機械通氣重症繼續教育課程

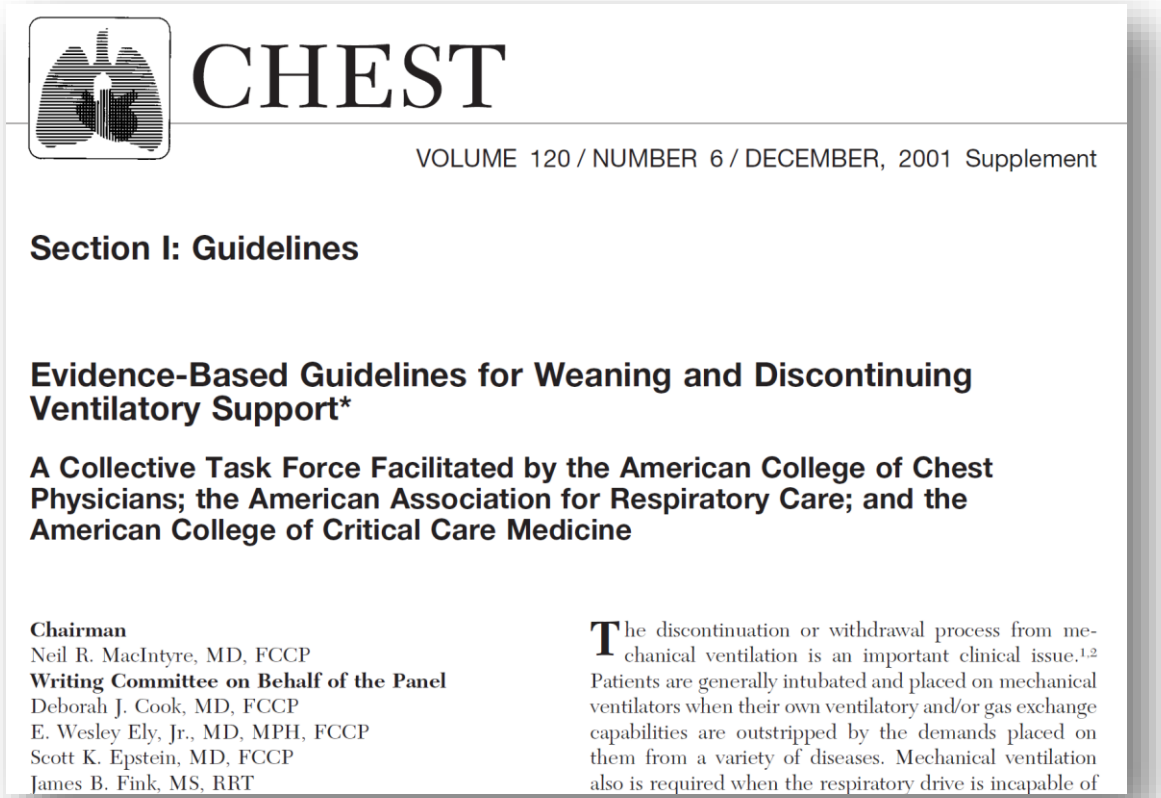
Weaning from mechanical ventilation and management of prolonged mechanical ventilation

台大醫院 ．阮聖元 醫師

Outline

- Overview of weaning guidelines
- Weaning outcome and epidemiology
- Weaning strategies
  - Spontaneous breathing trial (SBT) centered weaning strategy
  - SBT technique
- Decision to extubate
- Post-extubation care
- Prolonged mechanical ventilation

2001 ACCP/AARC Guidelines



CHEST

VOLUME 120 / NUMBER 6 / DECEMBER, 2001 Supplement

Section I: Guidelines

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

Chairman
Neil R. MacIntyre, MD, FCCP
Writing Committee on Behalf of the Panel
Deborah J. Cook, MD, FCCP
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Scott K. Epstein, MD, FCCP
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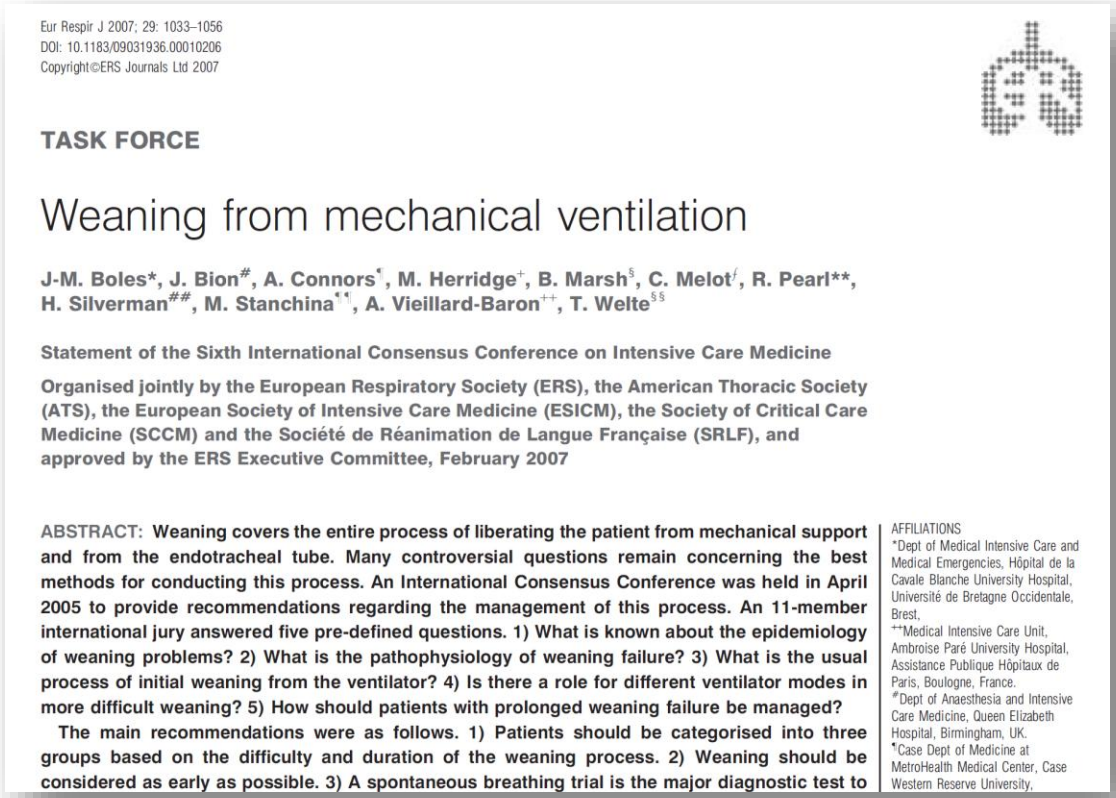
The discontinuation or withdrawal process from mechanical ventilation is an important clinical issue.[1,2] Patients are generally intubated and placed on mechanical ventilators when their own ventilatory and/or gas exchange capabilities are outstripped by the demands placed on them from a variety of diseases. Mechanical ventilation also is required when the respiratory drive is incapable of

- 12 recommendations.
- Provide a framework for ventilator weaning.
- Emphasize the importance of SBT.

2007 ERS/ESICM/ATS/SCCM Guidelines



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/, 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

ABSTRACT: **Weaning covers the entire process of liberating the patient from mechanical support and from the endotracheal tube. Many controversial questions remain concerning the best methods for conducting this process. An International Consensus Conference was held in April 2005 to provide recommendations regarding the management of this process. An 11-member international jury answered five pre-defined questions. 1) What is known about the epidemiology of weaning problems? 2) What is the pathophysiology of weaning failure? 3) What is the usual process of initial weaning from the ventilator? 4) Is there a role for different ventilator modes in more difficult weaning? 5) How should patients with prolonged weaning failure be managed?**

The main recommendations were as follows. 1) Patients should be categorised into three groups based on the difficulty and duration of the weaning process. 2) Weaning should be considered as early as possible. 3) A spontaneous breathing trial is the major diagnostic test to

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- Offer a structured approach to weaning.
- Provide definitions & epidemiology about weaning.
- Pathophysiology of weaning failure.

