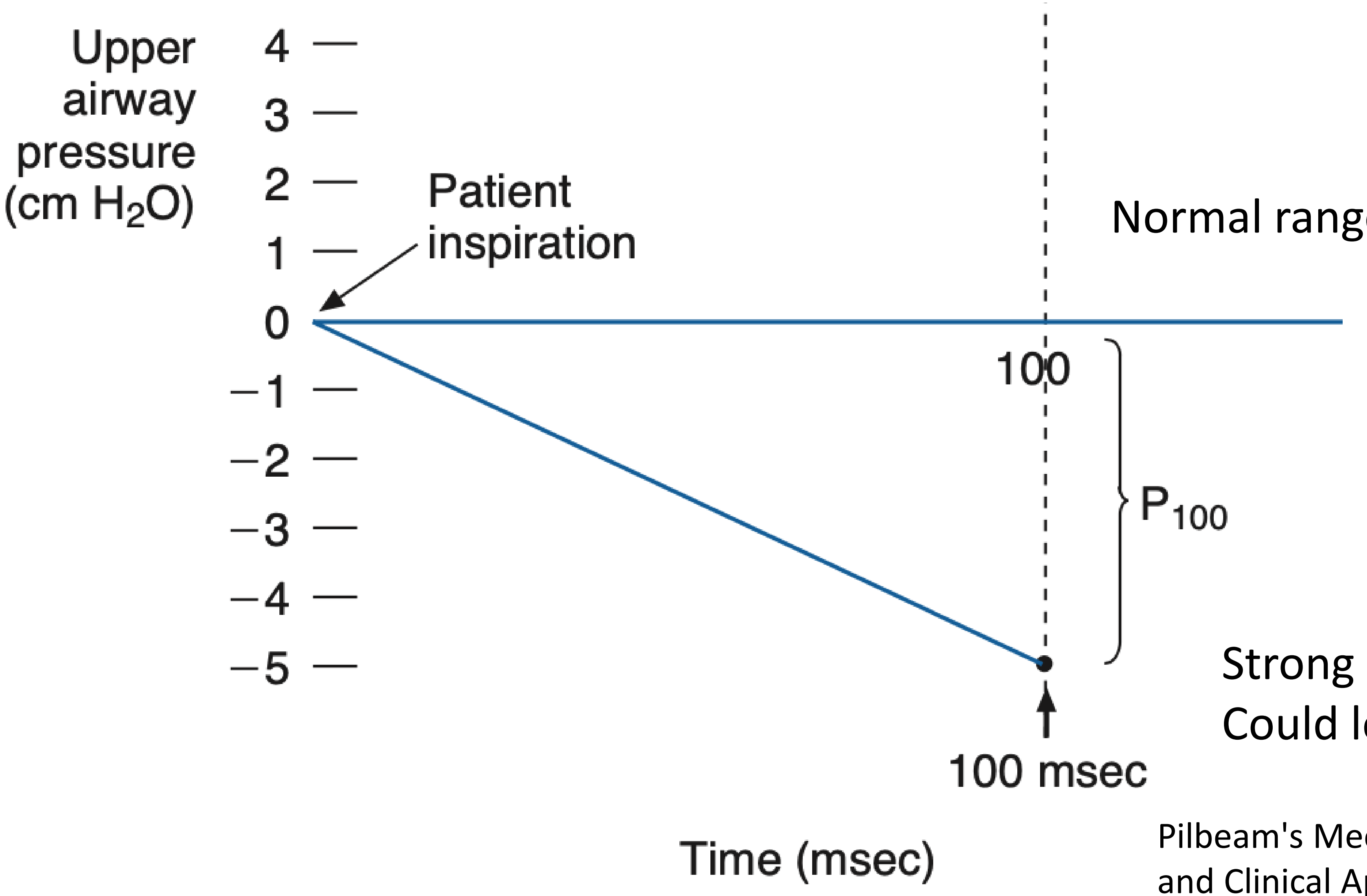
The maximum inspiratory pressure (MIP)

- Mechanical ventilation causes rapid diaphragmatic wasting, weakening the very muscle.
- (MIP) is a good parameter to determine respiratory muscular capacity, a predictive factor for weaning success.
- A successful weaning outcome was likely if MIP values $< -30\ cmH_2O$ and a weaning failure was likely if MIP $< -20\ cmH_2O$
- Wide range of normal values can be closely related to the voluntary effort.

Journal of Critical Care 48 (2018) 56–62

Measurement of drive to breathe $P_{0.1}$

$P_{0.1}$ value, reported as an absolute number



Normal range 0 to -2 cmH_2O

< -6 cmH_2O

Strong respiratory muscle drive

Could lead to fatique.

Pilbeam's Mechanical Ventilation Physiological and Clinical Applications, 6e 6th Edition

Ultrasound (US) evaluation of the diaphragm

- A marker for diaphragmatic function and directly affect weaning and extubation outcomes
- The percent change in diaphragm thickness (T_{di}) ≥ 30% between end-expiration and end-inspiration ($\Delta T_{di}\%$), evaluated in the zone of apposition, has a sensitivity and specificity for extubation success of 88% and 71%
- $\Delta T_{di}\% > 20$ is a robust predictor of extubation success within 48 hr.
- $\Delta T_{di}\% > 34.2$ is a cutoff value associated with successful extubation.

Journal of Critical Care 48 (2018) 56–62

Diaphragm Ultrasound in Weaning From Mechanical Ventilation

Check for updates

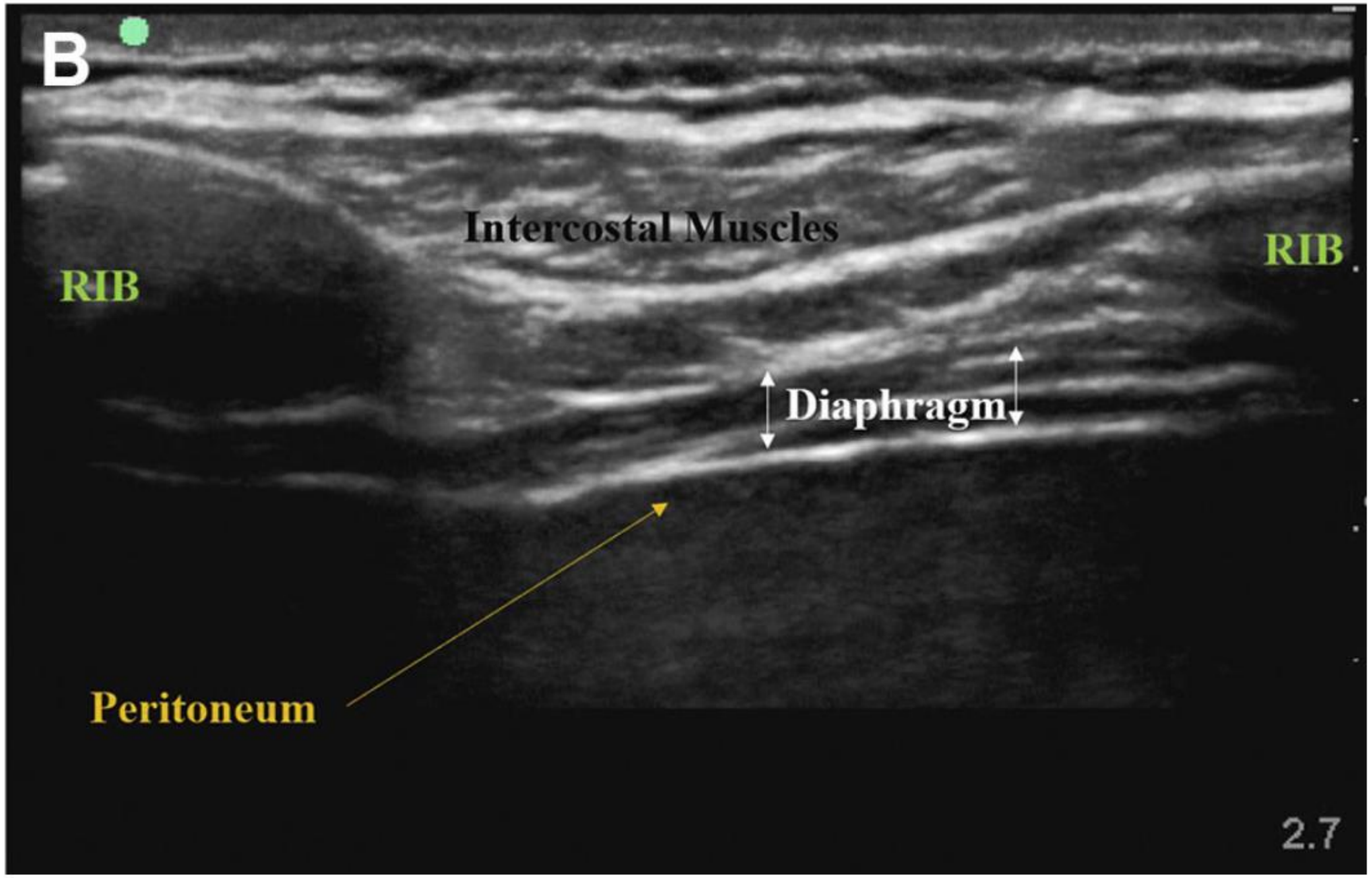
Deepti Kilaru, MBBS; Nova Panebianco, MD, MPH; and Cameron Baston, MD, MSCE

- A potential contributing factor of weaning failure is diaphragm weakness or atrophy.
- Ventilator- induced diaphragm dysfunction (VIDD).
- Each day on the ventilator has been associated with a reduction in diaphragmatic thickness by an average of 6%.
- Mortality is higher in diaphragmatic dysfunction. (49% vs 7%)
- More commonly seen when mechanical ventilation is combined with sepsis.

CHEST 2021; 159(3):1166-1172

Linear transducer placed longitudinally

B mode ultrasound image
Musculoskeletal preset



Anterior axillary line
Right 8th – 10th intercostal space

Cephalad

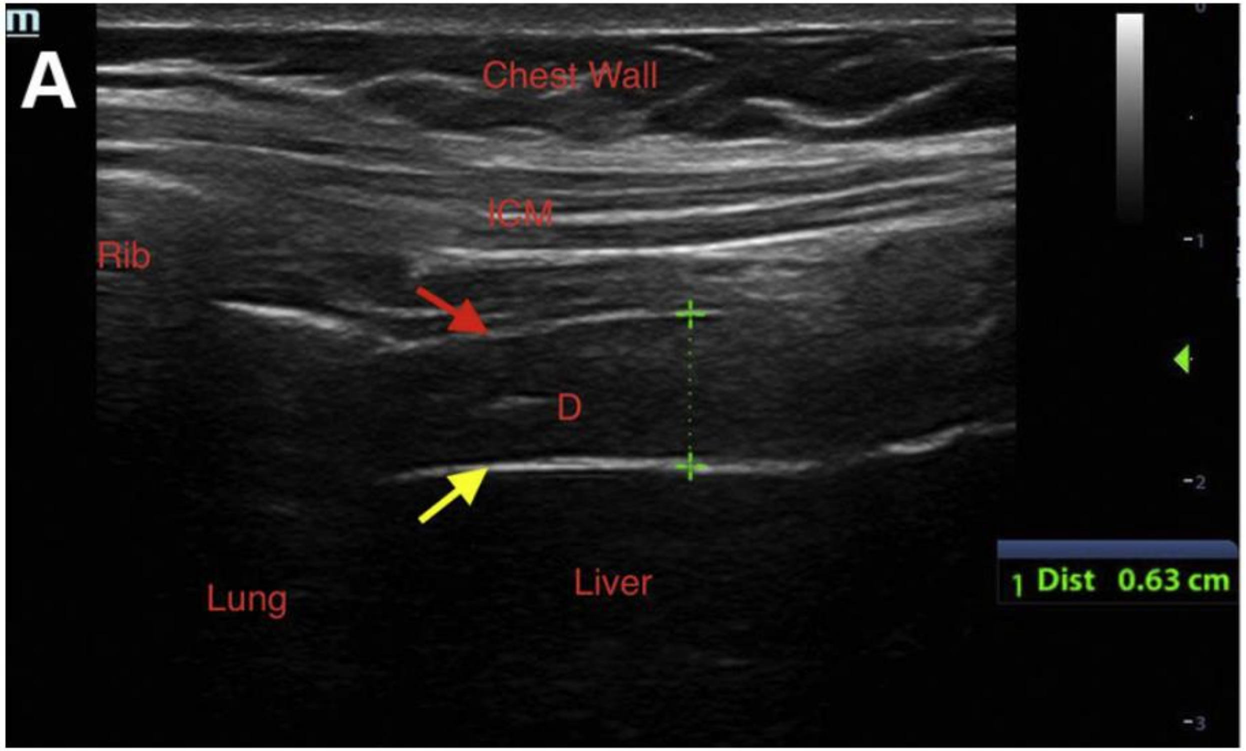
Diaphragm thickness
Zone of apposition

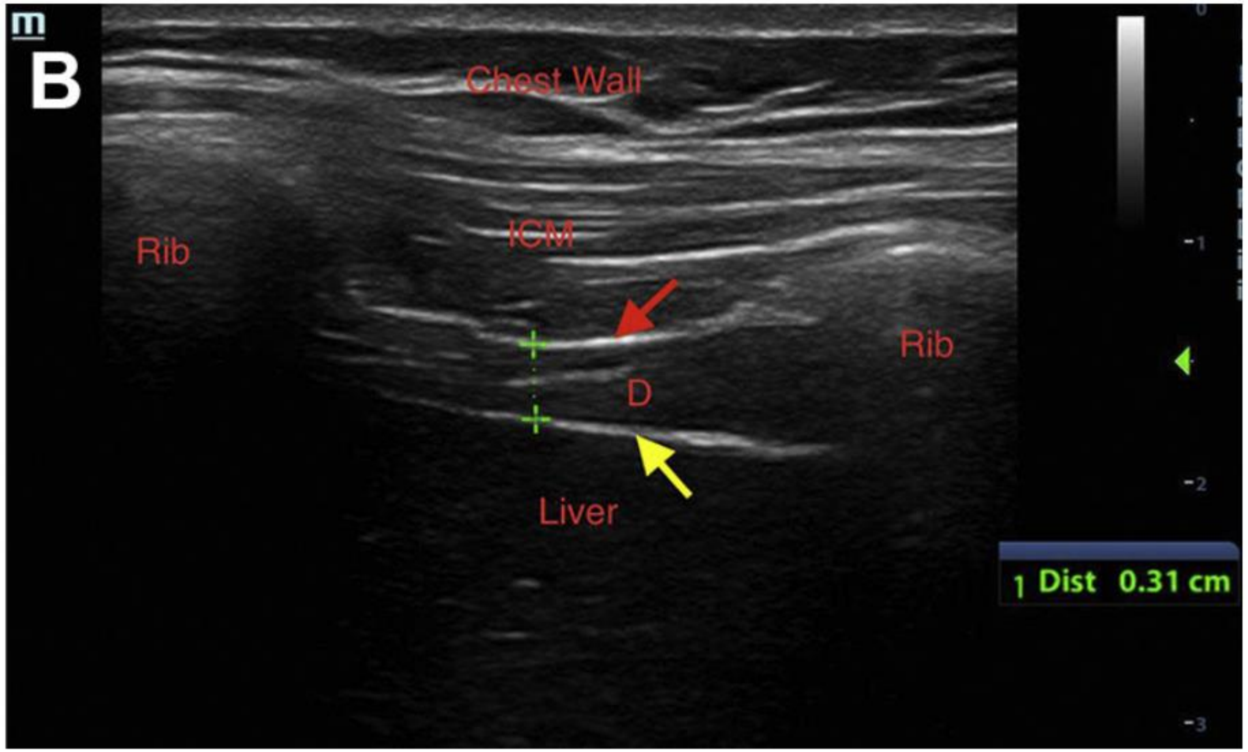
Caudal

Diaphragm thickness

Diaphragm measured at the end of inspiration

Diaphragm measured at the end of expiration





Clinical application of diaphragm ultrasound

- Diaphragm thickening fraction (DTF) and diaphragm excursion are the variables that are assessed for predicting weaning.
- Thickening fraction =

[(End Inspiratory Diaphragm Thickness - End Expiratory Diaphragm Thickness) / End Expiratory Diaphragm Thickness] × 100.

