20260510 機械通氣重症繼續教育課程(中區)
Weaning from mechanical ventilator

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Outline

- Definition
- Readiness testing and weaning predictors
- Physiological barriers
- Weaning strategies
- Concerns of extubation
- Post extubation care

Definition

- The process of freeing the patient from the ventilator has been referred to as weaning, liberation, or discontinuation.

- Weaning: The process of gradual or progressive withdrawal of ventilator support.

- One of the most important question an intensive care unit physician can ask each day at the bedside is

  " Can this patient breathe spontaneously today? "

  - ➢ beginning with the day of intubation
  - ➢ inciting factors improve
  - ➢ be evaluated at least daily

Egan's fundamentals of respiratory care 12thedition
A Practical Guide to Mechanical Ventilation, 1st Edition.

Definition

- **Classification**
  - ✓ 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 >7days of weaning after first SBT

Eur Respir J 2007; 29: 1033–1056
DOI: 10.1183/09031936.00010206

TASK FORCE

Weaning from mechanical ventilation

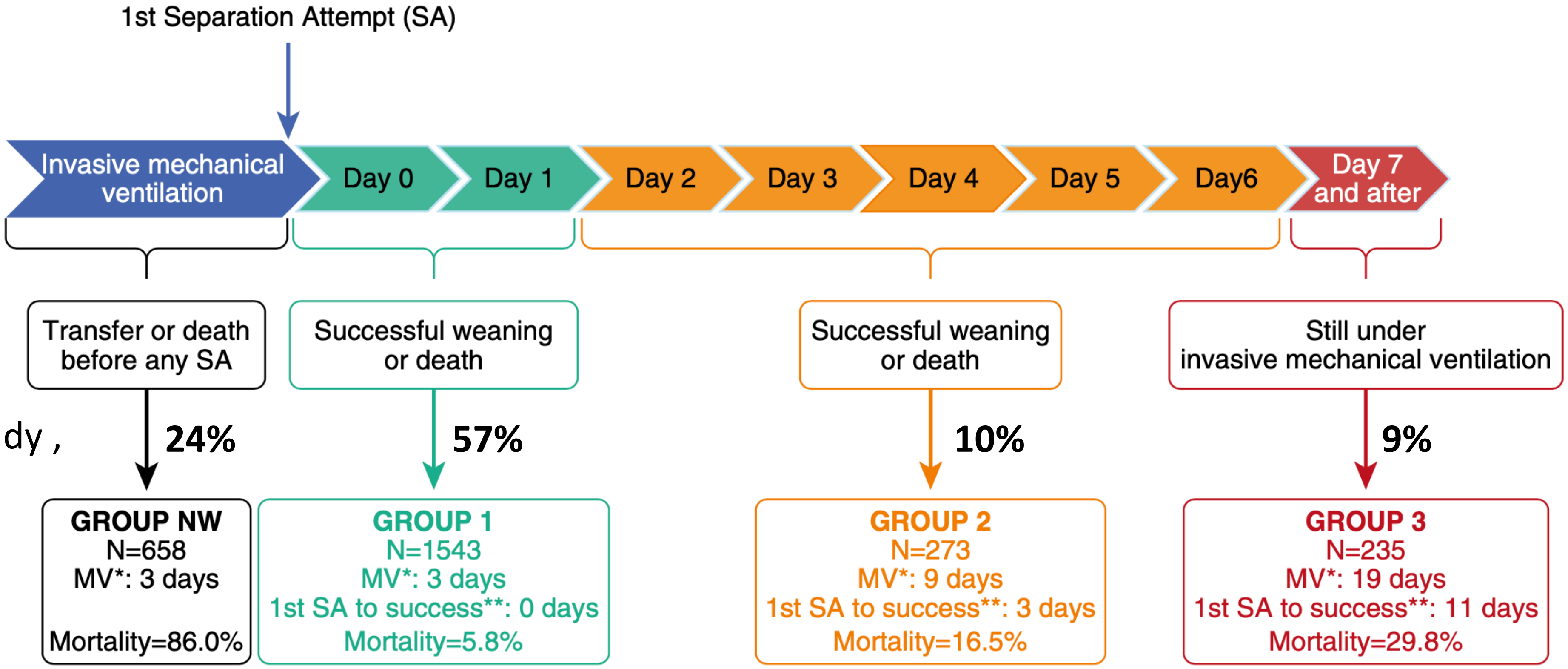
J-M. Boles*, J. Bion[#], A. Connors[¶], M. Herridge[+], B. Marsh[§], C. Melot[ƒ], R. Pearl**, H. Silverman[##], M. Stanchina[¶¶], A. Vieillard-Baron[++], T. Welte[§§]

Statement of the Sixth International Consensus Conference on Intensive Care Medicine

Organised jointly by the European Respiratory Society (ERS), the American Thoracic Society (ATS), the European Society of Intensive Care Medicine (ESICM), the Society of Critical Care Medicine (SCCM) and the Société de Réanimation de Langue Française (SRLF), and approved by the ERS Executive Committee, February 2007

