Weaning

Definition

The process of liberating patients from the ventilator, begins as soon as the patient is intubated by tailoring settings to the needs of the patient

Hall J, Wood L JAMA 1987

Weaning is important

- *weaning tends to be delayed, exposing the patient to unnecessary discomfort and increased risk of complications*

Subjects receiving prolonged mechanical ventilation account for 6% of all ventilated patients but consume 37% of intensive care unit (ICU) resources

Weaning is Delayed

Unplanned extubation 179 (3.4%) patients

reintubation was required in 74 (41.3%)

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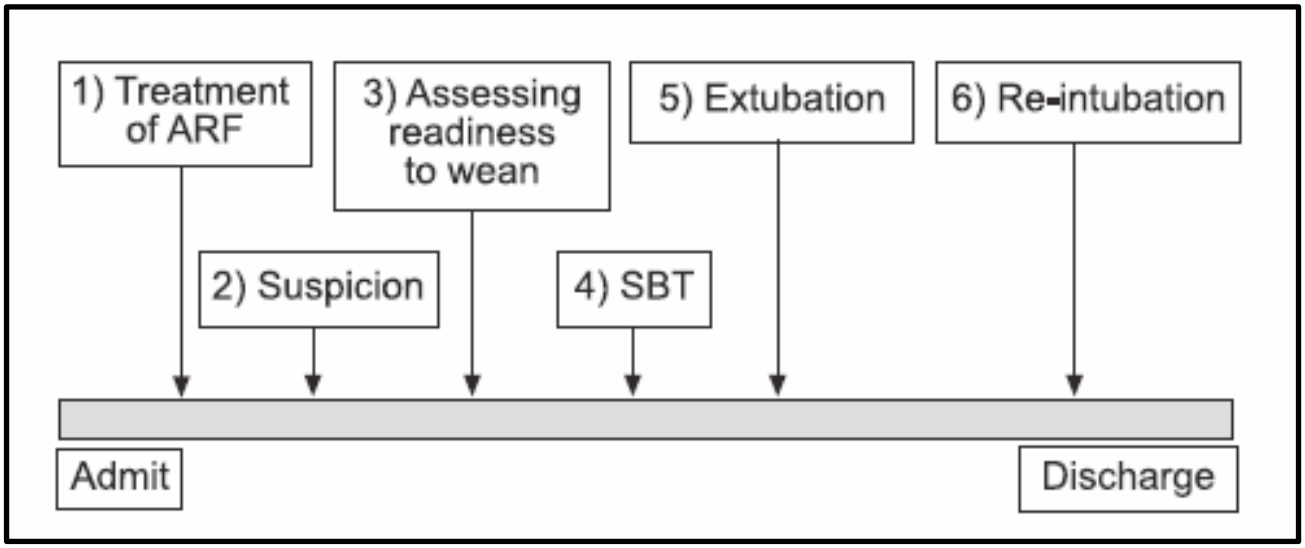
Characteristics and Outcomes in Adult Patients Receiving Mechanical Ventilation

A 28-Day International Study

JAMA, January 16, 2002—Vol 287, No. 3

Admission to Discharge



The weaning process begins with the first SBT, defined as a T-tube trial or a low-level pressure support (<8 cmH2O)

Definitions

Treatment of ARF	Period of care and resolution of the disorder that caused respiratory failure and prompted mechanical ventilation
Suspicion	The point at which the clinician suspects the patient may be ready to begin the weaning process
Assessing readiness to wean	Daily testing of physiological measures of readiness for weaning (MIP, f_R/V_T) to determine probability of weaning success
Spontaneous breathing trial	Assessment of the patient's ability to breathe spontaneously
Extubation	Removal of the endotracheal tube
Reintubation	Replacement of the endotracheal tube for patients who are unable to sustain spontaneous ventilation

Pooled Analysis of Weaning trials

First author [Ref.]	Yr	Subjects	Failed initial SBT	Passed Initial SBT	Re-intubated	Total failed weaning	Successful weaning
Farias [24]	2001	257	56 (22)	201	28 (14)	84 (32.7)	173
Esteban [22]	1999	526	73 (14)	453	61 (13)	134 (25.5)	392
Vallverdu [17]	1998	217	69 (32)	148	23 (16)	92 (42.4)	125
Esteban [25]	1997	484	87 (18)	397	74 (19)	161 (33.3)	323
Esteban [16]	1995	546	130 (24)	416	58 (14)	188 (34.4)	358
Brochard [18]	1994	456	109 (24)	347	8 (3)	117 (25.6)	339
Total		2486	524/2486 (21%)	1962/2486 (79%)	252/1962 (13%)	776 (31.2%)	1710/2486 (68.8%)

Data are presented as n or n (%), unless otherwise stated. SBT: spontaneous breathing trial

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.

The New England Journal of Medicine

Design of the study

- Daily screening of respiratory function
  - $PaO_2/FiO_2 > 200$
  - $PEEP < 5\ cmH_2O$
  - $f/V_T < 105$
  - No vasopressors or sedatives
- A 2 hour trial of spontaneous breathing
- Notification of the physician of the successful results

The New England Journal of Medicine
1864 · December 19, 1996

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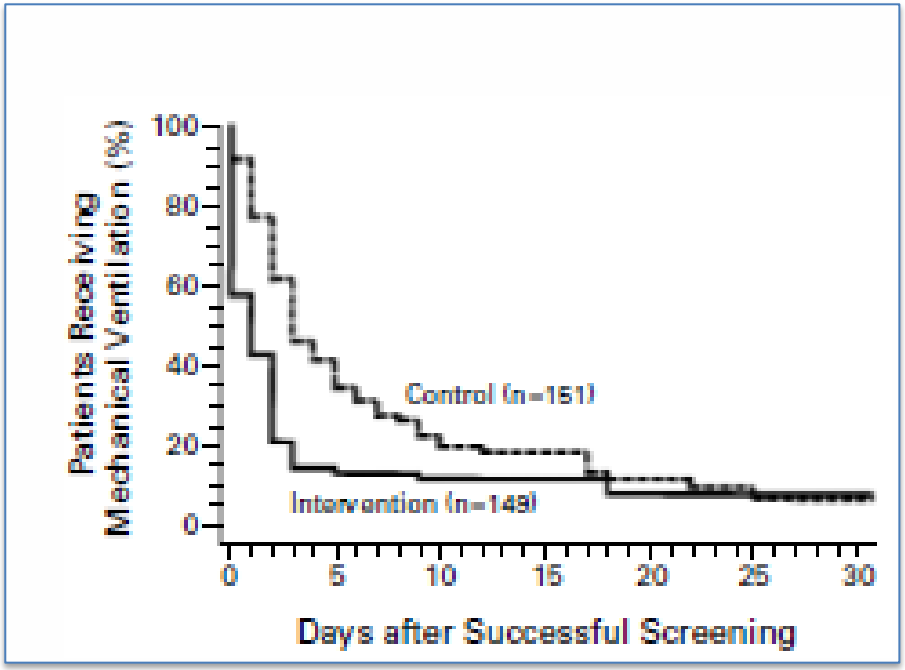