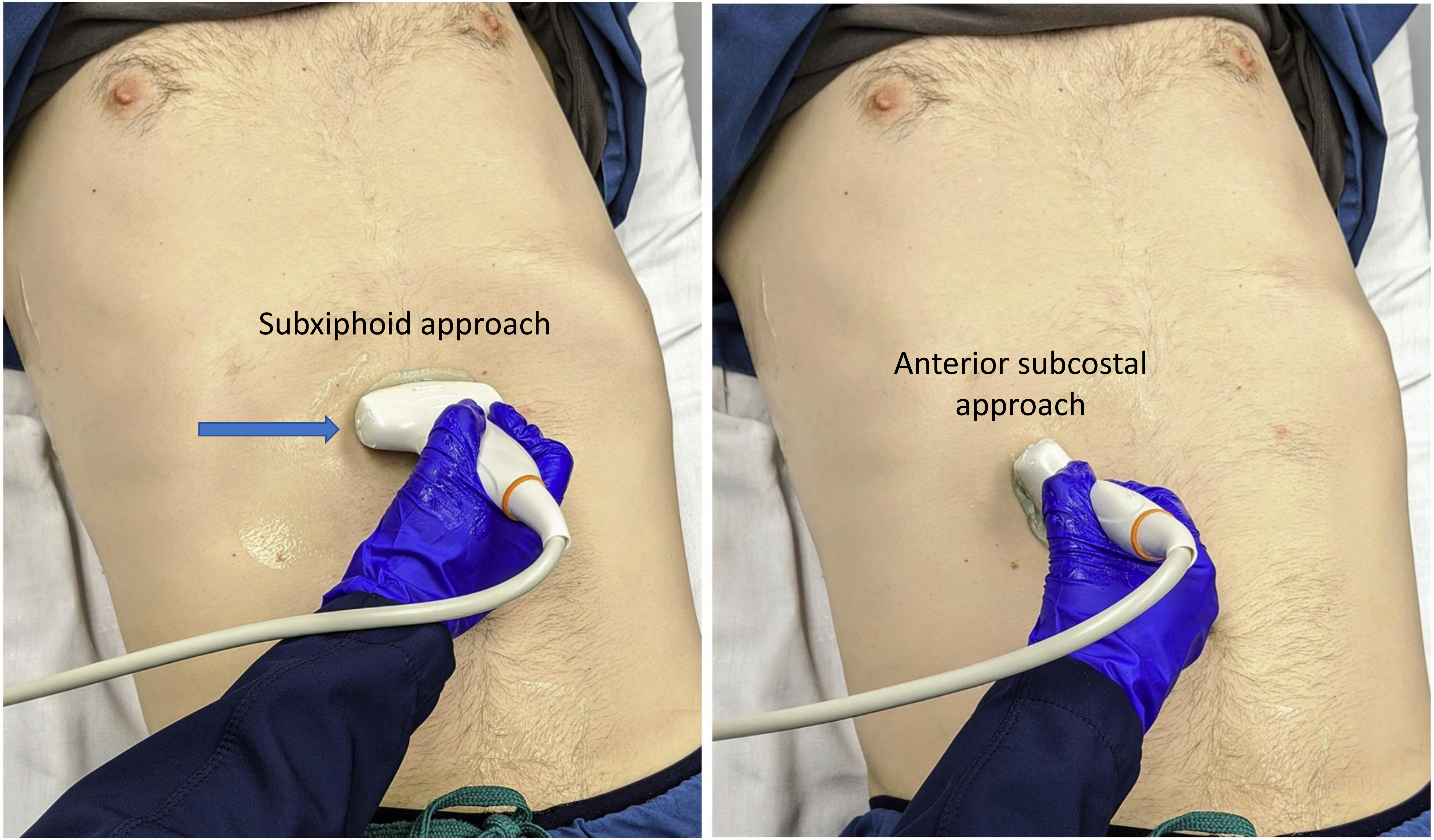
- DTF >30% to 36% has been proposed as a cutoff to predict successful weaning from mechanical ventilation.
- Sensitivity range from 82% to 88% and specificity 71% to 88%
- DTF < 20% predictive of diaphragm paralysis.

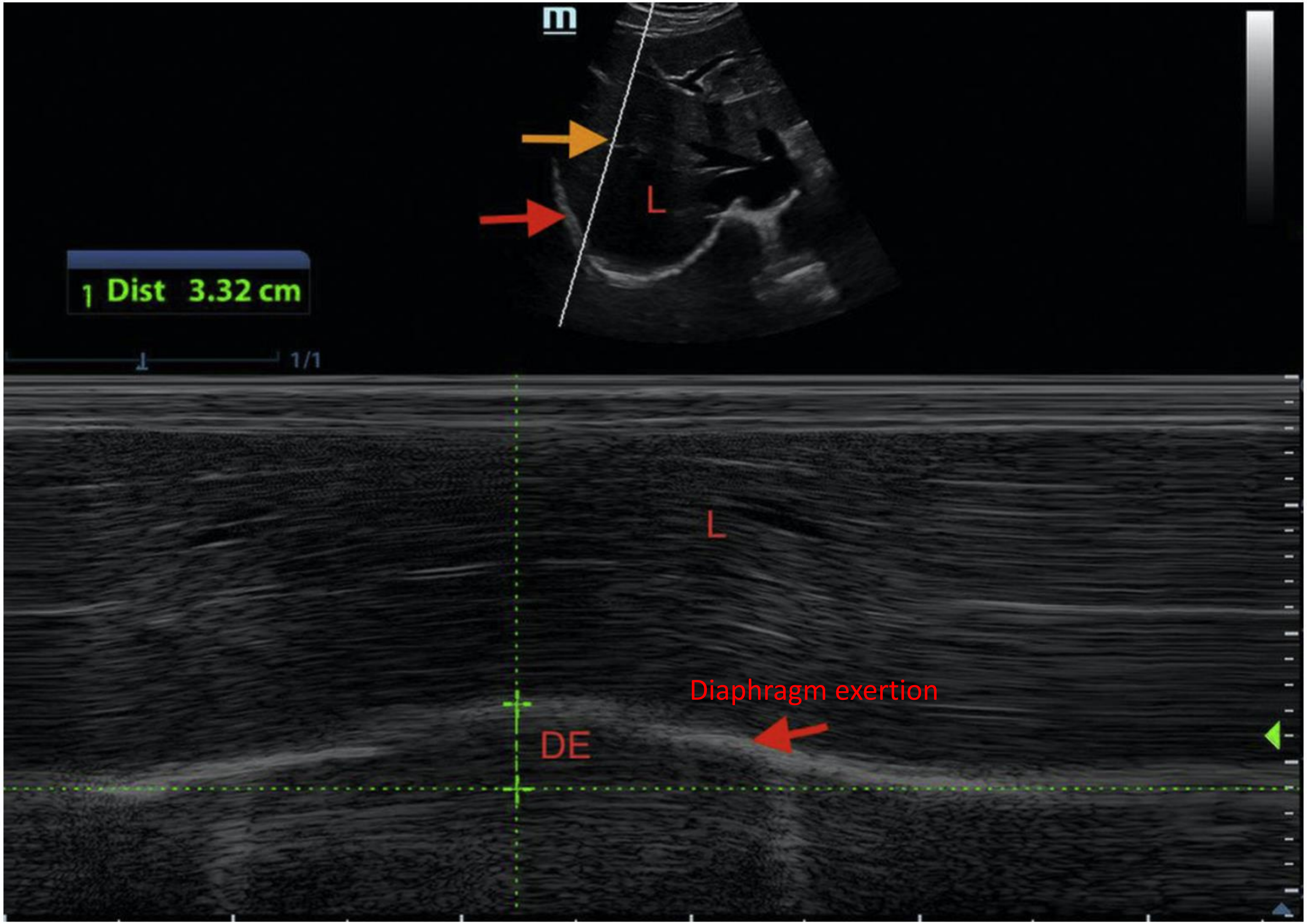
CHEST 2021; 159(3):1166-1172

Clinical application of diaphragm ultrasound

- DTF should be obtained during a SBT to help predict success in weaning.
- The performance characteristics of DTF are better at lower levels of pressure support (PS 10cmH_2O).
- More accurately demonstrates the expected post-extubation diaphragmatic workload.
- When compared directly with RSBI, DTF is more specific for predicting successful extubation.

CHEST 2021; 159(3):1166-1172


Subxiphoid approach
Anterior subcostal
approach


m
L
1 Dist 3.32 cm
1/1
L
Diaphragm exertion
DE

Clinical application of diaphragm ultrasound

- Diaphragm excursion can be used to predict failure of extubation.
- An excursion > 10 to 14 mm has been shown to predict successful extubation with a sensitivity (78.9% to 87.5%) and specificity (70.8% to 71.5%)
- Even a completely paralyzed diaphragm will have an excursion proportional to lung compliance and driving pressure.
- Specific threshold during spontaneous breathing trials for all patients ?

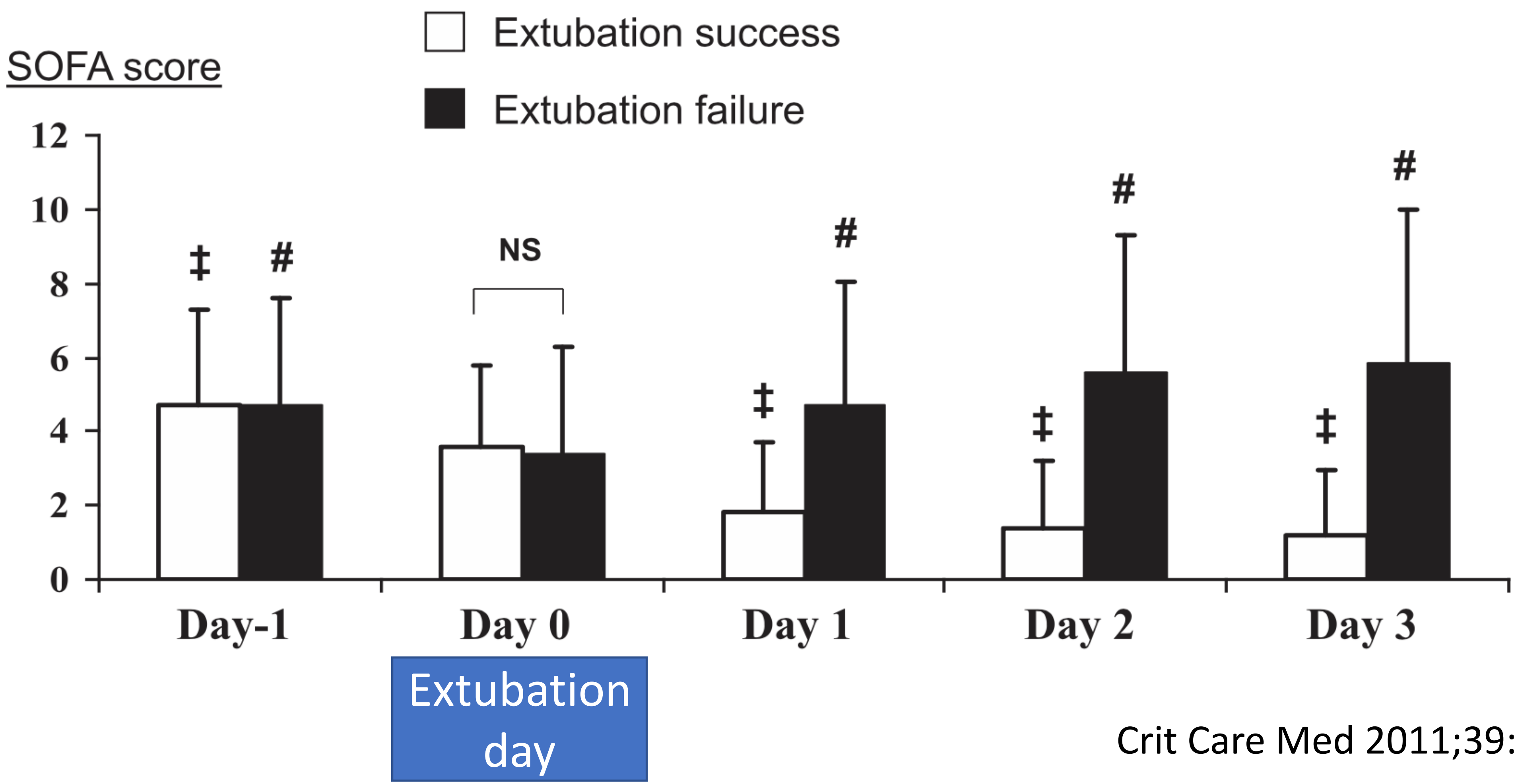
CHEST 2021; 159(3):1166-1172

The APACHE II and SOFA

- APACHE II scores were statistically higher in the weaning/extubation failure group.
- May not always reflect the current state of a patient, as the score is applied within 24 h of patient's admission to the ICU, and weaning can start several days later.
- The SOFA score is normally used continuously during patients' ICU stay, which accounts for the severity of a patient's illness at the moment of weaning or extubation.
- A more reliable predictor of weaning outcome.

Electron Physician 2016;8:1955–63

The daily SOFA score



Crit Care Med 2011;39:2612–2618

Nutrition and anemia

- Malnutrition → impairment in respiratory function.
- Fatigue, decreased respiratory muscle strength and endurance, depletion of diaphragmatic muscle mass.
- Total protein, albumin and creatinine height index correlated with the weaning outcome.
- Anemia can exacerbate the insufficient global O_2 delivery (DO_2) and myocardial ischemia.
- Hb <10 g/dL more likely to have unsuccessful extubations.

Chest 2001;120:1262–70

Fluid and renal function

- Side effect of IMV is hypotension, caused by a reduction in venous return.
- Positive fluid balance in the 24 h prior to extubation can predict the extubation failure.
- From last 48 h, 72 h and even in accumulation since hospital admission is a significantly greater predictor of weaning failures.
- Parameters linked to renal function, such as BUN, creatinine and the patients' need for hemodialysis, can also predict the weaning and extubation outcome.

