Weaning from Mechanical Ventilation

胸腔內科 · 內科加護病房

阮聖元 醫師

Objectives

- Epidemiology of ventilator weaning
- Usual process of weaning from MV
  - Readiness to wean (SBT)
  - SBT technique (mode, duration, failure criteria)
- Decision to extubate
- Protocolized weaning
- Difficult-to-wean patients

Epidemiology

- ✓ Mortality, successful liberation
- ✓ Prognosis & weaning process

JAMA®
The Journal of the American Medical Association

Characteristics and Outcomes in Adult Patients Receiving Mechanical Ventilation

A 28-Day International Study

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Context The outcome of patients receiving mechanical ventilation for particular indications has been studied, but the outcome in a large number of unselected, heterogeneous patients has not been reported.

Objective To determine the survival of patients receiving mechanical ventilation and the relative importance of factors influencing survival.

Design, Setting, and Subjects Prospective cohort of consecutive adult patients admitted to 361 intensive care units who received mechanical ventilation for more than 12 hours between March 1, 1998, and March 31, 1998. Data were collected on each patient at initiation of mechanical ventilation and daily throughout the course of mechanical ventilation for up to 28 days.

Main Outcome Measure All-cause mortality during intensive care unit stay.

Results Of the 15757 patients admitted, a total of 5183 (33%) received mechanical ventilation for a mean (SD) duration of 5.9 (7.2) days. The mean (SD) length of stay in the intensive care unit was 11.2 (13.7) days. Overall mortality rate in the intensive care unit was 30.7% (1590 patients) for the entire population, 52% (120) in patients who received ventilation because of acute respiratory distress syndrome, and 22% (115) in patients who received ventilation for an exacerbation of chronic obstructive pulmonary disease. Survival of unselected patients receiving mechanical ven-

N = 5183,

361 ICUs in 20 countries

Esteban. JAMA 2002

Outcomes

- Mortality: 30.7%
- Extubation: 55% (12% re-intubation)

	Mean	Median
Duration of MV	5.9	3
Duration of weaning	4.2	2
Length of ICU stay	11.2	7

Esteban. JAMA 2002

Mortality Determinant

Mortality determinant	OR
1 Factors at start of MV	2.98
2 Patient management	3.67
3 Complication during MV	8.71

Esteban. JAMA 2002

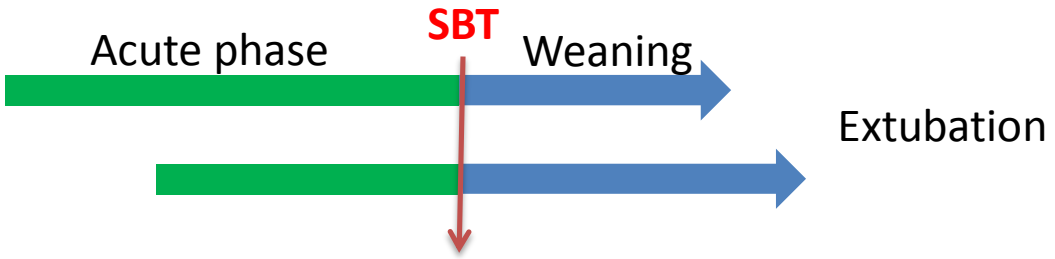
Mechanical Ventilation, Taiwan

	2013	2014	2015
New MV event	168,217	171,016	173,331
>21 days	25,217 (15%)	25,155 (15%)	24,576 (14%)
1-21d ICU stay, mean, d	5.7	5.7	5.5
Mortality	19%	19%	17%
22-63d Mortality	21.2%	21.6%	20.1%
Weaning success	44.9%	45.6%	48.1%

National Health Insurance Administration, Taiwan

Classification of Weaning Process

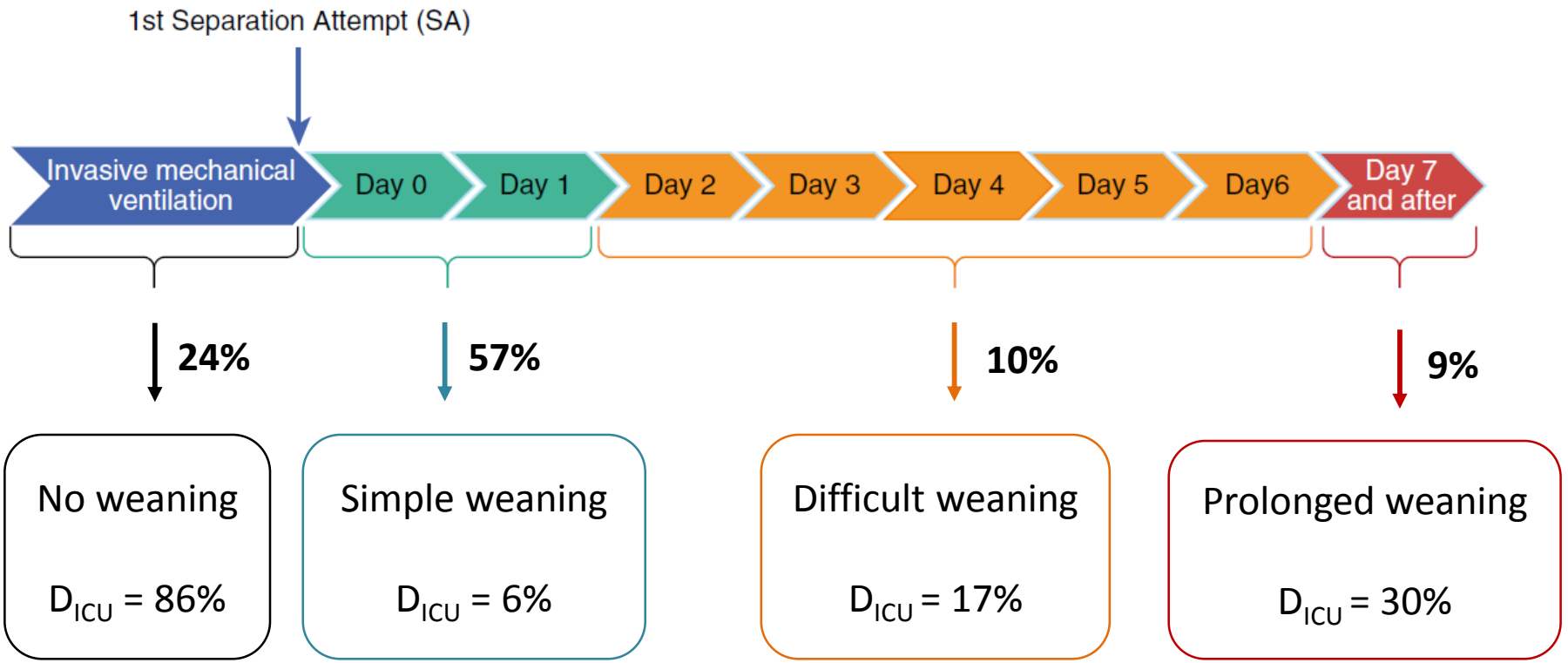
Category	Definition
Simple weaning	第1次SBT即通過,並成功拔管
Difficult weaning	第2次或第3次SBT才通過,並成功拔管,且拔管日離第1次SBT ≤7天
Prolonged weaning	至少3次SBT失敗,或 第1次SBT後超過7天仍無法拔管



Boles. Eur Respir J 2007

Define Prognosis by Weaning Process

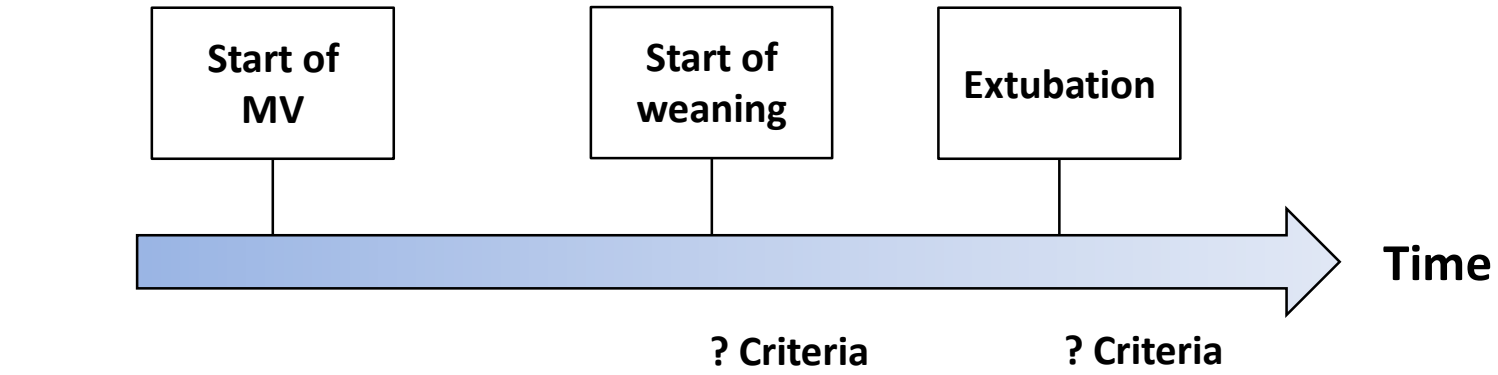
Multinational prospective study, n = 2709