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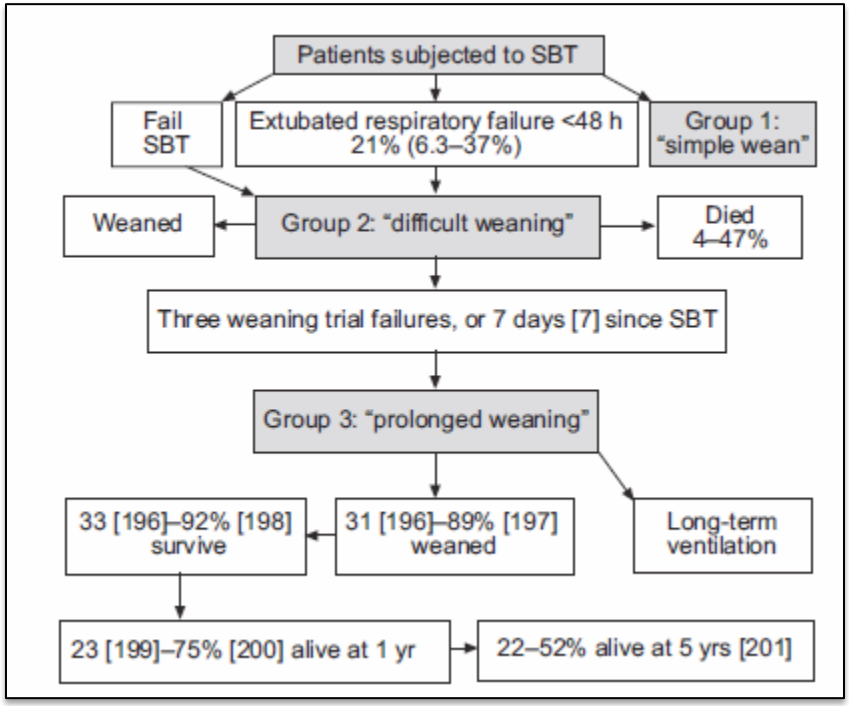
TABLE 3. COMPLICATIONS OF RESPIRATORY FAILURE.

COMPLICATION	INTERVENTION GROUP (N = 149)	CONTROL GROUP (N = 151)	P VALUE
	no. of patients (%)		
Any	30 (20)	62 (41)	0.001
Reintubation within 48 hr	5 (3)	12 (8)	0.08
Any reintubation	6 (4)	15 (10)	0.04
Self-extubation	2 (1)	5 (3)	0.25
Tracheostomy	13 (9)	22 (15)	0.10
Mechanical ventilation for >21 days	9 (6)	20 (13)	0.04

Weaning classification

Simple weaning	Patients who proceed from the initiation of weaning to successful extubation on the first attempt without difficulty
Difficult weaning	Patients who fail initial weaning and require up to three spontaneous breathing trials or as long as 7 days from the first spontaneous breathing trial to achieve successful weaning
Prolonged weaning	Patients who fail at least three weaning attempts or require >7 days of weaning after the first spontaneous breathing trial

Mortality and prolonged weaning



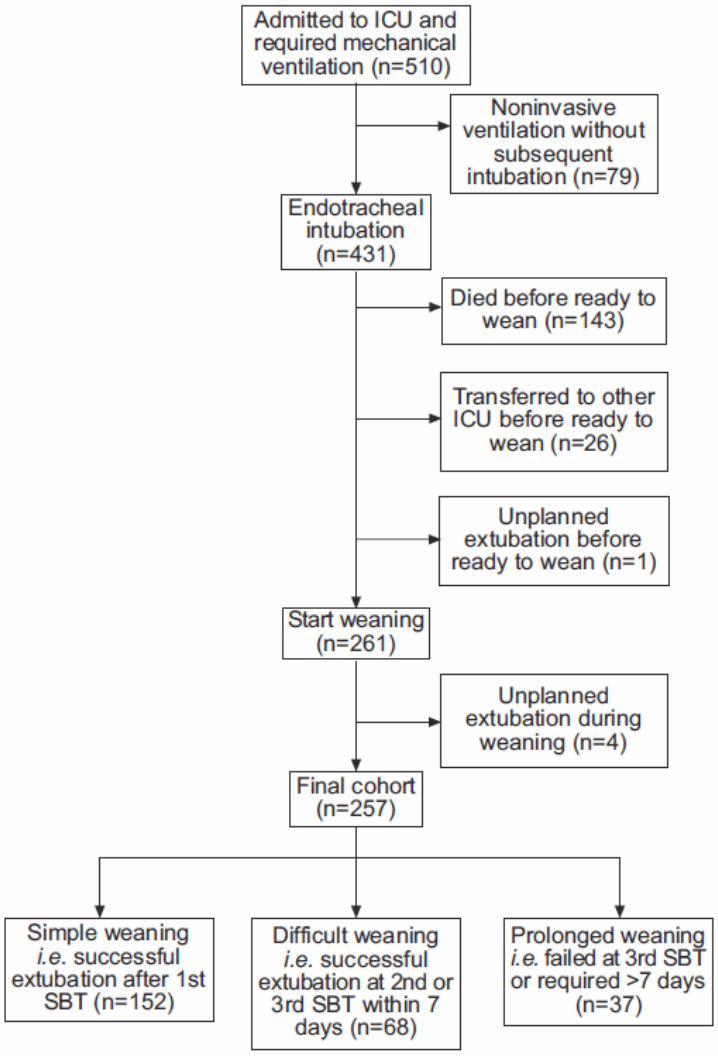
Incidence and outcome of weaning from mechanical ventilation according to new categories

G-C. Funk*, S. Anders*, M-K. Breyer*, O.C. Burghuber*, G. Edelmann#, W. Heindl*, G. Hinterholzer¶, R. Kohansal*, R. Schuster+, A. Schwarzmaier-D'Assie§, A. Valentin§ and S. Hartl*