Respir Care 2014;59:1042–7

Respirology 2014;19:576–82

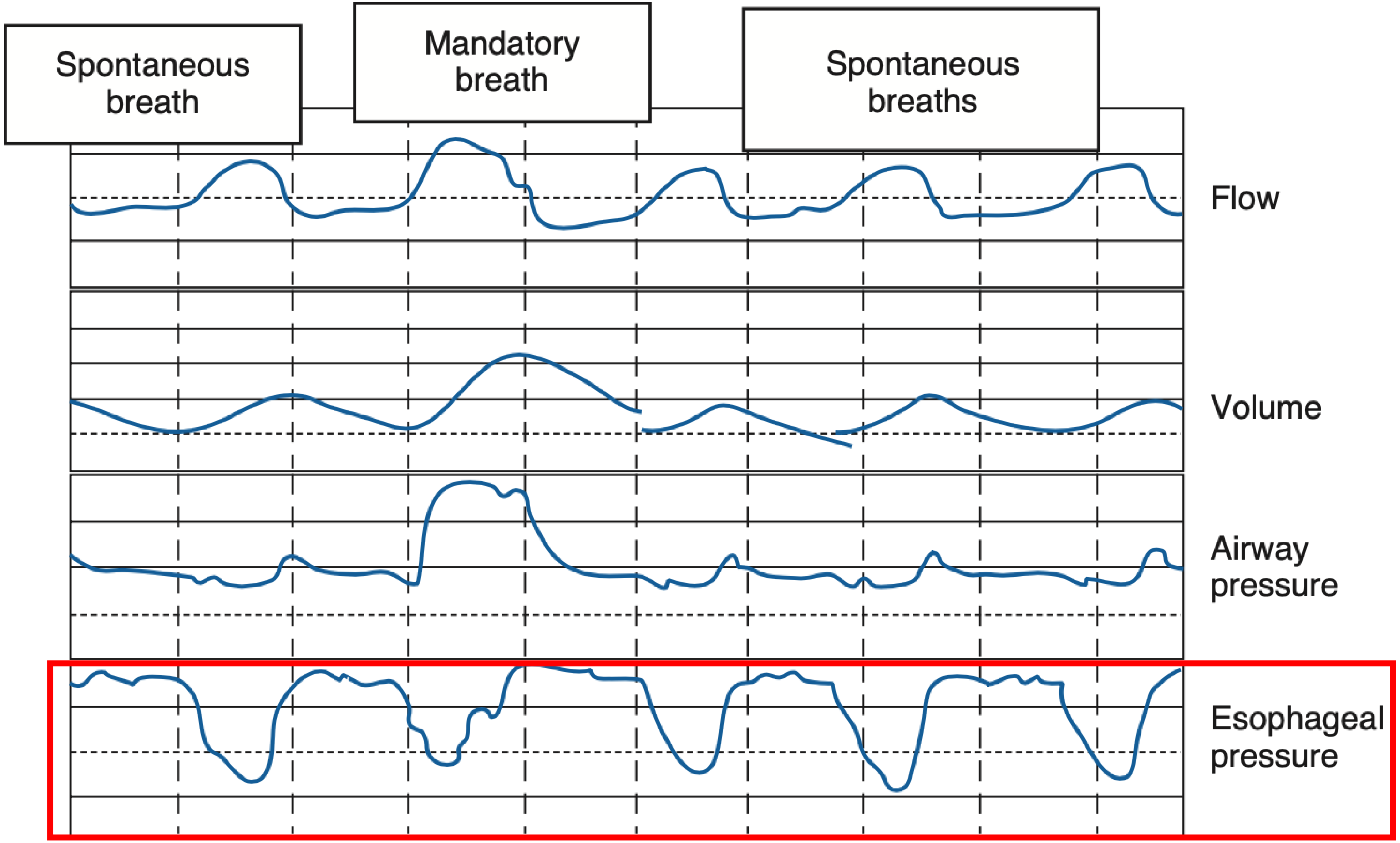
Outline

Readiness testing	Weaning	Extubation
Objective clinical criteria Physiological tests	Spontaneous breathing trials SBT	Airway patency Airway protection

Methods of titrating ventilator support during weaning

- Simultaneous intermittent mandatory ventilation (SIMV)
- Pressure support ventilation (PSV)
- T-piece weaning (using a ventilator)

SIMV



Should not be used as a weaning mode.

Prolongs the weaning phase and total length of ventilatory support.

The least effective method.

Respir Care 47:1007-1017, 2002

Closed–loop control modes for ventilator discontinuation

- Automated tube compensation (ATC)
- Volume-target pressure support ventilation
- Automode and variable pressure support/variable pressure control
- Mandatory minute ventilation
- Adaptive support ventilation
- Artificial intelligence system

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Potential advantages of ATC

- Support or overcome the WOB imposed by the artificial airway.
- Improve patient-ventilator synchrony through variable compensation of inspiratory flow based on patient demand.
- Unload the inspiratory muscles and increase alveolar ventilation without adverse cardiopulmonary side effects.
- Reduce the risk of air trapping caused by expiratory resistance from the endotracheal tube.
- Facilitate accurate prediction of readiness for extubation.

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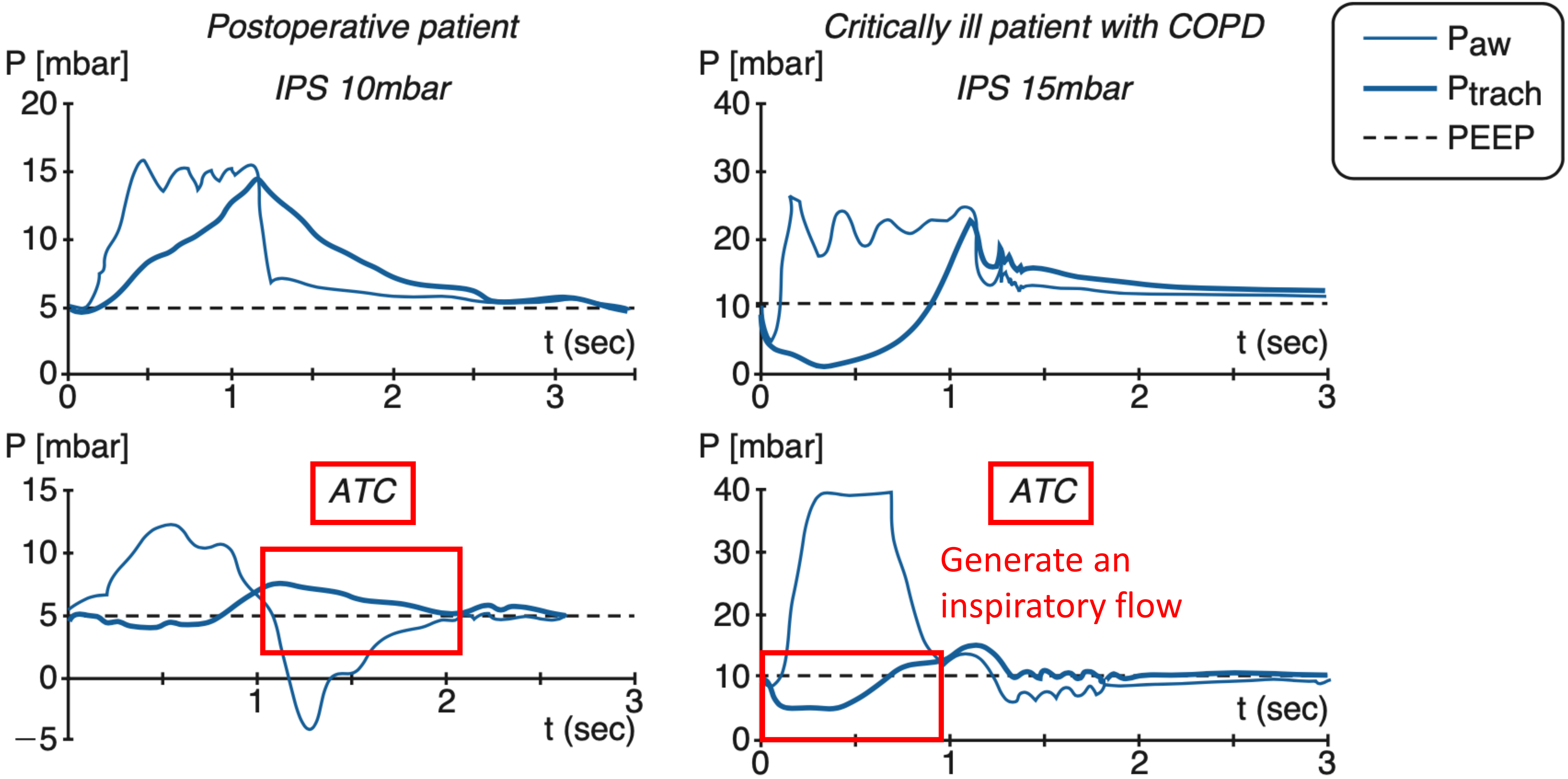

Control of the expiratory valve

Intensive Care Med 23:545-552, 1997

Spontaneous breathing trial (SBT)

- Perhaps the best way to determine readiness to wean is a carefully supervised SBT.
- Consider ready for weaning is tolerate an SBT for 30-120min.
- 77-85% of patients who pass an SBT can be successfully weaned and extubated.
- Simple T-piece (using a ventilator)
- CPAP (5cmH_2O)
- Low level of pressure support (5-8cmH_2O)

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Liberation From Mechanical Ventilation in Critically Ill Adults

Executive Summary of an Official American College of Chest Physicians/American Thoracic Society Clinical Practice Guideline

- For acutely hospitalized patients ventilated >24 h.
- We suggest that the initial SBT be conducted with inspiratory pressure augmentation (PS 5-8 cm H_2O) rather than without (T-piece or CPAP)

CHEST 2017; 151(1):160-165

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

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

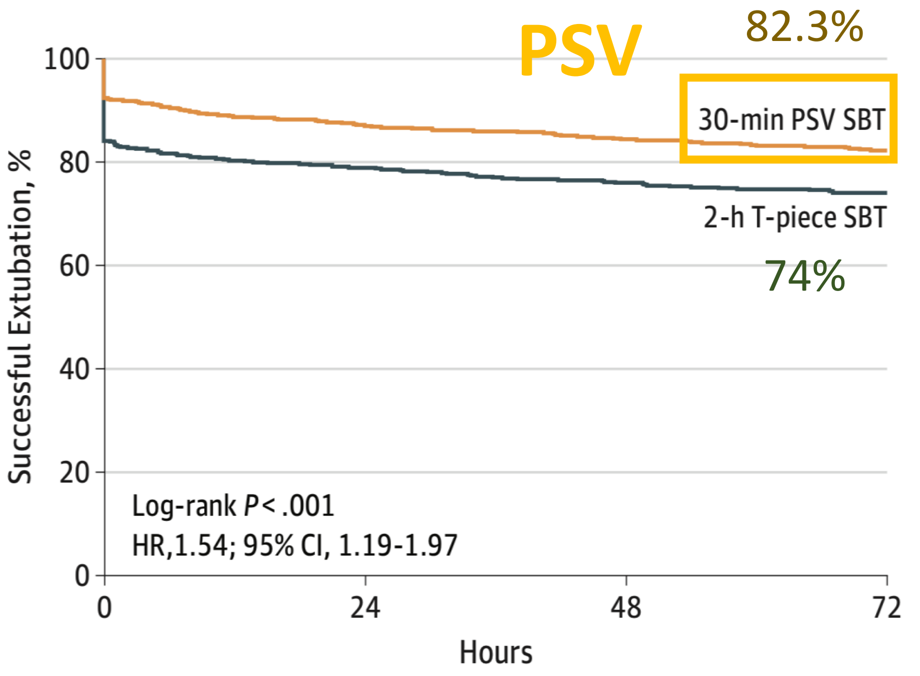
A Randomized Clinical Trial

- 1153 patients, 18 ICUs in Spain.
- A SBT consisting of 30 minutes of PSV (PS 8cmH_2O), compared with 2 hours of T-piece ventilation.
- PSV led to significantly higher rates of successful extubation.
- These findings support the use of a shorter, less demanding ventilation strategy for spontaneous breathing trials.

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

PSV: higher successful extubation

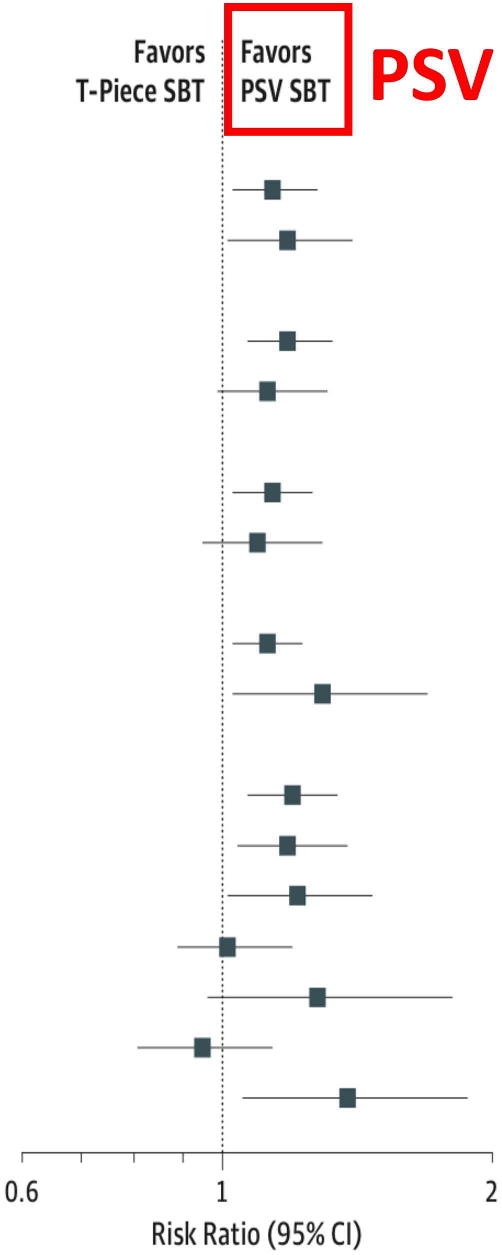
Figure 2. Probability of Successful Extubation After First SBT in Each Group



No. at risk				
30-min PSV SBT	575	501	484	472
2-h T-piece SBT	578	456	438	426

Figure 3. Unadjusted Risk Ratios for Successful Extubation After First SBT in Predefined Subgroups

	No./Total			
	30-min PSV SBT	2-h T-Piece SBT	Risk Ratio (95% CI)	
Age, y				
≤70	306/370	289/385	1.10 (1.02-1.19)	
>70	167/205	139/193	1.13 (1.01-1.26)	
Length of mechanical ventilation, d				
≤4	263/304	249/326	1.13 (1.05-1.22)	
>4	210/271	179/252	1.09 (0.99-1.21)	
APACHE II score				
≤20	329/410	296/404	1.10 (1.02-1.18)	
>20	133/164	132/174	1.07 (0.96-1.20)	
COPD				
No	387/465	351/460	1.09 (1.02-1.16)	
Yes	86/110	77/118	1.20 (1.02-1.41)	
Patient admission type				
Medical	329/404	283/396	1.14 (1.05-1.23)	
Nonrespiratory	182/215	154/206	1.13 (1.03-1.25)	
Respiratory	147/189	129/190	1.15 (1.01-1.30)	
Surgical	114/140	114/142	1.10 (0.91-1.14)	
Planned	33/35	23/29	1.19 (0.97-1.46)	
Emergency	81/105	91/113	0.96 (0.83-1.10)	
Trauma	30/31	31/40	1.25 (1.04-1.49)	



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

RESEARCH Open Access

Comparison of T-piece and pressure support ventilation as spontaneous breathing trials in critically ill patients: a systematic review and meta-analysis

Yuting Li, Hongxiang Li and Dong Zhang*

- 10 RCT, 3165 patients
- T-piece and PSV as SBTs are considered to have comparable predictive power of successful extubation in critically ill patients.
- No significant difference in the rate of reintubation, ICU and hospital length of stay, and ICU and hospital mortality

Li et al. Critical Care (2020) 24:67

Study or Subgroup	T-Piece Events	T-Piece Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chittawatanarat 2018	212	260	159	260	9.3%	2.81 [1.88, 4.19]
Esteban 1997	156	246	167	238	19.8%	0.74 [0.50, 1.08]
Haberthur 2002	19	30	18	30	2.1%	1.15 [0.41, 3.26]
Koh 2000	12	22	14	20	2.1%	0.51 [0.14, 1.84]
Matic 2004	80	110	120	150	8.8%	0.67 [0.37, 1.19]
Matic 2007	35	66	38	70	5.5%	0.95 [0.48, 1.87]
Santos Pellegrini 2018	78	99	71	91	5.0%	1.05 [0.52, 2.09]
Subira 2019	428	578	473	575	39.2%	0.62 [0.46, 0.82]
Teixeira 2015	56	66	38	46	2.2%	1.18 [0.43, 3.26]
Zhang 2014	90	115	78	93	6.0%	0.69 [0.34, 1.41]
Total (95% CI)		**1592**		**1573**	**100.0%**	**0.91 [0.78, 1.07]**
Total events	1166		1176			

Heterogeneity: Chi² = 41.96, df = 9 (P < 0.00001); I² = 79%
Test for overall effect: Z = 1.09 (P = 0.27)