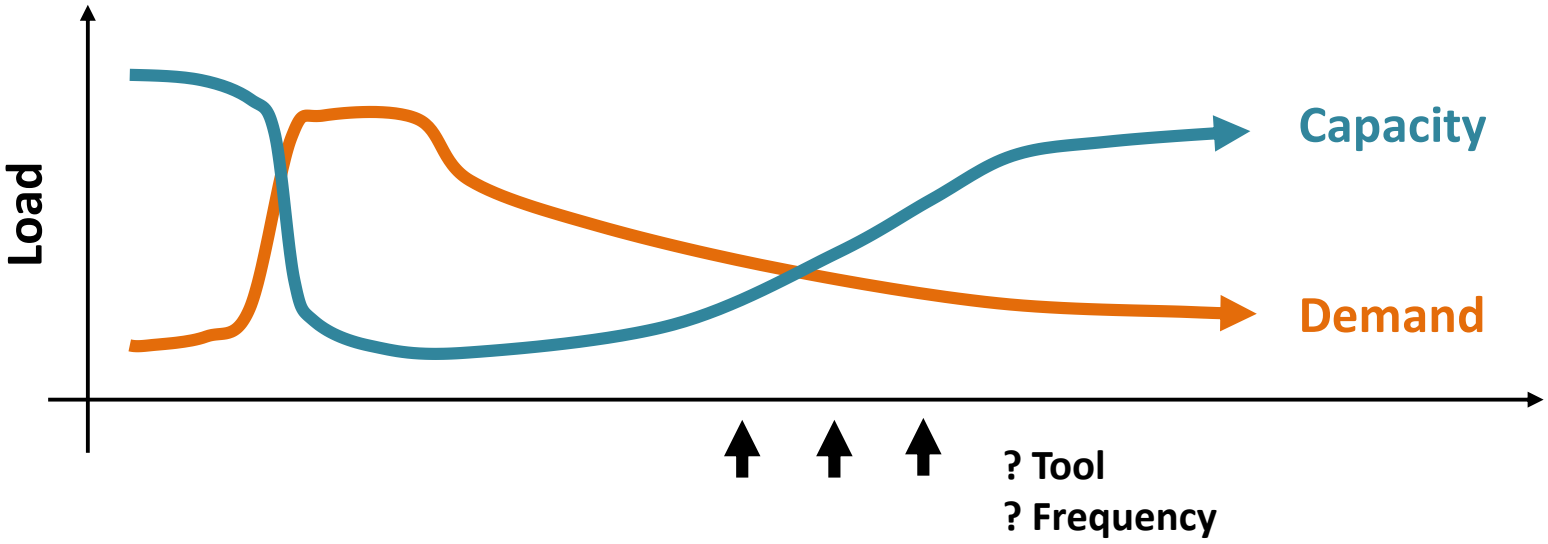


Beduneau. Am J Respir Crit Care Med. 2017

Usual Process of Weaning from MV

Clinical Course of Respiratory Failure





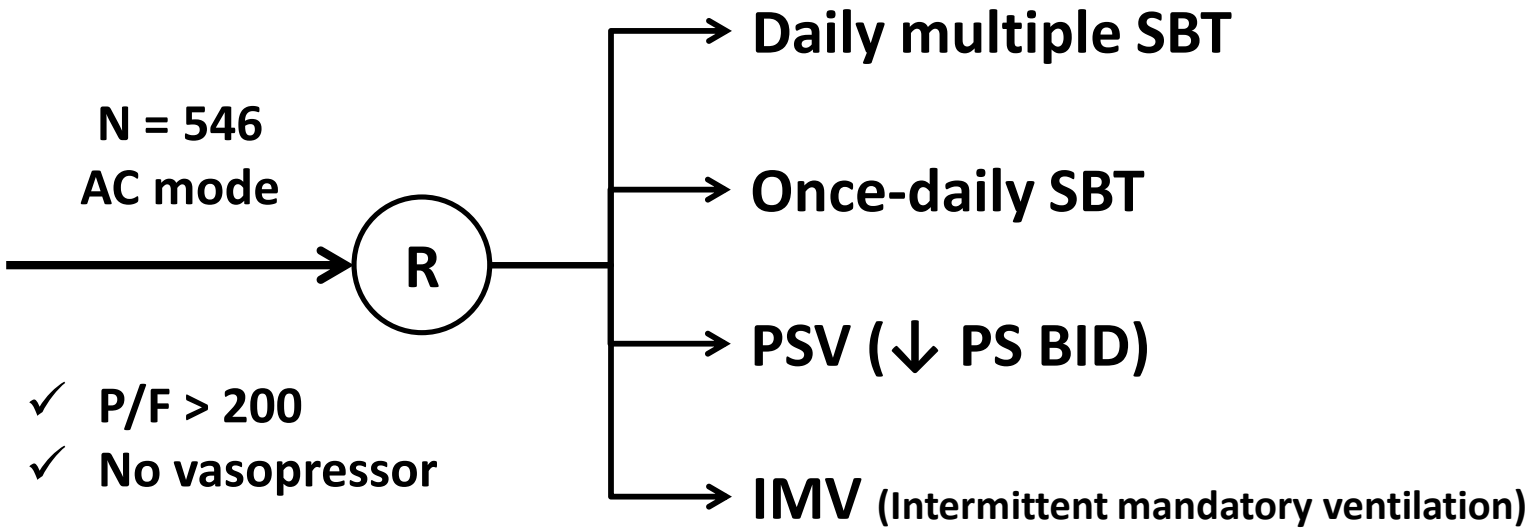
Tests (Predictors) of Weaning Success

- More than 60 predictors of weaning outcome published (Meade. CHEST 2001)
  - V_E, RSBI, $P_{0.1}$, CROP index, Pressure*time product……..
- Daily SBT is the best & most widely used approach
  - Once-daily SBT for discontinuation assessment is Grade A recommendation in ACCP guidelines.
  - Several techniques are used to conduct SBTs.