Physiology of Weaning Failure & Checklist

"Failure to wean" checklist

F	Fluid overload → diurese if indicated
A	Airway resistance → check endotracheal tube; is it obstructed or too small?
I	Infection → treat as indicated
L	Lying down causing V/Q mismatch → elevate head of bed
T	Thyroid, toxicity of drugs → check TFTs, check med list
O	Oxygen → increase FiO2 and/or the level of PEEP
W	Wheezing → treat with bronchodilators
E	Electrolytes, eating → correct K/Mg/PO4/Ca, provide adequate nutrition
A	Anti-inflammatory needed? → consider steroids in asthma/COPD or for failed cuff
N	Neuromuscular disease, neuro status compromised → myasthenia gravis, ALS, steroid/paralytic neuropathy, etc.; assure that patient is neurologically stable

AMERICAN THORACIC SOCIETY DOCUMENTS

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

Gregory A. Schmidt, Timothy D. Girard, John P. Kress, Peter E. Morris, Daniel R. Ouellette, Waleed Alhazzani, Suzanne M. Burns, Scott K. Epstein, Andres Esteban, Eddy Fan, Miguel Ferrer, Gilles L. Fraser, Michelle Ng Gong, Catherine L. Hough, Sangeeta Mehta, Rahul Nanchal, Sheena Patel, Amy J. Pawlik, William D. Schweickert, Curtis N. Sessler, Thomas Strøm, Kevin C. Wilson, and Jonathon D. Truwit; on behalf of the ATS/CHEST *Ad Hoc* Committee on Liberation from Mechanical Ventilation in Adults

This official clinical practice guideline of the American Thoracic Society (ATS) and the American College of Chest Physicians (CHEST) was approved by the ATS Board of Directors, December 2016, and by the CHEST Board of Regents, October 2016

Background: This clinical practice guideline addresses six questions related to liberation from mechanical ventilation in critically ill adults. It is the result of a collaborative effort between the American Thoracic Society and the American College of Chest Physicians.

Methods: A multidisciplinary panel posed six clinical questions in a Population, Intervention, Comparator, and Outcomes format. A comprehensive literature search and evidence synthesis was performed for each question, which included appraising the certainty in the evidence (i.e., the quality of evidence) using the Grading of Recommendations, Assessment, Development, and Evaluation approach. The Evidence-to-Decision framework was applied to each question, requiring the panel to evaluate and weigh the importance of the problem, the confidence in the evidence, the certainty about how much the public values the main outcomes, the magnitude and balance of desirable and undesirable outcomes, the resources and costs associated with the intervention, the impact on health disparities, and the acceptability and feasibility of the intervention.

Results: Evidence-based recommendations were formulated and graded initially by subcommittees and then modified after full-panel discussions. The recommendations were confirmed by confidential electronic voting; approval required that at least 80% of the panel members agree with the recommendation.

Conclusions: The panel provides recommendations regarding liberation from mechanical ventilation. The details regarding the evidence and rationale for each recommendation are presented in the *American Journal of Respiratory and Critical Care Medicine* and *Chest*.

ATS/ACCP 2017
Weaning Guidelines

ATS/ACCP 2017 Weaning Guidelines

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

SBT採用 PSV 5-8 (vs T-piece)

使用Protocols 以減少Sedation

高風險拔管者 Preventive NIV

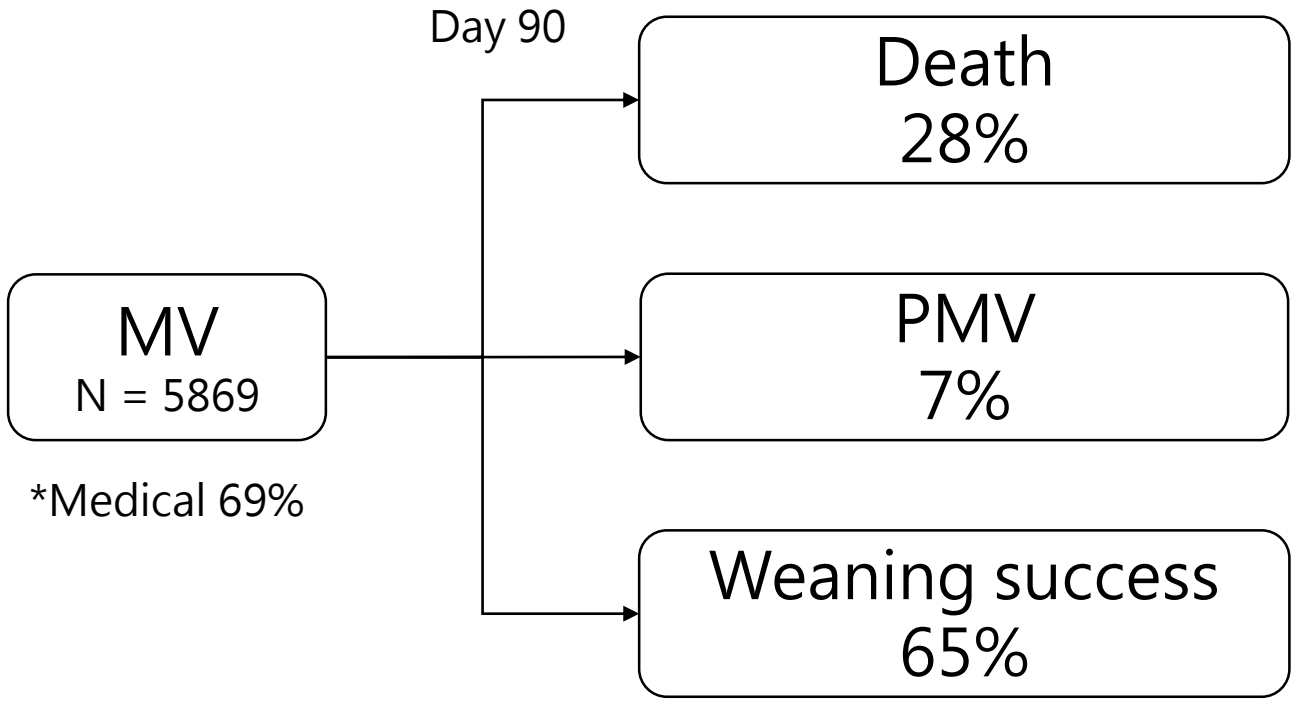
Rehabilitation protocol

建議使用 Weaning protocol

高風險PES者, 做 Cuff leak test
- Cuff leak沒過, 給 steroids

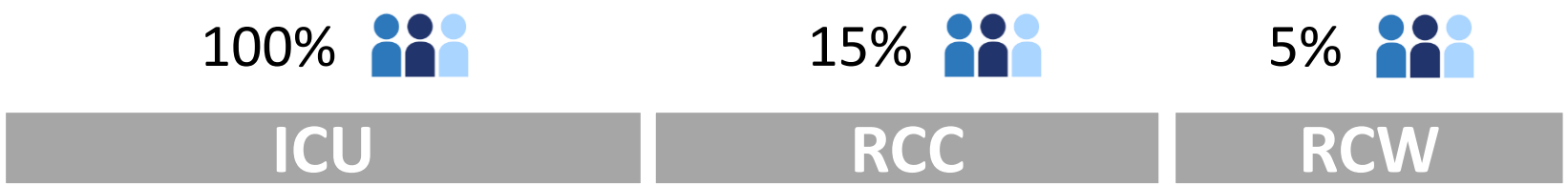
Overview of Weaning Outcome

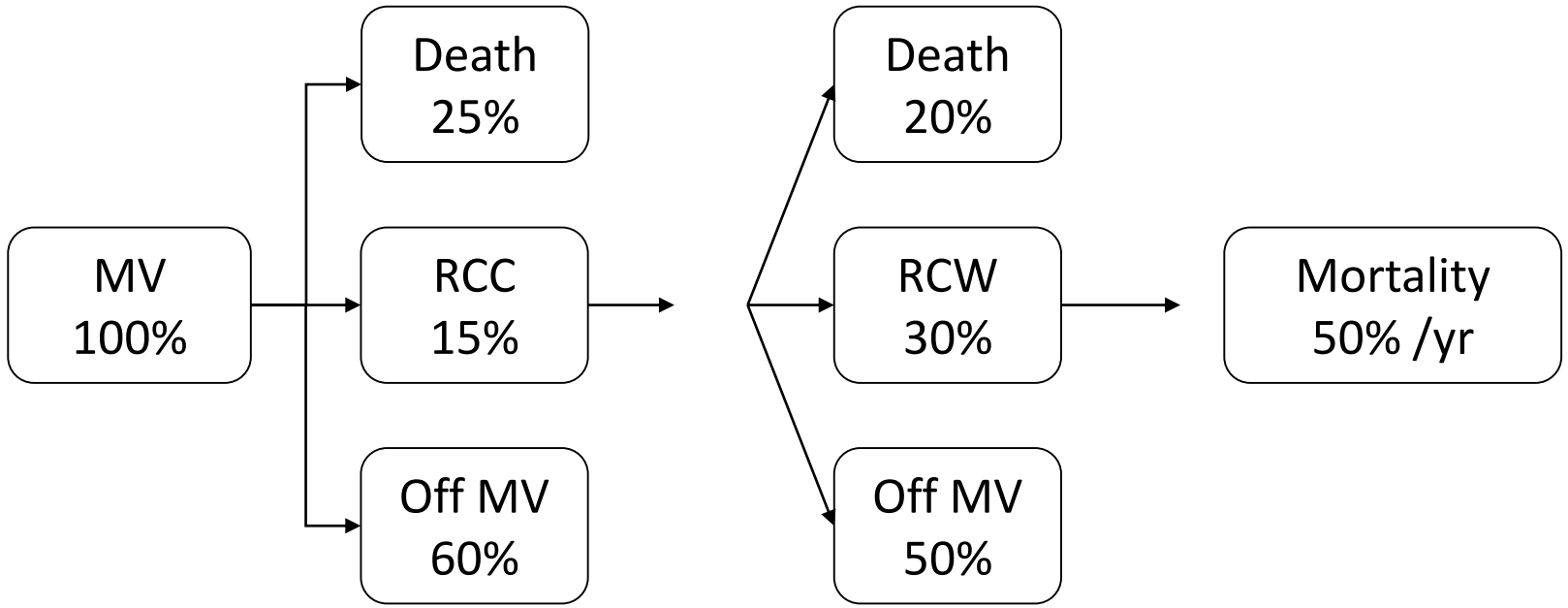
Weaning Outcomes (Wean Safe Study)