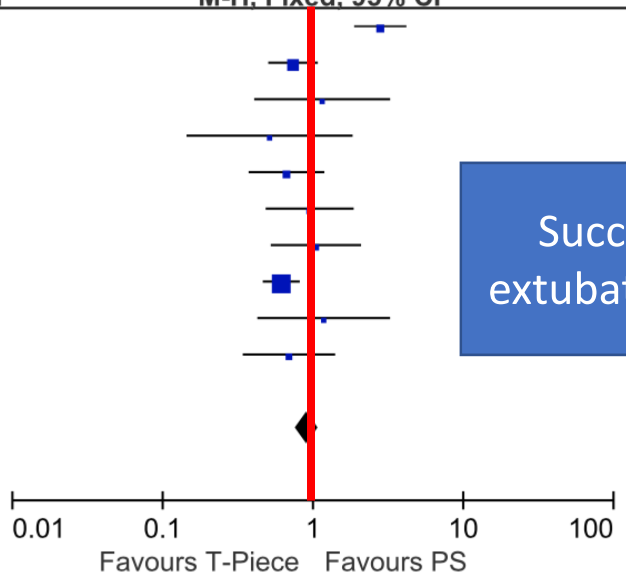


Fig. 4 Forest plot for successful extubation rate

Successful extubation rate

Study or Subgroup	T-Piece Events	T-Piece Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chittawatanarat 2018	38	260	26	260	16.0%	1.54 [0.91, 2.62]
Esteban 1997	36	246	38	238	23.8%	0.90 [0.55, 1.48]
Koh 2000	4	22	4	20	2.5%	0.89 [0.19, 4.15]
Santos Pellegrini 2018	35	99	40	91	19.4%	0.70 [0.39, 1.25]
Subira 2019	58	578	59	575	38.3%	0.98 [0.67, 1.43]
Total (95% CI)		**1205**		**1184**	**100.0%**	**0.99 [0.78, 1.26]**
Total events	171		167			

Heterogeneity: Chi² = 4.20, df = 4 (P = 0.38); I² = 5%
Test for overall effect: Z = 0.06 (P = 0.95)

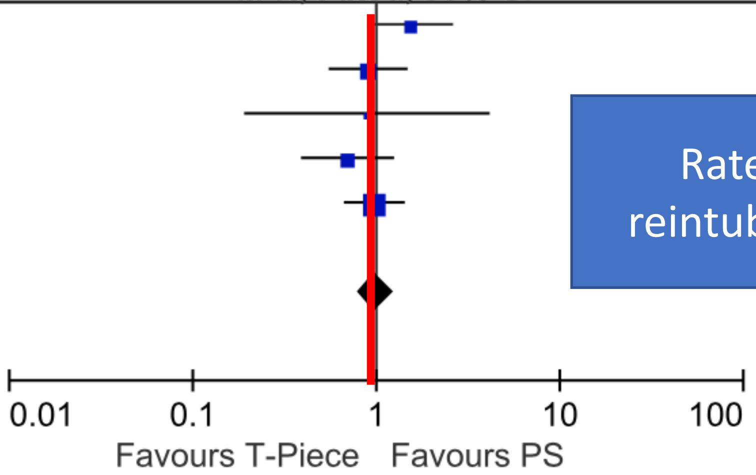
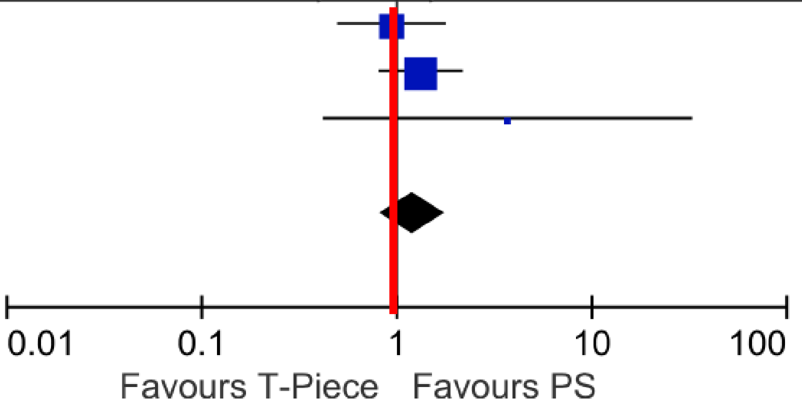


Fig. 6 Forest plot for rate of reintubation

Rate of reintubation

Study or Subgroup	T-Piece Events	T-Piece Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Santos Pellegrini 2018	26	99	25	91	40.5%	0.94 [0.49, 1.79]
Subira 2019	38	578	29	575	57.2%	1.32 [0.81, 2.18]
Teixeira 2015	5	66	1	46	2.3%	3.69 [0.42, 32.67]
Total (95% CI)		**743**		**712**	**100.0%**	**1.22 [0.83, 1.80]**
Total events	69		55			

Heterogeneity: $Chi^2 = 1.73$, df = 2 (P = 0.42); $I^2 = 0\%$
Test for overall effect: Z = 1.03 (P = 0.30)

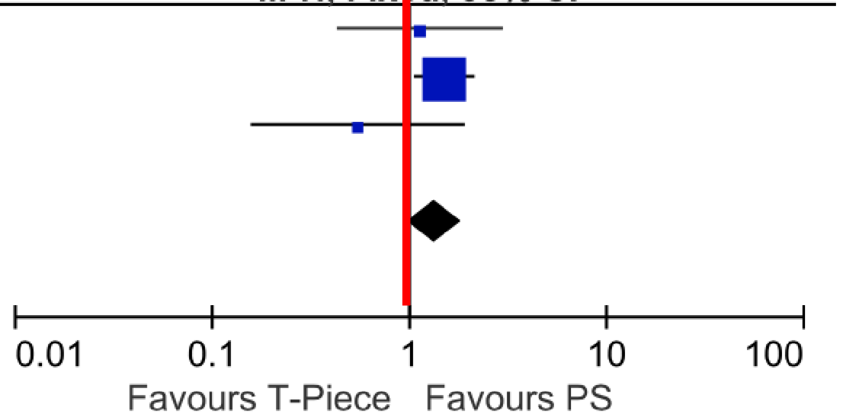


ICU mortality

Fig. 7 Forest plot for ICU mortality

Study or Subgroup	T-Piece Events	T-Piece Total	PS Events	PS Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Chittawatanarat 2018	9	260	8	260	11.8%	1.13 [0.43, 2.97]
Subira 2019	86	578	60	575	78.2%	1.50 [1.06, 2.13]
Teixeira 2015	5	66	6	46	10.0%	0.55 [0.16, 1.91]
Total (95% CI)		**904**		**881**	**100.0%**	**1.36 [0.99, 1.87]**
Total events	100		74			

Heterogeneity: $Chi^2 = 2.48$, df = 2 (P = 0.29); $I^2 = 19\%$
Test for overall effect: Z = 1.90 (P = 0.06)



Hospital mortality

Fig. 8 Forest plot for hospital mortality

Study or Subgroup	T-Piece Mean	T-Piece SD	T-Piece Total	PS Mean	PS SD	PS Total	Weight	Mean Difference IV, Fixed, 95% CI
Chittawatanarat 2018	4	2.9819	260	4.3333	3.7274	260	71.4%	-0.33 [-0.91, 0.25]
Santos Pellegrini 2018	13	12.0371	99	11	7.5329	91	3.0%	2.00 [-0.83, 4.83]
Subira 2019	10.6667	8.9181	578	10.3333	8.9182	575	22.7%	0.33 [-0.70, 1.36]
Teixeira 2015	12	8.1	66	11.9	7.4	46	2.9%	0.10 [-2.80, 3.00]
Total (95% CI)			**1003**			**972**	**100.0%**	**-0.10 [-0.59, 0.39]**

Heterogeneity: $Chi^2 = 3.43$, df = 3 (P = 0.33); $I^2 = 13\%$
Test for overall effect: Z = 0.40 (P = 0.69)

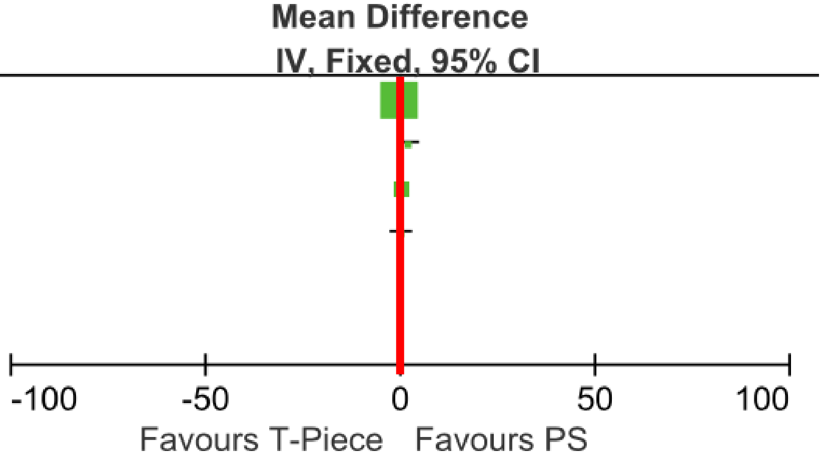


Fig. 9 Forest plot for ICU length of stay

ICU LOS

Study or Subgroup	T-Piece Mean	T-Piece SD	T-Piece Total	PS Mean	PS SD	PS Total	Weight	Mean Difference IV, Fixed, 95% CI
Chittawatanarat 2018	17.3333	10.4366	260	18.5	11.9276	260	51.0%	-1.17 [-3.09, 0.76]
Santos Pellegrini 2018	32.5	31.5973	99	32	33.1449	91	2.2%	0.50 [-8.73, 9.73]
Subira 2019	26	17.8362	578	26.3333	18.5796	575	42.8%	-0.33 [-2.44, 1.77]
Teixeira 2015	25.1	16.5	66	27.6	19.8	46	3.9%	-2.50 [-9.47, 4.47]
Total (95% CI)			**1003**			**972**	**100.0%**	**-0.82 [-2.20, 0.55]**

Heterogeneity: $Chi^2 = 0.63$, df = 3 (P = 0.89); $I^2 = 0\%$
Test for overall effect: Z = 1.17 (P = 0.24)

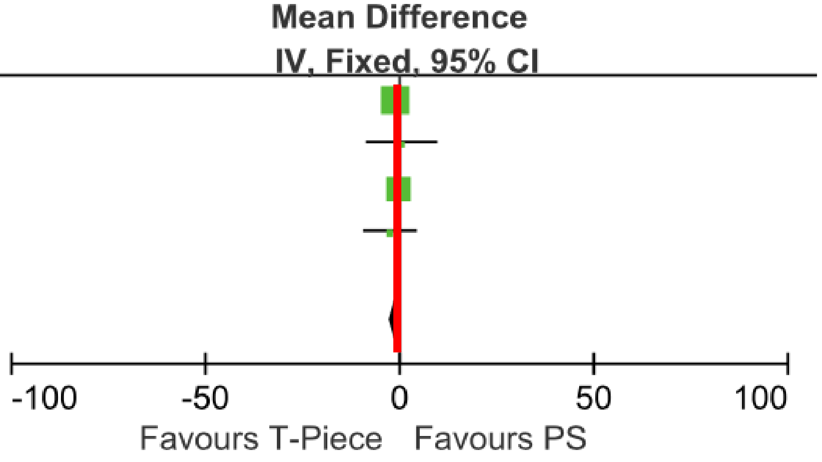


Fig. 10 Forest plot for hospital length of stay

Hospotal LOS

Clinical Signs and Symptoms Indicating Problems during a SBT

- Respiratory rate > 30 to 35 /min (clinicians also should watch for ↑ >10 / min or RR < 8 /min).
- Tidal volume (V_T) ↓ < 250 to 300mL
- Deterioration of ABG values and SpO_2
- BP changing significantly, as demonstrated by
  - SBP ↓ 20 mmHg or ↑ 30 mmHg
  - SBP >180 mmHg or a change of 10 mmHg diastolic
- Heart rate ↑ > 20% or > 140 / min.
- Sudden onset of frequent PVC > 4 to 6/min.

Pilbeam's Mechanical Ventilation Physiological and Clinical Applications, 6e 6th Edition

Patient evaluation during SBT

- Irregular ventilatory pattern.
- Palpable scalene muscle during inspiration.
- Palpable abdominal muscle tensing during expiration.
- Inability to alter the ventilatory pattern on command.

- 1 or 2 signs → usually need continue support.
- ≥3 signs → poor prognosis for ventilator removal

Hess DR. Mechanical ventilation of the adult patient

Rule of thumb in initial approach to liberating

- SBT is the best approach.
- Ideally applied with zero PS and zero PEEP for 30-120 min via the mechanical ventilator. (for monitoring)
- Single daily trial may be preferred.
- Patients who have been received MV for >72 hr.
- The most common method is SBT interspersed with continued ventilatory support.
- Patient should not be overstressed, exhaustion → delay weaning.
- It will take >24 h to completely recover from fatique.

Egan’s fundamentals of respiratory care 12th edition

AMERICAN THORACIC SOCIETY DOCUMENTS

An Official American Thoracic Society/American College of Chest Physicians Clinical Practice Guideline: Liberation from Mechanical Ventilation in Critically Ill Adults
Rehabilitation Protocols, Ventilator Liberation Protocols, and Cuff Leak Tests

- For acutely hospitalized adults who have been mechanically ventilated for more than 24 hours.
- Suggest protocolized rehabilitation directed toward early mobilization (conditional recommendation, low certainty in the evidence).
- A ventilator liberation protocol is suggested.

AJRCCM Volume 195 Number 1 January 1 2017

Daily screening liberation assessment

- Global variation exists in the use of protocols.
- Written directives to screen for readiness 5-83%
- Frequency of daily screening varied widely.
- Liberation protocols may not be beneficial in all settings.
- Should be tailored to the patients population.
- Not superior to usual care in highly staffed, closed ICU in an academic hospital.

AJRCCM. 2004;169(6):673

JAMA 2021 Mar 23; 325(12): 1173–1184

Recommendations in SBT

- An SBT should be performed every 24 hours.
- Avoid pushing patients to the point of exhaustion during the weaning process because this ultimately can delay liberation.
- It is important that clinicians wait >24 hours before attempting another SBT in patients for whom it fails.
- Frequent SBTs over a single day are not helpful and can lead to serious consequences.
- Even twice-daily SBTs offer no advantage over testing once a day.

Outline

Readiness testing	Weaning	Extubation
Objective clinical criteria Physiological tests	Spontaneous breathing trials SBT	Airway patency Airway protection

Weaning and extubation

- > 10% of extubations fail, and IMV has to be reinitiated.
- The pathogenesis of weaning and extubation failure may differ significantly.
- "weaning success" when a patient successfully passes an SBT.
- "extubation success" when a patient is extubated after the SBT and is not reintubated during the next 48 h.

Eur Respir J 2007;29:1033–1056

If failed

- 7 times more likely to die.
- 31 times more likely to spend ≥14 days in ICU.
- 6 times more likely to need transfer to long term or rehabilitation facility.

CHEST 1997; 112:186-92

Incidence of failed extubation and mortality

CHEST /112 / 1 1JULY, 1997

Table 5—*Studies Reporting the Incidence of Failed Extubation**

Study (Year)	Patient Type	No. of Patients	% Reintubated	% Mortality
Sahn et al (1973)[5]	MICU/SICU	100	17.0	NR
Hilberman et al (1976)[8]	Cardiac surgery	124	17.7	NR
Tahvanainen et al (1983)[6]	MICU	47	19.0	22.2
DeHaven et al (1986)[10]	SICU/trauma	48	6.3	NR
Demling et al (1988)[1]	General SICU	400	5.5	40.0
	Burn/trauma unit	300	3.3	10.0
Krieger et al (1989)[7]	MICU/SICU	269	10.4	NR
Sassoon et al (1993)[11]	MICU	40	12.5	NR
Mohsenifar et al (1993)[12]	RICU	29	14.3	NR
Lee et al (1994)[3]	MICU	52	17.0	33.3
Brochard et al (1994)[9]	MICU/SICU	109	11.0	NR
Torres et al (1995)[2]	MICU/SICU	170	23.5	35.0
Esteban et al (1995)[4]	MICU/SICU	530	15.7	NR
Current study	MICU	289	14.5	42.5
			3.3-23.5%	22.2-42.5%

*MICU=medical ICU; SICU=surgical ICU; RICU=respiratory ICU; NR=not reported.

