Predictors for Extubation Failure

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What is extubation failure

- Reintubation within 24-48 hours of a planned extubation
- Occurs 10%-20% but can vary with patient population

Consequences of extubation failure

- Increased duration of mechanical ventilation
- Increased LOS
- Increased nosocomial infections
- Increased mortality
- Likelihood of getting pneumonia
- Need for tracheostomy

Risk factors (pre-extubation)

- Inadequate respiratory capacity as a result of diaphragmatic weakness
- Left ventricular dysfunction
- Older patients
- Upper airway obstruction
- Ineffective clearance of respiratory secretions
- Severity of illness upon admission to ICU
- Prolonged mechanical ventilation
- Neurologic impairment
- Pre-extubation hypercapnia PCO_2 > 44mmHg

Extubation failure (post extubation)

- Increased work of breathing
- Accessory muscle use
- Hypoxia or hypercapnia
- Upper airway edema
- Inadequate muscle strength and glottic incompetence
- Excessive secretions
- Residual effects of sedatives
  - RASS Score
- Depressed mental status

Extubation Criteria

- Vital signs
- Underlying medical condition improves
- Lung mechanics
- NIF
- Gas exchange
- Frequency/tidal volume (RSBI)
  - New studies show it should be <65
- Severity of illness measures (APACHE, SAPS2)