Weaning from mechanical ventilation ERJ 2007;29:1033

Definition

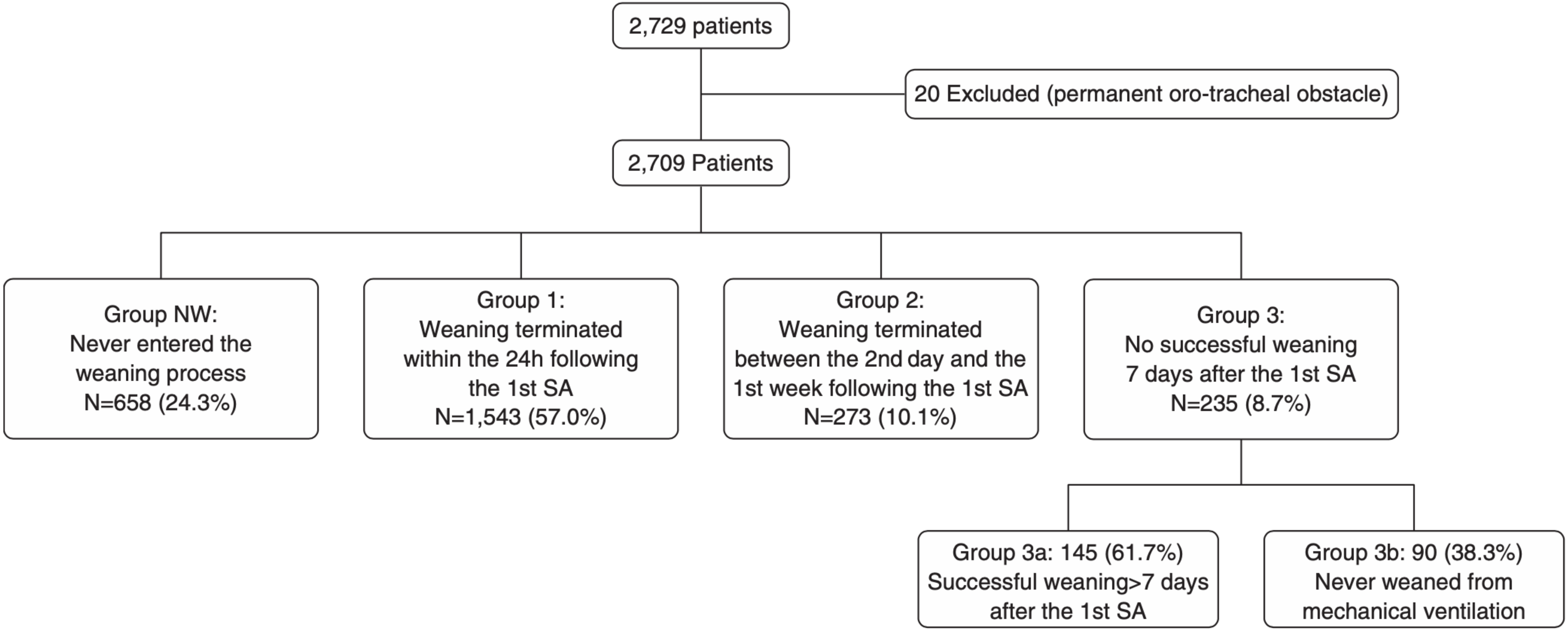


Multinational study , n= 2709

Figure 2. Group definitions and mortality. This figure shows the group classification according to the number of days between the first separation attempt and the weaning termination. Group numbers, total duration of mechanical ventilation, number of days between the first separation attempt and the weaning success, and mortality are displayed. *Median duration of mechanical ventilation (d). **Median number of days between the first separation attempt and the weaning success (patients who never had a weaning success are excluded from this calculation). MV = mechanical ventilation; NW = no weaning process; SA = separation attempt.

Epidemiology of Weaning Outcome according to a New Definition. The WIND Study
Am J Respir Crit Care Med Vol 195, Iss6, pp 772–783, Mar 15, 2017

Definition



Epidemiology of Weaning Outcome according to a New Definition. The WIND Study
Am J Respir Crit Care Med Vol 195, Iss6, pp 772–783, Mar 15, 2017

Burden and outcome

Year	New Ventilated Patients (n.)	Days 22–63 Patients (n.)	>Days 63 Patients (n.)	Incidence Rate (%)	
				Days 22-63	>Days 63
2005	156,887	28,477	10,483	18.15%	6.68%
2006	156,816	26,294	9250	16.77%	5.90%
2007	164,734	27,881	9780	16.92%	5.94%
2008	167,740	27,844	9723	16.60%	5.80%
2009	169,684	27,379	9582	16.14%	5.65%
2010	172,351	27,851	9710	16.16%	5.63%
2011	173,652	27,578	9520	15.88%	5.48%
2012	173,895	27,110	9457	15.59%	5.44%
2013	168,217	25,217	8560	14.99%	5.09%
2014	171,016	25,155	8257	14.71%	4.83%
2015	173,331	24,576	7814	14.18%	4.51%
2016	176,871	24,483	7467	13.84%	4.22%
2017	175,148	22,860	6545	13.05%	3.74%
2018	181,414	23,559	6715	12.99%	3.70%
2019	186,202	24,003	6532	12.89%	3.51%
2020	178,464	22,951	6003	12.86%	3.36%
2021	177,951	23,650	6187	13.29%	3.48%
2022	180,339	24,350	6268	13.50%	3.48%

A longitudinal study of ventilator-dependent patients in Taiwan, Journal of the Formosan Medical Association, 2026

Burden and outcome

Year	Mortality Rate			Weaning Successful			
	Days 1-21	Days 22-63	Days >63	Days 1-21	Days 22-63	Day 94	Day 124
2005	25%	23%	30%	57%	40%	13%	18%
2006	24%	24%	29%	60%	41%	12%	18%
2007	23%	23%	29%	60%	42%	13%	18%
2008	23%	24%	28%	61%	41%	12%	17%
2009	22%	24%	27%	62%	41%	11%	14%
2010	22%	23%	29%	62%	42%	11%	15%
2011	21%	22%	25%	64%	43%	11%	15%
2012	20%	22%	26%	65%	44%	12%	15%
2013	19%	21%	22%	66%	45%	10%	14%

Year	Mortality Rate			Weaning Successful			
	Days 1-21	Days 22-63	Days >63	Days 1-21	Days 22-63	Day 94	Day 124
2014	19%	22%	22%	66%	46%	11%	15%
2015	17%	20%	22%	68%	48%	12%	16%
2016	19%	22%	24%	68%	48%	11%	14%
2017	17%	20%	19%	70%	51%	12%	15%
2018	18%	23%	25%	69%	49%	12%	15%
2019	18%	23%	26%	69%	50%	13%	16%
2020	17%	23%	26%	70%	50%	12%	16%
2021	18%	23%	27%	69%	50%	13%	17%
2022	18%	24%	29%	68%	50%	12%	16%

A longitudinal study of ventilator-dependent patients in Taiwan,
Journal of the Formosan Medical Association, 2026

Readiness testing

Clinical criteria used to determine readiness for trials of ventilator liberation

Required criteria
1. The cause of the respiratory failure has improved
2. $PaO_2/FiO_2 \geq 150$* or $SpO_2 \geq 90\%$ on $FiO_2 \leq 40\%$ and PEEP ≤ 5 cmH_2O
3. pH >7.25
4. Able to initiate an inspiratory effort
Additional criteria (optional criteria)
1. Hemoglobin ≥7 g/dL
2. Follows commands
3. Hemodynamic stability (no or low dose vasopressor medications)
4. Minimal or thin secretions
5. Presence of cough or gag reflex

FiO_2: fraction of inspired oxygen; PaO_2: arterial oxygen tension; PEEP: positive end-expiratory pressure; SpO_2: arterial oxygen saturation.

* A threshold of $PaO_2/FiO_2 \geq 120$ can be used for patients with chronic hypoxemia. Some patients require higher levels of PEEP to avoid atelectasis during mechanical ventilation.

Adapted from: MacIntyre NR, Cook DJ, Ely EW Jr, et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. Chest 2001; 120:375S.

Readiness testing

Table 3.2.1 Criteria used to determine readiness for trials of spontaneous breathing.

Required criteria

1. $PaO_2/FiO_2 \geq 150$[a] or $SaO_2 \geq 90\%$ on $FiO_2 \leq 40\%$ and positive end-expiratory pressure (PEEP) ≤5 cm H_2O
2. Hemodynamic stability (no or low dose vasopressor medications, e.g., dopamine at a dose ≤5 mcg/kg/min)

Additional criteria[b]

1. Weaning parameters: respiratory rate ≤35 breaths/min, spontaneous tidal volume >5 ml/kg, negative inspiratory force (NIF) <–20 to –25 cm H_2O, $f/V_T < 105$ breaths/min/l
2. Hemoglobin ≥8–10 mg/dl
3. Core temperature ≤38–38.5 degrees Celsius
4. Mental status awake and alert or easily arousable

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Readiness testing

➢ **Weaning Parameters**

- **The oxygenation status**
  - ✓ PaO_2, P/F ratio, PaO_2/PAO_2 ratio, A-a DO_2 gradient
- **The performance of the respiratory muscles**
  - ✓ respiratory rate, tidal volume, levels of $PaCO_2$, minute ventilation, Pimax, forced vital capacity, maximum voluntary ventilation, ultrasonographic evaluation of the diaphragm
- **The work of breathing**
  - ✓ dynamic and static compliance
- **The central respiratory drive**
  - ✓ $P_{0.1}$, mean inspiratory flow

Weaning predictors

Table 3.2.2 Tests used to predict weaning outcome ("weaning predictors").