Incidence of failed extubation and mortality

AJRCCM Vol 187, Iss. 12, pp 1294–1302, Jun 15, 2013

TABLE 1. RATES OF PLANNED EXTUBATION FAILURE AND MORTALITY

Study (Reference)	Number of Extubations	Rate of Extubation Failure [% (*n*)]	ICU Mortality in Reintubated Patients [% (*n*)]	ICU Mortality in Nonreintubated Patients (%)
Esteban *et al.*, 1997 (1)	397	19 (74)	27 (20)	3
Esteban *et al.*, 1999 (2)	453	13 (61)	33 (20)	5
Epstein *et al.*, 1997 (4)	287	14 (40)	43 (17)	12
Vallverdu *et al.*, 1998 (3)	148	15.5 (23)	35 (8)	5.6
Thille *et al.*, 2011 (6)	168	15 (26)	50 (13)	5
Frutos-Vivar *et al.*, 2011 (14)	1,152	16 (180)	28 (50)	7
Funk *et al.*, 2009 (38)	257	10 (26)	Not available	Not available
Tonnelier *et al.*, 2011 (39)	115	10 (12)	Not available	Not available
Sellares *et al.*, 2011 (34)	181	20 (36)	Not available	Not available
Peñuelas *et al.*, 2011 (40)	2,714	10 (278)	26 (72)	5

10-19%

26-50%

Risk factors for post-extubation stridor

- Prolonged intubation (variably defined as ≥36 hours to ≥6 days)
- Age > 80 years
- A large ETT

(>8 mm in men, >7 mm in women)

- A ratio of ETT to laryngeal diameter greater than 45% on CT
- A small ratio of patient height (mm) to ETT diameter (mm)
- An elevated APACHE II score
- A GCS score <8
- Traumatic intubation
- Female gender
- A history of asthma
- Excessive tube mobility due to insufficient fixation
- Insufficient or lack of sedation
- Aspiration

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Extubation management in the adult intensive care

Cuff leak test

- Qualitative: stethoscope
- Quantitative assessment assessment: Cuff leak volumes
- Cuff leak volumes ≥ 110 mL or >24% of the delivered tidal volume is considered a normal cuff leak test.

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Extubation management in the adult intensive care u

- Simultaneous assessment of both cough and cuff leak may improve prediction of post extubation stridor.
- The absence of both an audible cough and a cuff leak indicates the patient is 10 times more likely to develop post extubation stridor.

J Crit Care. 2004;19(1):23

AMERICAN THORACIC SOCIETY DOCUMENTS

An Official American Thoracic Society/American College of Chest Physicians Clinical Practice Guideline: Liberation from Mechanical Ventilation in Critically Ill Adults

Rehabilitation Protocols, Ventilator Liberation Protocols, and Cuff Leak Tests

- Performing a cuff leak test in mechanically ventilated adults who meet extubation criteria and are deemed high risk for post extubation stridor.
- For adults who have failed a cuff leak test but are otherwise ready for extubation, we suggest administering systemic steroids for ≥4 hours before extubation.

[Original Research Critical Care]

CHEST

Akira Kuriyama, MD, MPH; Noriyuki Umakoshi, MD; and Rao Sun, MD, PhD

Prophylactic Corticosteroids for Prevention of Postextubation Stridor and Reintubation in Adults

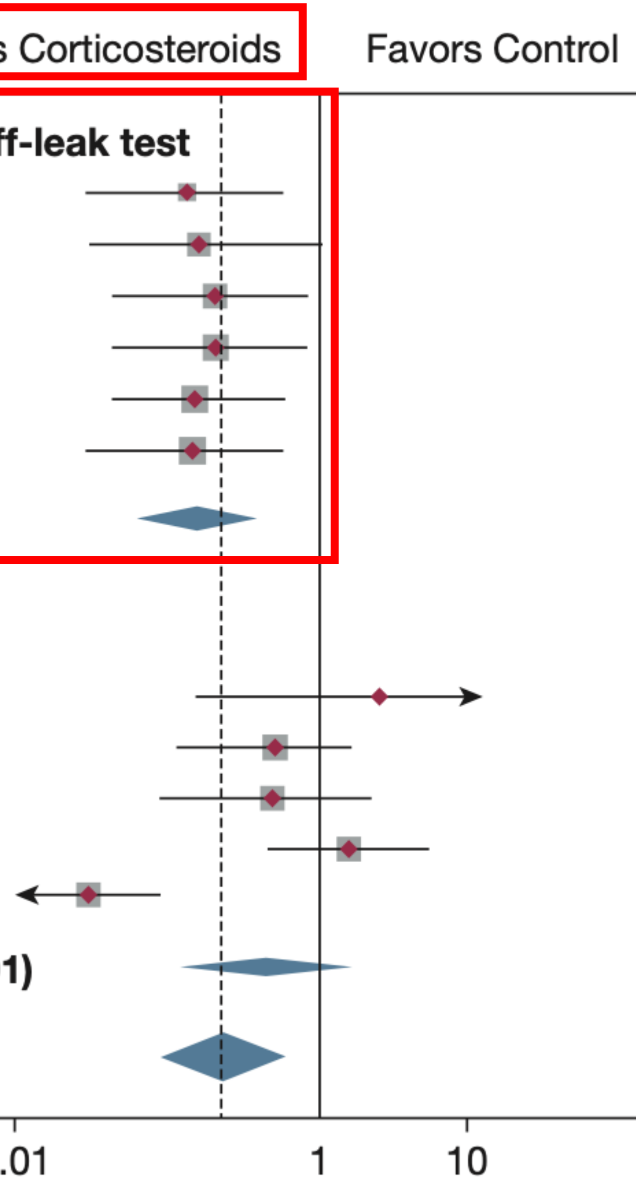
A Systematic Review and Meta-analysis

CrossMark

- Administration of prophylactic corticosteroids before elective extubation was associated with significant reductions in the incidence of postextubation airway events and reintubation (57% reduction), with few adverse events.
- It is reasonable to select patients at high risk for airway obstruction who may benefit from prophylactic corticosteroids.

CHEST 2017; 151(5):1002-1010

Relative risk of post extubation airway events

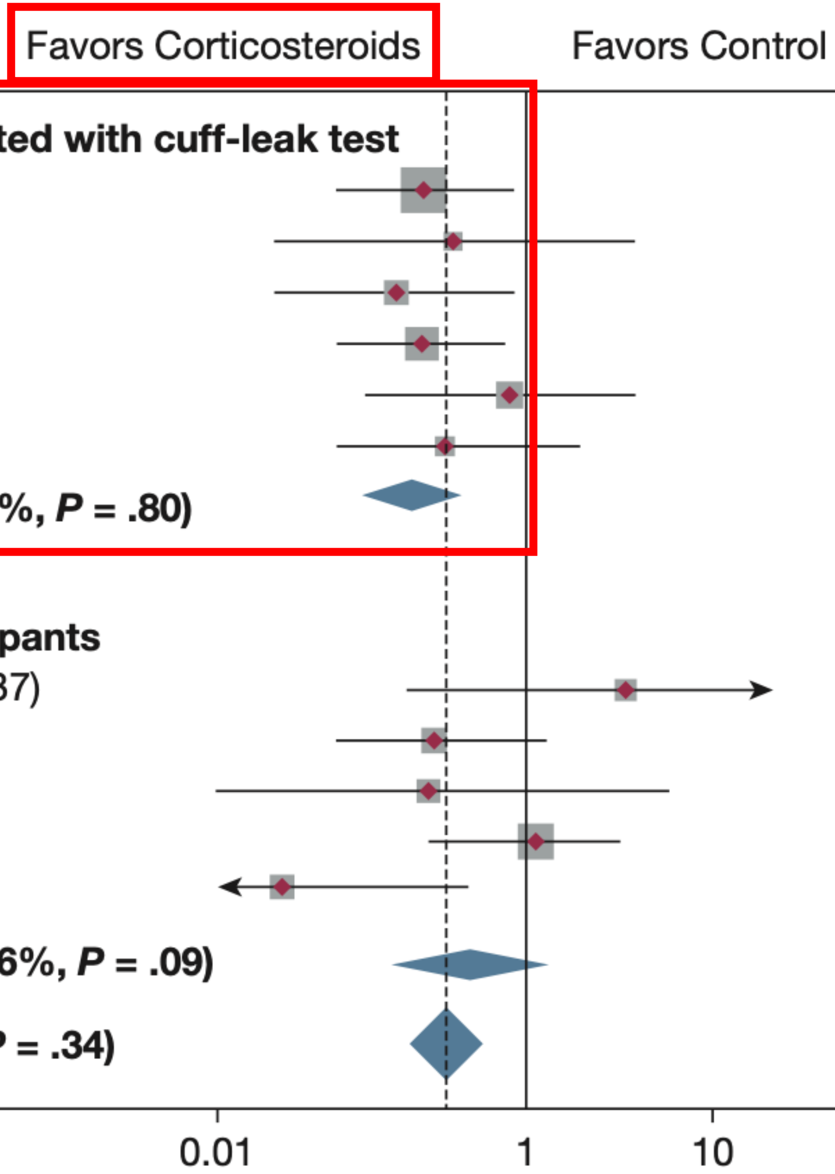


Trial (Year)	RR (95% CI)	Corticosteroids event/total	Control event/total	Weight
Participants selected with cuff-leak test				
Cheng (2006)	0.31 (0.14-0.69)	8/85	13/43	9.61
Lee (2007)	0.36 (0.13-1.05)	4/40	11/40	7.60
Baloch (2010)	0.40 (0.17-0.94)	6/46	15/46	9.16
Cheng (2011)	0.40 (0.17-0.94)	6/38	20/33	9.22
Yu (2014)	0.33 (0.17-0.67)	11/109	16/53	10.55
Lin (2016)	0.28 (0.12-0.65)	7/83	13/43	9.27
Subtotal (I^2 = 0.0%, P = .99)	0.34 (0.24-0.48)			
Unselected participants				
Gaussorgues (1987)	2.00 (0.37-10.74)	4/138	2/138	4.35
Darmon (1992)	0.67 (0.32-1.40)	11/327	17/337	10.11
Ho (1996)	0.68 (0.29-1.61)	7/39	10/38	9.14
Shih (2007)	1.22 (0.56-2.69)	9/49	11/49	9.73
François (2007)	0.14 (0.08-0.26)	11/355	76/343	11.26
Subtotal (I^2 = 84.0%, P < .001)	0.62 (0.24-1.61)			
Total (I^2 = 63.2%, P = .002)	**0.43 (0.29-0.66)**	**86/1,309**	**195/1,163**	**100.00**

Note: Box size is proportional to study weight

CHEST 2017; 151(5):1002-1010

Relative risk of reintubation



Trial (Year)	RR (95% CI)	Corticosteroids event/total	Control event/total	Weight
Participants Selected with cuff-leak test				
Cheng (2006)	0.32 (0.11-0.91)	5/85	8/43	18.87
Lee (2007)	0.50 (0.05-5.30)	1/40	2/40	4.59
Baloch (2010)	0.22 (0.05-0.97)	2/46	9/46	10.82
Cheng (2011)	0.26 (0.08-0.87)	3/38	10/33	15.31
Yu (2014)	0.97 (0.18-5.14)	4/109	2/53	8.74
Lin (2016)	0.52 (0.08-3.55)	2/83	2/43	6.72
Subtotal (I^2 = 0.0%, *P* = .80)	0.35 (0.20-0.64)			
Unselected Participants				
Gaussorgues (1987)	5.00 (0.24-103.20)	2/138	0/138	2.85
Darmon (1992)	0.41 (0.08-2.11)	2/327	5/337	9.06
Ho (1996)	0.33 (0.01-7.74)	0/39	1/38	2.61
Shih (2007)	1.25 (0.36-4.38)	5/49	4/49	14.30
François (2007)	0.07 (0.01-0.52)	1/355	14/343	6.13
Subtotal (I^2 = 49.6%, *P* = .09)	0.53 (0.15-1.89)			
Total (I^2 = 10.8%, *P* = .34)	**0.42 (0.25-0.71)**	**27/1,309**	**57/1,163**	**100.00**

Note: Box size is proportional to study weight

Risk factors for reintubation

- A weak cough (cough peak expiratory flow rate ≤60 L/min)
- Frequent suctioning (every 1-2 hr, sputum volume >2.5 mL/hour)
- Glasgow Coma Score < 8
- A positive fluid balance during the 24 hours preceding extubation.
- Pneumonia as the reason for the initial intubation.
- Patients who are ≥65 years old with severe chronic cardiac or respiratory disease.
- A reduced or absent cuff leak, those with altered mental status.

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Extubation management in the adult intensive ca

Reintubation

- Ranges from 4-33%
- 10-19% may be clinically acceptable.
- Nosocomial pneumonia ↑ 8 folds
- Mortality ↑ 6-12 folds
- Up to 80% of intentionally self extubate do not require reintubation.

Pilbeam's Mechanical Ventilation Physiological and Clinical Applications, 6e 6th Edition

Liberation From Mechanical Ventilation in Critically Ill Adults

Executive Summary of an Official American College of Chest Physicians/American Thoracic Society Clinical Practice Guideline

CrossMark

- For patients at high risk for extubation failure who have been receiving mechanical ventilation for > 24 h and who have passed an SBT, we recommend extubation to preventive NIV
- Include those patients with hypercapnia, COPD, congestive heart failure, or other serious comorbidities.

(Strong Recommendation, Moderate Quality Evidence)

CHEST 2017; 151(1):160-165

Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure

Bram Rochwerg [1], Laurent Brochard[2,3], Mark W. Elliott[4], Dean Hess[5], Nicholas S. Hill[6], Stefano Nava[7] and Paolo Navalesi[8] (members of the steering committee); Massimo Antonelli[9], Jan Brozek[1], Giorgio Conti[9], Miquel Ferrer[10], Kalpalatha Guntupalli[11], Samir Jaber[12], Sean Keenan[13,14], Jordi Mancebo[15], Sangeeta Mehta[16] and Suhail Raoof[17,18] (members of the task force)

TASK FORCE REPORT ERS/ATS GUIDELINES

Eur Respir J 2017; 50: 1602426

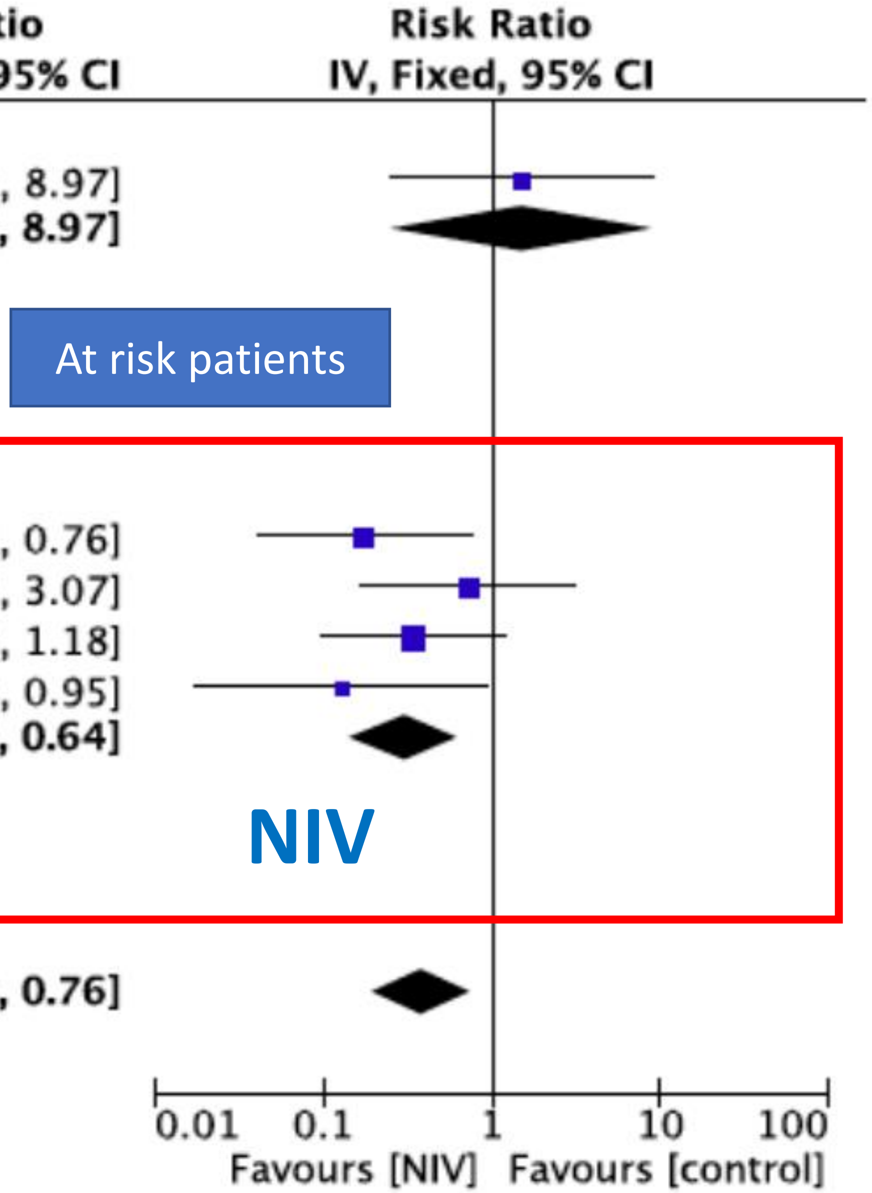
Should NIV be used to prevent respiratory failure post-extubation?