Not All Patients Are The Same

- **COPD**
- Surgical
- Cardiac
- **Neurosurgical**
- Medical

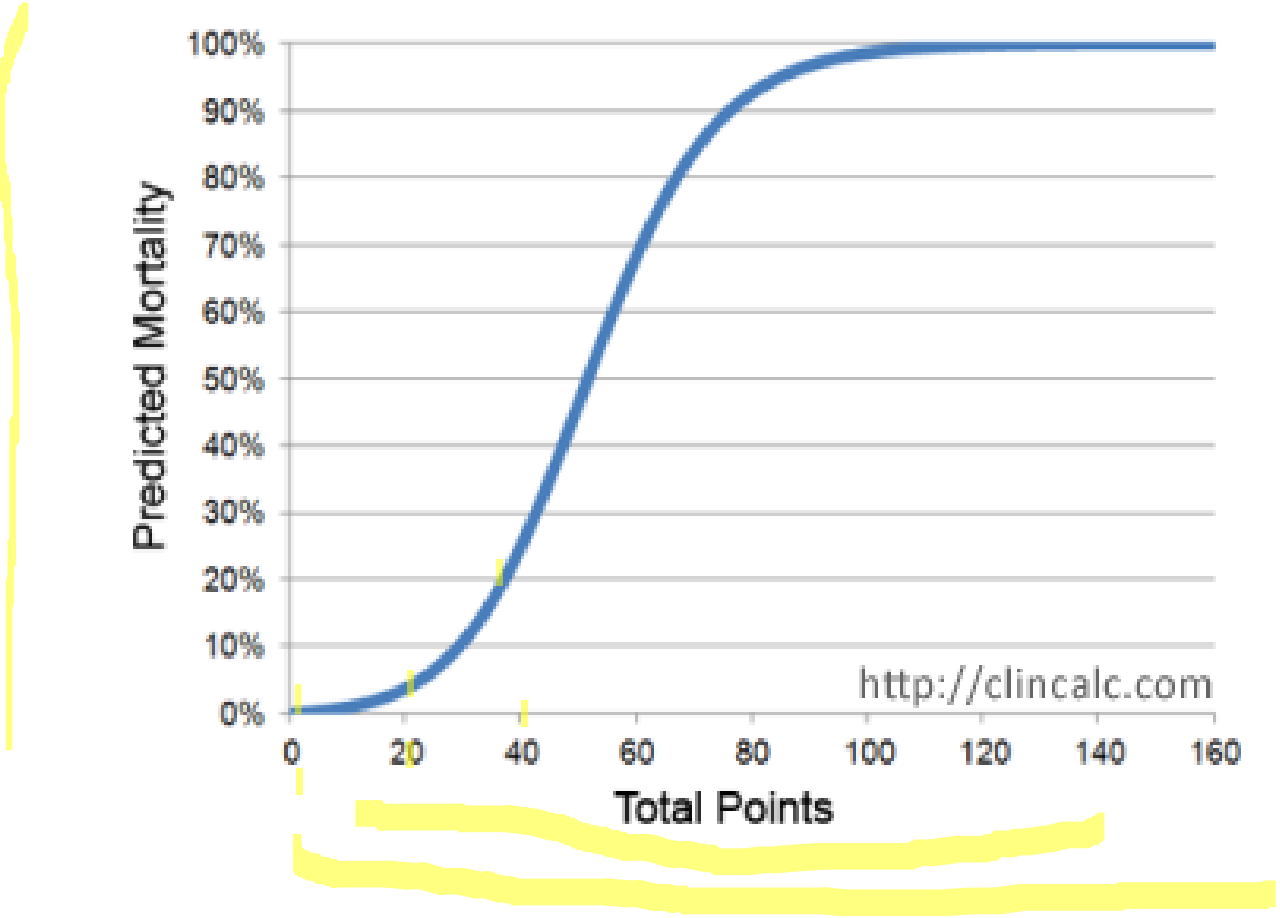
COPD

- "*Predictors of extubation failure in patients with chronic obstructive pulmonary disease*" Laurent Robriquet, Hugues Georges, Olivier Leroy, Patrick Devos, Thibaut D'escrivan and Benoit Guery Journal of Critical Care (2006) 21, 185-192

New Simplified Acute Physiology Score (SAPS2) collected first 24 hours

- Type of admission
- Chronic diseases
- Glasgow
- Age
- Systolic Blood Pressure
- Heart rate
- Temperature
- If MV or CPAP PaO2/FIO2(mmHg)
- Urine output
- Serum Urea or BUN
- WBC
- Potassium
- Sodium
- HCO3
- Bilirubin

SAP 2 score mortality chart



Robriquet Study

- Retrospective study
- January 1996 to May 2002
- 148 patients with COPD
- 65% had successful extubation
- 17% went to NIV
- 18% required reintubation

Characteristics of the 148 studied patients during ICU stay

Table 1 Characteristics of the 148 studied patients during ICU stay

Variables	Patients (n = 148)
Demographics	
Male sex	117 (79%)
Age (y)	68.4 ± 10.2
Home oxygen	37 (25%)
Home noninvasive ventilation	13 (8.7%)
Previous MV	21 (14.2%)
Diagnosis at admission	
Acute exacerbation	83 (56.1%)
Pneumonia	36 (24.3%)
Emergency surgery	9 (6.1%)
Planned surgery	6 (4%)
Other	20 (14%)
ICU stay	
SAPS II on ICU admission	38.6 ± 10.9
Duration of MV before first extubation attempt (d)	7.1 ± 5.2
Deaths	13 (9%)

Data are presented as n (%) or mean ± SD. Among medical patients, many diagnoses at admission were possible.

Patient characteristics on ICU admission and during ICU stay before extubation

Table 2 Patient characteristics on ICU admission and during ICU stay before extubation

Variables	Extubation success (n = 96)	Extubation failure (n = 52)	*P*
Baseline characteristics			
Age (y)	67.3 ± 10.9	70.2 ± 8.5	.09
SAPS II	36.6 ± 10.9	42.2 ± 10.3	.003
Sex (male/female)	80/16	37/15	.08
Home oxygen	21 (22%)	16 (31%)	.23
Home noninvasive MV	3 (3%)	10 (19%)	.001
Previous MV	13 (14%)	8 (15%)	.75
Diagnosis at admission			
Acute exacerbation	53 (55%)	30 (58%)	.77
Pneumonia	21 (22%)	15 (29%)	.34
Emergency surgery	7 (7%)	2 (4%)	.4
Planned surgery	6 (6%)	0	.06
Others	13 (14%)	7 (13%)	.98
ICU stay			
Duration of MV (d)	6.5 ± 5.5	8.1 ± 4.5	.07
Use of sedation	82 (85%)	46 (88%)	.6
Duration of sedative drugs (n = 128) (d)	3.96 ± 3.75	4.47 ± 2.76	.32
Use of NBA	5 (5%)	2 (4%)	.52
Use of PSV	76 (79%)	41 (79%)	.96
Duration of PSV (n = 117) (d)	3.2 ± 2.9	3.4 ± 2.9	.7