Measurements of oxygenation and gas exchange	
	PaO_2/FiO_2, PaO_2/PAO_2
	Alveolar–arterial O_2 gradient
	Dead space, V_D/V_T
Simple measurements of respiratory load and muscular capacity	
	Negative inspiratory force, maximal inspiratory pressure
	Respiratory system compliance (static or dynamic)
	Respiratory system resistance
	Minute ventilation
	Respiratory frequency
	Tidal volume
	Maximal voluntary ventilation
	Vital capacity
Measurements integrating multiple factors	
	Frequency–tidal volume ratio, f/V_T
	CROP index (compliance, respiratory rate, oxygenation, pressure)
Complex integrative measurements requiring special equipment	
	Airway occlusion pressure
	P0.1/MIP
	Work of breathing
	Oxygen cost of breathing
	Gastric intramucosal pH

A Practical Guide to Mechanical Ventilation, 1st Edition.

Weaning predictors

- **Rapid Shallow Breathing Index (RSBI) Test**
  - ✓ In 1991, Yang and Tobin
  - ✓ The ratio of respiratory rate (RR) to tidal volume (VT)
  - ✓ **a value <105 breaths/min/L was linked to a successful liberation**
  - ✓ moderate sensitivity and poor specificity

A Prospective Study of Indexes Predicting the Outcome of Trials of Weaning from Mechanical Ventilation

Authors: Karl L. Yang, M.D., and Martin J. Tobin, M.D. Author Info & Affiliations

Published May 23, 1991 | N Engl J Med 1991;324:1445-1450 | DOI: 10.1056/NEJM199105233242101

VOL. 324 NO. 21

The Usefulness of the Rapid Shallow Breathing Index in Predicting Successful Extubation

A Systematic Review and Meta-analysis

CHEST 2022; 161(1):97-111

- The conditions that can affect the results of the RSBI
  - ✓ sepsis, fever, supine position, anxiety, restrictive lung disease, female gender, diameter of the endotracheal tube and suctioning

Weaning predictors

- The pressure that can be generated against an occluded airway during a 1 second **maximal inspiratory effort**, initiated near RV, is a measure of **global inspiratory muscle strength.** (by keeping the valve occluded for up to 20 – 25 seconds)
  - negative inspiratory force (NIF)
  - maximal inspiratory pressure (MIP)
  - ➢ depends upon coordination, chest wall compliance, lung volume, respiratory drive, patient effort/ cooperation and investigator technique
  - ✓ A successful weaning outcome was likely if MIP values < −30 cmH2O and a weaning failure was likely if MIP < −20 cmH2O

A Practical Guide to Mechanical Ventilation, 1st Edition.
Predictive factors of weaning from mechanical ventilation and extubation outcome: A systematic review Journal of Critical Care 48 (2018) 56–62

Physiological barriers

Table 3.2.7 Criteria indicating that a patient is not tolerating a trial of spontaneous breathing.

Objective criteria

1. $SaO_2 < 0.90$ or $PaO_2 < 60$ mm Hg on $FiO_2 > 0.40$–0.50 or $PaO_2/FiO_2 < 120$–150
2. Increase in $PaCO_2 > 10$ mm Hg or decrease in pH > 0.10
3. Respiratory rate >35 breaths/min
4. Heart rate >140 bpm or an increase >20% of baseline
5. Systolic blood pressure <90 mm Hg or >160 mm Hg or change of >20% from baseline

Subjective criteria

1. Presence of signs of increased work of breathing including thoracoabdominal paradox or excessive use of accessory respiratory muscles
2. Presence of other signs of distress such as diaphoresis or agitation

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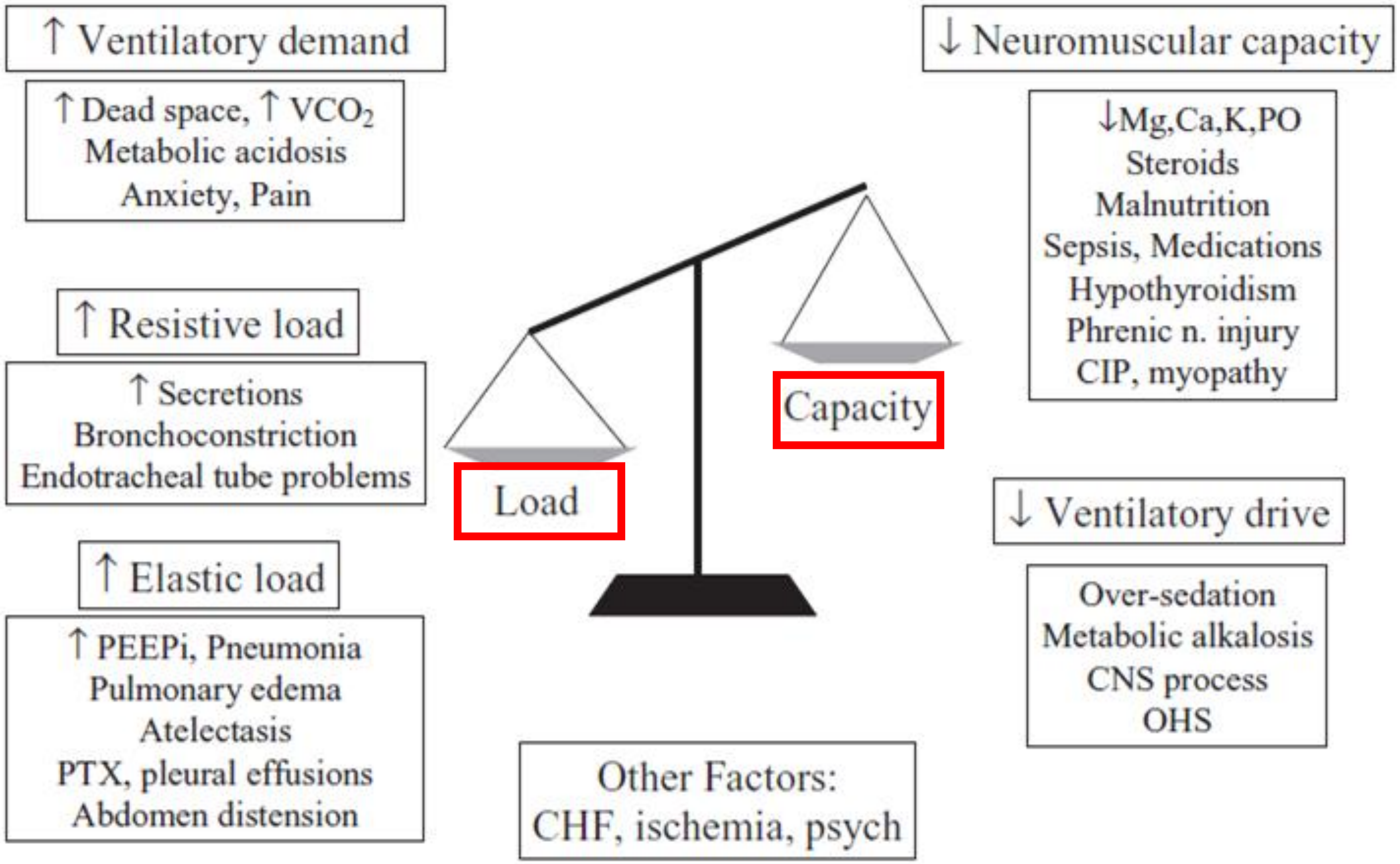
Physiological barriers



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Physiological barriers

Table 3.3.1 Barriers to weaning: increased load.