- NIV be used to prevent post-extubation respiratory failure in high-risk patients post-extubation. (Conditional recommendation, low certainty of evidence.)
- Patients at risk: age >65years, underlying cardiac or respiratory disease.
- NIV should not be used to prevent post-extubation respiratory failure in non-high-risk patients. (Conditional recommendation, very low certainty of evidence.)

TASK FORCE REPORT ERS/ATS GUIDELINES
Eur Respir J 2017; 50: 1602426

Mortality

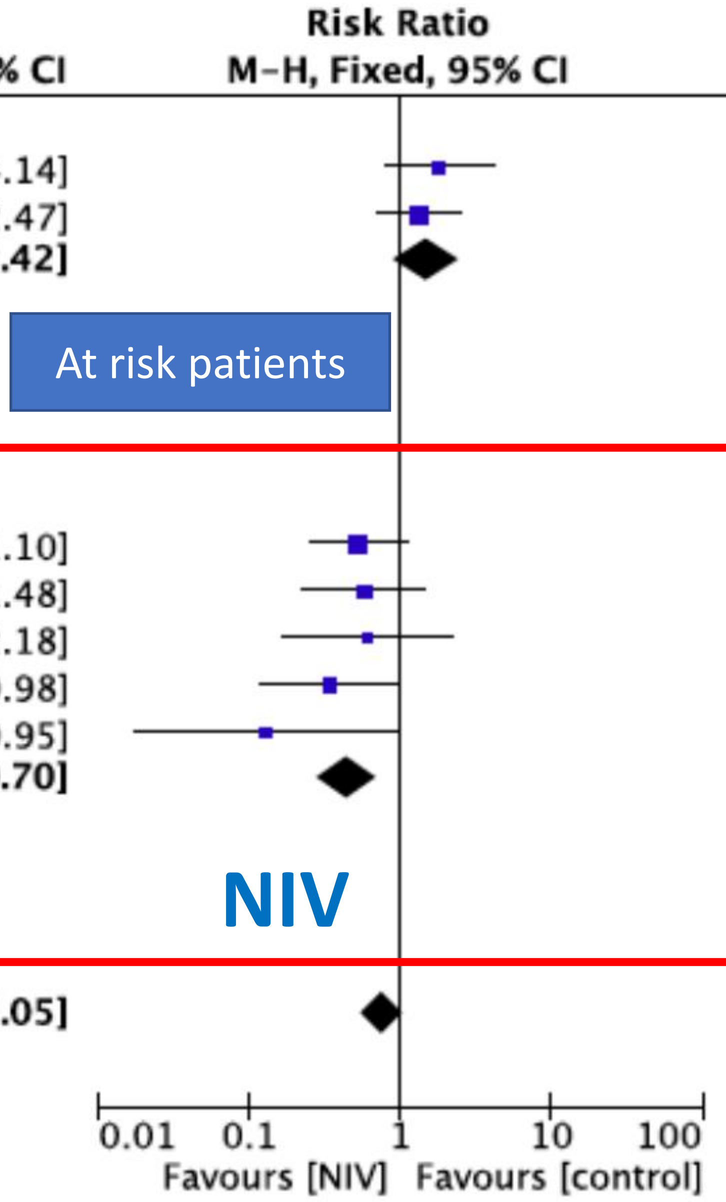
Study or Subgroup	NIV Events	NIV Total	Control Events	Control Total	Weight	Risk Ratio IV, Fixed, 95% CI
1.2.1 Unselected Patients						
Su 2012	3	202	2	204	14.7%	1.51 [0.26, 8.97]
Subtotal (95% CI)		**202**		**204**	**14.7%**	**1.51 [0.26, 8.97]**
Total events	3		2			
Heterogeneity: Not applicable						
Test for overall effect: Z = 0.46 (P = 0.65)						
1.2.2 At Risk Patients						
Ferrer 2006	2	79	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		32			
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), $I^2 = 62.3\%$						



Eur Respir J 2017; 50: 1602426

Re-intubation

Study or Subgroup	NIV Events	NIV Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 Unselected Patients						
Jiang 1999	13	47	7	46	9.4%	1.82 [0.80, 4.14]
Su 2012	21	202	16	204	21.2%	1.33 [0.71, 2.47]
Subtotal (95% CI)		**249**		**250**	**30.7%**	**1.48 [0.90, 2.42]**
Total events	34		23			
Heterogeneity: $Chi^2 = 0.36$, df = 1 (P = 0.55); $I^2 = 0\%$						
Test for overall effect: Z = 1.54 (P = 0.12)						
1.1.2 At Risk Patients						
Ferrer 2006	9	79	18	83	23.4%	0.53 [0.25, 1.10]
Ferrer 2009	6	54	10	52	13.6%	0.58 [0.23, 1.48]
Kihlnani 2011	3	20	5	20	6.7%	0.60 [0.17, 2.18]
Nava 2005	4	48	12	49	15.8%	0.34 [0.12, 0.98]
Ornico 2013	1	20	7	18	9.8%	0.13 [0.02, 0.95]
Subtotal (95% CI)		**221**		**222**	**69.3%**	**0.44 [0.28, 0.70]**
Total events	23		52			
Heterogeneity: $Chi^2 = 2.43$, df = 4 (P = 0.66); $I^2 = 0\%$						
Test for overall effect: Z = 3.50 (P = 0.0005)						
Total (95% CI)		**470**		**472**	**100.0%**	**0.76 [0.55, 1.05]**
Total events	57		75			
Heterogeneity: $Chi^2 = 14.06$, df = 6 (P = 0.03); $I^2 = 57\%$						
Test for overall effect: Z = 1.67 (P = 0.09)						
Test for subgroup differences: $Chi^2 = 12.29$, df = 1 (P = 0.0005), $I^2 = 91.9\%$						



Eur Respir J 2017; 50: 1602426

Should NIV be used in the treatment of respiratory failure that develops post-extubation?

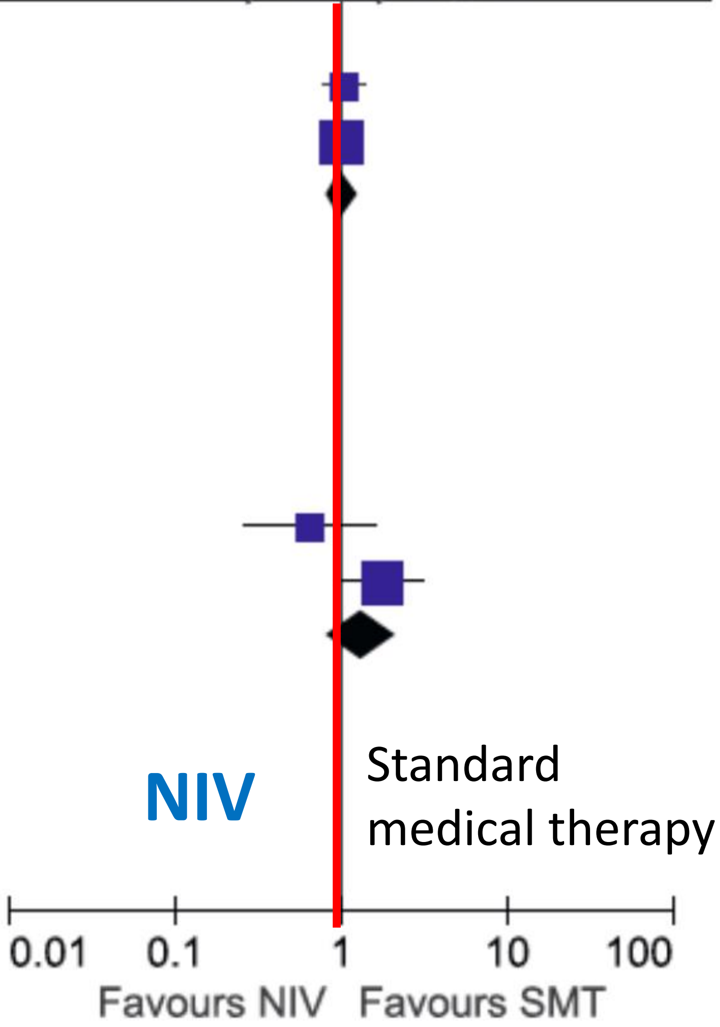
- NIV should not be used in the treatment of patients with established post-extubation respiratory failure. (Conditional recommendation, low certainty of evidence.)

TASK FORCE REPORT ERS/ATS GUIDELINES
Eur Respir J 2017; 50: 1602426

Mortality and re-intubation

Study or Subgroup	NIV group Events	NIV group Total	SMT group Events	SMT group 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)							

Risk Ratio
M-H, Fixed, 95% CI



Eur Respir J 2017; 50: 1602426

Should NIV be used to facilitate weaning patients from invasive mechanical ventilation?

- NIV be used to facilitate weaning from mechanical ventilation in patients with hypercapnic respiratory failure.

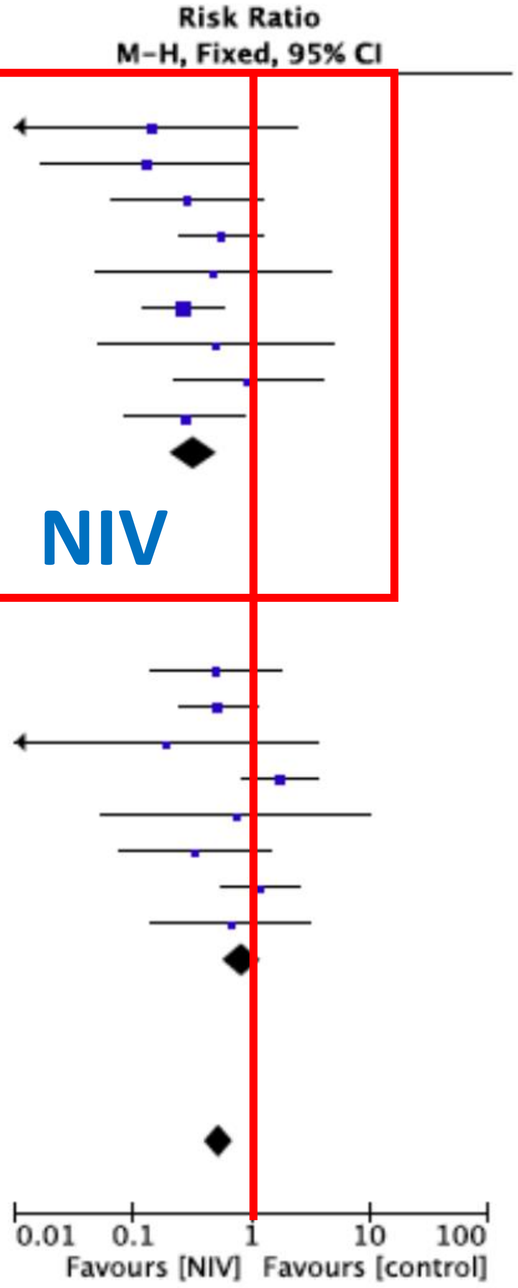
  (Conditional recommendation, moderate certainty of evidence)
- No recommendation for hypoxemic patients.

TASK FORCE REPORT ERS/ATS GUIDELINES
Eur Respir J 2017; 50: 1602426

Mortality

COPD

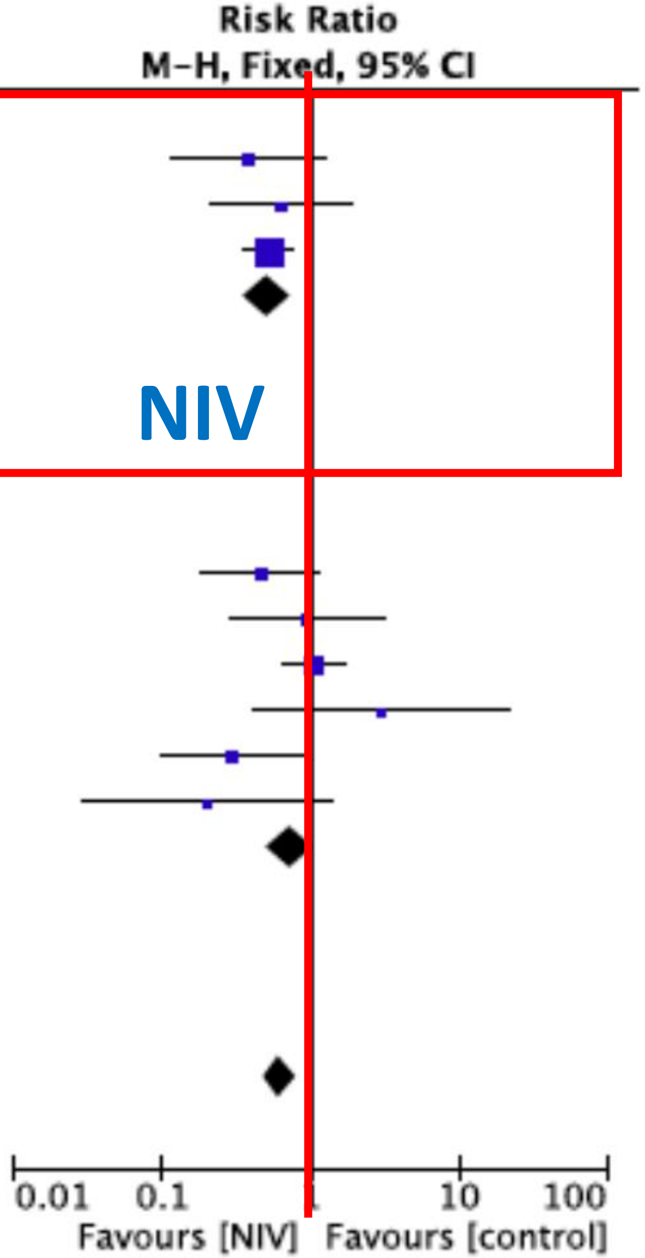
Study or Subgroup	NIV Events	NIV Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.1.1 COPD						
Chen 2001	0	12	3	12	2.9%	0.14 [0.01, 2.50]
CRGNMV 2005	1	47	7	43	6.1%	0.13 [0.02, 1.02]
Nava 1998	2	25	7	25	5.9%	0.29 [0.07, 1.24]
Prasad 2009	5	15	9	15	7.5%	0.56 [0.24, 1.27]
Rabie Agmy 2004	1	19	2	18	1.7%	0.47 [0.05, 4.78]
Rabie Agmy 2012	7	134	26	130	22.1%	0.26 [0.12, 0.58]
Wang 2004	1	14	2	14	1.7%	0.50 [0.05, 4.90]
Zheng 2005	3	17	3	16	2.6%	0.94 [0.22, 4.00]
Zou 2006	3	38	11	38	9.2%	0.27 [0.08, 0.90]
Subtotal (95% CI)		**321**		**311**	**59.8%**	**0.33 [0.21, 0.50]**
Total events	23		70			
Heterogeneity: $Chi^2 = 5.39$, df = 8 (P = 0.71); $I^2 = 0\%$						
Test for overall effect: Z = 5.10 (P < 0.00001)						
1.1.2 Mixed Etiology						
Carron 2014	3	32	6	32	5.0%	0.50 [0.14, 1.83]
Ferrer 2003	6	21	12	22	9.8%	0.52 [0.24, 1.14]
Girault 1999	0	17	2	16	2.2%	0.19 [0.01, 3.66]
Girault 2011	16	69	9	69	7.5%	1.78 [0.84, 3.75]
Hill 2000	1	12	1	9	1.0%	0.75 [0.05, 10.44]
Tawfeek 2012	2	21	6	21	5.0%	0.33 [0.08, 1.47]
Trevisan 2008	9	28	10	37	7.2%	1.19 [0.56, 2.53]
Vaschetto 2012	2	10	3	10	2.5%	0.67 [0.14, 3.17]
Subtotal (95% CI)		**210**		**216**	**40.2%**	**0.85 [0.59, 1.22]**
Total events	39		49			
Heterogeneity: $Chi^2 = 9.29$, df = 7 (P = 0.23); $I^2 = 25\%$						
Test for overall effect: Z = 0.88 (P = 0.38)						
Total (95% CI)		**531**		**527**	**100.0%**	**0.54 [0.41, 0.70]**
Total events	62		119			
Heterogeneity: $Chi^2 = 23.53$, df = 16 (P = 0.10); $I^2 = 32\%$						
Test for overall effect: Z = 4.48 (P < 0.00001)						
Test for subgroup differences: $Chi^2 = 10.99$, df = 1 (P = 0.0009), $I^2 = 90.9\%$						