Characteristics of the patient

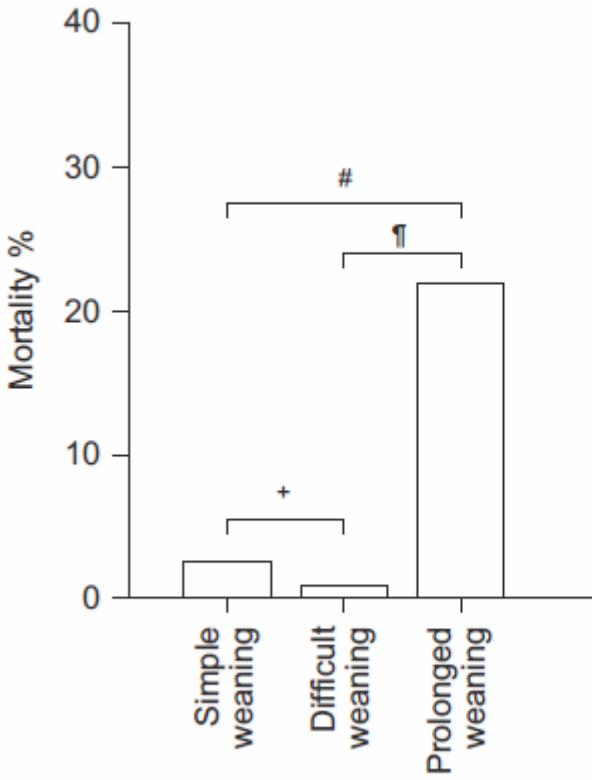
TABLE 2 Baseline characteristics of the 257 patients who started weaning, stratified by weaning category

	Simple weaning	Difficult weaning	Prolonged weaning	p-value
Subjects	152 (59)	68 (26)	37 (14)	
Age yrs	60±17	61±13	64±12	0.5786
Males	81 (53)	33 (49)	22 (59)	0.8831
Number of comorbidities on ICU admission	1 (0–1)	0 (0–1)	1 (0–1.5)	0.4341
Types of comorbidity				
Non-metastasising malignancy	17 (11)	3 (4)	1 (3)	0.0402#
Chronic renal failure	10 (7)	7 (10)	4 (11)	0.2851
Chronic respiratory failure	19 (13)	11 (16)	10 (27)	0.0346¶
Chronic heart failure	11 (7)	0 (0)	1 (3)	0.0616
Insulin-dependent diabetes	8 (5)	3 (4)	5 (14)	0.1391
Types of ICU admission				
Medical	88 (58)	43 (63)	25 (68)	0.2348
Surgery: elective	22 (14)	8 (12)	4 (11)	0.4832
Surgery: emergency	40 (26)	17 (25)	8 (22)	0.5675
SAPS II score	45±19	48±18	45±16	0.5552
SAPS II predicted mortality %	39±29	42±29	37±28	0.5582
Cause of admission				
Gastrointestinal surgery	10 (7)	10 (15)	5 (14)	0.0756
Cardiovascular surgery	0 (0)	0 (0)	1 (3)	0.0479
Neurosurgery	18 (12)	5 (7)	5 (14)	0.8977
Other types of surgery	22 (14)	3 (4)	0 (0)	0.0019+
Cardiovascular disease	21 (14)	8 (12)	4 (11)	0.5699
Neurological disease	23 (15)	11 (16)	3 (8)	0.4038
Respiratory disease	25 (16)	17 (25)	14 (38)	0.0038§


Admitted to ICU and required mechanical ventilation (n=510)
Noninvasive ventilation without subsequent intubation (n=79)
Endotracheal intubation (n=431)
Died before ready to wean (n=143)
Transferred to other ICU before ready to wean (n=26)
Unplanned extubation before ready to wean (n=1)
Start weaning (n=261)
Unplanned extubation during weaning (n=4)
Final cohort (n=257)
Simple weaning *i.e.* successful extubation after 1st SBT (n=152)
Difficult weaning *i.e.* successful extubation at 2nd or 3rd SBT within 7 days (n=68)
Prolonged weaning *i.e.* failed at 3rd SBT or required >7 days (n=37)

60% 27% 13%

Mortality and weaning



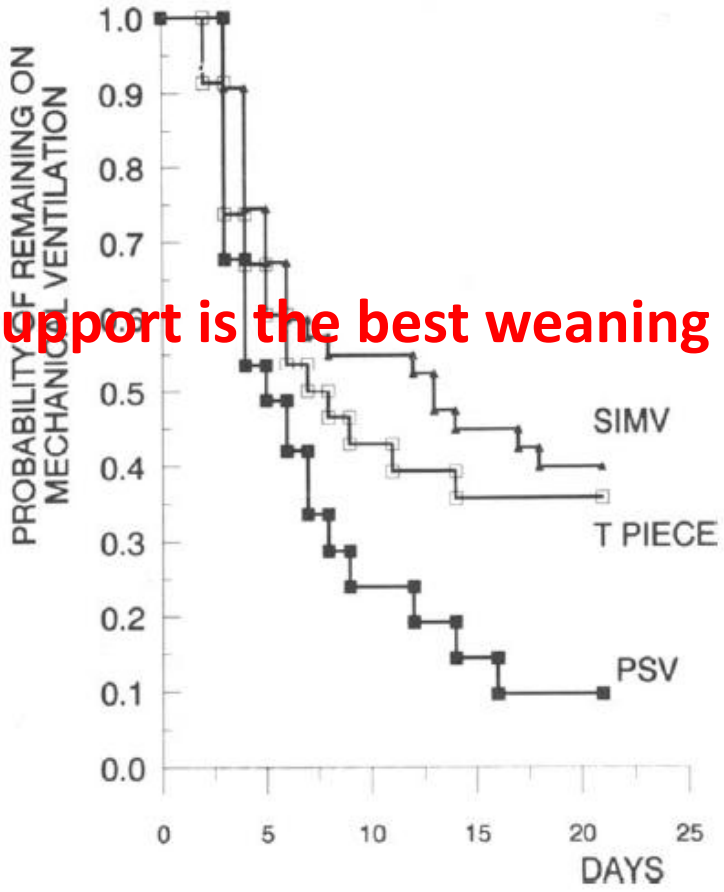
Which mode is best for SBT

- Pressure support
- T piece trial
- Synchronized intermittent Mandatory Ventilation

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

LAURENT BROCHARD, ALAIN RAUSS, SALVADOR BENITO, GIORGIO CONTI, JORDI MANCEBO, NOURREDINE REKIK, ALESSANDRO GASPARETTO, and FRANÇOIS LEMAIRE