Barrier to weaning	Examples	Therapeutic consideration
↑ Ventilatory demand		
Hypoxemia	1. Atelectasis 2. Morbid obesity, abdominal distension 3. Underlying lung disease 4. ↑ peripheral O_2 utilization (anxiety, fever, sepsis)	1. ↑ PEEP 2. Keep patient in upright position, >45 ° 3. ↑ FiO_2 4. Sedation, antipyretics, antibiotics
↑ Dead space	1. Hyperinflation 2. Intravascular volume depletion 3. Pulmonary embolism	1. Bronchodilators, steroids, ↓ minute ventilation 2. Intravenous fluids 3. Anticoagulation

Table 3.3.1 *(Continued)*

Barrier to weaning	Examples	Therapeutic consideration
↑CO_2 production (VCO_2)	1. Fever 2. Overfeeding 3. Increased metabolic rate	1. Antipyretics 2. ↓ calories administered 3. Treat underlying cause (sepsis, hyperthyroidism)
Metabolic acidosis	1. Renal Failure	1. Dialysis, Bicarbonate
Neuropsychiatric	1. Delirium 2. Anxiety 3. Pain	1. Antipsychotics (e.g., haldol, olanzepine) 2. Sedative hypnotic agents (e.g., lorazepam) 3. Opiates (e.g., morphine, fentanyl)
↑ Resistive load		
Bronchoconstriction	1. COPD and asthma	1. Bronchodilators, steroids
Airway edema	1. COPD and asthma 2. Lower respiratory tract infection	1. Steroids 2. Antibiotics
↑ Secretions	1. Tracheobronchitis 2. Pneumonia	1. Antibiotics, airway suctioning 2. Antibiotics, airway suctioning
Respiratory equipment	1. Endotracheal or tracheal tube luminal narrowing 2. Heat and moisture exchangers (HME)	1. Replace tube or consider extubation 2. Remove HME during SBT or change to heated humidifier

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Physiological barriers

Table 3.3.1 Barriers to weaning: increased load.

Barrier to weaning	Examples	Therapeutic consideration
↑ Elastic load		
Dynamic hyperinflation	1. COPD and asthma 2. States associated with ↑ minute ventilation (fever, hypoxemia, anxiety) 4. ↑ peripheral O_2 utilization (anxiety, fever, sepsis)	1. Bronchodilators, steroids, ↓ minute ventilation, add extrinsic PEEP to help patient trigger the ventilator 2. Antipyretics, ↑ FiO_2, sedation 4. Sedation, antipyretics, antibiotics
Pulmonary edema	1. Congestive heart failure 2. Acute lung injury	1. Diuretics, inotropic agents 2. Lung protective strategy with ↓ tidal volume (e.g., 6 ml/kg IBW), titrate PEEP
Other alveolar filling	Pneumonia	Antibiotics
Atelectasis	1. After low spontaneous tidal volumes 2. Excess respiratory secretions 3. Process obstructing airway	1. ↑ tidal volume, ↑ PEEP 2. Chest physiotherapy and airway suctioning 3. Bronchoscopy
Pleural disease	1. Pleural effusion 2. Pneumothorax (PTX)	1. Thoracentesis, pigtail catheter drainage 2. Chest tube
Chest wall disease Abdominal distension	1. Morbid obesity 2. Ileus 3. Ascites	1. Wean with patient sitting at ≥45° 2. Decompress abdomen with NGT suction, treat causes of ileus (d/c opiates, correct hypokalemia) 3. Paracentesis

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Physiological barriers

Table 3.3.2 Barriers to weaning: decreased respiratory muscle capacity.

Barrier to weaning	Examples	Therapeutic consideration
↓ Neuromuscular capacity		
Electrolyte abnormality	1. ↓ Magnesium (Mg) 2. ↓ Calcium (Ca) 3. ↓ Potassium (K) 4. ↓ Phosphorus (PO)	1–4. Assess electrolyte concentrations and replete if deficiencies detected
Medications	1. Corticosteroids 2. Neuromuscular blocking agents (NMBs)	1., 2. Minimize use of these agents and, if possible, avoid simultaneous use 2. Use of train of four monitoring to avoid excess use of NMBs, dose NMBs cautiously in setting of hepatic or renal disease
Metabolic conditions	1. Malnutrition 2. Hypothyroidism 3. Adrenal insufficiency	1. Enteral or parenteral feeding (avoid overfeeding) 2. Thyroid hormone replacement 3. Hydrocortisone
Inflammatory states	1. Severe sepsis	1. Antibiotics, consider activated protein C, consider corticosteroids
Neuropathy	1. Phrenic nerve injury (post-CABG, trauma) 2. Guillain–Barre syndrome 3. Critical illness polyneuropathy (CIP)	1. Prevention is key, recovery takes months to a year 2. Plasmapharesis or gamma globulin 3. Supportive care, tight glucose control, spontaneous recovery in weeks to months
Myopathy	1. Critical illness myopathy 2. VIDD	1. Minimize duration and dose of corticosteroids, supportive care, recovery in weeks to months 2. Avoid prolonged controlled mechanical ventilation

↓ Ventilatory Drive		
Excess Sedation	1. Use of intravenous sedation 2. Failure to use a sedation algorithm or sedation scoring system	1. Use sedation algorithm driven by a sedation scoring system (e.g., SAS, RASS) 2. Use strategy of daily cessation of sedation
Metabolic Alkalosis	1. NG suctioning 2. Alkali administration 3. Post-hypercapnic 4. Volume depletion, overdiuresis 5. Chloride depletion 6. Corticosteroids	1. Maintain intravascular volume, use PPI or H_2 blocker 2. Be cautious in administering sodium bicarbonate 3. Target baseline $PaCO_2$ when setting ventilator. 4. Maintain euvolemia 5. Replete chloride and potassium 6. Acetazolamide (Diamox)
CNS Process	1. Stroke 2. Meningoencephalitis 3. Toxic metabolic encephalopathy	1. Avoid sedative hypnotics, avoid ↓ cerebral perfusion 2. Antibiotics 3. Correct metabolic abnormalities, use antidotes for toxic ingestions
Sleep apnea	1. Central sleep apnea 2. Obesity hypoventilation syndrome (OHS)	1., 2. Avoid sedative hypnotic medications. Avoid overventilation (hypocapnia), consider respiratory stimulants (progesterone, theophylline, doxapram)

Weaning strategies

Table 3.4.1 Modes of progressive withdrawal.

Mode	Method of decreasing level of ventilator support	Duration of tolerance indicating readiness for liberation
T-piece	Increase as tolerated or increase incrementally	2 h
CPAP, 5 cm H_2O	Increase as tolerated or increase incrementally	2 h
PSV	Decrease PSV level by 2–4 cm H_2O two or more times each day	2–24 h at 5–8 cm H_2O
SIMV	Decrease by 2–4 breaths/min two or more times each day	2–24 h at IMV ≤ 5 breaths/min
SIMV + PSV	Decrease by 2–4 breaths/min two or more times each day followed by decrease PSV level by 2–4 cm H_2O two or more times each day	2–24 h at 5–8 cm H_2O (IMV = 0)

CPAP = constant positive airway pressure; PSV = pressure support ventilation; SIMV = synchronized intermittent mandatory ventilation.