Comparison of Weaning Methods

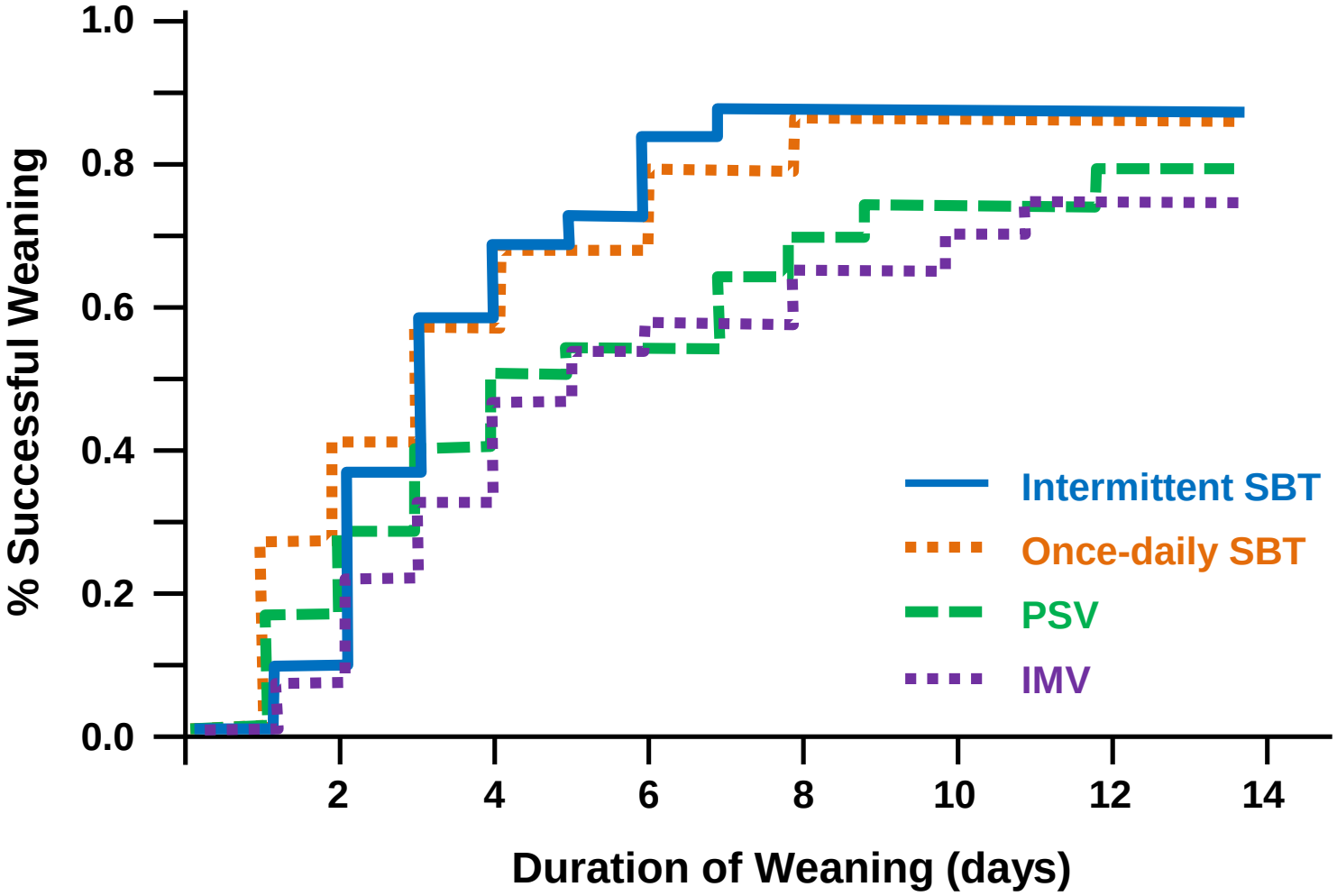
The NEW ENGLAND JOURNAL of MEDICINE

A COMPARISON OF FOUR METHODS OF WEANING PATIENTS FROM MECHANICAL VENTILATION



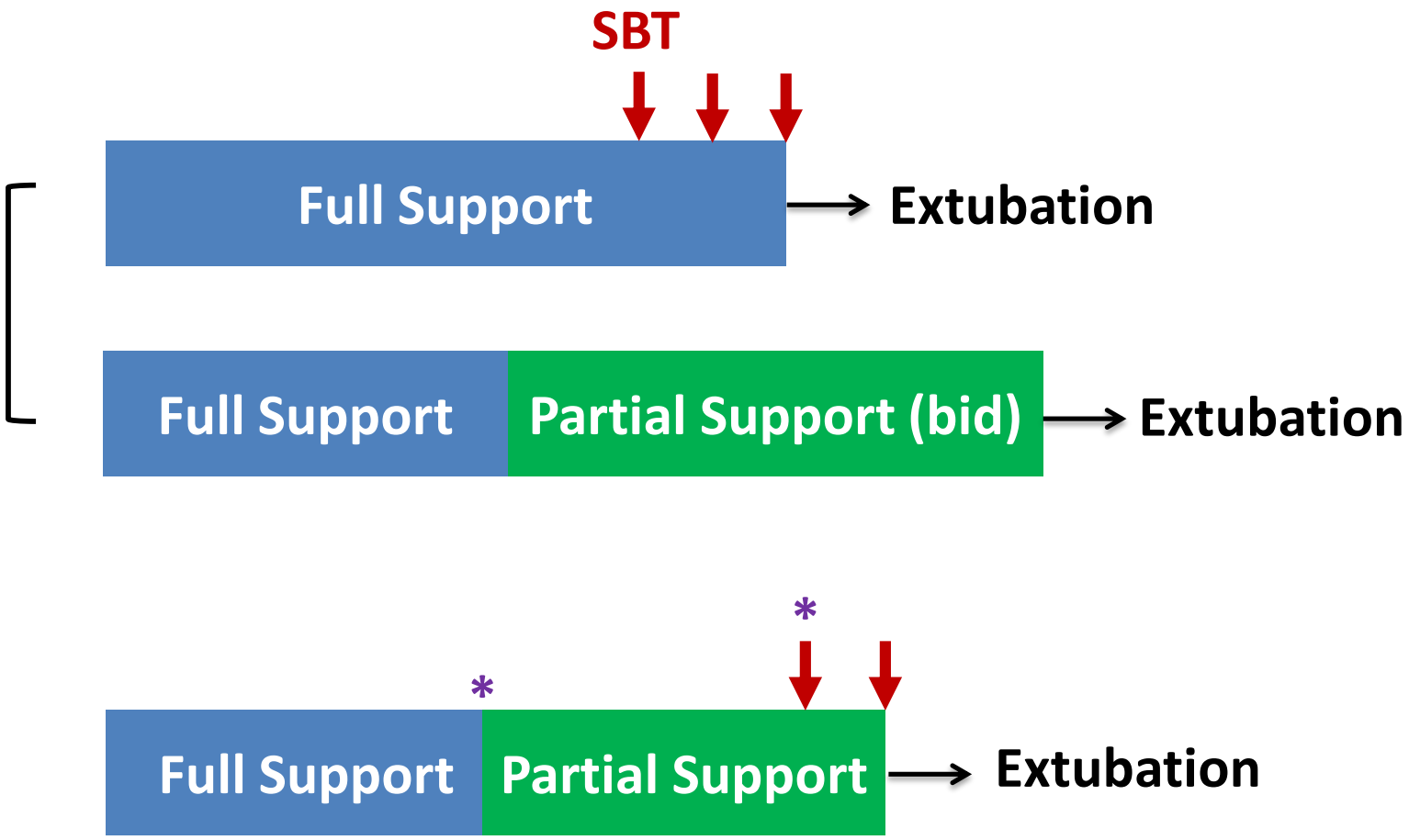
Esteban. N Engl J Med 1995

Comparison of Weaning Methods

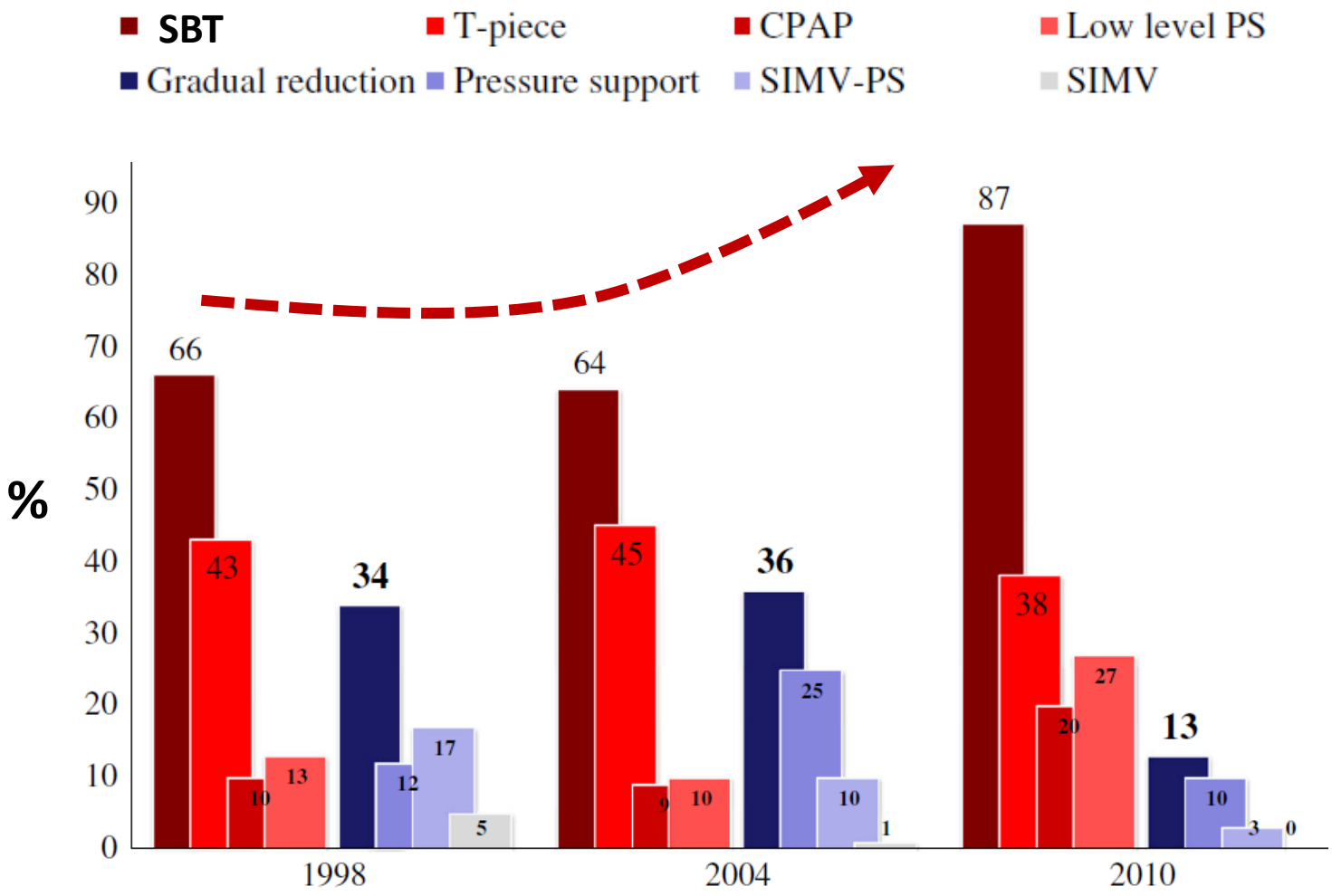


Esteban. N Engl J Med 1995

SBT *vs.* Non-SBT Protocols



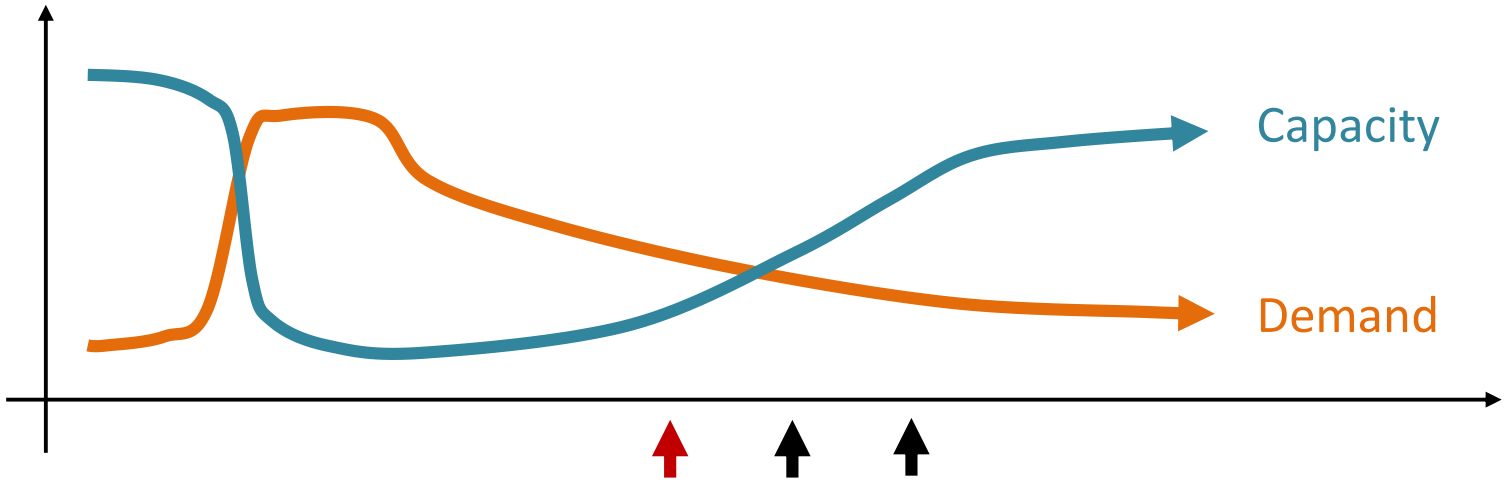
Evolution of Clinical Practice



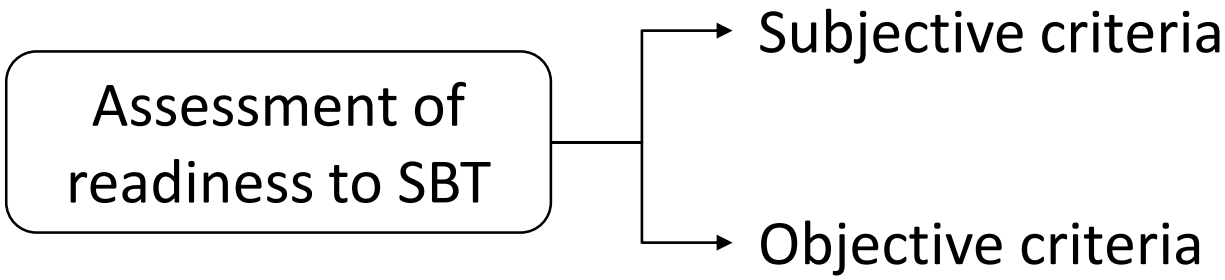
Frutos-Vivar. Intensive Care Med 2014

Assessment of Readiness to Wean

(Criteria to Start SBTs)