Pressure support is the best weaning method



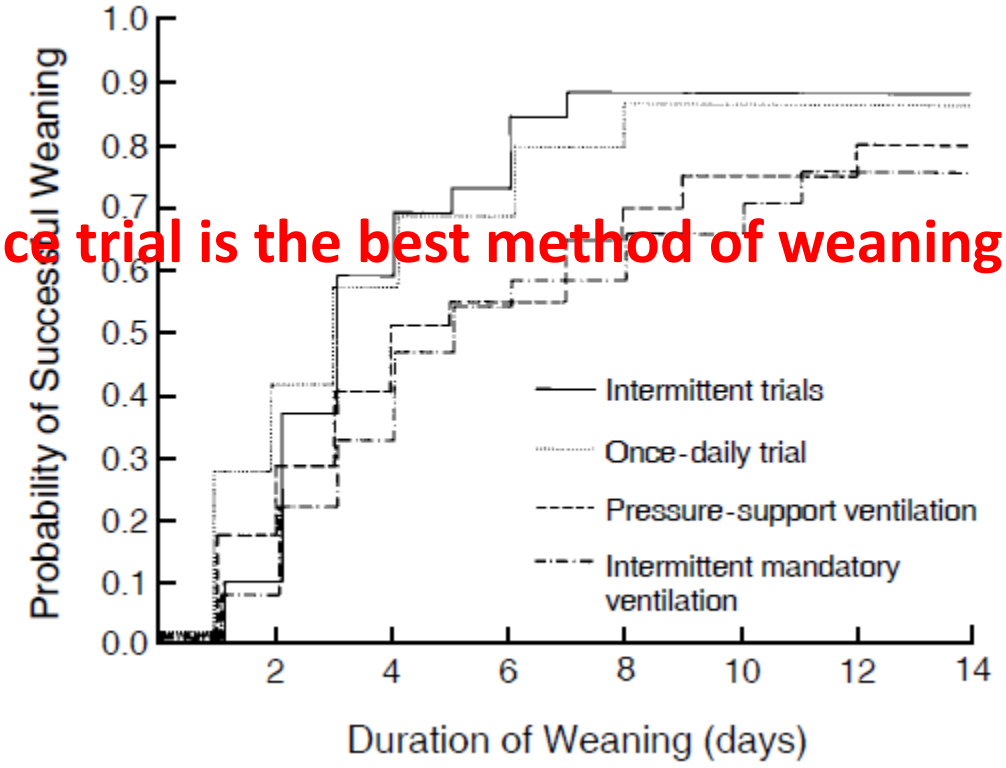
The New England
Journal of Medicine

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*

T-piece trial is the best method of weaning



Hemodynamic changes during a Spontaneous Breathing Trial

Weaning and Cardiovascular stress

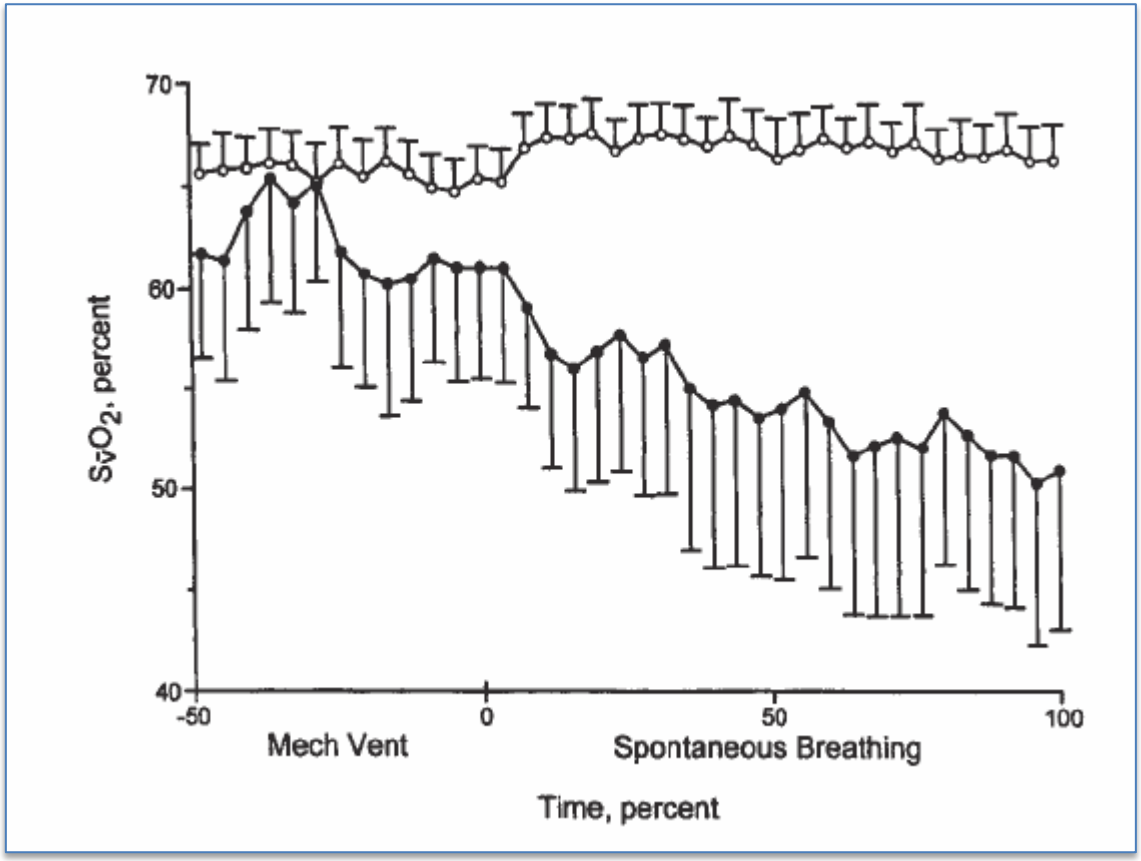
- Spontaneous breathing is exercise
- Spontaneous breathing increases intrathoracic blood volume/preload
- Spontaneous breathing increases LV afterload

Continuous Recordings of Mixed Venous Oxygen Saturation during Weaning from Mechanical Ventilation and the Ramifications Thereof

AMAL JUBRAN, MALI MATHRU, DAVID DRIES, and MARTIN J. TOBIN

Division of Pulmonary and Critical Care Medicine, Edward Hines Jr. Veterans Administration Hospital, Loyola University of Chicago Stritch School of Medicine, Hines; and RML Specialty Hospital, Hinsdale, Illinois

AM J RESPIR CRIT CARE MED 1998;158:1763–1769.