Data are presented as n (%) or mean ± SD. Among medical patients, many diagnoses at admission were possible.

Characteristics of EA cultures results and antimicrobial chemotherapy in the studied population

Table 4 Characteristics of EA cultures results and antimicrobial chemotherapy in the studied population

	Extubation success (n = 96)	Extubation failure (n = 52)	*P*
Positive EA (n)	22 (23%)	25 (48%)	.001
Isolated pathogens			.42
Pseudomonas aeruginosa	9	11	
Staphylococcus aureus	7	4	
Streptococcus pneumoniae	0	1	
Enteric gram-negative bacilli	3	4	
Haemophilus influenzae	0	3	
Other species	3	2	
Antibiotics on the day of extubation	61	32	.25

Data are presented as n (%).

Multiple logistic regression analysis of variables predictive of extubation failure

Table 5 Multiple logistic regression analysis of variables predictive of extubation failure

Predictor variables	Adjusted odds ratio	95% confidence interval	*P*
Home noninvasive ventilation	12.99	2.86-58.89	.0009
SAPS II >35 on ICU admission	3.88	1.65-9.12	.001
Sterile EA on the day of extubation	0.23	0.10-0.52	.0005

Take home notes on COPD

- Extubation failure occurs 35%
- Mortality is around 9% - 15%
- Severity of illness on admission results in longer MV and difficult weaning (SAP2 or APACHE)
- Predisposing risk factors
  - Existence of NIV at home
  - SAPS 2 score greater than 35 on admission
  - Positive culture of endotracheal aspirates within 72 hours preceding extubation (you want no growth)

More take home notes on COPD

- Suctioning greater than every 1-2 hours results in an 8-fold increase in extubation failure
- Try the WCT (white card test) to see if adequate strength in secretion removal
- Be ready to utilize NIV in case of failure especially if patient uses NIV at home
- Be aware that is SAP2 score is > 35 upon admission that this patient may fail extubation attempt

Neurosurgical patients

- Retrospective and prospective investigations have documented increased rates of:
  - Reintubation
  - Pneumonia
  - Tracheostomy
  - Prolonged mechanical ventilation among patients with acute brain injury

"Predictors of Successful Extubation in Neurosurgical Patients"

- ANDREW M. NAMEN, E. WESLEY ELY, STEPHEN B. TATTER, L. DOUGLAS CASE, MICHAEL A. LUCIA
  American Journal Respiratory Critical Care Med Vol 163. pp 658–664, 2001

APACHE Score

- APACHE (Acute Physiology And Chronic Health Evaluation)
- System for classifying patients in the intensive care unit for severity of illness
- Patients are evaluated by physiologic scores and evaluation of chronic health status
- Physiologic scores correlate with severity of illness
- Used to estimate the mortality rate for patients in the ICU and during the hospitalization

APACHE Score

- Cardiovascular: 7 variables (MAP, HR, BP)
- Respiratory: 3 variables (RR, FIO2, pH)
- Renal: 3 variables (Creatine)
- Gastrointestinal: 6 variables (abdominal distention, enteroparalysis)
- Hematologic: 4 variables (WBC, Hematocrit)
- Septic: 4 variables (multiple organ dysfunction syndrome)
- Metabolic: 6 variables (K+, Na+)
- Neurologic: 1 variable (GCS)
- Add all these scores