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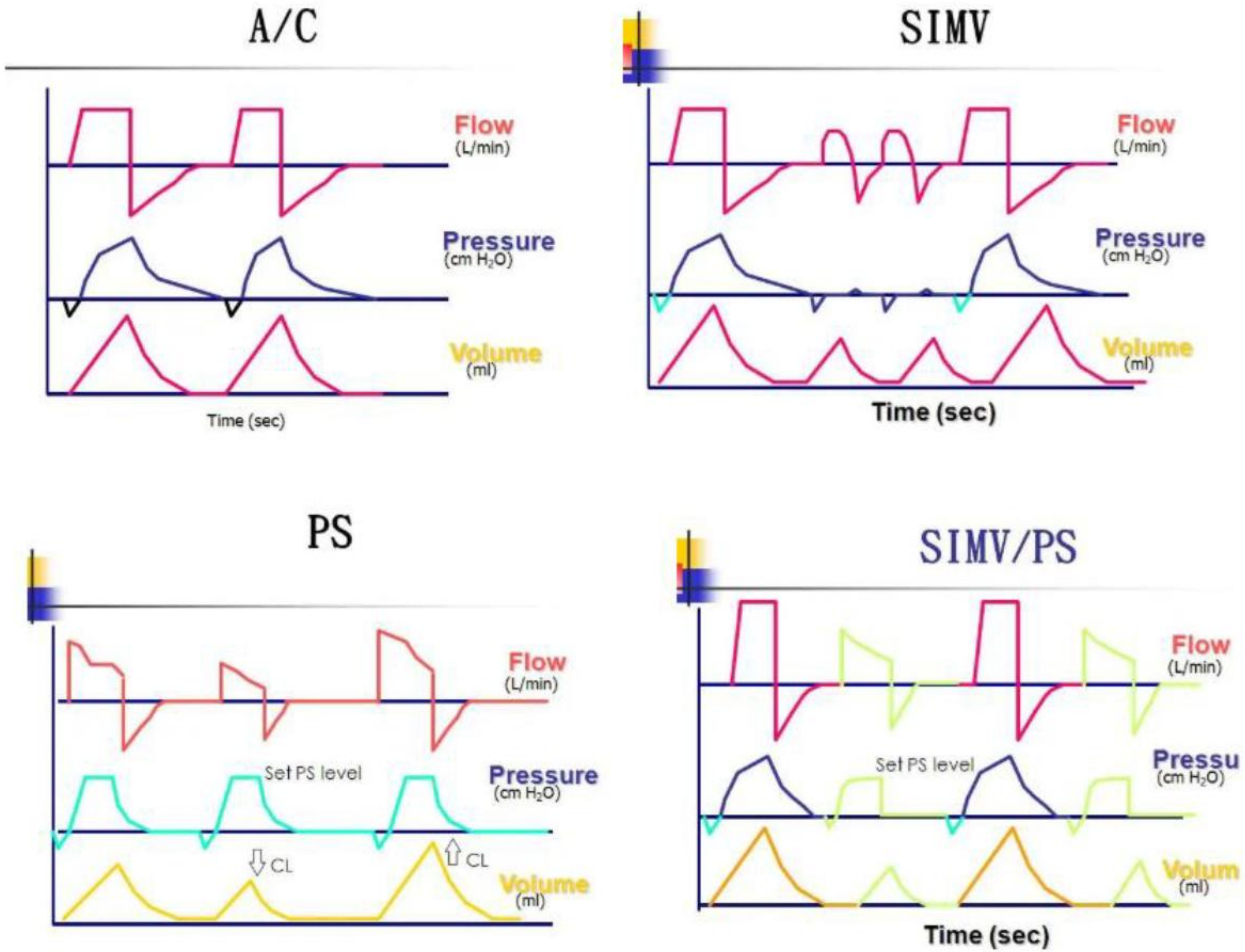
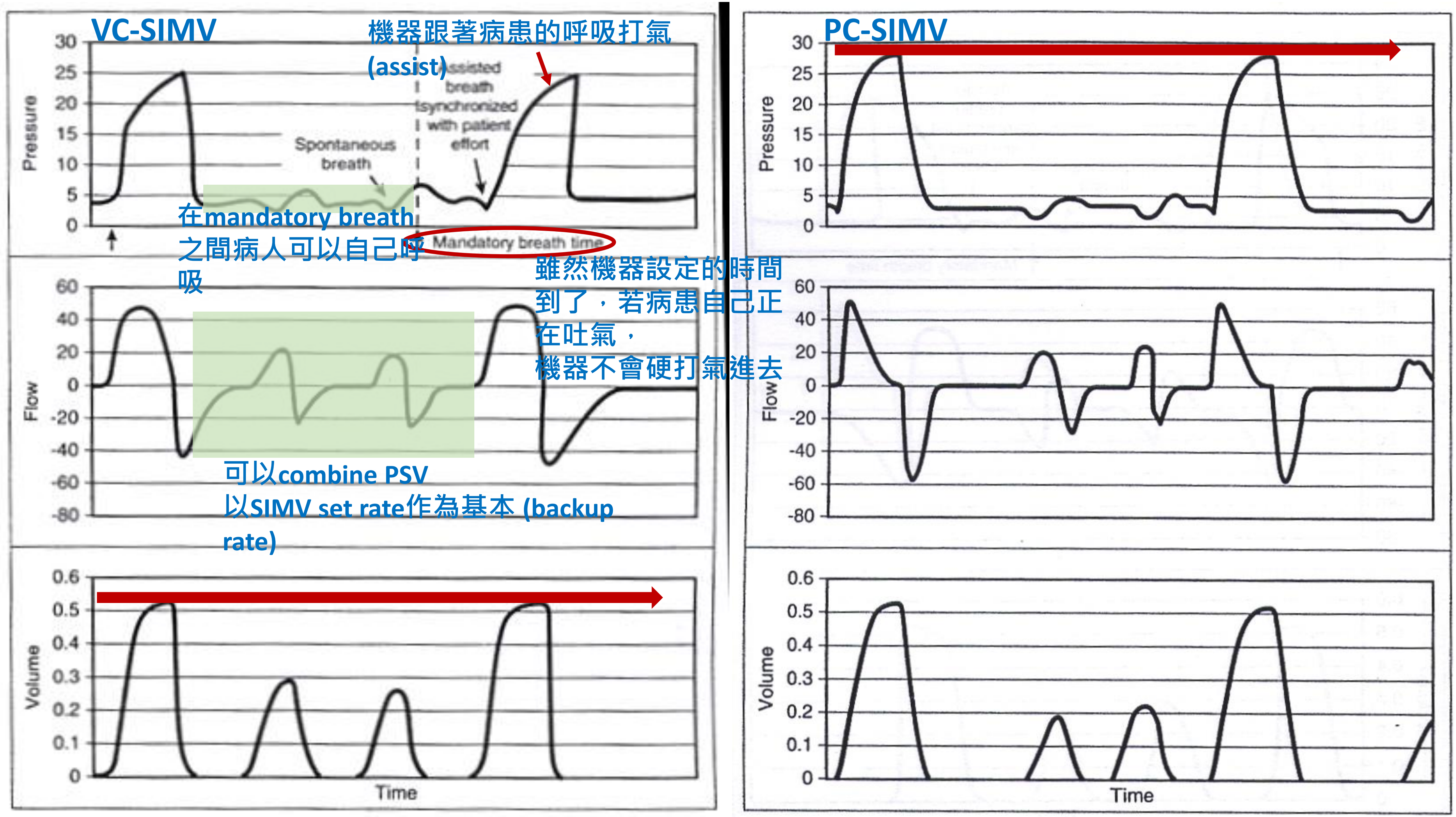
Weaning strategies