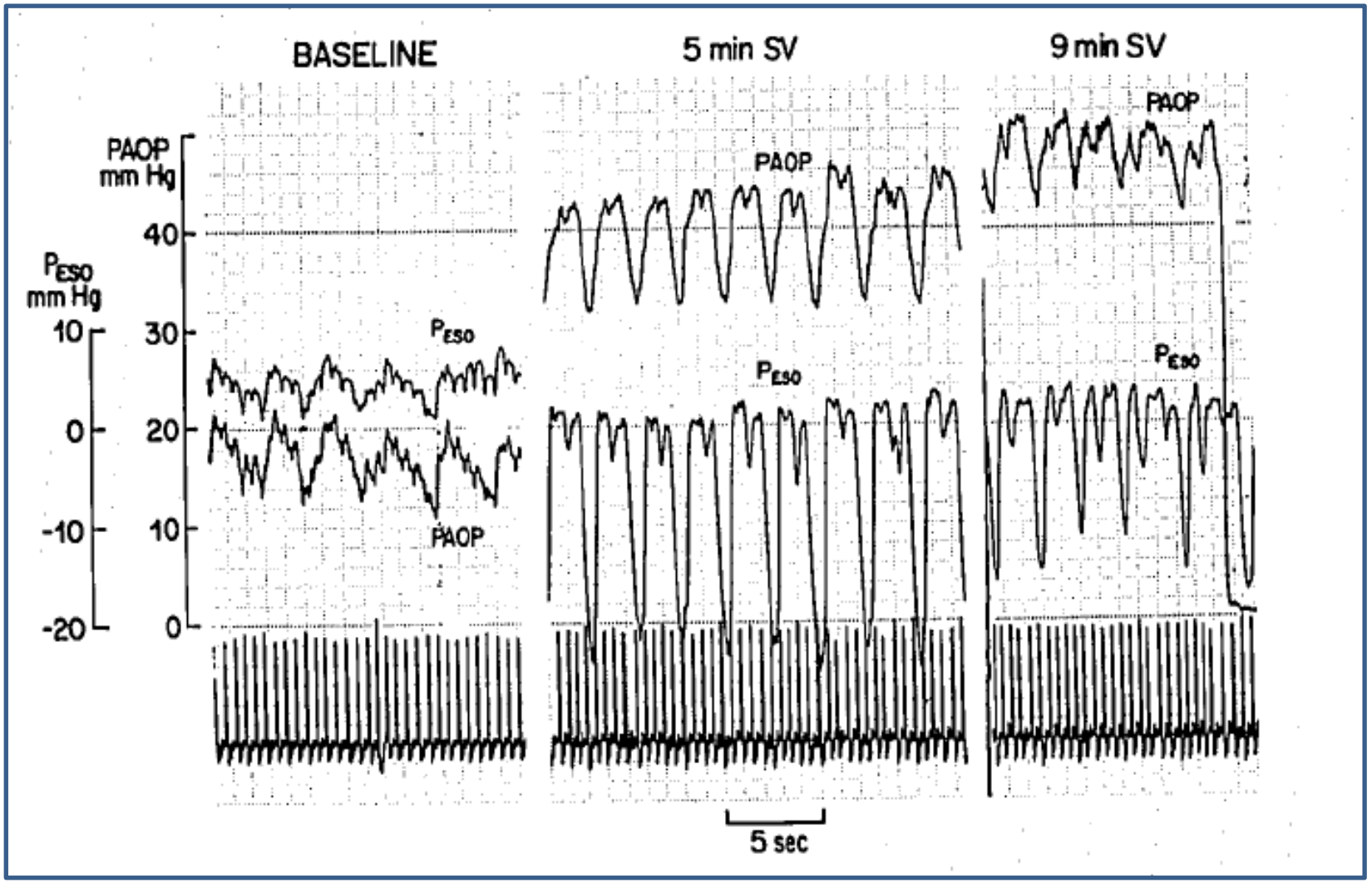
AM J RESPIR CRIT CARE MED 1998;158:1763–1769.

Weaning is a cardiac stress test

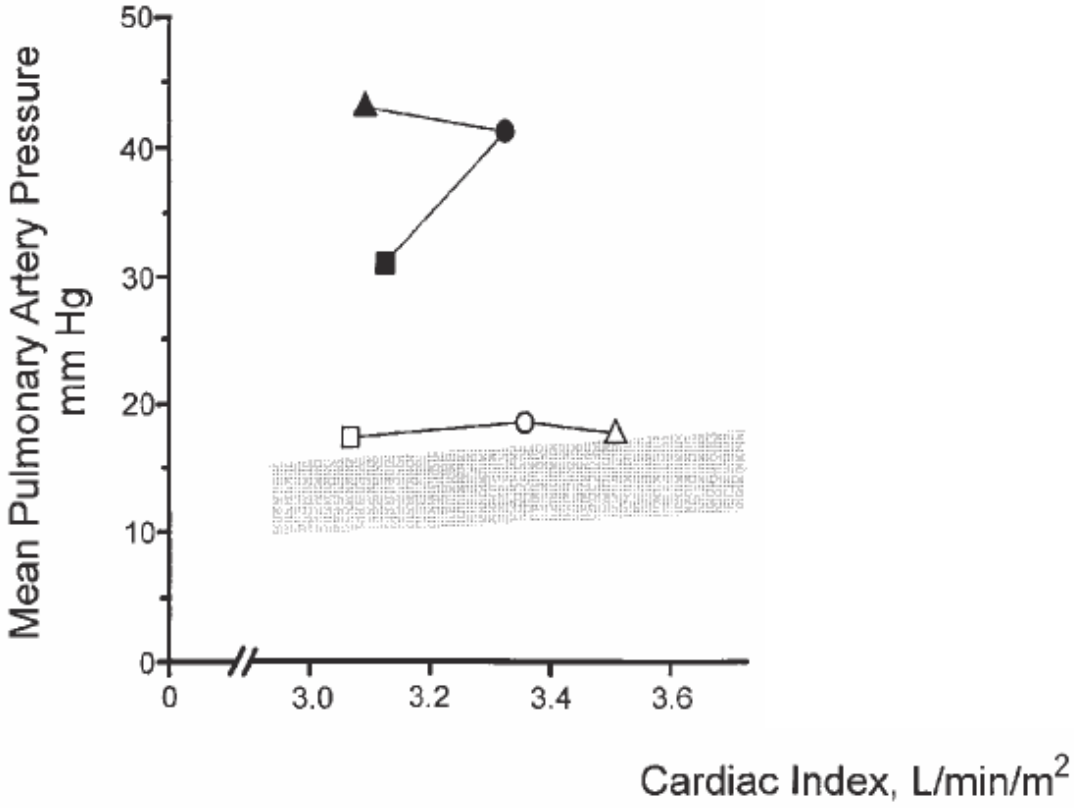
Anesthesiology
69:171–179, 1988

Acute Left Ventricular Dysfunction during Unsuccessful Weaning from Mechanical Ventilation