Probability of Death in Hospital based on APACHE score

Score	Mortality Rate
0 – 5	2.3%
6 – 10	4.3%
11 – 15	8.6%
16 – 20	16.4%
21 – 25	28.6%
26 – 30	56.4%
31+	70%

Glasgow Coma Scale

Fig. 2

Glasgow Coma Scale for Head Injury

Glasgow Coma Scale,	
Eye opening	
Spontaneous	4
To loud voice	3
To pain	2
None	1
Verbal response	
Oriented	5
Confused, disoriented	4
Inappropriate words	3
Incomprehensible sounds	2
None	1
Best motor response	
Obeys	6
Localizes	5
Withdraws (flexion)	4
Abnormal flexion posturing	3
Extension posturing	2
None	1

Glasgow Coma Scale Interpretation

- Severe, with GCS ≤ 8
- Moderate, GCS 9 - 12
- Minor, GCS ≥ 13

RASS score

Score	Descriptor	Characteristics
+4	Combative	Combative, violent, immediate danger to staff
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive
+2	Agitated	Frequent nonpurposeful movement, fights ventilator
+1	Restless	Anxious, apprehensive but movements not aggressive or vigorous
0	Alert and calm	
-1	Drowsy	Not fully alert, but has sustained awakening to voice (eye opening and contact >10 seconds)
-2	Light sedation	Briefly awakens to voice (eye opening and contact <10 seconds)
-3		
-4	Moderate sedation	Movement or eye opening to voice (but no eye contact)
	Deep sedation	No response to voice, but movement or eye opening to physical stimulation
-5	Unarousable	No response to voice or physical stimulation

Neurosurgical patients' premise

- Literature doesn't support the concept of delaying extubation with impaired neurologic status as sole reason for prolonging intubation

Study Design (Neuro)

- Randomized control trial
- Primary outcomes included
  - Overall duration of mechanical ventilation
  - Length of ICU stay
  - Time to successful extubation

Study Design (Neuro)

- Secondary outcomes were:
  - Reintubation
  - Self-extubation
  - Tracheostomy
  - Mechanical ventilation exceeding 21 days
  - Costs of mechanical ventilation
  - LOS
  - Mortality

Outcomes

- There were no significant differences between the Intervention and Control groups
- Basically, a well-balanced study

Neurosurgical patients

TABLE 1. BASELINE CHARACTERISTICS OF MECHANICALLY VENTILATED NEUROSURGERY PATIENTS

Characteristics	Total (*n* = *100*)	Intervention Group (*n* = *49*)	Control Group (*n* = *51*)	p Value*
Median age (range)	59 (18-91)	55 (18-91)	64 (19-88)	0.252
Male sex, n (%)	55 (55%)	24 (49%)	30 (59%)	0.323
Race				0.887
White	79 (79%)	39 (80%)	40 (78%)	
Other	21 (21%)	10 (20%)	11 (22%)	
APACHE II score, median (interquartile range)	14.5 (5-21)	14 (5-29)	14.9 (8-29)	0.844
Acute-lung-injury score, median (interquartile range)	0.88 (0-3)	0.75 (0-3)	1.0 (0-2.8)	0.455
Chronic disease	18 (18%)	7 (14%)	10 (20%)	0.479
Mode of ventilation, n (%)				0.525
Intermittent mandatory ventilation	22 (22%)	9 (18%)	13 (26%)	
Pressure-support ventilation	25 (25%)	11 (22%)	14 (27%)	
Both	52 (52%)	28 (57%)	24 (47%)	
Assist-control ventilation	1 (1%)	1 (2%)	0 (0%)	
Cause of neurosurgical admission				0.281
Head trauma	23 (23%)	12 (25%)	11 (22%)	
Subarachnoid hemorrhage	19 (19%)	13 (27%)	6 (16%)	
Intracerebral hemorrhage/AVM	34 (34%)	15 (31%)	19 (37%)	
Tumor	8 (8%)	4 (8%)	4 (8%)	
nal trauma	4 (4%)	3 (6%)	1 (2%)	
ner	10 (10%)	2 (4%)	8 (16%)	