Assessment of Readiness to SBT



- Subjective criteria
  - Physician believes discontinuation possible
  - Resolution of disease acute phase

- Objective criteria

MacIntyre. Chest 2001
Boles. Eur Respir J 2007

Assessment of Readiness to SBT

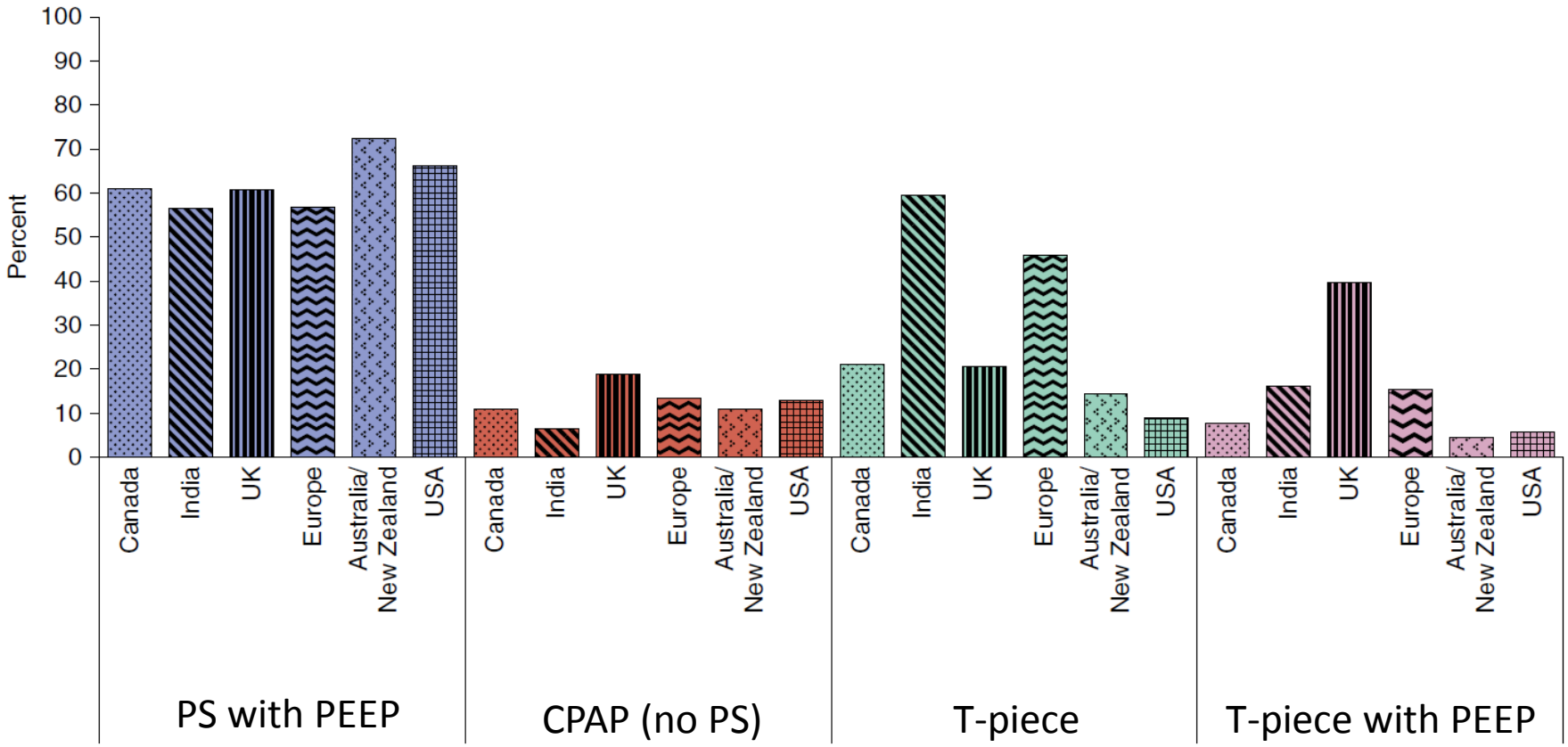
- Objective criteria (cont')
  - No vasopressor, HR < 140
  - Adequate mentation (GCS ≥ 13?)
  - Adequate oxygenation
    - P/F ratio ≥ 150 or FiO_2 ≤ 0.4
    - PEEP ≤ 8 cm H_2O
  - Adequate pulmonary function
    - RR ≤ 35/min
    - MIP ≤ -25
    - V_T > 5 mL/kg
    - RSBI < 105

MacIntyre. Chest 2001
Boles. Eur Respir J 2007

How to Conduct an SBT ?

- Mode
- Duration
- SBT Failure criteria

Practice Variation in SBT Techniques



Burns. Ann Am Thorac Soc. 2018

SBT Techniques

Inspiratory Pressure Augmentation (-)

- **T-piece**
- **External CPAP**
- **CPAP**

Inspiratory Pressure Augmentation (+)

- **PS 5-8 cm H_2O**
- **Automatic tube compensation**

SBT Duration

30’ ~ 120’

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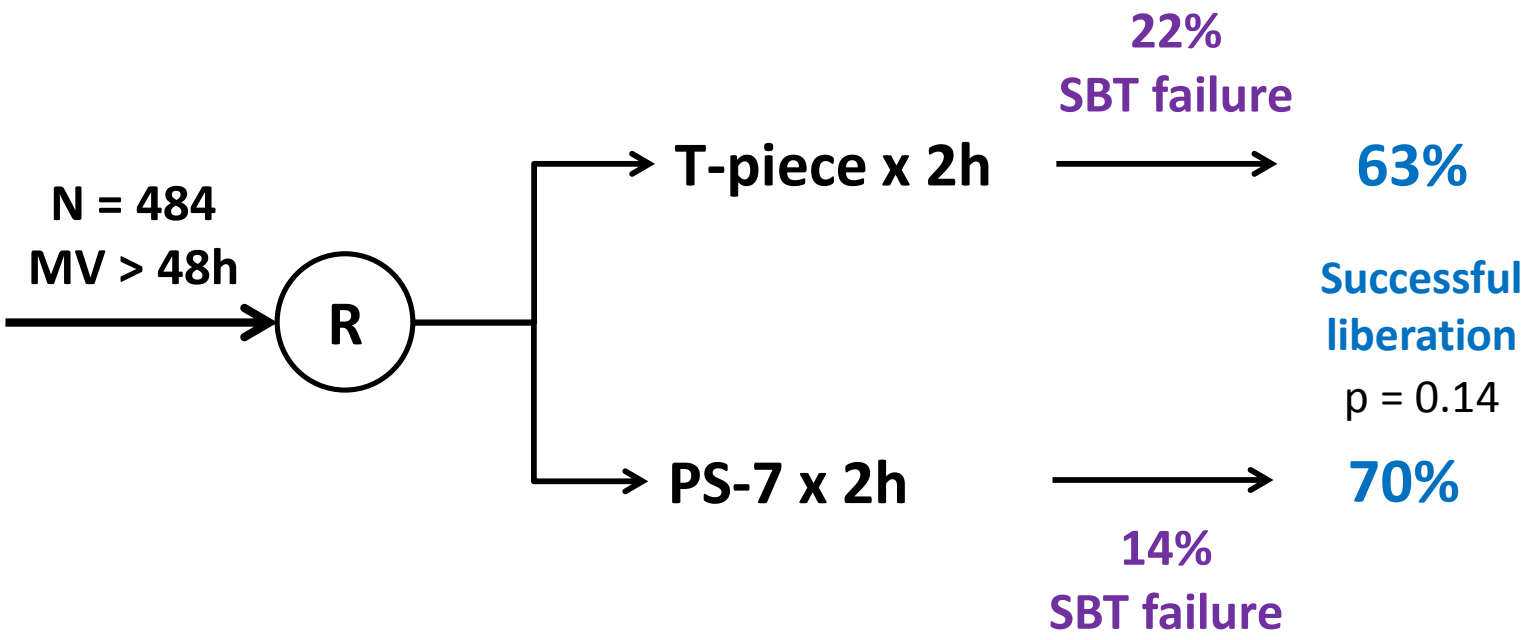
Respiratory and
Critical Care Medicine®