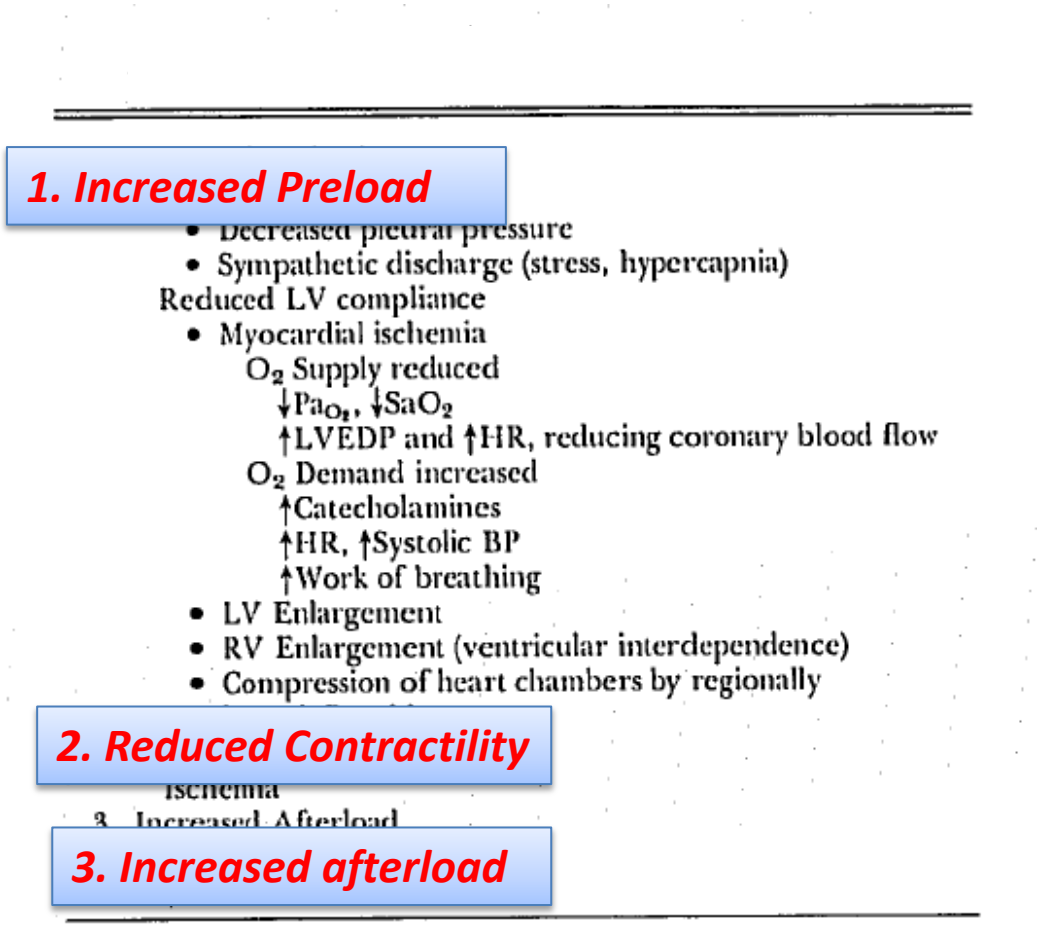
Francois Lemaire, M.D., Jean-Louis Teboul, M.D.,† Luc Cinotti, M.D.,‡ Guillen Giotto, M.D.,§ Fekri Abrouk, M.D.,§ Gabriel Steg, M.D.,§ Isabelle Macquin-Mavier, M.D.,¶ Warren M. Zapol, M.D.***


BASELINE
5 min SV
9 min SV
PAOP
mm Hg
40
30
20
10
0
P_{ESO}
mm Hg
10
0
-10
-20
P_{ESO}
PAOP
PAOP
P_{ESO}
PAOP
P_{ESO}
5 sec

Cardiac response during weaning



Factors increasing PAOP during weaning failure



1. Increased Preload

- Decreased pleural pressure
- Sympathetic discharge (stress, hypercapnia)

Reduced LV compliance

- Myocardial ischemia
  - O_2 Supply reduced
    - ↓Pa_{O_2}, ↓SaO_2
    - ↑LVEDP and ↑HR, reducing coronary blood flow
  - O_2 Demand increased
    - ↑Catecholamines
    - ↑HR, ↑Systolic BP
    - ↑Work of breathing
- LV Enlargement
- RV Enlargement (ventricular interdependence)
- Compression of heart chambers by regionally