Findings

- RCP performed an SBT on 99% (199 of 201) of the patients
  - Extubation was made for only 25% of patients who passed an SBT
    - Why??
- Primary reasons for not extubating such patients included concerns about
  - Patient's level of consciousness (84%)
  - Perform tracheostomy (10%)
  - Other reasons (6%)
- This goes against the premise previously mentioned

Factors Associated with Successful Extubation of neurosurgical patients

TABLE 4. ODDS OF SUCCESSFUL EXTUBATION FOR NEUROLOGIC AND RESPIRATORY PREDICTORS

Parameters	OR	95% CI	p Value
f/VT ≤ 105	10.3	1.2–87	0.02
P/F ratio ≥ 200	3.3	1.8–6	0.0001
GCS score ≥ 8	4.9	2.8–8.3	≤ 0.001
P/F ratio, GCS score, *f*/VT ratio	5.1	3.1–8.4	≤ 0.001
P/F ratio, GCS score	4.8	2.9–8	≤ 0.001
f/VT ratio, GCS score	4.9	2.9–8.5	≤ 0.001

Definition of abbreviations: CI = confidence Interval; *f* = frequency of respiration; GCS = Glasgow Coma Scale; OR = odds ratio; P/F = $Pa_{O_2}/F_{I_{O_2}}$; VT = tidal volume.

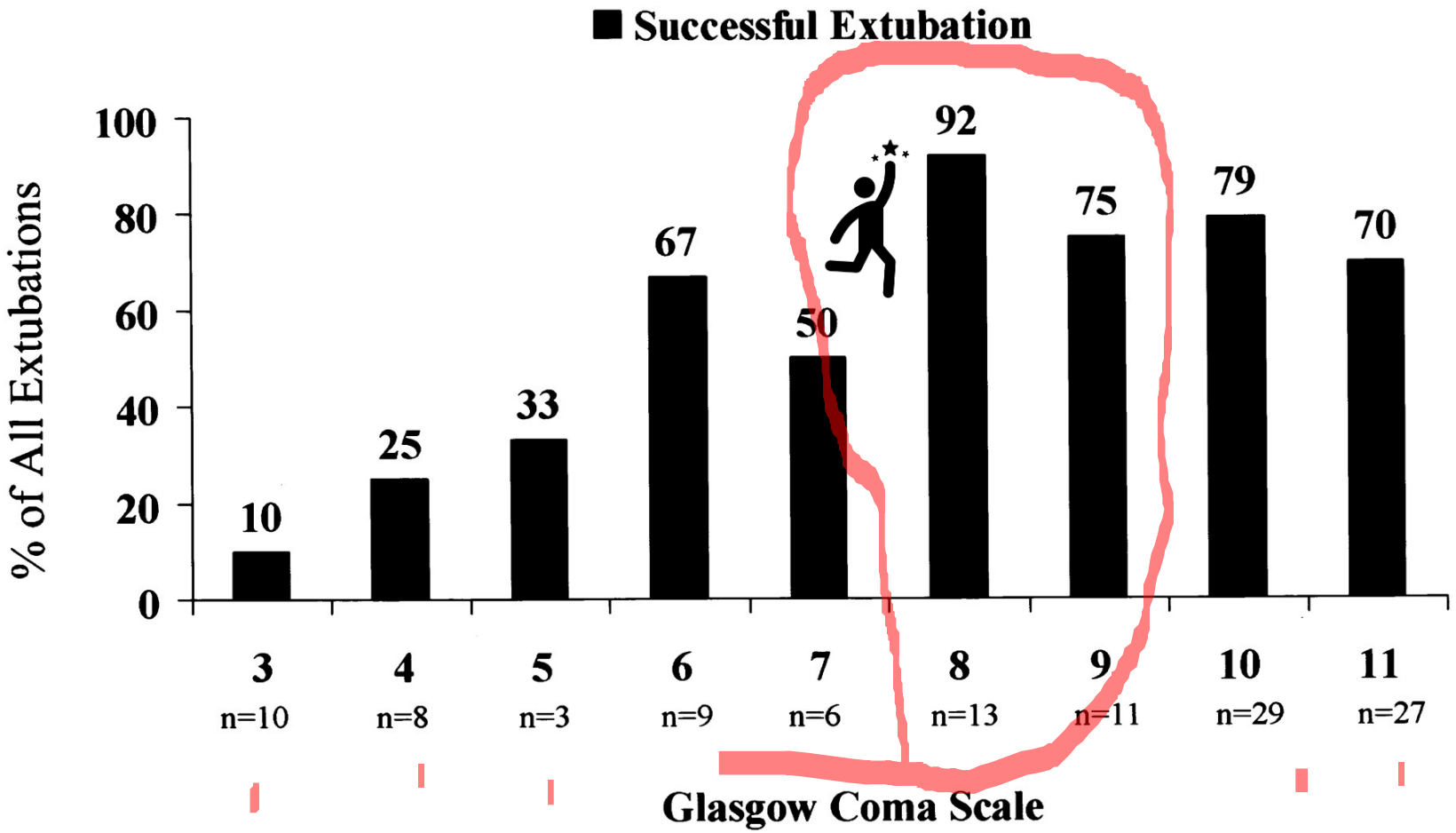
Factors Associated with Successful Extubation