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



Esteban. Am J Respir Crit Care Med 1997

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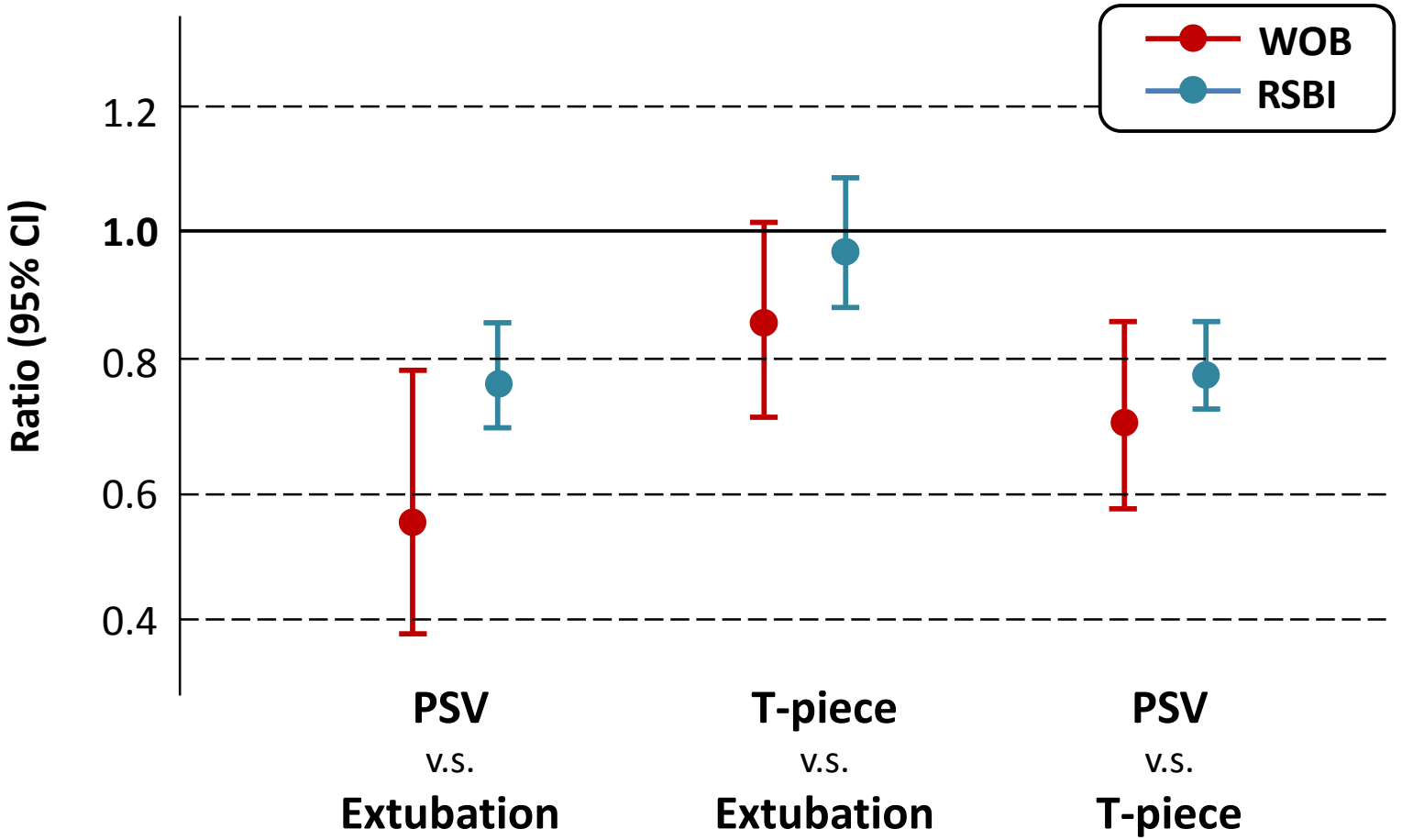
Critical Care Medicine®

Effort to Breathe with Various Spontaneous Breathing Trial Techniques

A Physiologic Meta-analysis



Sklar. Am J Respir Crit Care Med. 2017

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

Outcome	No. of Studies	No. of Patients	Pooled Risk Ratio
Successful SBT	8	1381	1.06 [1.01-1.12]
Extubation success	11	1904	1.06 [1.02-1.1]
Re-intubation	7	823	0.92 [0.66-1.26]
ICU mortality	5	725	0.81 [0.53-1.23]

Burns. Crit Care. 2017
Ladeira. Cochrane Database Syst Rev. 2014

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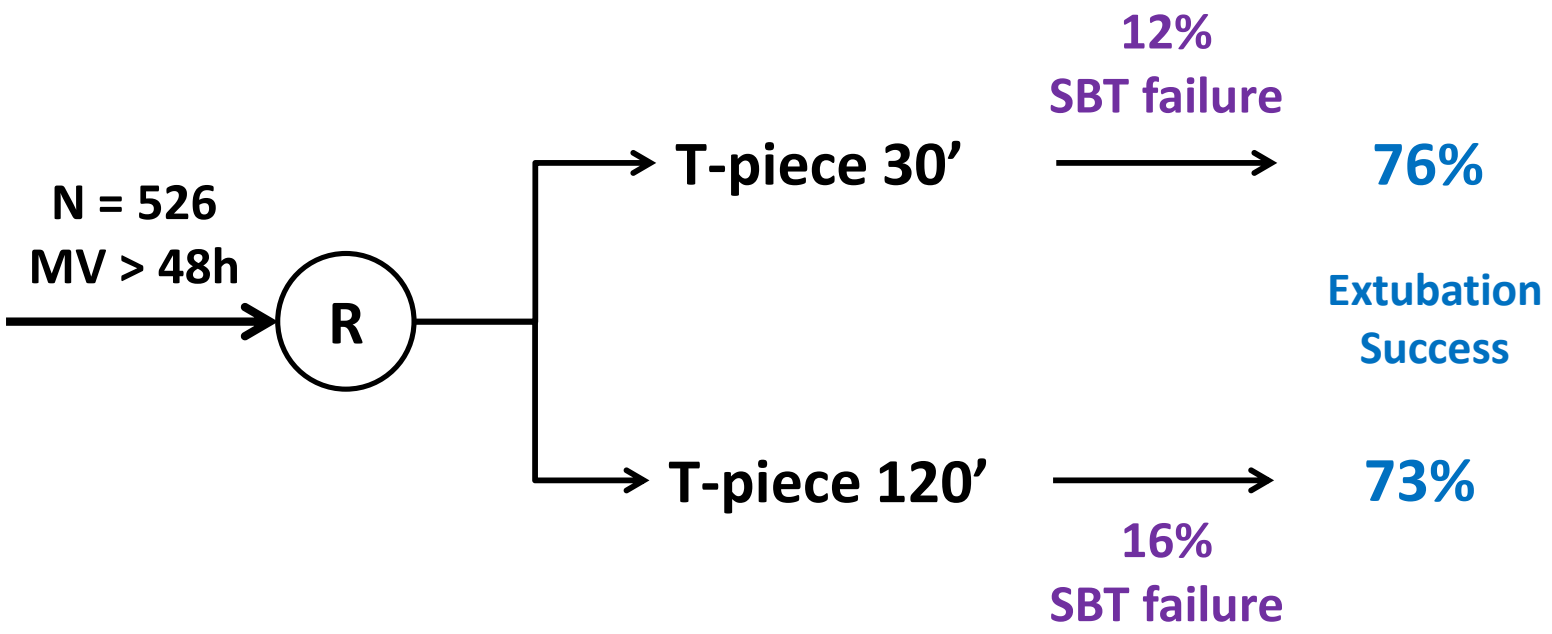
Effect of Spontaneous Breathing Trial Duration on Outcome of Attempts to Discontinue Mechanical Ventilation



Esteban. Am J Respir Crit Care Med 1999

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

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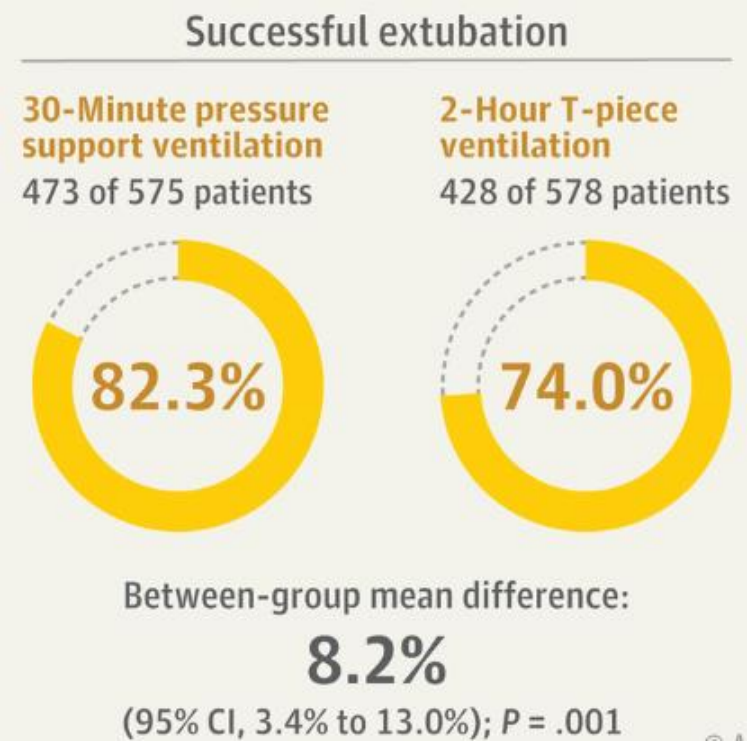
Effect of Pressure Support vs T-Piece Ventilation Strategies During Spontaneous Breathing Trials on Successful Extubation Among Patients Receiving Mechanical Ventilation

A Randomized Clinical Trial



Subirà. JAMA. 2019

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Respiratory and
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Extubation and the Myth of "Minimal Ventilator Settings"

Martin J. Tobin M.D.

I have been recently consulted about a number of patients who had been breathing comfortably at a low level of pressure support and positive end-expiratory pressure (PEEP) before extubation but, after extubation, developed immediate respiratory compromise followed by cardiorespiratory arrest and irreversible hypoxic brain injury. Analysis of these cases has motivated me to write this commentary.