Pham. Lancet Respir Med. 2023

Weaning Outcomes in Taiwan (NHI data)





Define Prognosis by Weaning Process

Multinational study, n = 2709

No weaning	Simple weaning	Difficult weaning	Prolonged weaning
*86%	*6%	*17%	*30%

*ICU mortality

Beduneau. Am J Respir Crit Care Med. 2017

Weaning Strategies

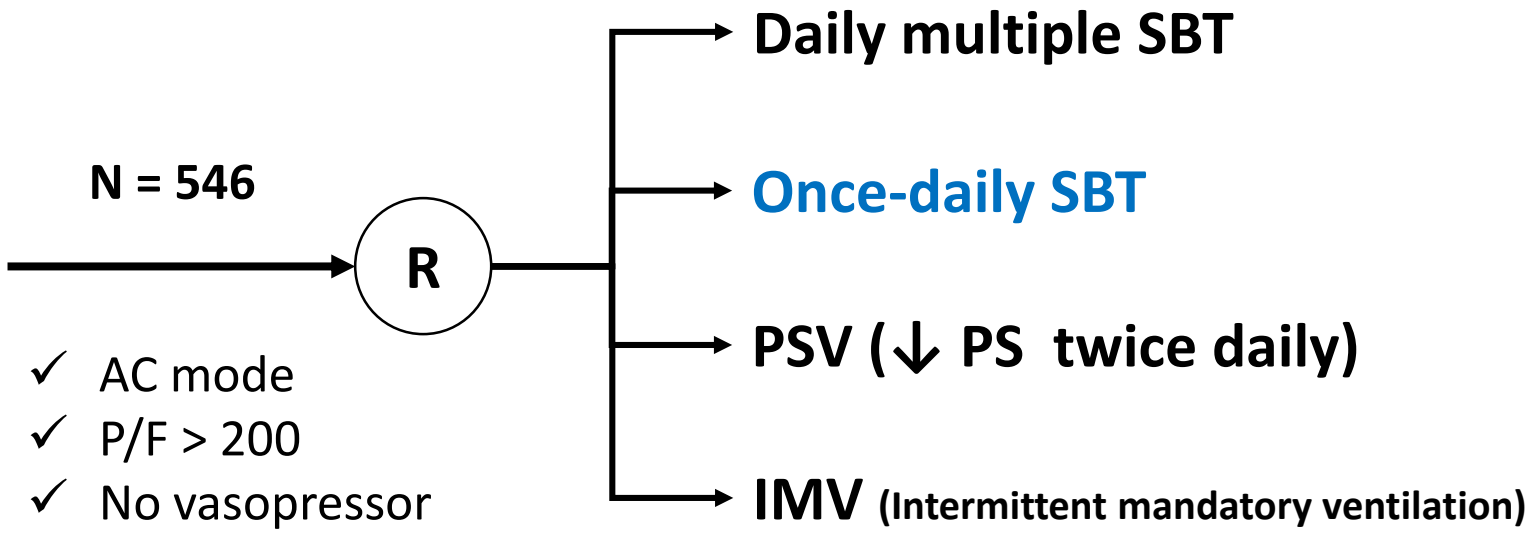
Best Practice for Weaning Strategy

- Once-daily SBT for discontinuation assessment is recommended in weaning guidelines
  (MacIntyre. CHEST 2001, Boles. Eur Respir J 2007)

- Extubation failure after SBT success: 10-20%
  (Thille. Am J Respir Crit Care Med. 2013)

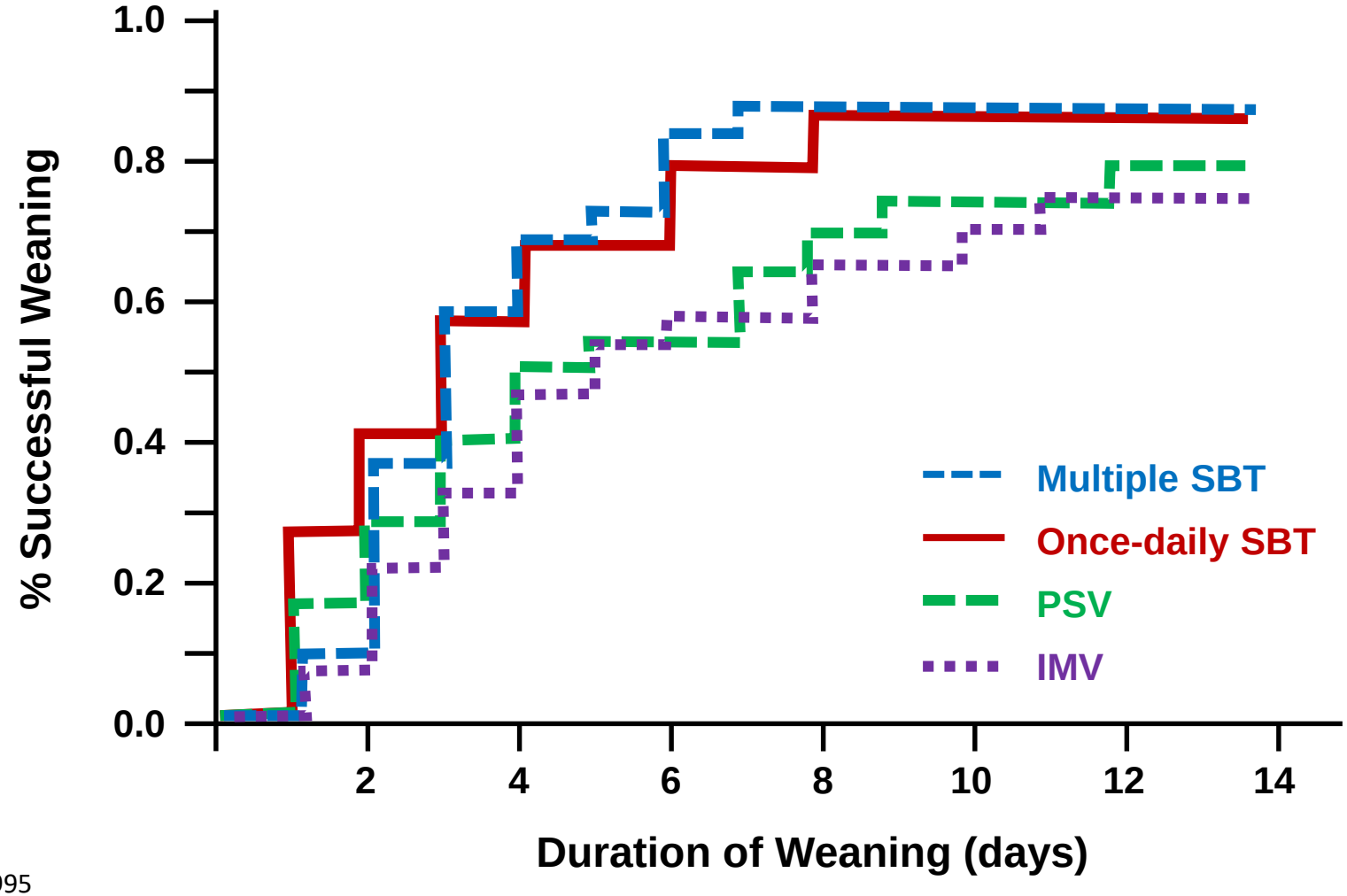
Landmark Study Comparing Weaning Strategies

The NEW ENGLAND JOURNAL of MEDICINE



Esteban. N Engl J Med 1995

Comparison of Weaning Methods



Esteban. N Engl J Med 1995

The NEW ENGLAND JOURNAL of MEDICINE

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.