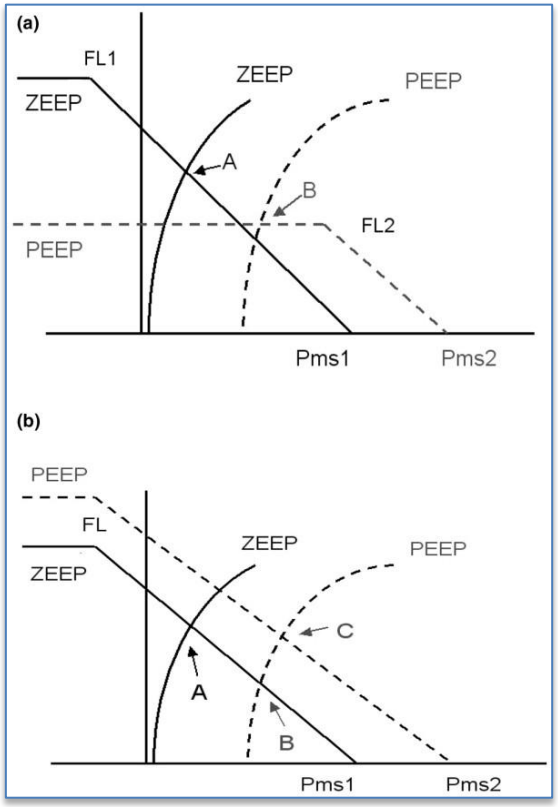
2. Reduced Contractility

ischemia

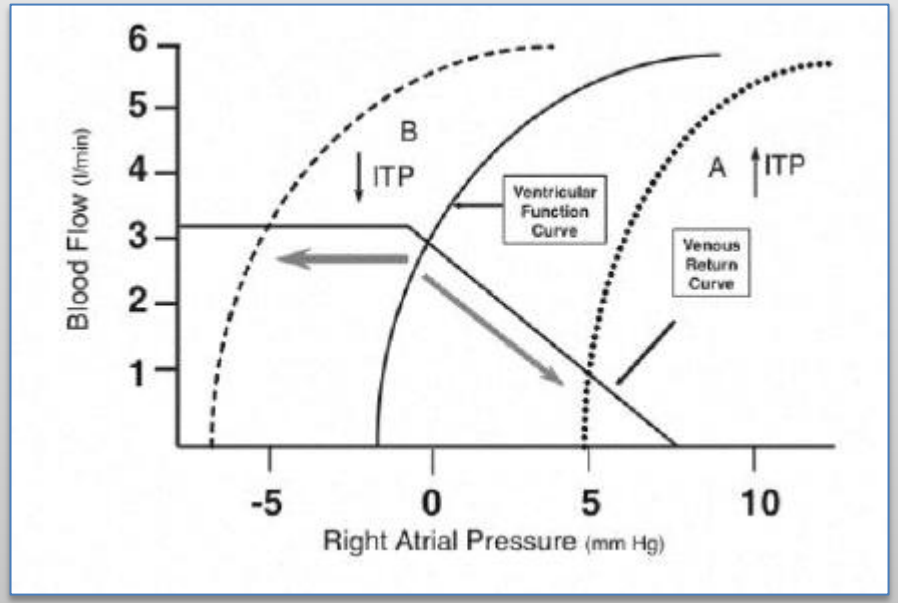
3. Increased Afterload

3. Increased afterload

Effect of mechanical ventilation on preload/venous return

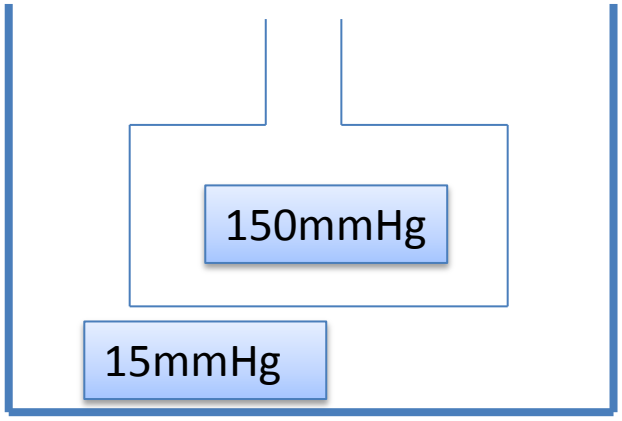


Effect of weaning on preload



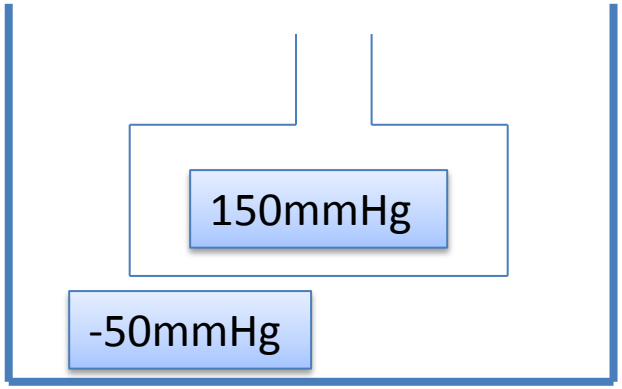
Effect of weaning on afterload

Mechanical Ventilation



Ptm = 150 – 15 = 135mmHg

Weaning



Ptm = 150 – (-50) = 200mmHg

Mechanisms of difficult weaning

- Weaning possible but unidentified
- Fluid overload
- Respiratory muscle weakness
- Severe underlying cardiac disease
- Severe underlying lung disease

Common pathophysiologies which may impact on the ability to wean a patient from mechanical ventilation

Respiratory Load

- Increased work of breathing: inappropriate ventilator settings
- Reduced compliance: pneumonia (ventilator-acquired); cardiogenic or noncardiogenic oedema; pulmonary fibrosis; pulmonary haemorrhage; diffuse pulmonary infiltrates
- Airway bronchoconstriction
- Increased resistive load

  During SBT: endotracheal tube

  Post-extubation: glottic oedema; increased airway secretions; sputum retention

- **Cardiac load** Cardiac dysfunction prior to critical illness Increased cardiac workload leading to myocardial dysfunction, dynamic hyperinflation
- **Neuromuscular** Depressed central drive: metabolic alkalosis; mechanical ventilation; sedative/hypnotic medications primary causes of neuromuscular weakness;
- **Neuropsychological** Delirium Anxiety, depression
- **Metabolic** Metabolic disturbances Role of corticosteroids Hyperglycaemia
- **Nutrition** Overweight Malnutrition
- **Ventilator-induced diaphragm dysfunction**
- **Anaemia**

Failure Criteria of Spontaneous Breathing Trial

Clinical assessment and subjective indices

- Agitation and anxiety
- Depressed mental status
- Diaphoresis
- Cyanosis
- Evidence of increasing effort
    - Increased accessory muscle activity
    - Facial signs of distress
    - Dyspnoea

Objective measurements (1)

- PaO_2 < 50–60 mmHg on FiO_2 >0.5 or SaO_2 <90%
- $PaCO_2$ >50 mmHg or increase in $PaCO_2$ >8 mmHg
- pH < 7.32 or a decrease in pH >0.07 pH units
- f_R/V_T >105 breaths/min/L

Objective measurements (2)

- f_R >35 breaths/min or increased by >50%
- f_C >140 beats/min or increased by >20%
- Systolic BP >180 mmHg or increased by >20%
- Systolic BP <90 mmHg
- Cardiac arrhythmias

NIV for Weaning

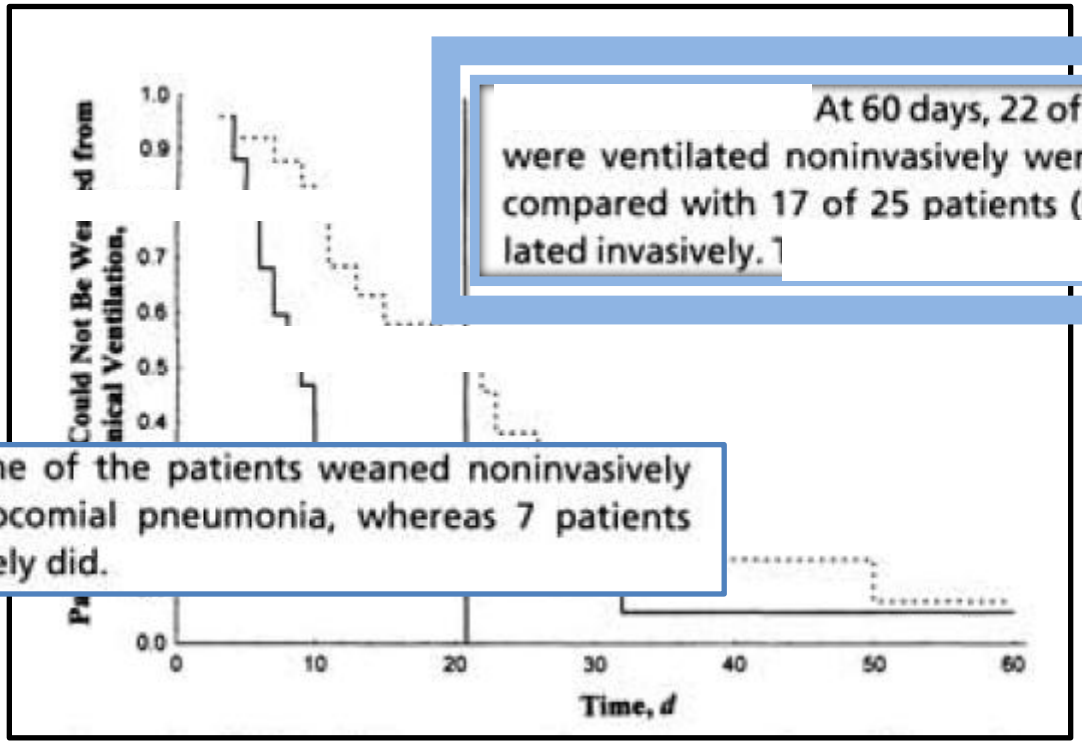
Noninvasive Mechanical Ventilation in the Weaning of Patients with Respiratory Failure Due to Chronic Obstructive Pulmonary Disease