The vast majority of patients can be successfully weaned from mechanical ventilation irrespective of whether this is executed by intermittent mandatory ventilation, pressure support, or T-tube trials. Randomized controlled trials have revealed differences in the

Tobin. Am J Respir Crit Care Med. 2012

Criteria of SBT Failure

- Subjective
  - Agitation, diaphoresis, cyanosis
  - Evidence of increasing effort

- Objective
  - SpO_2 < 90% or PaO_2 < 50-60 mmHg
  - $PaCO_2$ > 50 or ↑ > 8 mmHg
  - RR > 35/min or ↑ ≥ 50%
  - HR > 140/min or ↑ ≥ 20%
  - Systolic BP > 180/min or ↑ ≥ 20%

Boles. Eur Respir J 2007

Decision to Extubate

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

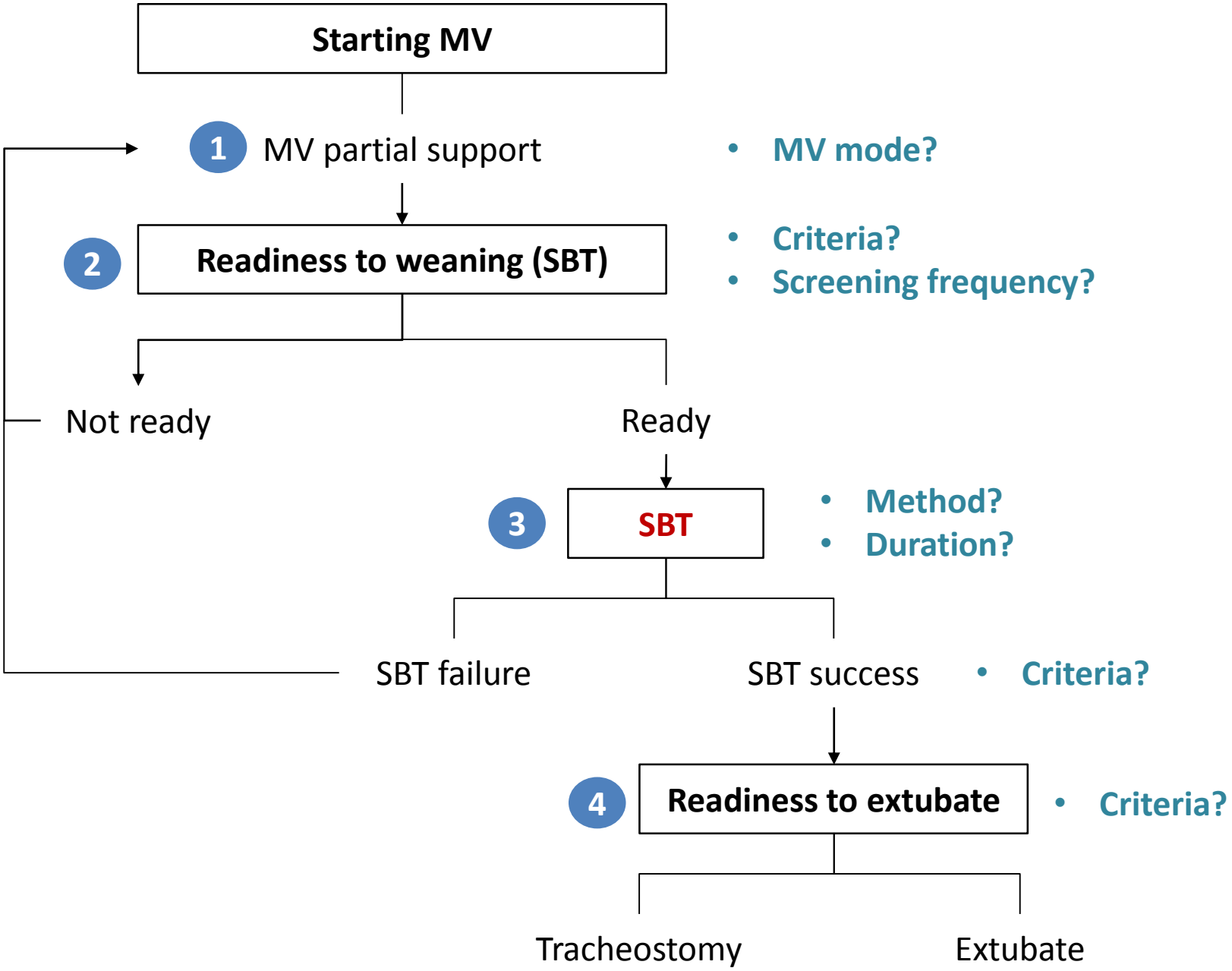
Epstein. Intensive Care Med 2002
Thille. Am J Respir Crit Care Med. 2013

Post-extubation Stridor

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

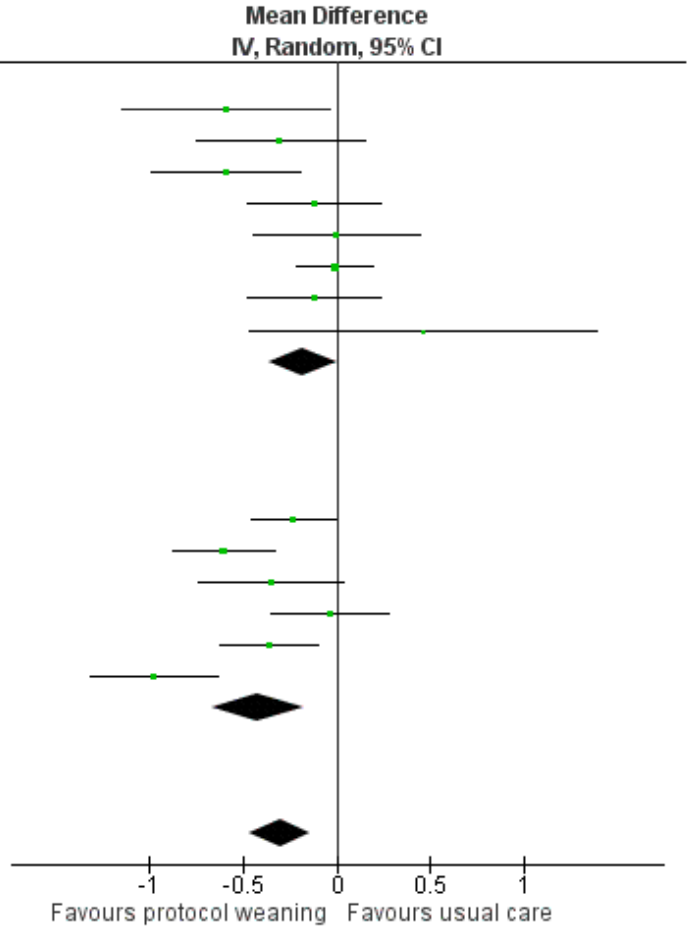
Girard. Am J Respir Crit Care Med. 2017

Protocolized Weaning


Starting MV
1
MV partial support
MV mode?
2
Readiness to weaning (SBT)
Criteria?
Screening frequency?
Not ready
Ready
3
SBT
Method?
Duration?
SBT failure
SBT success
Criteria?
4
Readiness to extubate
Criteria?
Tracheostomy
Extubate

Efficacy of Protocolized Weaning

Study or Subgroup	Protocolized weaning Mean	SD	Total	Usual care Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
1.3.1 SBT protocol								
Chaiwat 2010	3.69	1.2	51	4.28	1.59	49	4.8%	-0.59 [-1.14, -0.04]
de Carvalho Oliveira 2002	4.16	0.83	20	4.46	0.6	20	6.0%	-0.30 [-0.75, 0.15]
Ely 1996	4.18	2.1	149	4.77	1.3	151	6.8%	-0.59 [-0.99, -0.19]
Krishnan 2004	4.1	1.32	115	4.22	1.37	109	7.4%	-0.12 [-0.47, 0.23]
Namen 2001	4.97	0.75	49	4.97	1.4	51	6.2%	0.00 [-0.44, 0.44]
Navalesi 2008	4.328	0.92	165	4.338	0.96	153	9.7%	-0.01 [-0.22, 0.20]
Ogica 2007	4.62	0.73	33	4.74	0.76	37	7.4%	-0.12 [-0.47, 0.23]
Piotto 2011	4.27	1.39	18	3.81	1.44	18	2.4%	0.46 [-0.46, 1.38]
Subtotal (95% CI)			**600**			**588**	**50.7%**	**-0.18 [-0.36, 0.00]**
Heterogeneity: Tau² = 0.02; Chi² = 11.53, df = 7 (P = 0.12); I² = 39%								
Test for overall effect: Z = 1.95 (P = 0.05)								
1.3.2 Stepwise reduction protocol								
Kollef 1997	3.33	1.2	179	3.56	0.96	178	9.4%	-0.23 [-0.46, -0.00]
Marelich 2000	4.22	1.2	166	4.82	1.36	169	8.6%	-0.60 [-0.87, -0.33]
Roh 2012	5.1	1.08	61	5.45	1.07	61	7.0%	-0.35 [-0.73, 0.03]
Rose 2008	4.793	0.752	51	4.828	0.863	51	8.0%	-0.04 [-0.35, 0.28]
Simeone 2002	1.72	0.54	24	2.08	0.39	25	8.8%	-0.36 [-0.62, -0.10]
Stahl 2009	4.91	0.81	26	5.88	0.35	26	7.6%	-0.97 [-1.31, -0.63]
Subtotal (95% CI)			**507**			**510**	**49.3%**	**-0.42 [-0.66, -0.18]**
Heterogeneity: Tau² = 0.07; Chi² = 20.41, df = 5 (P = 0.001); I² = 75%								
Test for overall effect: Z = 3.39 (P = 0.0007)								
Total (95% CI)			**1107**			**1098**	**100.0%**	**-0.30 [-0.46, -0.14]**
Heterogeneity: Tau² = 0.06; Chi² = 39.85, df = 13 (P = 0.0001); I² = 67%								
Test for overall effect: Z = 3.67 (P = 0.0002)								
Test for subgroup differences: Chi² = 2.42, df = 1 (P = 0.12), I² = 58.6%								