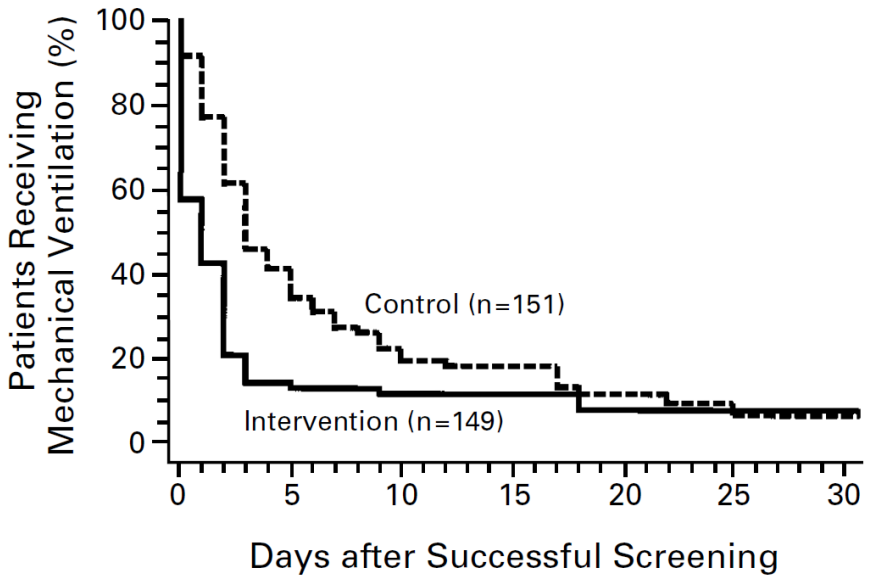
Abstract

Background Prompt recognition of the reversal of respiratory failure may permit earlier discontinuation of mechanical ventilation, without harm to the patient.

Methods We conducted a randomized, controlled trial in 300 adult patients receiving mechanical ventilation in medical and coronary intensive care units. In the intervention group, patients underwent daily screening of respiratory function by physicians, respiratory therapists, and nurses to identify those possibly capable of breathing spontaneously; successful tests were followed by two-hour trials of spontaneous breathing in those who met the criteria. Physicians were notified when their patients successfully

FOR over two decades, physicians have attempted to define the best methods of discontinuing mechanical ventilation in patients recovering from respiratory failure. An early study of weaning[1] noted that the clinical decision to discontinue mechanical ventilation is often arbitrary, based on "judgment and experience." With increasing recognition of the risks and economic consequences of prolonged ventilation, identifying strategies that reduce the duration of mechanical ventilation remains a high priority,[2,3] but no single approach has been established as the best one. Many measures have been proposed to identify patients ready for extubation,[1,4-15] ranging from simple ma-

Intervention:
- Daily SBT
- 口頭+紙條 通知醫師



Ely. N Engl J Med 1996

Performance of Weaning Parameters

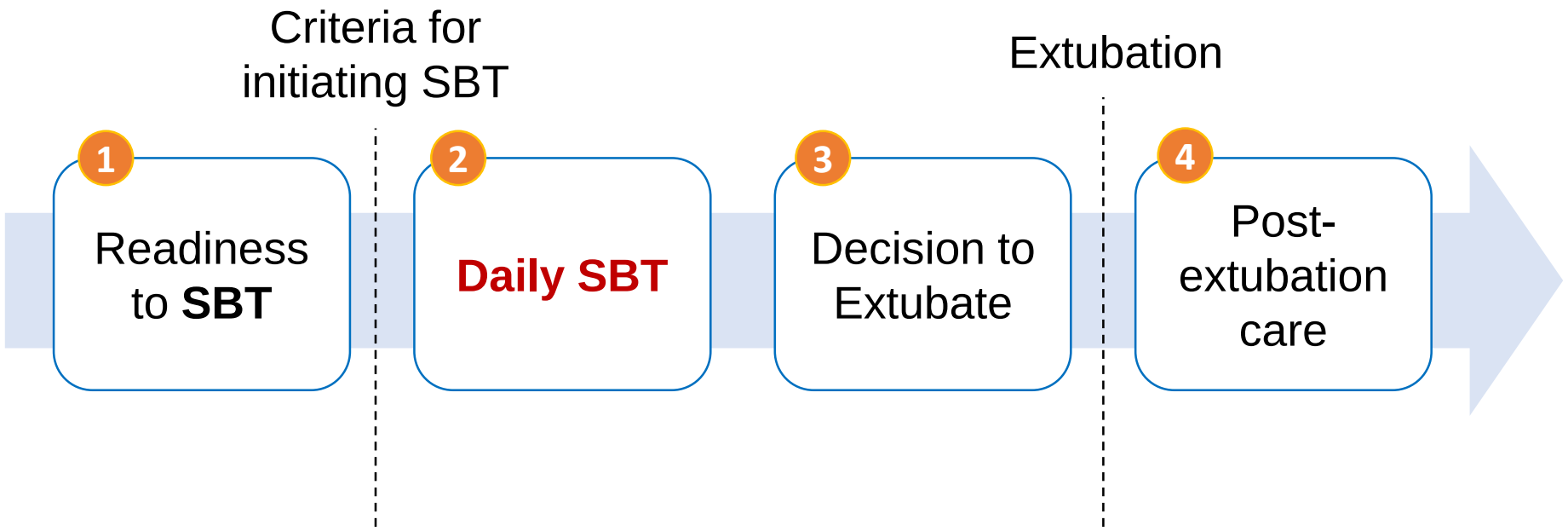
Index	AUC±SE	Sensitivity	Specificity	LR	P(W+|T+)	P(W+|T-)
VC (ml/kg)	0.71±0.07	0.43	0.64	1.3	0.76	0.69
V_T (ml/kg)	0.64±0.07	0.54	0.57	1.54	0.76	0.67
f/V_T (breaths/min per l)	0.70±0.07	0.81	0.14	0.69	0.71	0.78
$P_{0.1}$ (cmH_2O)	0.47±0.09	0.94	0.07	1.17	0.72	0.64
$P_{0.1}$/MIP	0.71±0.08	0.92	0.14	1.87	0.73	0.59
V_{MIN} (l)	0.54±0.08	0.86	0.14	1	0.72	0.69
RR (breaths/min)	0.52±0.09	0.94	0.07	1.17	0.72	0.64
MIP (cmH_2O)	0.57±0.09	0.92	0.07	0.87	0.72	0.75
$P_{0.1} \times f/V_T$ (cmH_2O/ breaths per min per l)	0.67±0.08	0.89	0.07	0.61	0.72	0.80

⇨ All indexes are **poor predictors** of weaning outcome!