Weaning strategies



Weaning strategies

The New England Journal of Medicine

Volume 332 FEBRUARY 9, 1995 Number 6

A COMPARISON OF FOUR METHODS OF WEANING PATIENTS FROM MECHANICAL VENTILATION

Andrés Esteban, M.D., Ph.D., Fernando Frutos, M.D., Martin J. Tobin, M.D., Inmaculada Alía, M.D., José F. Solsona, M.D., Inmaculada Valverdú, M.D., Rafael Fernández, M.D., Miguel A. de la Cal, M.D., Salvador Benito, M.D., Ph.D., Roser Tomás, M.D., Demetrio Carriedo, M.D., Santiago Macías, M.D., and Jesús Blanco, M.D., for the Spanish Lung Failure Collaborative Group*

JOURNAL ARTICLE

Comparison of Three Methods of Gradual Withdrawal from Ventilatory Support During Weaning from Mechanical Ventilation

Get access >

L Brochard, A Rauss, S Benito, G Conti, J Mancebo, N Rekik, A Gasparetto, F Lemaire

American Journal of Respiratory and Critical Care Medicine, Volume 150, Issue 4, October 1994, Pages 896–903, https://doi.org/10.1164/ajrccm.150.4.7921460

Published: 01 October 1994

✓ SIMV slows the process of liberation

- Progressive withdrawal建議用T piece/PSV而非IMV，若要用IMV要加PSV一起使用

Table 3.4.2 Comparison of two major randomized controlled trials examining different modes of weaning from mechanical ventilation.

	Study of Brochard *et al.*	Study of Esteban *et al.*
Number of patients screened	456	546
Number of patients randomized	109	130
Duration of mechanical ventilation at randomization	14 days	9 days
Weaning modes tested	Pressure support (PSV) SIMV T-piece (incremental)	Pressure support (PSV) SIMV T-piece (once daily) T-piece (multiple daily)
Protocol for weaning	PSV: ↓ by 2–4 cm H2O, 2×/day SIMV: ↓ by 2–4 breaths/min, 2×/day T-piece: progressively increase to 2 h	PSV: ↓ by 2–4 cm H2O, 2x/day SIMV: ↓ by 2–4 breaths/min, 2×/day T-piece (once): as tolerated up to 2 h T-piece (multiple): T-piece or CPAP 5 cm H2O as tolerated multiple times per day (up to 2 h per trial)
Criteria for successful weaning	PSV: 8 cm H2O for 24 h SIMV: 4 breaths/min for 24 h T-piece: 2 h (1–3 times/24 h)	PSV: 5 cm H2O for 2 h SIMV: 5 breaths/min for 2 h T-piece: 2 h (once)
Primary outcome assessed	Weaning success at 21 days	Weaning success at 14 days
Main results	PSV decreased percentage of patients with weaning failure (23% v. T-piece 43%, SIMV 42%) Shorter mean duration of weaning with PSV (5.7 days) compared to pooled T-piece and SIMV patients (9.3 days)	Weaning failure: Once daily T-piece (29%), Multiple daily T-piece (18%), PSV (38%), SIMV (31%) Shorter median duration of weaning with T-piece, once (3 days) and T-piece, multiple (3 days) compared to PSV (4 days) and SIMV (5 days)

A Practical Guide to Mechanical Ventilation, 1st Edition.

Weaning strategies

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Volume 332 FEBRUARY 9, 1995 Number 6

A COMPARISON OF FOUR METHODS OF WEANING PATIENTS FROM MECHANICAL VENTILATION

Andrés Esteban, M.D., Ph.D., Fernando Frutos, M.D., Martin J. Tobin, M.D., Inmaculada Alía, M.D., José F. Solsona, M.D., Inmaculada Valverdú, M.D., Rafael Fernández, M.D., Miguel A. de la Cal, M.D., Salvador Benito, M.D., Ph.D., Roser Tomás, M.D., Demetrio Carriedo, M.D., Santiago Macías, M.D., and Jesús Blanco, M.D., for the Spanish Lung Failure Collaborative Group*

Table 2. The Length of Time from the Initiation of Weaning to Successful Extubation in the Four Groups.

Weaning Technique	Median	First Quartile	Third Quartile
		days	
Intermittent mandatory ventilation	5	3	11
Pressure-support ventilation	4	2	12
Intermittent trials of spontaneous breathing	3	2	6
Once-daily trial of spontaneous breathing	3	1	6

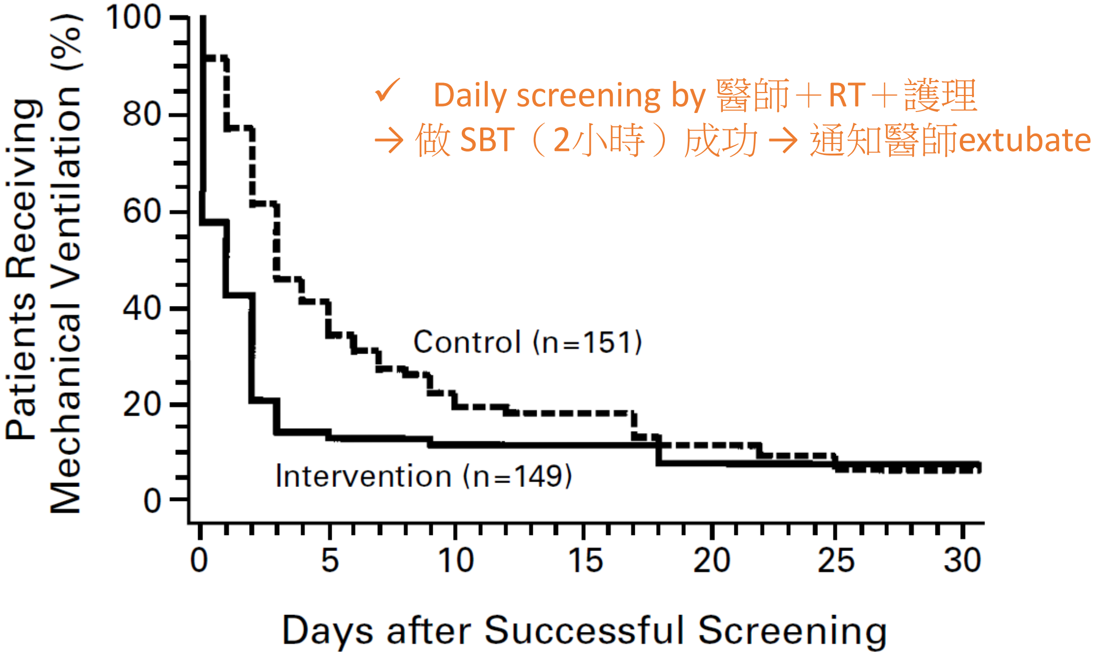
*N=130 (respiratory distress during a two-hour trial of spontaneous breathing)

The New England Journal of Medicine

EFFECT ON THE DURATION OF MECHANICAL VENTILATION OF IDENTIFYING PATIENTS CAPABLE OF BREATHING SPONTANEOUSLY

E. Wesley Ely, M.D., M.P.H., Albert M. Baker, M.D., Donnie P. Dunagan, M.D., Henry L. Burke, M.D., Allen C. Smith, M.D., Patrick T. Kelly, M.D., Margaret M. Johnson, M.D., Rick W. Browder, M.D., David L. Bowton, M.D., and Edward F. Haponik, M.D.