Blackwood. Cochrane Database Syst Rev. 2014

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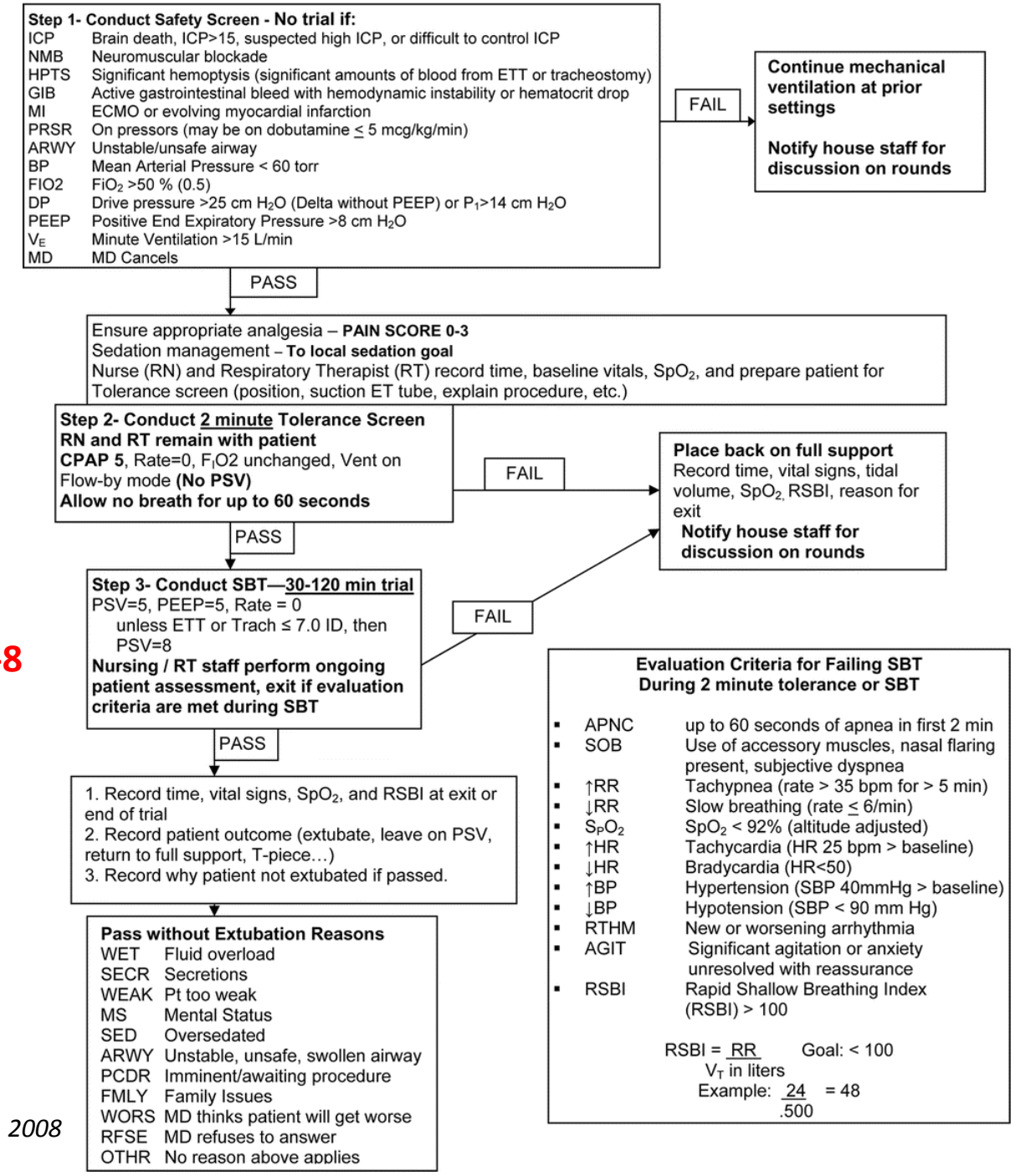
ATS/CHEST recommendation. We suggest managing acutely hospitalized adults who have been mechanically ventilated for more than 24 hours with a ventilator liberation protocol (Conditional recommendation).

Schmidt. Am J Respir Crit Care Med. 2017

Readiness to wean (SBT)

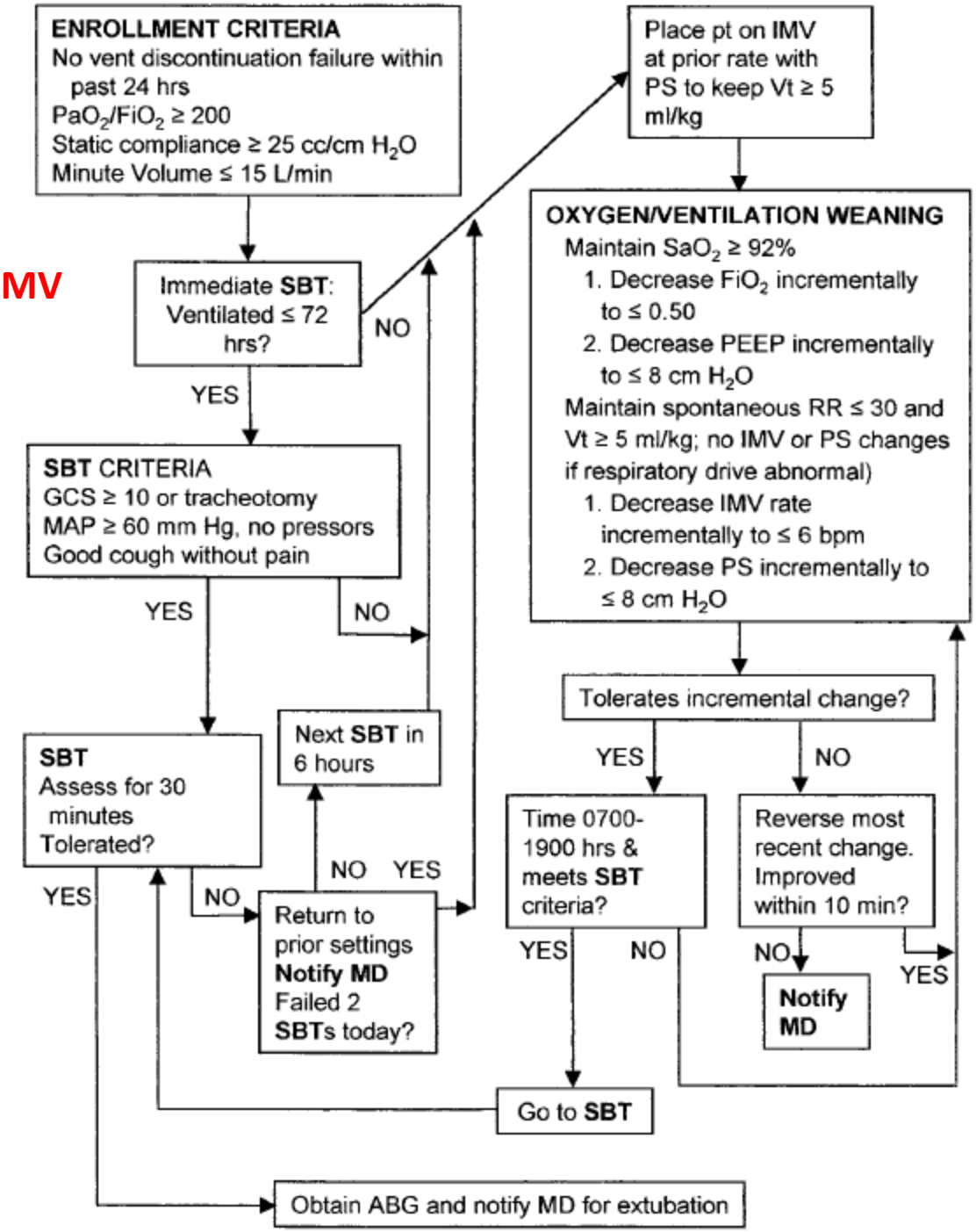
2’ CPAP 5

SBT = PS 5-8



Robertson. Crit Care Med. 2008

Stratified by MV days



Stepwise reduction protocol

Marelich. Chest. 2000

Key Components of a Weaning Protocol

- Criteria for readiness to SBT (daily screening)
  - SBT safety screening
  - Stepwise reduction protocol
- Once daily SBT
  - Method & duration
  - Criteria of SBT failure
- Extubation criteria
- Criteria for preventive NIV

Prolonged Mechanical Ventilation

&

Difficult-To-Wean

Facts about Difficult-To-Wean

- Epidemiology
  - PMV in Taiwan: 15%
  - Difficult & prolonged weaning: 20%
  - Associated with high mortality
- Limited EBM recommendations
- Permanently ventilator-dependent: 3 months of weaning attempts have failed
  - Unless there is evidence for clearly irreversible disease
  - ACCP 2001 guidelines
- Structural approach

Structural Approach (ABCDE)