Conti. Intensive Care Med. 2004

SBT-centered Weaning Strategy

SBT-centered Weaning Strategy

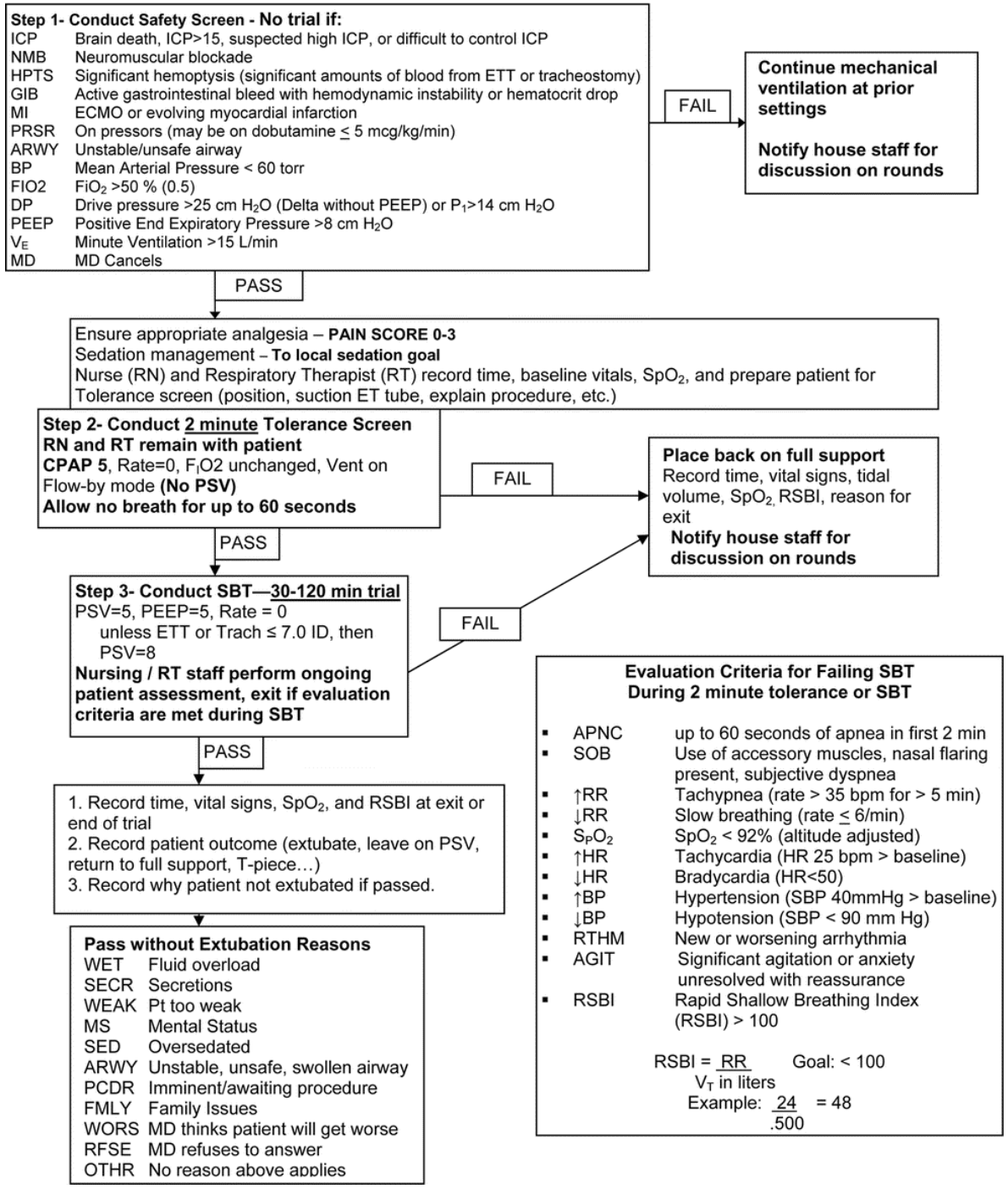


- Several techniques are used to conduct an SBT
  - With *vs.* without inspiratory pressure augmentation (Schmidt. Am J Respir Crit Care Med. 2017)

Readiness to wean (SBT)

2-min CPAP 5

SBT 30'-120'



Robertson. Crit Care Med. 2008

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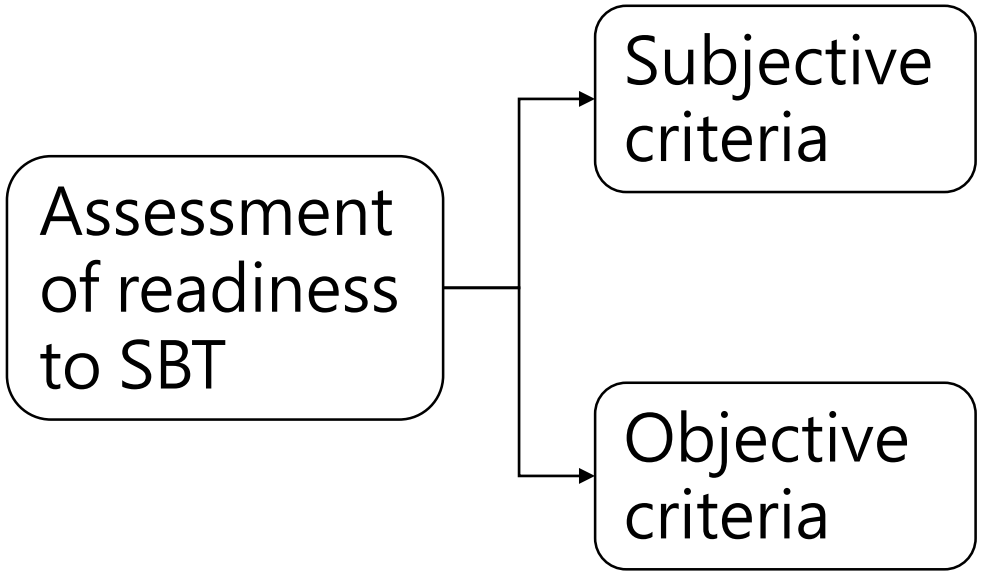
Assessment of Readiness to SBT



Subjective criteria
• Resolution of disease acute phase • Physician believes discontinuation possible
Objective criteria

• No vasopressor, HR < 140
• Adequate mentation
• Adequate oxygenation
  • P/F ratio ≥ 150 or FiO_2 ≤ 0.4
  • PEEP ≤ 8 cm H_2O
• Adequate pulmonary function
  • RR ≤ 35/min
  • MIP ≤ -25
  • V_T > 5 mL/kg
  • RSBI < 105

MacIntyre. Chest 2001
Boles. Eur Respir J 2007

SBT Techniques

Method? Duration? Failure criteria?

SBT Techniques: Methods & Durations

Inspiratory Pressure Augmentation (-)

- T-piece
- T-piece with PEEP
- CPAP

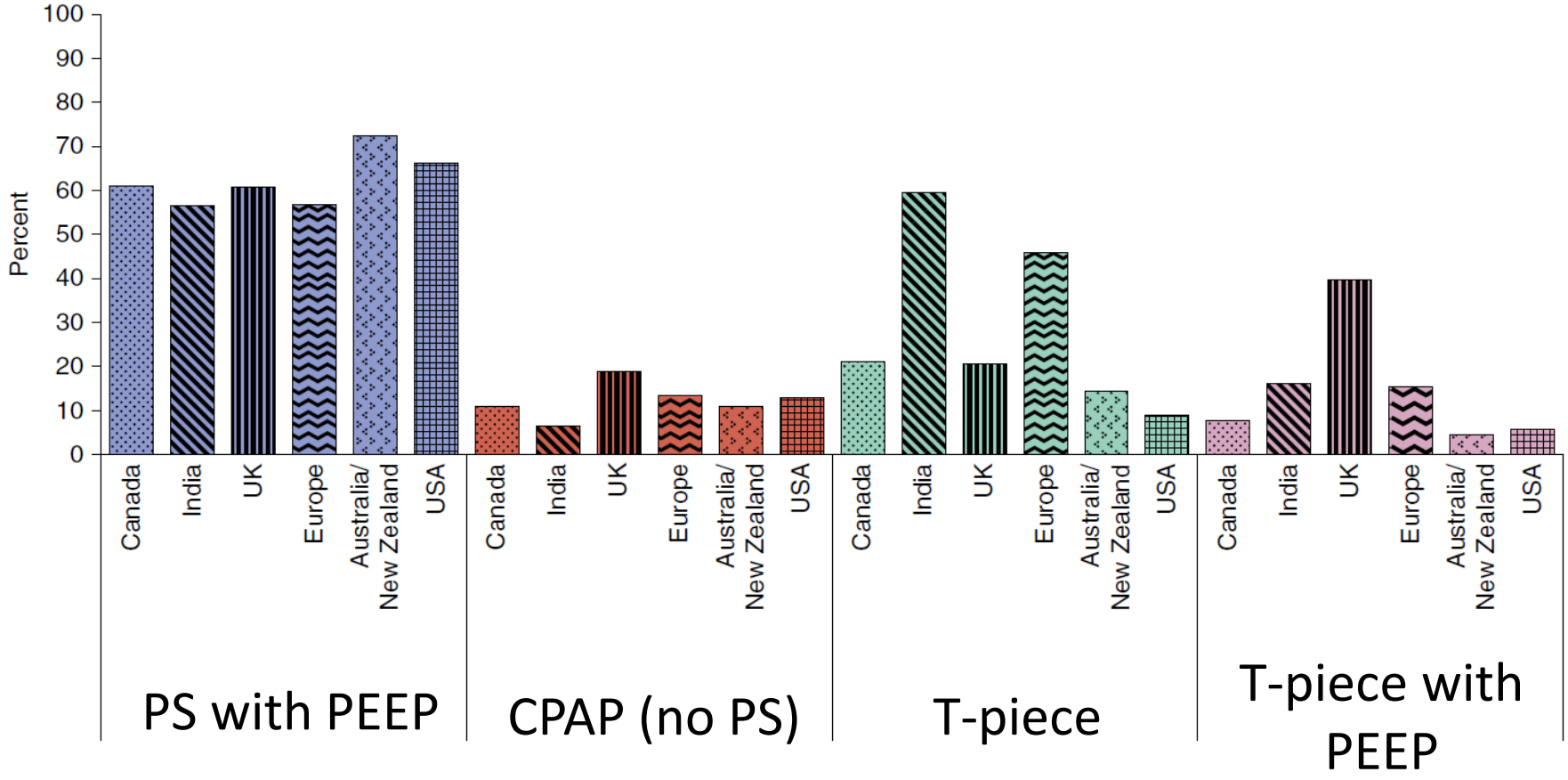
Inspiratory Pressure Augmentation (+)