A Randomized, Controlled Trial

Stefano Nava, MD; Nicolino Ambrosino, MD; Enrico Clini, MD; Maurizio Prato, MD; Giacomo Orlando, MD; Michele Vitacca, MD; Paolo Brigada, MD; Claudio Fracchia, MD; and Fiorenzo Rubini, MD

Ann Intern Med. 1998;128:721-728.

Survival rates at 60 days differed (92% for patients who received noninvasive ventilation and 72% for patients who received invasive ventilation; $P = 0.009$).



At 60 days, 22 of 25 patients (88%) who were ventilated noninvasively were successfully weaned compared with 17 of 25 patients (68%) who were ventilated invasively.

None of the patients weaned noninvasively developed nosocomial pneumonia, whereas 7 patients weaned invasively did.

Noninvasive Ventilation during Persistent Weaning Failure

A Randomized Controlled Trial

Miquel Ferrer, Antonio Esquinas, Francisco Arancibia, Torsten Thomas Bauer, Gumersindo Gonzalez, Andres Carrillo, Robert Rodriguez-Roisin, and Antoni Torres

AMERICAN JOURNAL OF RESPIRATORY AND CRITICAL CARE MEDICINE VOL 168 2003

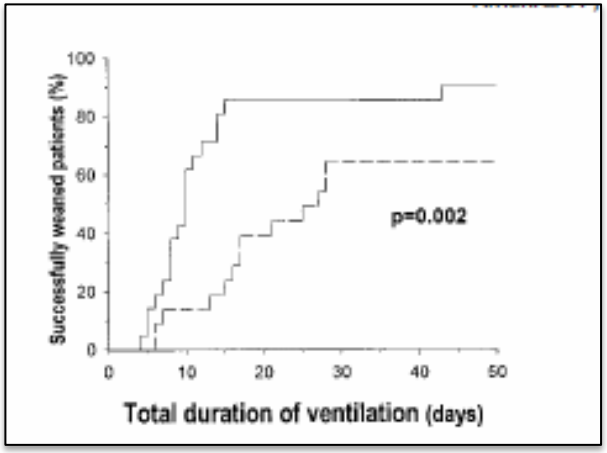
TABLE 3. WEANING RESULTS, LENGTH OF STAY, OUTCOME VARIABLES, AND CAUSES OF DEATH FOR THE NONINVASIVE VENTILATION AND THE CONVENTIONAL-WEANING GROUPS

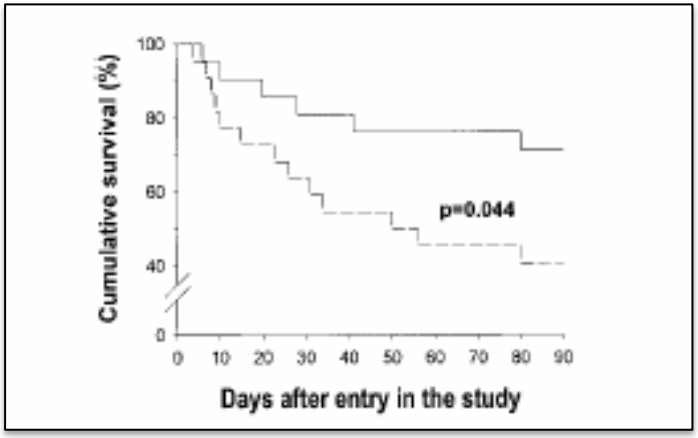
	NIV Group (n = 27)	Conventional-Weaning Group (n = 22)	p Value
Duration of invasive ventilation, d	9.5 ± 8.3	20.1 ± 13.1	0.003
Total period of ventilatory support*, d	11.4 ± 8.0	20.1 ± 13.1	0.012
ICU stay, d	14.1 ± 9.2	25.0 ± 12.5	0.002
Hospital stay, d	27.8 ± 14.6	40.8 ± 21.4	0.026
Reintubation, n (%)	3 (14)	6 (27)	0.457
Main causes of reintubation, n			
Severe persistent hypoxemia	1	3	
Severe dyspnea	–	2	
Inability to manage secretions	2	–	
Hemodynamic instability	–	1	
Tracheotomy, n (%)	1 (5)	13 (59)	<0.001
ICU survival, n (%)	19 (90)	13 (59)	0.045
Causes of death within 90 d after entry in the study			
Septic shock/MOF	1	9	
Refractory hypoxemia	1	2	
Cardiac arrest	2	1	
Pneumothorax	–	1	
Stroke	1	–	
Pulmonary embolism	1	–	

Noninvasive Ventilation during Persistent Weaning Failure

A Randomized Controlled Trial

Miquel Ferrer, Antonio Esquinas, Francisco Arancibia, Torsten Thomas Bauer, Gumersindo Gonzalez, Andres Carrillo, Robert Rodriguez-Roisin, and Antoni Torres





Conclusions-Recommendations

Reversible pathology should be aggressively and repeatedly sought in all patients in groups 2 and 3.

Weaning should be considered as early as possible in patients receiving mechanical ventilation

The initial SBT should last 30 min and consist of either T-tube breathing or low levels of PS (5–8 cmH2O in adults) with or without 5 cmH2O PEEP

Conclusions-Recommendations

SIMV should be avoided as a weaning modality

NIV techniques to shorten the duration of intubation should be considered in selected patients, especially those with hypercapnic respiratory failure

Ευχαριστώ