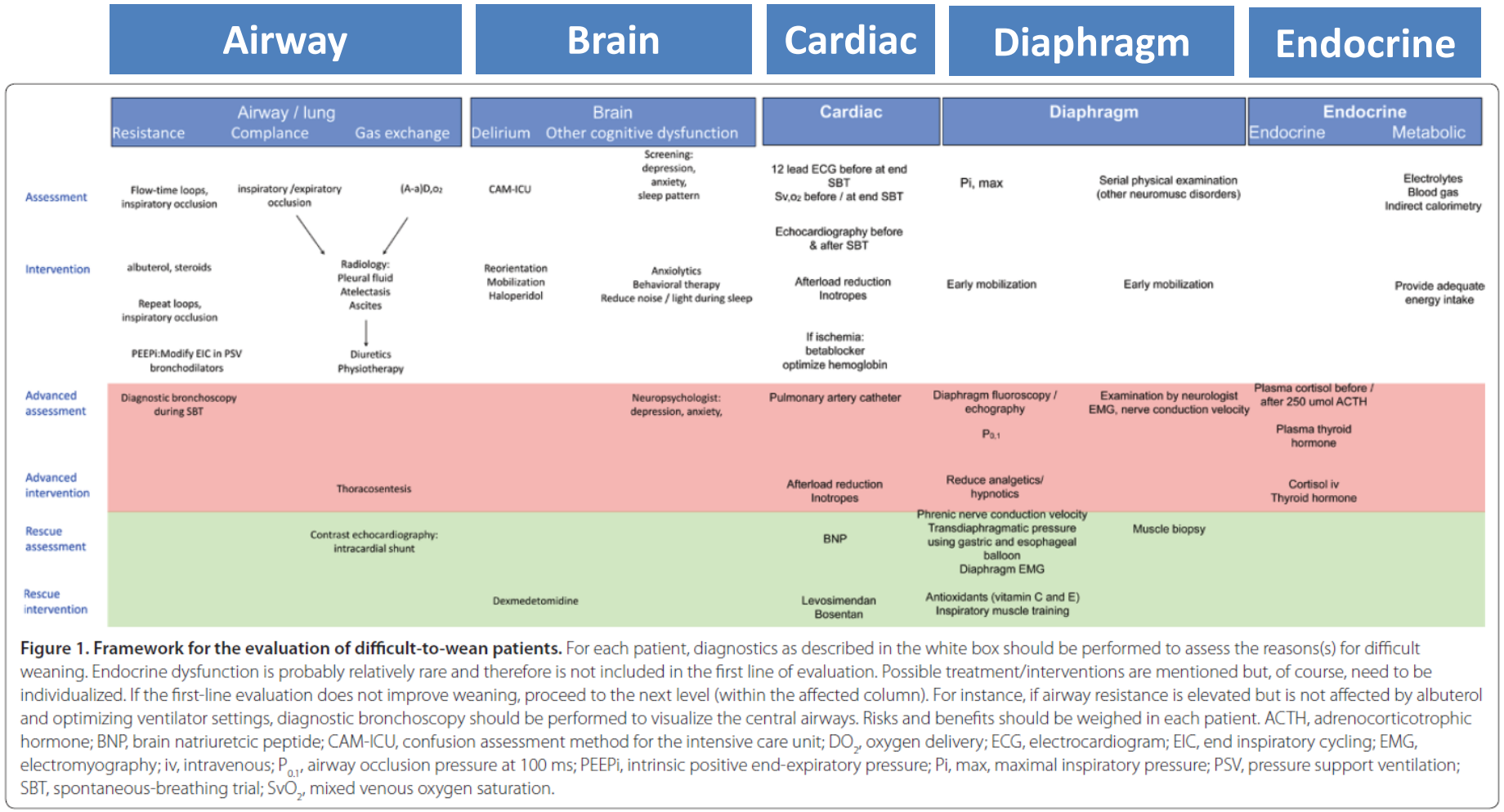
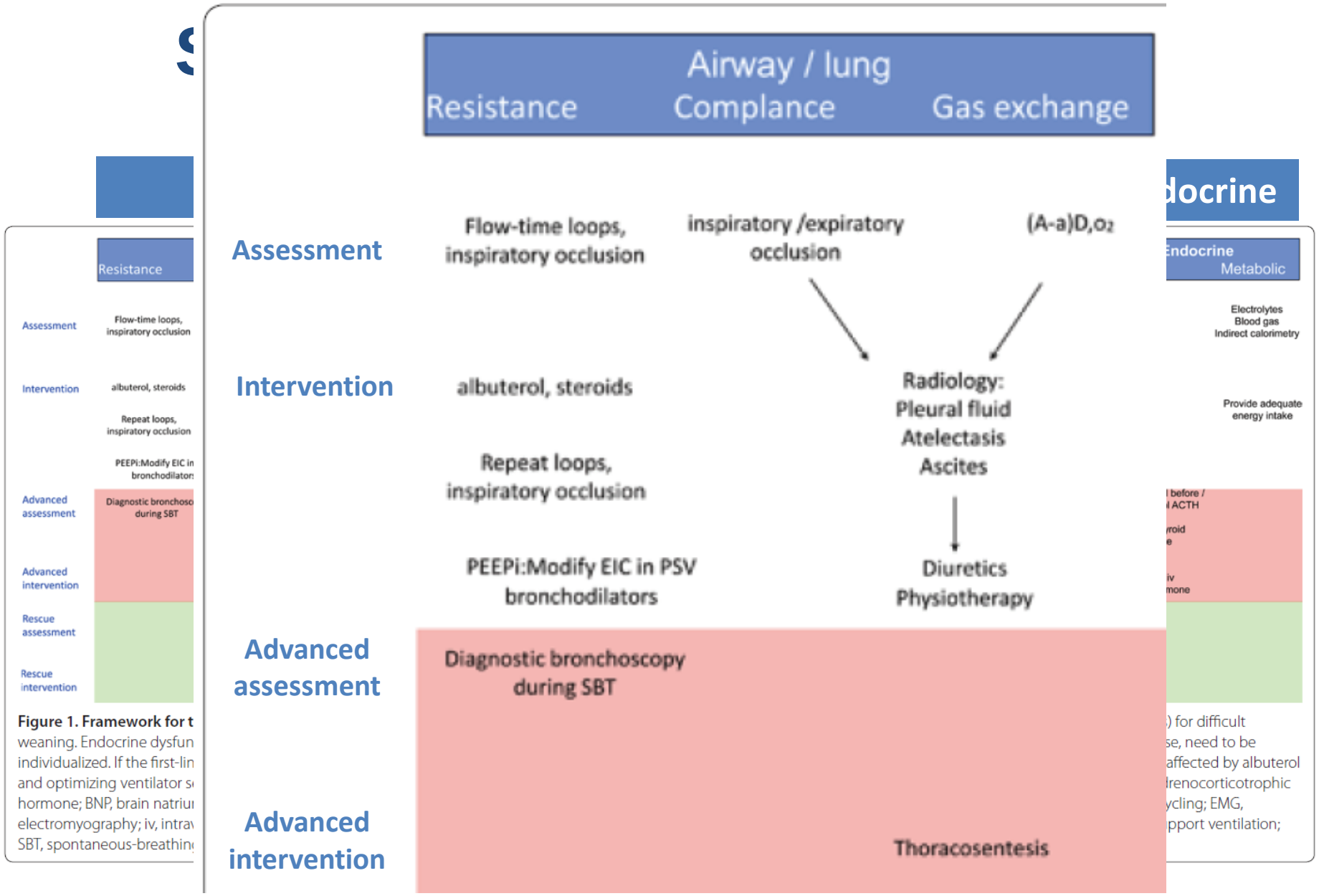


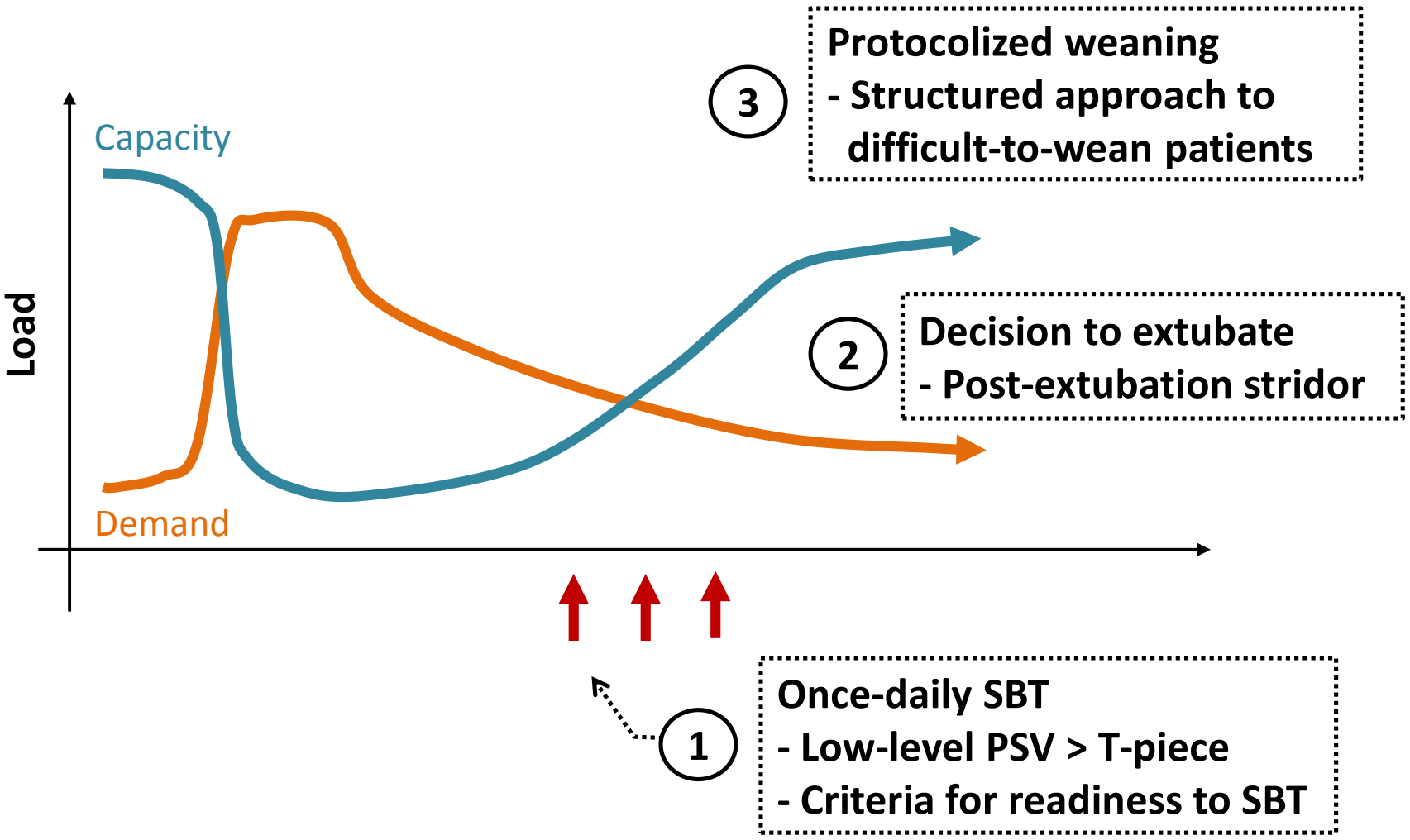
Figure 1. Framework for the evaluation of difficult-to-wean patients. For each patient, diagnostics as described in the white box should be performed to assess the reasons(s) for difficult weaning. Endocrine dysfunction is probably relatively rare and therefore is not included in the first line of evaluation. 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.

Heunks. Crit care. 2010



Heunks. Crit care. 2010

Take-home Messages



Thank You for Listening

阮聖元

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