- PS 5-8 cm H_2O
- Automatic tube compensation

SBT Duration

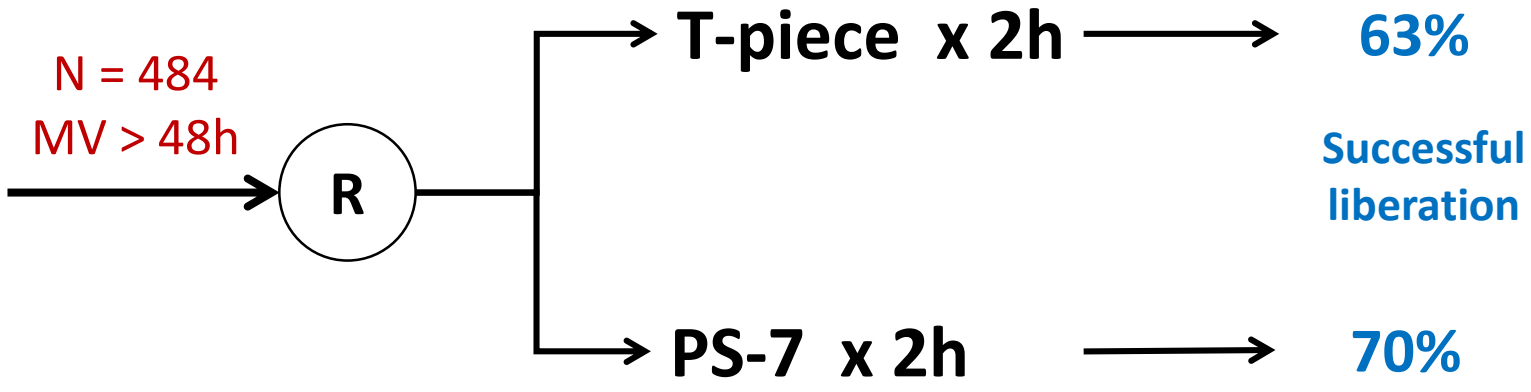
30′ ~ 120′

Practice Variation in SBT Techniques



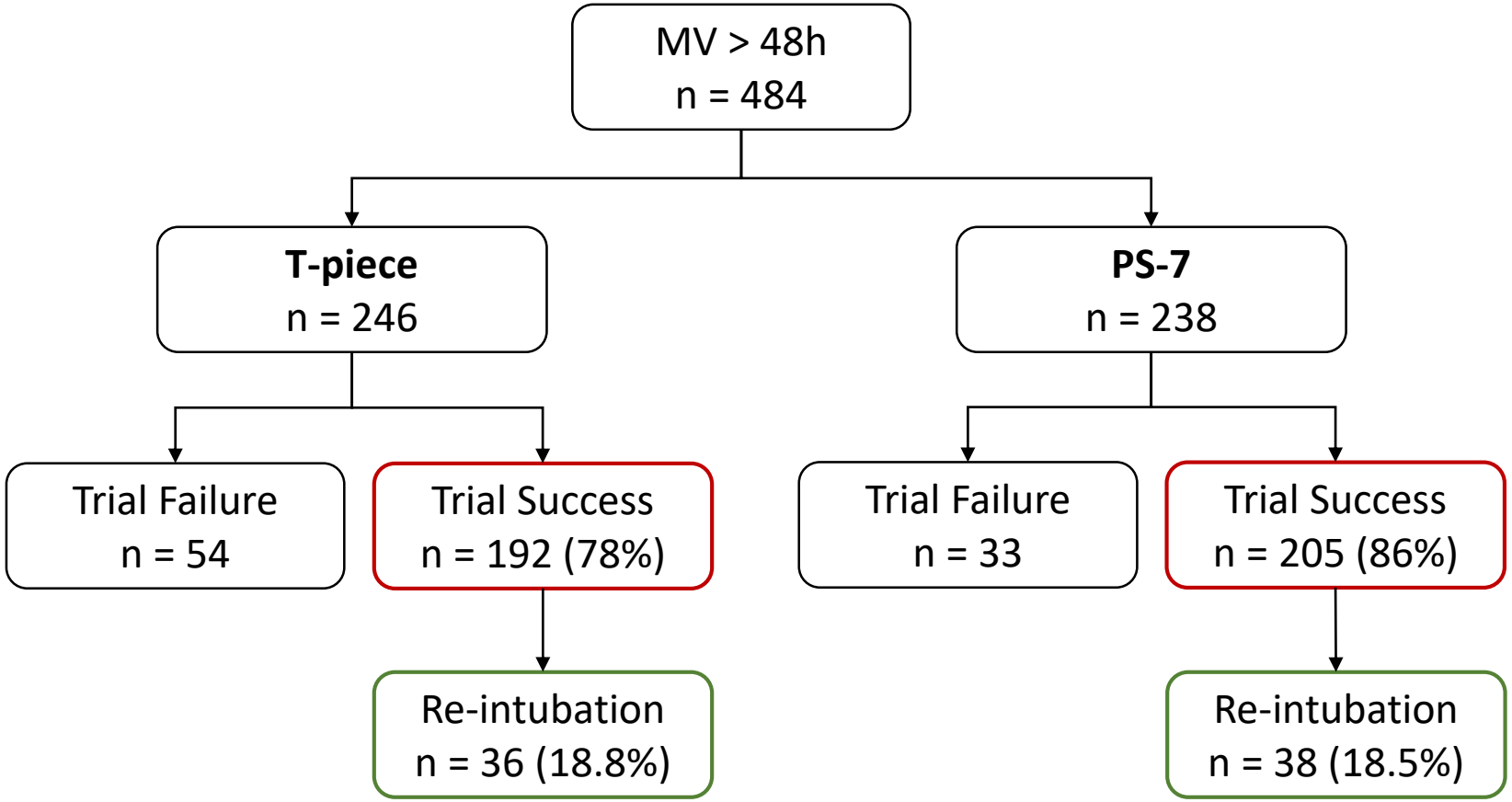
Burns. Ann Am Thorac Soc. 2018

Landmark Study Comparing T-piece & PS 7



Esteban. Am J Respir Crit Care Med 1997

Liberation Success % = (SBT success %) x (1 – Reintubation %)



Esteban. Am J Respir Crit Care Med 1997

PSV *vs.* T-piece, Meta-analysis

Outcome	No. of Studies	No. of Patients	Pooled Risk Ratio
SBT success	8	1381	1.06 [1.01-1.12]*
Re-intubation	7	1365	0.93 [0.72-1.20]
Liberation success	11	1904	1.06 [1.02-1.10]*