Weaning failure

COPD

Study or Subgroup	NIV Events	NIV Total	Control Events	Control Total	Weight	Risk Ratio M-H, Fixed, 95% CI
1.2.1 COPD						
Nava 1998	3	25	8	25	6.7%	0.38 [0.11, 1.25]
Rabie Agmy 2004	4	19	6	18	5.1%	0.63 [0.21, 1.88]
Rabie Agmy 2012	28	134	52	130	43.9%	0.52 [0.35, 0.77]
Subtotal (95% CI)		**178**		**173**	**55.7%**	**0.51 [0.36, 0.73]**
Total events	35		66			
Heterogeneity: $Chi^2 = 0.41$, df = 2 (P = 0.82); $I^2 = 0\%$						
Test for overall effect: Z = 3.70 (P = 0.0002)						
1.2.2 Mixed Etiology						
Carron 2014	5	32	11	32	9.2%	0.45 [0.18, 1.16]
Girault 1999	4	17	4	16	3.4%	0.94 [0.28, 3.14]
Girault 2011	23	69	22	69	18.3%	1.05 [0.65, 1.69]
Hill 2000	4	12	1	9	1.0%	3.00 [0.40, 22.47]
Tawfeek 2012	3	21	10	21	8.3%	0.30 [0.10, 0.94]
Vaschetto 2012	1	10	5	10	4.2%	0.20 [0.03, 1.42]
Subtotal (95% CI)		**161**		**157**	**44.3%**	**0.74 [0.52, 1.05]**
Total events	40		53			
Heterogeneity: $Chi^2 = 9.17$, df = 5 (P = 0.10); $I^2 = 45\%$						
Test for overall effect: Z = 1.68 (P = 0.09)						
Total (95% CI)		**339**		**330**	**100.0%**	**0.61 [0.48, 0.79]**
Total events	75		119			
Heterogeneity: $Chi^2 = 12.07$, df = 8 (P = 0.15); $I^2 = 34\%$						
Test for overall effect: Z = 3.85 (P = 0.0001)						
Test for subgroup differences: $Chi^2 = 2.00$, df = 1 (P = 0.16), $I^2 = 50.0\%$						



SYSTEMATIC REVIEW

Non-invasive ventilation as a strategy for weaning from invasive mechanical ventilation: a systematic review and Bayesian meta-analysis

University of Warwick, Coventry, UK

Joyce Yeung, Keith Couper, Elizabeth G. Ryan, Simon Gates, Nick Hart and Gavin D. Perkins

- The use of NIV in weaning from mechanical ventilation decreases hospital mortality, the incidence of VAP and ICU stay.
- NIV as a weaning strategy appears to be most beneficial in COPD.

Intensive Care Med (2018) 44:2192–2204
https://doi.org/10.1007/s00134-018-5434-z

Hospital mortality rate for NIV and invasive weaning

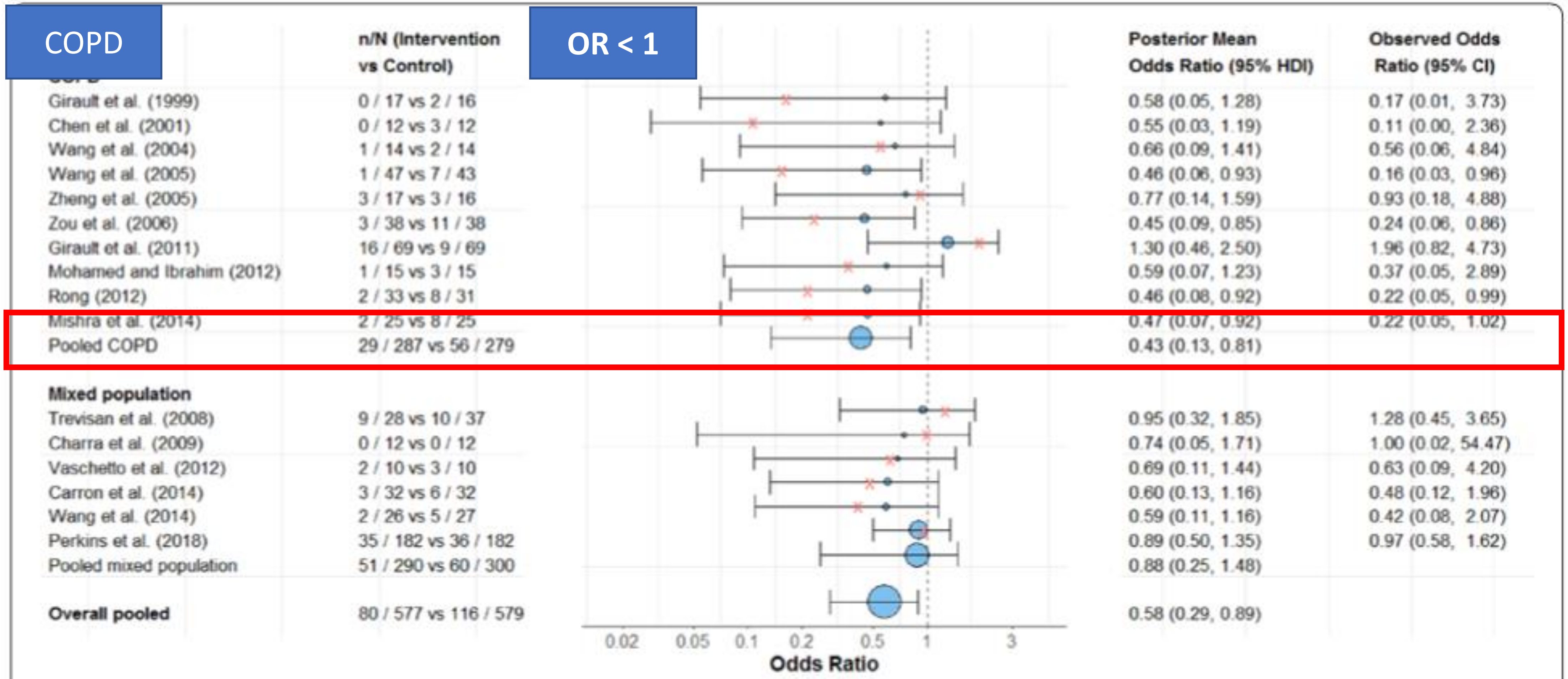


Fig. 3 Forest plot comparing hospital mortality rates for NIV and invasive weaning, by patient population (COPD vs. mixed ICU population). The estimated odds ratio (OR) from the posterior distribution for each study is shown as a circle, with 95% HDI represented by horizontal lines. The observed OR are given by crosses. The pooled OR estimates (and 95% HDI) are also displayed as the last row for each patient population, and the overall pooled estimate for all studies is displayed as the last row. An OR < 1 means that the intervention is superior

High flow nasal cannula (HFNC)

- Some high risk patients should receive HFNC for 24-48 hr.
- Patients with severe hypoxemic respiratory failure or high O_2 requirement.
- Provide small amount of PEEP.
- HFNC establishes 1cmH_2O for 10L/min flow delivered.

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Extubation management in the adult intensive ca

JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

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
A Randomized Clinical Trial

- In mechanically ventilated patients at high risk of extubation failure.
- The use of HFNC with NIV immediately after extubation significantly decreased the risk of reintubation compared with HFNC alone.

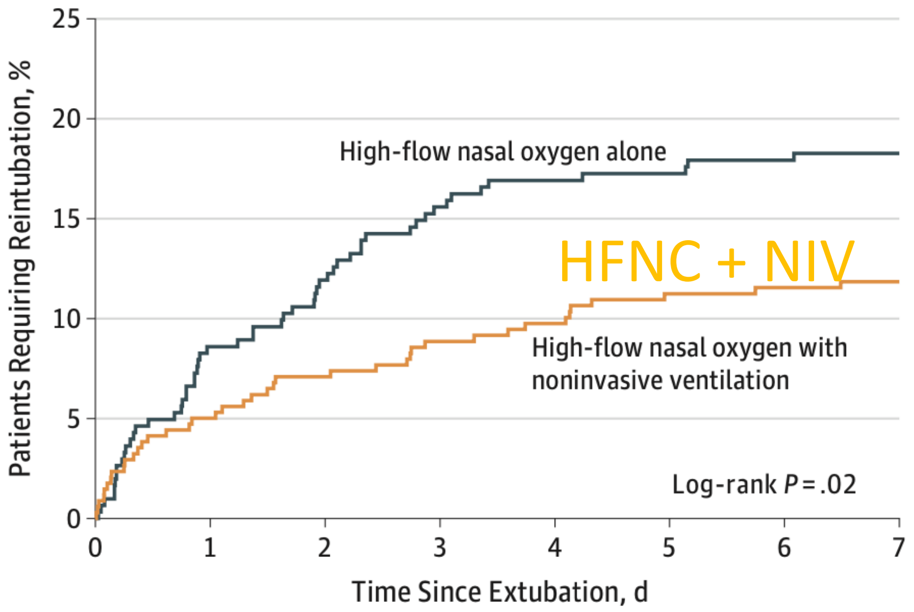
JAMA. 2019;322(15):1465-1475

Table 2. Primary, Secondary, and Exploratory Outcomes

	No. (%)			
	High-Flow Nasal Oxygen Alone (n = 302)	High-Flow Nasal Oxygen With NIV (n = 339)	Absolute Difference, % (95% CI)	*P* Value
Primary Outcome				
Reintubation at day 7	55 (18)	40 (12)	−6.4 (−12.0 to −0.9)	.02
Secondary Outcomes				
Postextubation respiratory failure at day 7	88 (29)	70 (21)	−8.5 (−15.2 to −1.8)	.01
Reintubation				
At 48 h	36 (12)	24 (7)	−4.8 (−9.6 to −0.3)	.04
At 72 h	47 (16)	30 (9)	−6.7 (−11.9 to −1.7)	.009
Up until ICU discharge	59 (20)	41 (12)	−7.4 (−13.2 to −1.8)	.009
Length of stay, median (IQR), days				
In ICU	11 (7 to 19)	12 (7 to 19)	0.5 (−1.6 to 2.6)	.55
In hospital	23 (15 to 39)	25 (15 to 42)	2.3 (−1.4 to 6.1)	.31
Mortality				
In ICU	26 (9)	21 (6)	−2.4 (−6.7 to 1.7)	.25
In hospital	46 (15)	54 (16)	0.7 (−5.0 to 6.3)	.80
At day 28	33 (11)	39 (12)	0.6 (−4.4 to 5.5)	.82
At day 90	65 (21)	62 (18)	−3.2 (−9.5 to 2.9)	.30
Exploratory Outcomes				
Patients meeting reintubation criteria during ICU stay	65 (22)	49 (14)	−7.1 (−13.1 to −1.1)	.02
Mortality or reintubation in ICU	64 (21)	51 (15)	−6.2 (−12.2 to −0.2)	.04
Mortality of reintubated patients	21/59 (36)	11/41 (27)	−8.8 (−25.7 to 9.9)	.35

Reintubation rate

Figure 2. Kaplan-Meier Analysis of Time From Extubation to Reintubation for the Overall Study Population

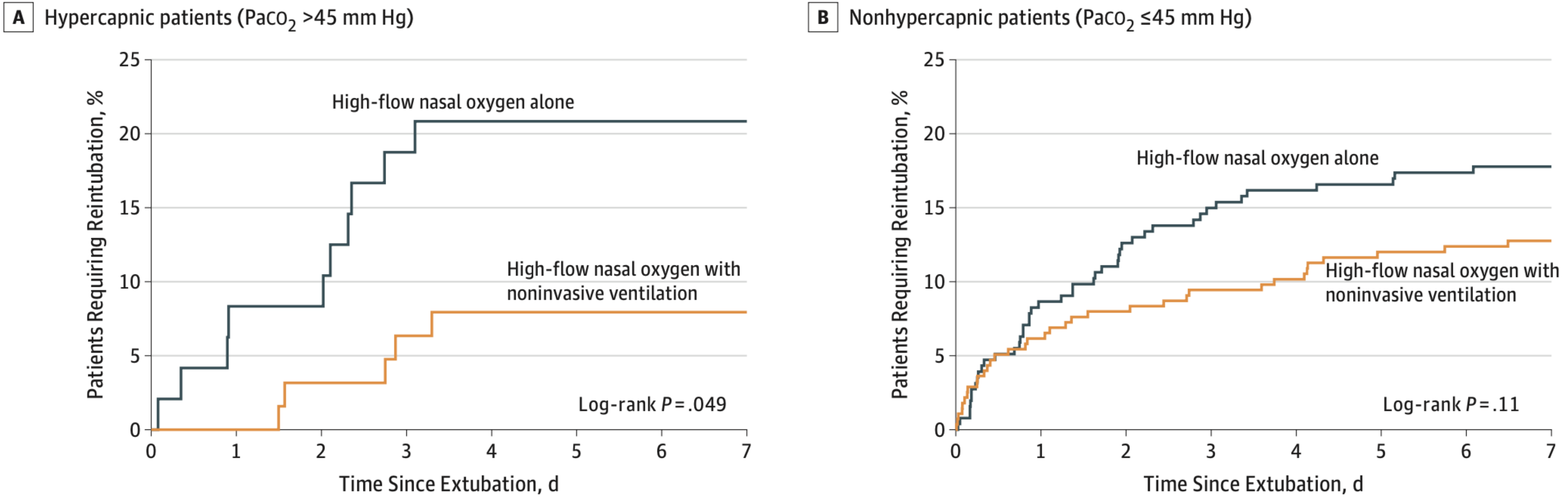


No. at risk								
High-flow nasal oxygen								
Alone	302	276	265	253	248	246	244	243
With noninvasive ventilation	339	321	314	308	305	294	292	291

The median observation time was 7 days (interquartile range, 7-7) in both treatment groups.

JAMA. 2019;322(15):1465-1475

Figure 3. Kaplan-Meier Analysis of Time From Extubation to Reintubation According to Predefined Strata



No. at risk (A)

High-flow nasal oxygen	0	1	2	3	4	5	6	7
Alone	48	44	44	39	38	37	37	37
With noninvasive ventilation	63	63	61	59	58	58	58	58

No. at risk (B)

High-flow nasal oxygen	0	1	2	3	4	5	6	7
Alone	254	232	221	214	210	209	207	206
With noninvasive ventilation	276	258	253	249	247	236	234	233

Results in hypercapnic patients with arterial partial pressure of carbon dioxide (Pa_{CO_2}) greater than 45 mm Hg (A) and in nonhypercapnic patients with Pa_{CO_2} of 45 mm Hg or less (B) are shown. The median observation time was 7 days (interquartile range, 7-7) in both treatment groups.

JAMA. 2019;322(15):1465-1475

The morbid obese patients

- BMI > 30-35
- CPAP should be used during SBT and post extubation.
- The larger the patient the greater the likelihood of atelectasis.
- Majority of these patients have sleep apnea
- High level of PEEP ($\geq$ 10cmH_2O) is required to stabilize the lung.