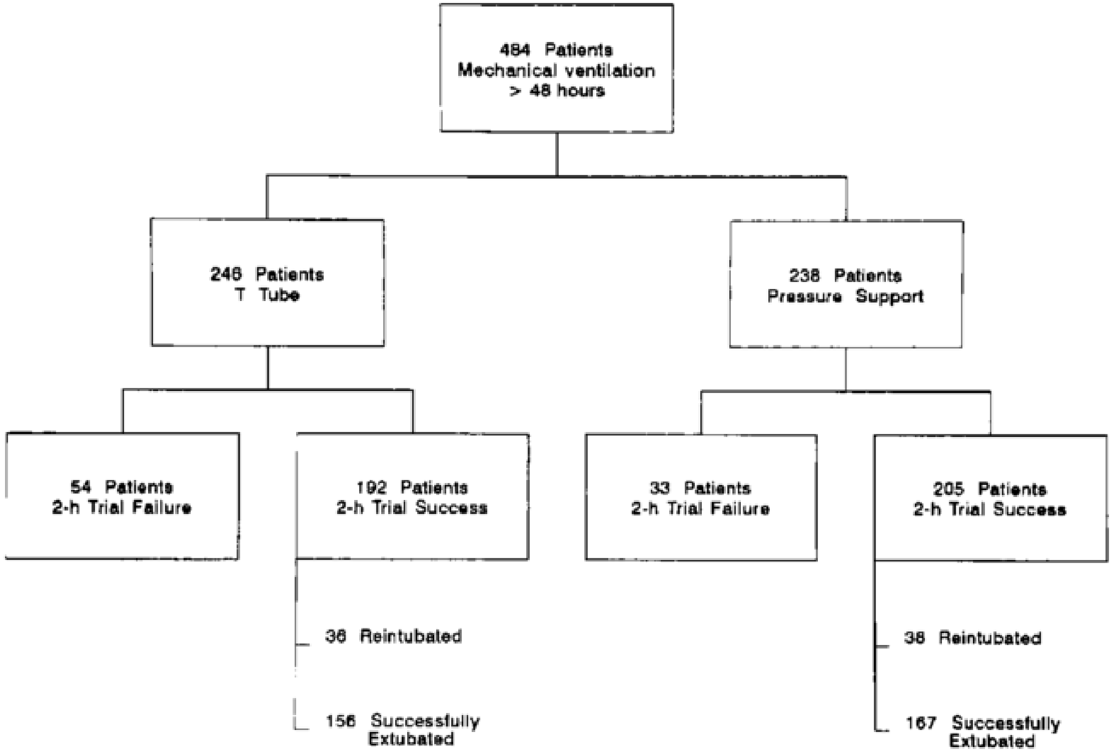
December 19, 1996



Weaning strategies

Extubation Outcome after Spontaneous Breathing Trials with T-Tube or Pressure Support Ventilation

ANDRÉS ESTEBAN, INMACULADA ALÍA, FEDERICO GORDO, RAFAEL FERNÁNDEZ, JOSÉ F. SOLSONA, INMACULADA VALLVERDÚ, SANTIAGO MACÍAS, JOSÉ M. ALLEGUE, JESÚS BLANCO, DEMETRIO CARRIEDO, MIGUEL LEÓN, MIGUEL A. de la CAL, FRANCISCO TABOADA, JUAN GONZALEZ de VELASCO, EUGENIO PALAZÓN, FRANCISCO CARRIZOSA, ROSER TOMÁS, JOSÉ SUAREZ, and ROSANNE S. GOLDWASSER for the Spanish Lung Failure Collaborative Group



- ✓ T piece V.S. PS 7
- ➢ 63% V.S. 70% (p=0.14)

AM J RESPIR CRIT CARE MED 1997;156:459–465.

Weaning strategies

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

ATS/CHEST recommendation. For acutely hospitalized patients ventilated more than 24 hours, we suggest that the initial SBT be conducted with inspiratory pressure augmentation (5-8 cm H_2O) rather than without (T-piece or continuous positive airway pressure) (Conditional recommendation).

CHEST 2017; 151(1):160-165

Weaning strategies

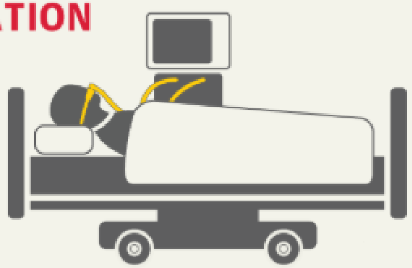
JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT

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

✓ 30 minutes of PSV (PS 8 cmH2O) V.S. 2 hours of T-piece ventilation

POPULATION



725 Men 428 Women

Adult ICU patients deemed ready for weaning after ≥24 hours of mechanical ventilation

Mean age: 62 years

LOCATIONS

18 ICUs in Spain

INTERVENTION

1153 Patients randomized

575
30-Minute pressure support ventilation
Less demanding spontaneous breathing trial

578
2-Hour T-piece ventilation
More demanding spontaneous breathing trial

PRIMARY OUTCOME

Successful extubation, defined as remaining free of mechanical ventilation for 72 hours after first spontaneous breathing trial

FINDINGS

Successful extubation

30-Minute pressure support ventilation	2-Hour T-piece ventilation
473 of 575 patients	428 of 578 patients

Between-group mean difference:

8.2%

(95% CI, 3.4% to 13.0%); *P* = .001

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

Weaning strategies

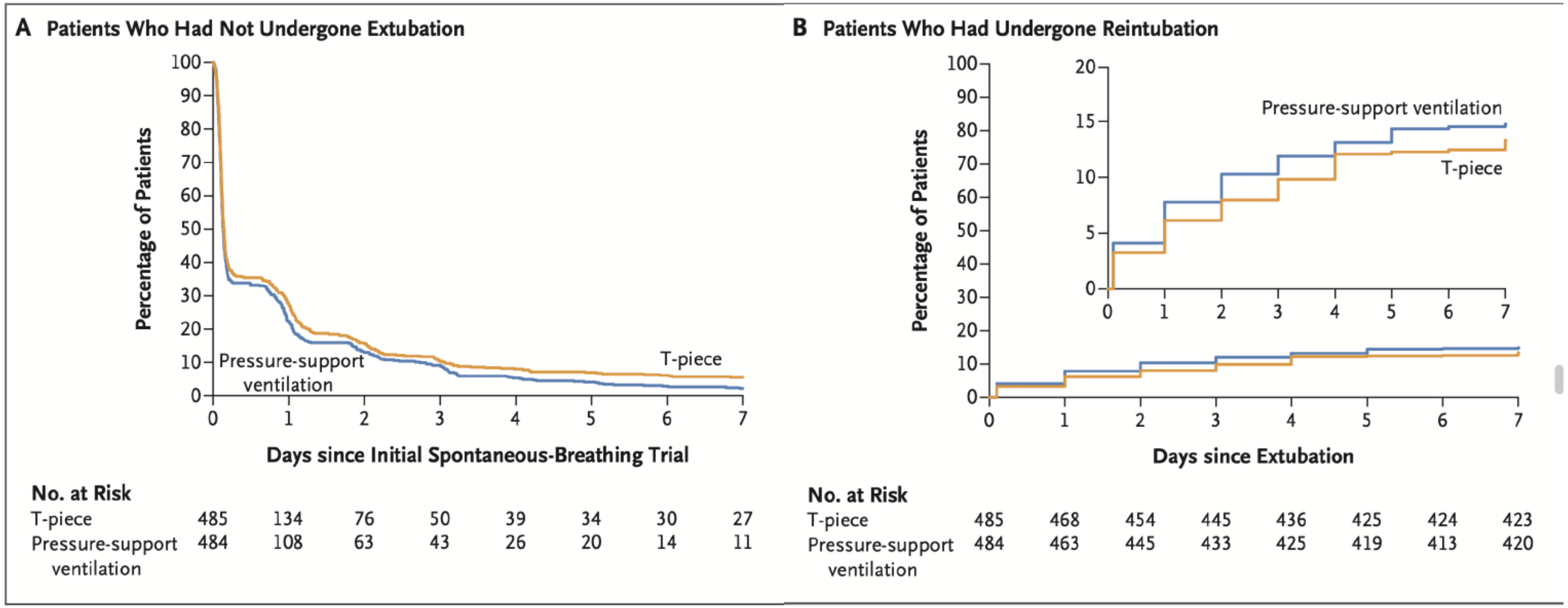
The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Spontaneous-Breathing Trials with Pressure-Support Ventilation or a T-Piece