Burns. Crit Care. 2017

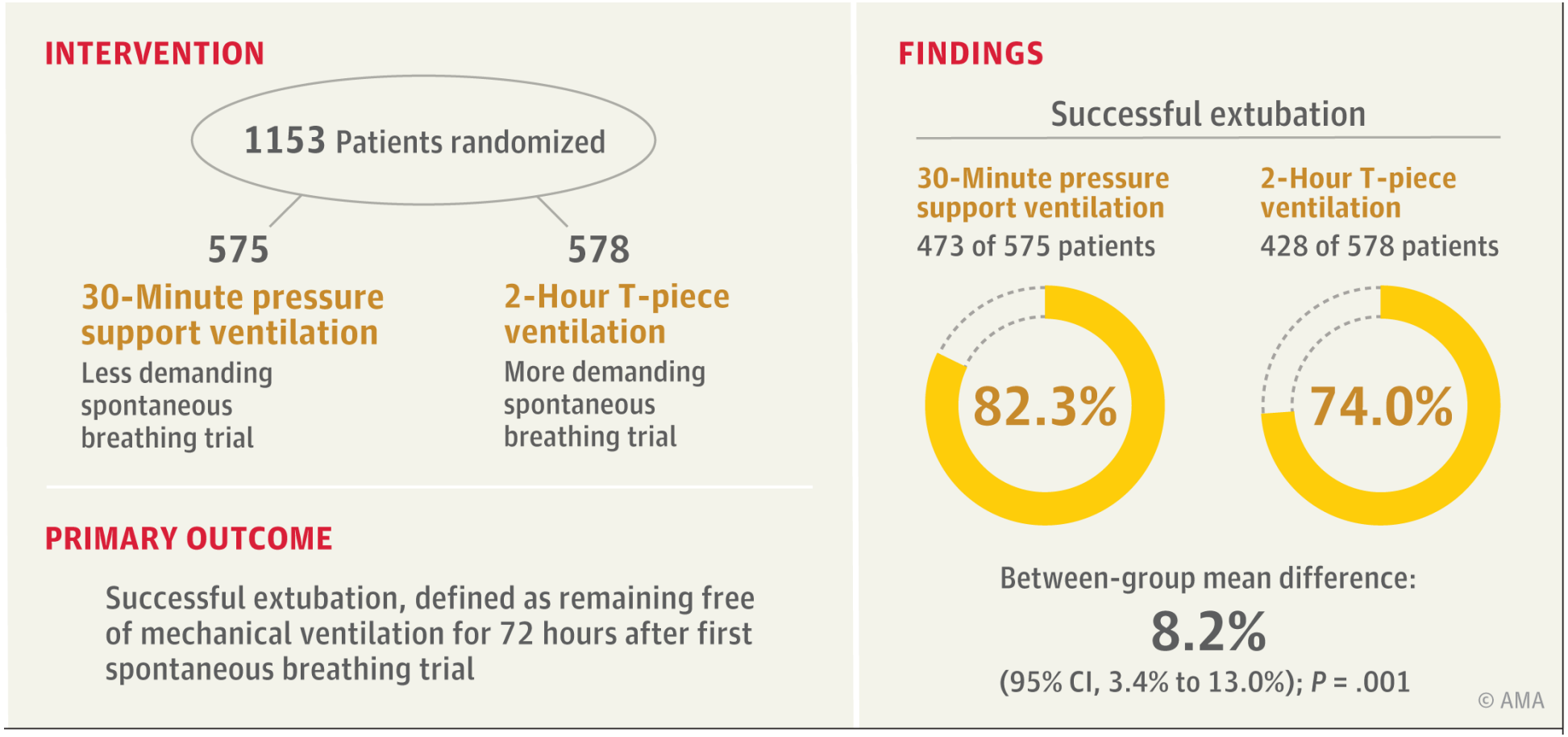
AMERICAN THORACIC SOCIETY DOCUMENTS

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

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).

Schmidt. Am J Respir Crit Care Med. 2017

PS-8 x 30′ *vs.* T-piece x 120′



Subirà. JAMA. 2019

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*

ABSTRACT

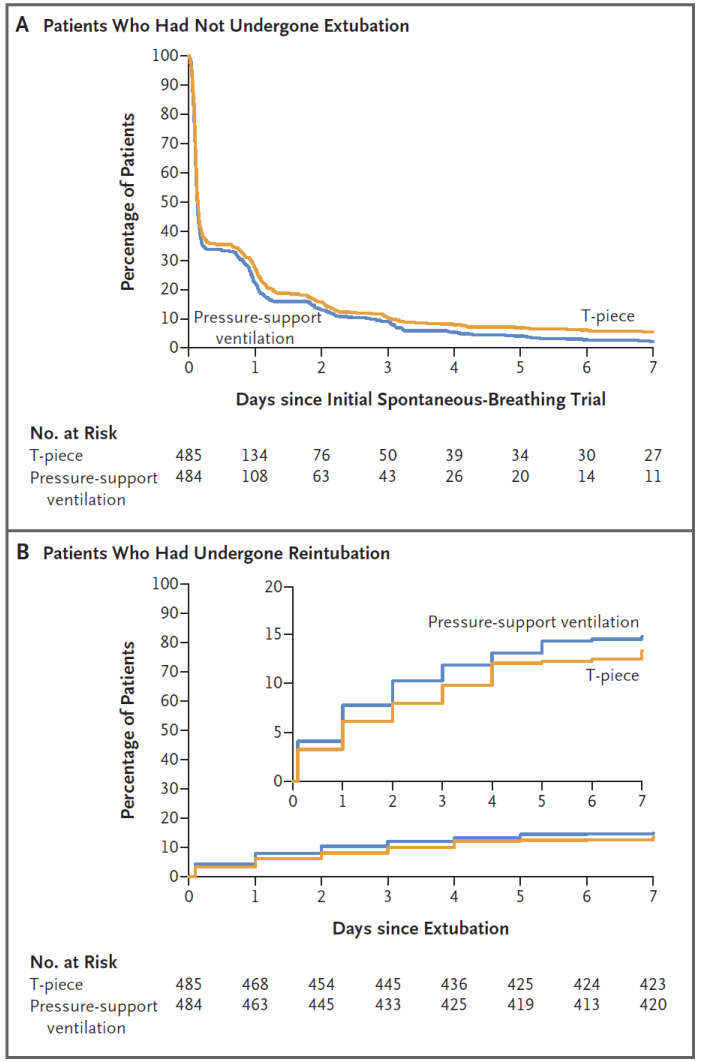
BACKGROUND

Spontaneous-breathing trials can be performed with the use of either pressure-support ventilation (PSV) or a T-piece. Whether PSV trials may result in a shorter time to tracheal extubation than T-piece trials, without resulting in a higher risk of reintubation, among patients who have a high risk of extubation failure is unknown.

METHODS

In this multicenter, open-label trial, we randomly assigned patients who had a high risk of extubation failure (i.e., were >65 years of age or had an underlying chronic cardiac or respiratory disease) to undergo spontaneous-breathing trials performed with the use of either PSV (with a pressure-support level of 8 cm of water and no positive end-expiratory pressure) or a T-piece. The primary outcome was the

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



No difference between PS-8 and T-piece

Decision to Extubate (After SBT Success)

Decision to Extubate: Airway Protection

- Neurological function
  - Glasgow Coma Scale
- Cough strength
  - Peak expiratory flow rate
  - Maximal expiratory pressure
  - White card test
- Secretion volume
  - Suctioning frequency
- Post-extubation airway edema
  - Cuff leak test

Epstein. Intensive Care Med 2002
Thille. Am J Respir Crit Care Med. 2013

Post-extubation Stridor

- Incidence: 6-37%
- A cuff leak test is suggested for high risk patients
- Risk factors:
  - Traumatic intubation
  - Intubation more than 6 days
  - Large endotracheal tube
  - Female sex
  - Reintubation
- Systemic steroids at least 4 hours before extubation
  - Conditional recommendation

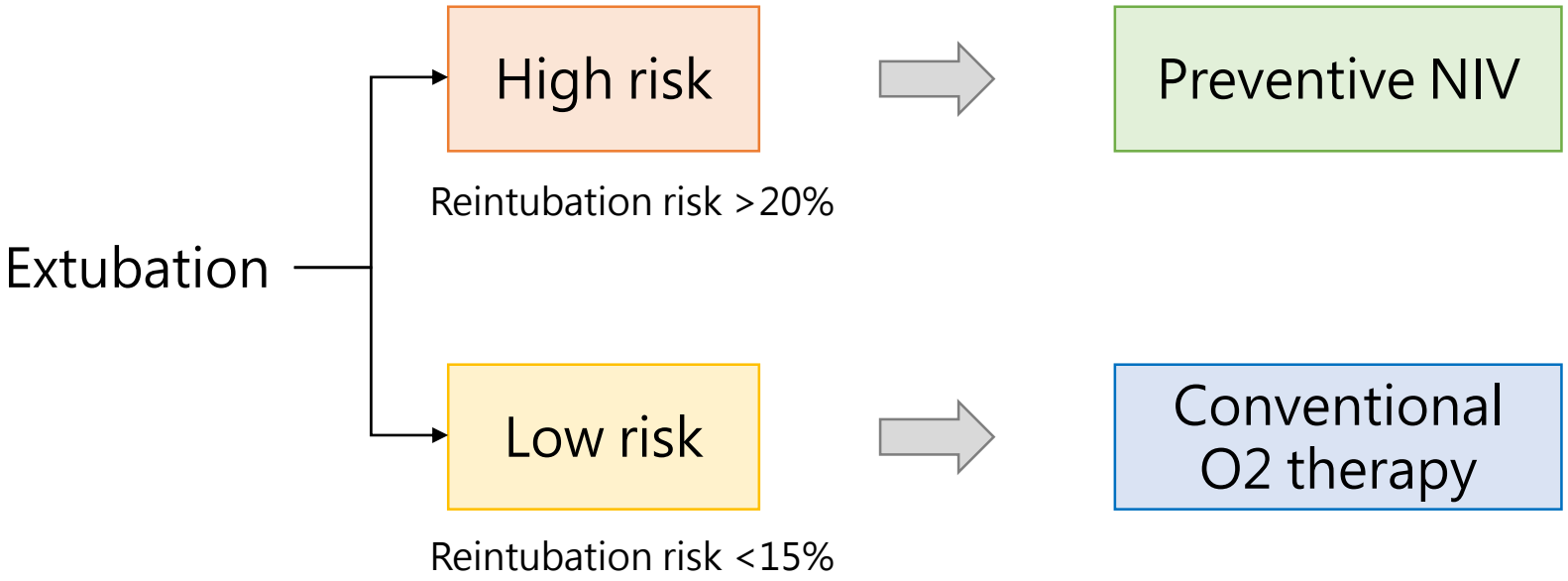
Girard. Am J Respir Crit Care Med. 2017

Post-extubation Care

At risk for extubation failure?

Preventive management?