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REVIEW

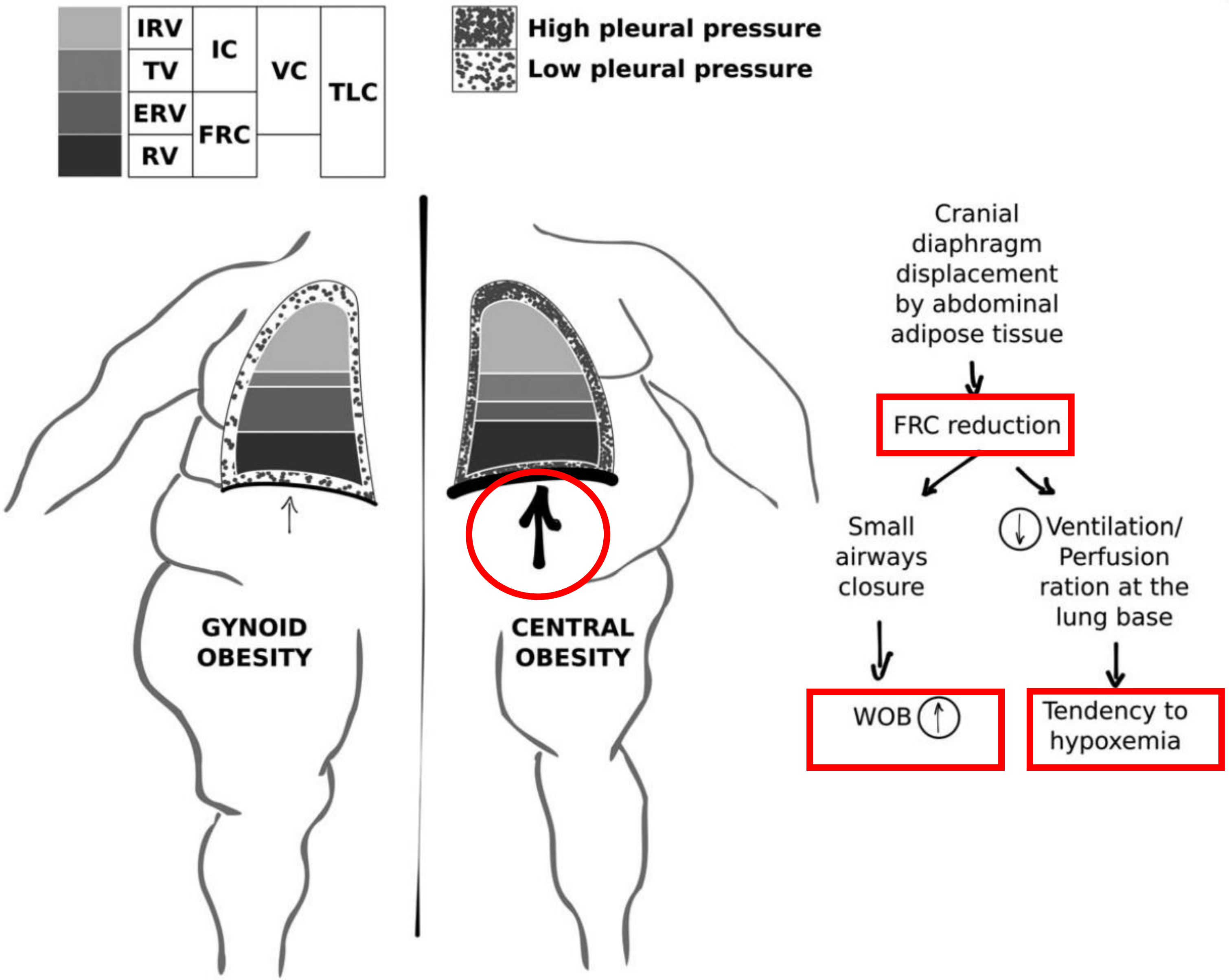
Weaning patients with obesity from ventilatory support

Robert M. Kacmarek[a,b,c], Hatus V. Wanderley[a,b,c], Jesús Villar[d,e] and Lorenzo Berra[a,c]

- Obesity greatly alters the respiratory system mechanics causing atelectasis and prolonged duration of mechanical ventilation.
- WOB is markedly increased because of their negative transpulmonary pressure.
- Patients should immediately be transitioned to

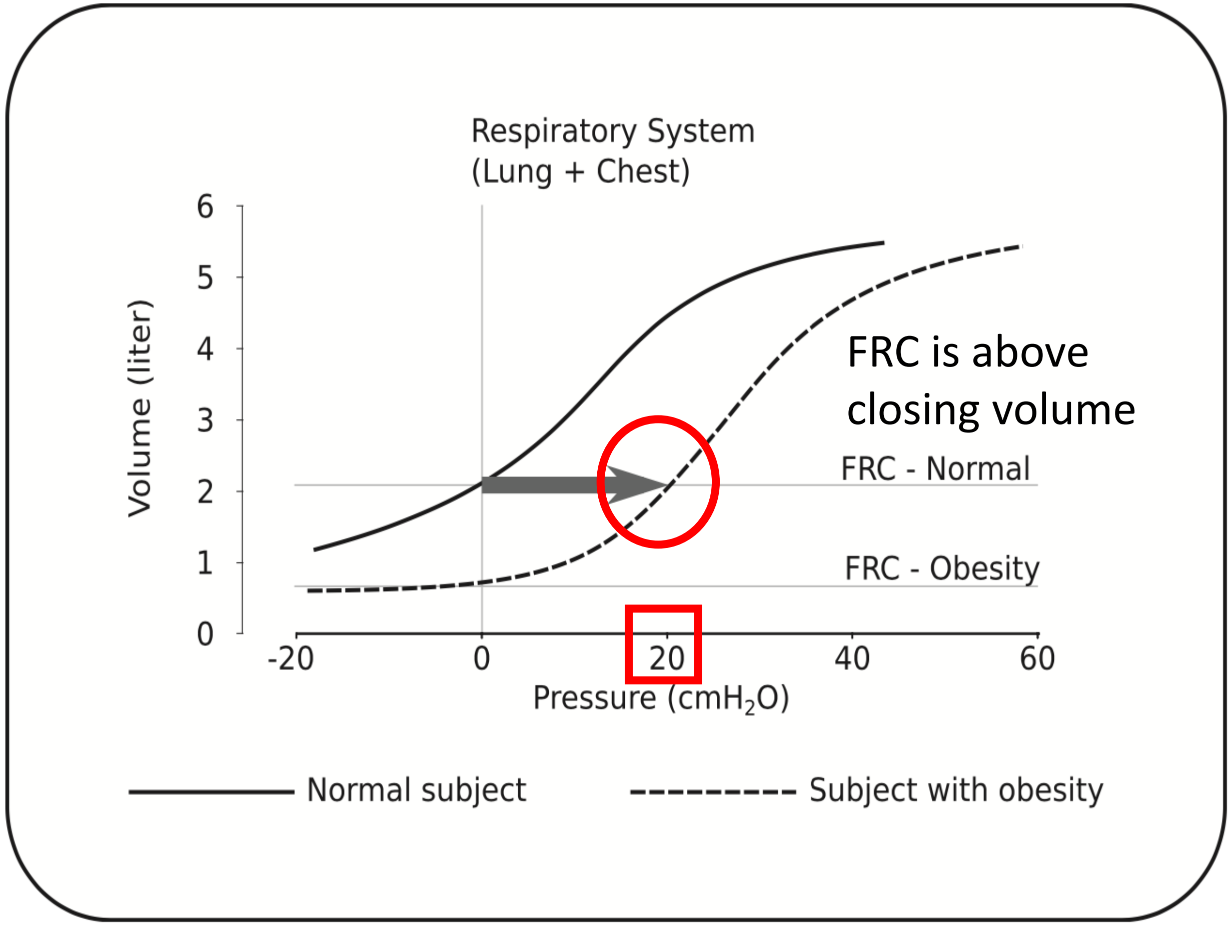
  Mask CPAP ≥10 cmH2O or equal to the applied PEEP during weaning or to their ordered CPAP setting for sleep apnea.

Curr Opin Crit Care 2021, 27:311 – 319



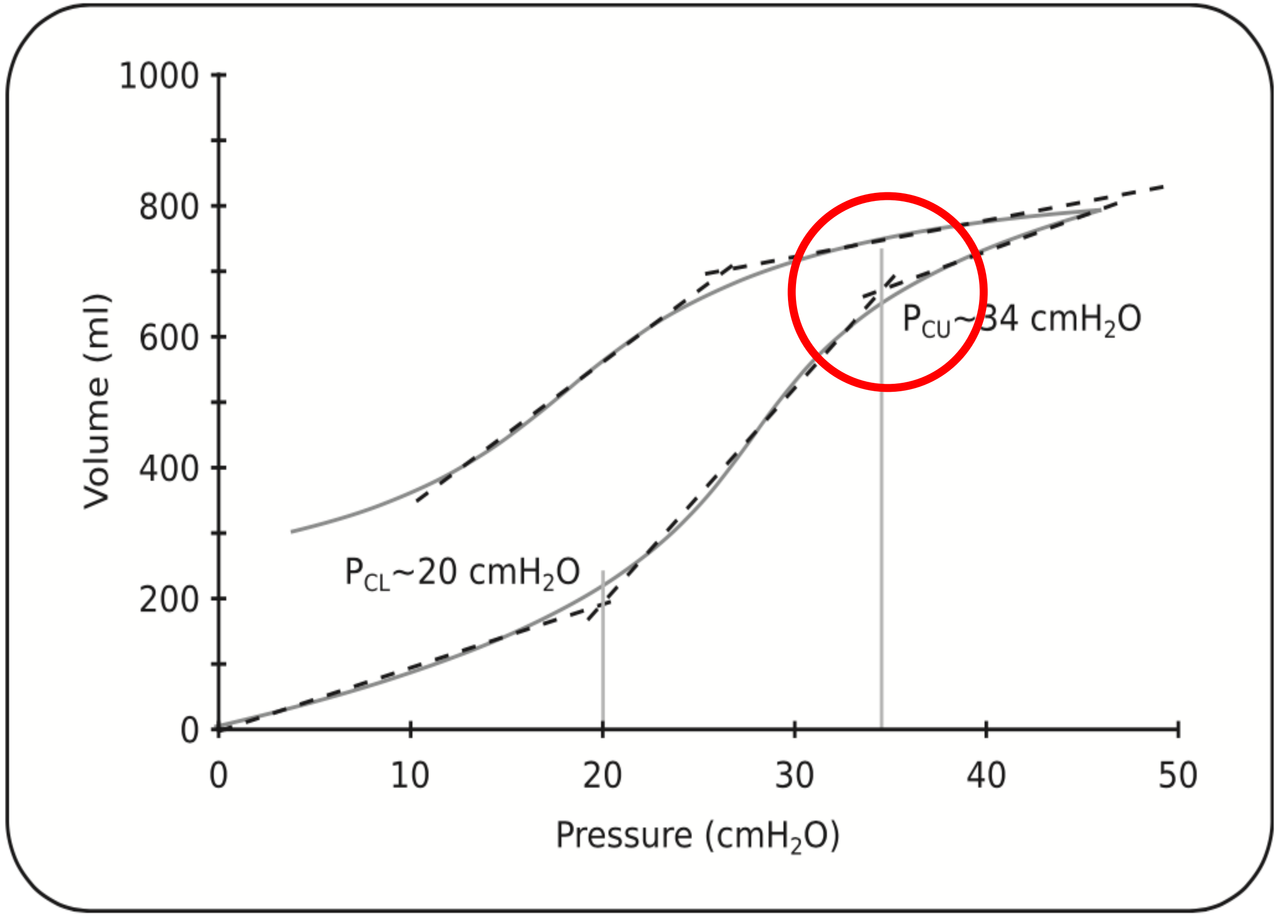
Gynoid/lean vs. central obesity

Comparison of the FRC



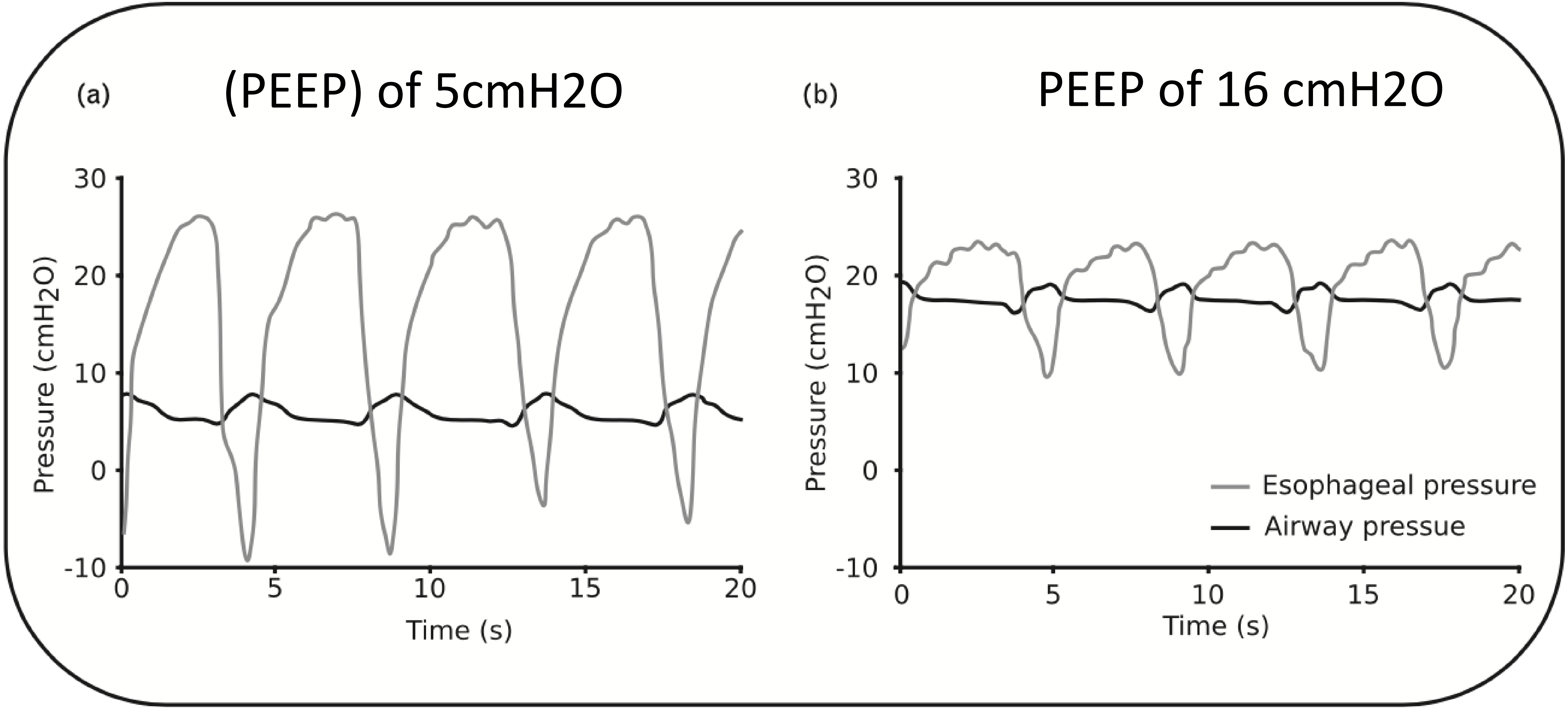
To maintain same FRC, the airway pressure in the subject with obesity needs to increase of about 20 cmH_2O above atmospheric pressure.

Lung recruitability



When lungs are recruitable, pressure reached during exhalation shows higher volumes than during inspiration, advocating for decremental PEEP trial rather than incremental PEEP trial.

PEEP for failed and success SBT



Take home message

- Discontinuing mechanical ventilation is a three-step process that consists of readiness testing, weaning and extubation.
- Verification the problems leading to mechanical ventilation have been resolved is the first step in successfully liberating a patient from ventilatory support.
- Evaluation of appropriate criteria and the use of therapist-driven protocols or nurse-directed protocols can facilitate the process.
- RSBI is the preferred indicator.

Take home message

- SBT and PSV result in faster discontinuation.
- Diaphragm ultrasound may be useful in identifying readiness.
- Carefully monitoring during weaning.
- Review the common causes of weaning failure.
- Assess for the ability to maintain and protect airway and the presence of upper airway edema before extubation.
- CPAP should be applied during SBT in morbid obese patients.

Thank you for your listening