A.W. Thille, A. Gacouin, R. Coudroy, S. Ehrmann, J.-P. Quenot, M.-A. Nay, C. Guitton, D. Contou, G. Labro, J. Reignier, G. Pradel, G. Beduneau, L. Dangers, C. Saccheri, G. Prat, G. Lacave, N. Sedillot, N. Terzi, B. La Combe, J.-P. Mira, A. Romen, M.-A. Azais, A. Rouzé, J. Devaquet, A. Delbove, M. Dres, J. Bourenne, A. Lautrette, J. de Keizer, S. Ragot, and J.-P. Frat, for the REVA Research Network*

- A multicenter, open-label trial, high risk of extubation failure patients.
- SBT performed with PSV(8 cmH2O) did not result in significantly more ventilator-free days at day 28 than SBT performed with a T-piece.



N Engl J Med 2022;387:1843-54.

Concerns of extubation

Table 3.5.1 Risk factors for extubation failure.

- Medical, pediatric, or multidisciplinary ICU patient
- Older age
- Pneumonia as cause for mechanical ventilation
- Higher severity of illness at the time of extubation
- Use of continuous intravenous sedation
- Abnormal mental status, delirium
- Semirecumbent positioning
- Transport out of ICU for procedures
- Decreased physician and nurse staffing in the ICU

A Practical Guide to Mechanical Ventilation, 1st Edition.

Concerns of extubation

Table 3.5.2 Causes for extubation failure.

- Imbalance between load on the respiratory system (work of breathing) and respiratory muscle capacity
- Cardiac disease
- Upper airway obstruction
- Ineffective cough
- Excess respiratory secretions
- Depressed mental status

✓ Glottic narrowing:
  - inflammation, granuloma formation, ulceration, or edema.

✓ Subglottic stenosis risk：
  - Balloon hyperinflation
  - 過長的插管時間
  - 太大的氣管內管
  - 氣管內管過度挪動
  - Trachea 感染
  - 女性

A Practical Guide to Mechanical Ventilation, 1st Edition.

Concerns of extubation

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

- **Post-extubation stridor**
  - ✓ Incidence: 6-37%
  - ✓ A **cuff leak test** is suggested for high risk patients
    - ➢ Cuff leak volumes ≥110 mL or >24% of the delivered tidal volume is considered a normal cuff leak test.
  - ✓ 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.

Am J Respir Crit Care Med. 2017

Concerns of extubation

- **Risk factors of post-extubation stridor**
  - ✓ Prolonged intubation
    (variably defined as ≥36 hours to ≥6 days)
  - ✓ Age > 80 years
  - ✓ Female gender
  - ✓ 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)
  - ✓ Excessive tube mobility due to insufficient fixation
  - ✓ An elevated APACHE II score
  - ✓ A GCS score <8
  - ✓ Traumatic intubation
  - ✓ A history of asthma
  - ✓ Insufficient or lack of sedation
  - ✓ Aspiration

Extubation management in the adult intensive care unit (uptodate)

Post extubation care

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 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 preventative NIV (Strong Recommendation, Moderate Grade of Evidence).
- High risk for failure of extubation :hypercapnia, COPD, CHF, or other serious comorbidities.

TABLE 6] Evidence Profile for Extubation to Noninvasive Ventilation Compared With Extubation Without Noninvasive Ventilation[35-39]

Quality Assessment							No. of Patients		Effect			
No. of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Extubation to Noninvasive Ventilation	Extubation Without Noninvasive Ventilation	Relative (95% CI)	Absolute (95% CI)	Quality	Importance
Extubation success												
5	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	230 of 261 (88.1%)	204 of 264 (77.3%)	RR, 1.14 (1.05-1.23)	11 less per 100 (from 4 less to 18 less)	Moderate	Critical
ICU LOS												
4	Randomized trials	Serious[a]	Not serious	Not serious	Not serious	None	241	244	. . .	MD 2.48 d less (4.03 d less to 0.93 d less)	Moderate	Important

CHEST 2017; 151(1):160-165

Post extubation care

Original Investigation | Caring for the Critically Ill Patient FREE

Effect of Postextubation High-Flow Nasal Cannula vs Noninvasive Ventilation on Reintubation and Postextubation Respiratory Failure in High-Risk Patients

A Randomized Clinical Trial

Gonzalo Hernández, MD, PhD[1]; Concepción Vaquero, MD[2]; Laura Colinas, MD[1]; et al

- Post extubation, High Flow Nasal Cannula vs NIV for 24 hrs
  - ✓ High Risk Patients (HFNC vs. NIV), N = 604
  - ✓ Reintubation within 72 hours : 22.8% vs. 19.1%
  - ✓ Postextubation respiratory failure within 72 hours : 26.9% vs 39.8%

Meaning High-flow nasal cannula immediately after scheduled extubation was not inferior to noninvasive mechanical ventilation for risk of reintubation and postextubation respiratory failure in patients at high risk of reintubation.

JAMA 2016;316;(15):1565-1574.

Post extubation care

Guideline Or Statement | ERS Guidelines ✓ Free

ERS clinical practice guidelines: high-flow nasal cannula in acute respiratory failure

Simon Oczkowski | Begüm Ergan | Lieuwe Bos Show More

European Respiratory Journal 2022 59(4): 2101574; DOI: https://doi.org/10.1183/13993003.01574-2021

HFNC to prevent extubation failure in nonsurgical patients

PICO question 6: Should HFNC or COT be used in nonsurgical patients after extubation?

Recommendation 6

We suggest HFNC over COT in nonsurgical patients after extubation at low or moderate risk of extubation failure (conditional recommendation, low certainty of evidence).

PICO question 7: Should HFNC or NIV be used in nonsurgical patients after extubation?

Recommendation 7

We suggest the use of NIV over HFNC after extubation for patients at high risk of extubation failure unless there are relative or absolute contraindications to NIV (conditional recommendation, moderate certainty of evidence).

Take home massage

- SBT should be initiated with the day of intubation and be evaluated at least daily.
- Physiological barriers should be managed, and assess weaning parameters before extubation.
- Identify the risk of post-extubation stridor and reintubation/post-extubation respiratory failure, and apply systemic steroids and preventive NIV respectively.

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Thank You for Listening

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