Post-extubation Respiratory Support Recommended in 2017 ATS/ACCP Guidelines



In high-risk patients receiving MV for more than 24 hours, does extubation to **preventive NIV** compared with **no NIV** have a favorable effect on outcomes?

- For patients at high risk for extubation failure, we recommend extubation to preventive NIV.
  (Strong recommendation, moderate certainty)

- High risk for failure of extubation:
  - ✓ Older age (?)
  - ✓ Hypercapnia during SBT
  - ✓ COPD
  - ✓ Congestive heart failure

There was heterogeneity in defining the high-risk patient.

Schmidt. Am J Respir Crit Care Med. 2017

Preventive NIV after Extubation for High-risk Patients

Outcome	No. of RCTs	No. of Patients	Pooled Risk Ratio
Extubation success	5	525	1.14 [1.05-1.23]*
ICU mortality	4	485	0.37 [0.19-0.70]*

Schmidt. Am J Respir Crit Care Med. 2017

Post-extubation High-Flow Nasal Cannula

- **Low-Risk** Patients (HFNC vs. COT)
  - N = 527
  - Reintubation: 4.9% *vs.* 12.2% (p= 0.004)

(*Hernández. JAMA. 2016*)

- **High-Risk** Patients (HFNC vs. NIV)
  - N = 604
  - Reintubation: 22.8% *vs.* 19.1%

(*Hernández. JAMA. 2016*)

Eur Respir J 2022; 59: 2101574

2022 ERS Guidelines for HFNC

PICO 6: Nonsurgical, low risk	HFNC > COT (Using HFNC)
PICO 7: Nonsurgical, high risk	NIV > HFNC (Using NIV unless contraindicated to NIV)

Prolonged Mechanical Ventilation

consensus statement

Management of Patients Requiring Prolonged Mechanical Ventilation*

Report of a NAMDRC Consensus Conference

Neil R. MacIntyre, MD, FCCP, Chair; Scott K. Epstein, MD, FCCP; Shannon Carson, MD; David Scheinhorn, MD, FCCP; Kent Christopher, MD, FCCP; and Sean Muldoon, MD, FCCP†

Patients requiring prolonged mechanical ventilation (PMV) are rapidly increasing in number, as improved ICU care has resulted in many patients surviving acute respiratory failure only to then require prolonged mechanical ventilatory assistance during convalescence. This patient population has clearly different needs and resource consumption patterns than patients in acute ICUs, and specialized venues, management strategies, and reimbursement schemes for them are rapidly emerging. To address these issues in a comprehensive way, a conference on the epidemiology, care, and overall management of patients requiring PMV was held. The goal was to not only review existing practices but to also develop recommendations on a variety of assessment, management, and reimbursement issues associated with patients requiring PMV. Formal presentations were made on a variety of topics, and writing groups were formed to address three specific areas: epidemiology and outcomes, management and care settings, and reimbursement. Each group was charged with summarizing current data and practice along with formulation of recommendations. A working draft of the products of these three groups was then created and circulated among all participants. The document was reworked with input from all concerned until a final product with consensus recommendations on 12 specific issues was achieved. *(CHEST 2005; 128:3937–3954)*

MacIntyre. CHEST 2005

Prolonged Mechanical Ventilation

- Epidemiology
  - PMV in Taiwan: 15%
  - Difficult & prolonged weaning: 20%
  - Associated with poor outcome (Risk factor studies)
- Limited EBM recommendations
- Permanently ventilator dependent: 3 months of weaning
- attempts have failed (2001 ACCP)
  - Unless there is evidence for clearly irreversible disease
- Structured approach

Structural Approach

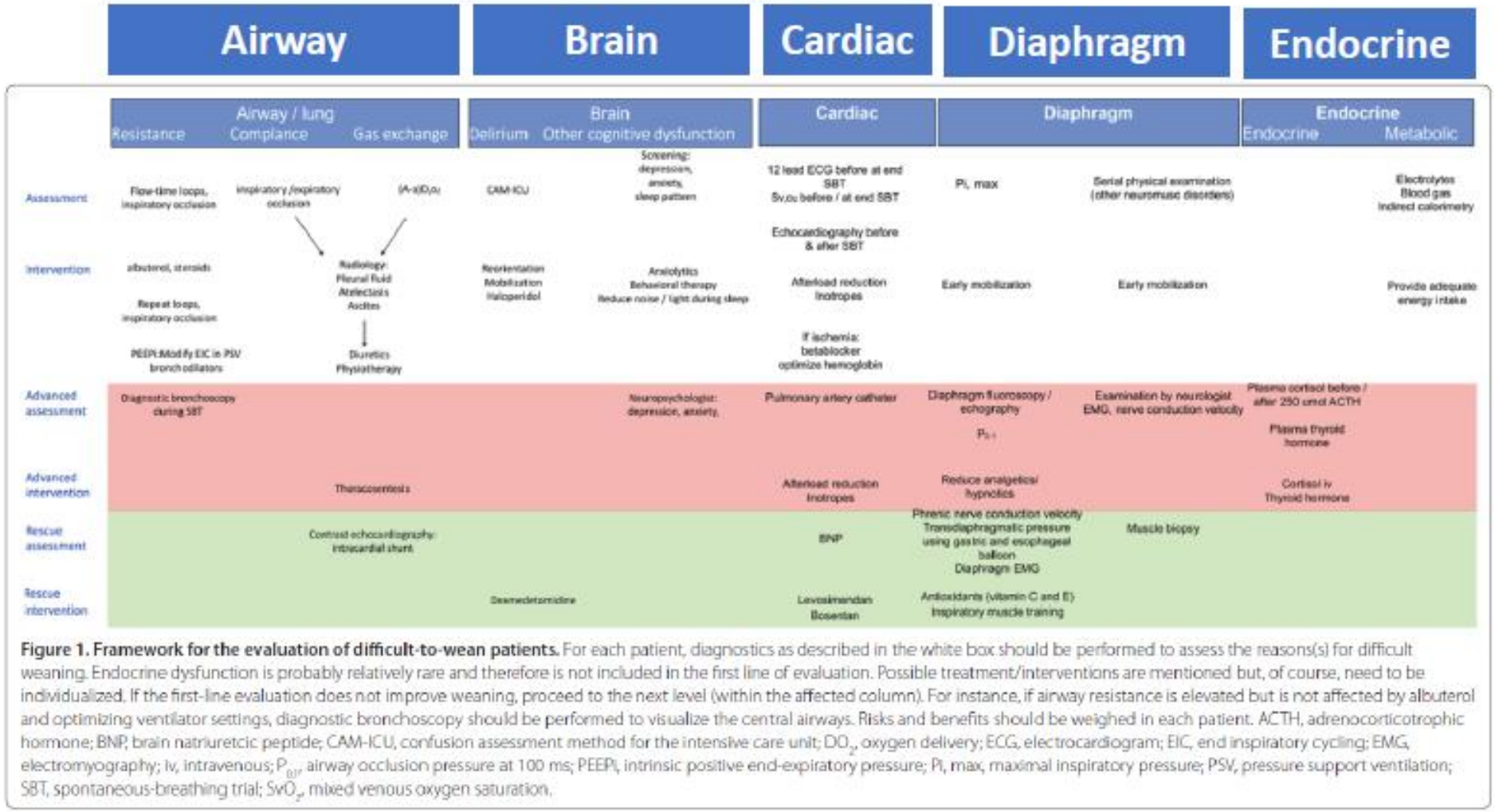


Figure 1. Framework for the evaluation of difficult-to-wean patients. For each patient, diagnostics as described in the white box should be performed to assess the reasons(s) for difficult weaning. Endocrine dysfunction is probably relatively rare and therefore is not included in the first line of evaluation. Possible treatment/interventions are mentioned but, of course, need to be individualized. If the first-line evaluation does not improve weaning, proceed to the next level (within the affected column). For instance, if airway resistance is elevated but is not affected by albuterol and optimizing ventilator settings, diagnostic bronchoscopy should be performed to visualize the central airways. Risks and benefits should be weighed in each patient. ACTH, adrenocorticotrophic hormone; BNP, brain natriuretcic peptide; CAM-ICU, confusion assessment method for the intensive care unit; DO_2, oxygen delivery; ECG, electrocardiogram; EIC, end inspiratory cycling; EMG, electromyography; iv, intravenous; $P_{0.1}$, airway occlusion pressure at 100 ms; PEEPi, intrinsic positive end-expiratory pressure; Pi, max, maximal inspiratory pressure; PSV, pressure support ventilation; SBT, spontaneous-breathing trial; SvO_2, mixed venous oxygen saturation.

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Take-home Message

- Use protocols for sedation and weaning.
- Use SBT-centered weaning strategy.
- Post-extubation respiratory support:
  - Preventive NIV for high risk group
  - High flow nasal cannula (Inconsistent recommendations)

Thank You for Listening

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