- Successful extubations were associated with higher GCS score greater than 8
- Higher P/F ratio
- Lower minute ventilation
- The *f*/VT ratio was similar for those patients having successful and unsuccessful extubations (very interesting)

Factors Associated with Successful Extubation-Most important

- GLS Must be > 8
- Odds of successful extubation increased 30% with every increment is GCS
- GCS greater than 8 had a 75% success rate
- GCS less than 8 had a success rate of 36%

GCS


Successful Extubation
% of All Extubations
100
80
60
40
20
0
10
25
33
67
50
92
75
79
70
3
n=10
4
n=8
5
n=3
6
n=9
7
n=6
8
n=13
9
n=11
10
n=29
11
n=27
Glasgow Coma Scale

Take home messages

Integrate GCS into weaning of neurosurgical patients

Tool for determining successful extubations

- The Early Phase of the Minute Ventilation Recovery Curve Predicts Extubation Failure Better Than the Minute Ventilation Recovery Time
- *Gonzalo Hernandez, MD, PhD; Rafael Fernandez, MD, PhD; Elena Luzon, MD; Rafael Cuena, MD; and Juan Carlos Montejo, MD, PhD*
- *CHEST 2007; 131:1315–1*

Hernandez Study

- Continuous objective minute-by-minute monitoring of the recovery time (RT) might improve the predictive power of extubation success
- Observe the minute ventilation of the patient
  - Pre SBT
  - During SBT
  - Post SBT
- Determine when minute ventilation goes back to baseline (how long did it take?

Hernandez Study

Table 2—*Univariate Analysis of Ventilatory Variables

Variables	Successful Extubation (n = 74)	Failed Extubation (n = 19)	p Value
Basal $\dot{V}_E$, L	11.2 ± 3	10.9 ± 2.9	0.7
Basal RR, breaths/min	20 ± 6	19.6 ± 6.2	0.8
Basal V_T, mL	557 ± 263	580 ± 249	0.7
RT of $\dot{V}_E$, min	5.4 ± 5.2	14.5 ± 9.7	0.001
RT of RR, min	9.2 ± 8.8	10.2 ± 9.4	0.8
RT50%Δ$\dot{V}_E$, min	2.7 ± 1.2	10.7 ± 8.4	0.001
RT50%ΔRR, min	4.3 ± 4.5	7.3 ± 8.7	0.8

*Data are presented as the mean ± SD, unless otherwise indicated. RT50%ΔRR = recovery time needed to reduce RR to half the difference between the RR measured at the end of a successful spontaneous breathing trial and basal RR.

Hernandez Study

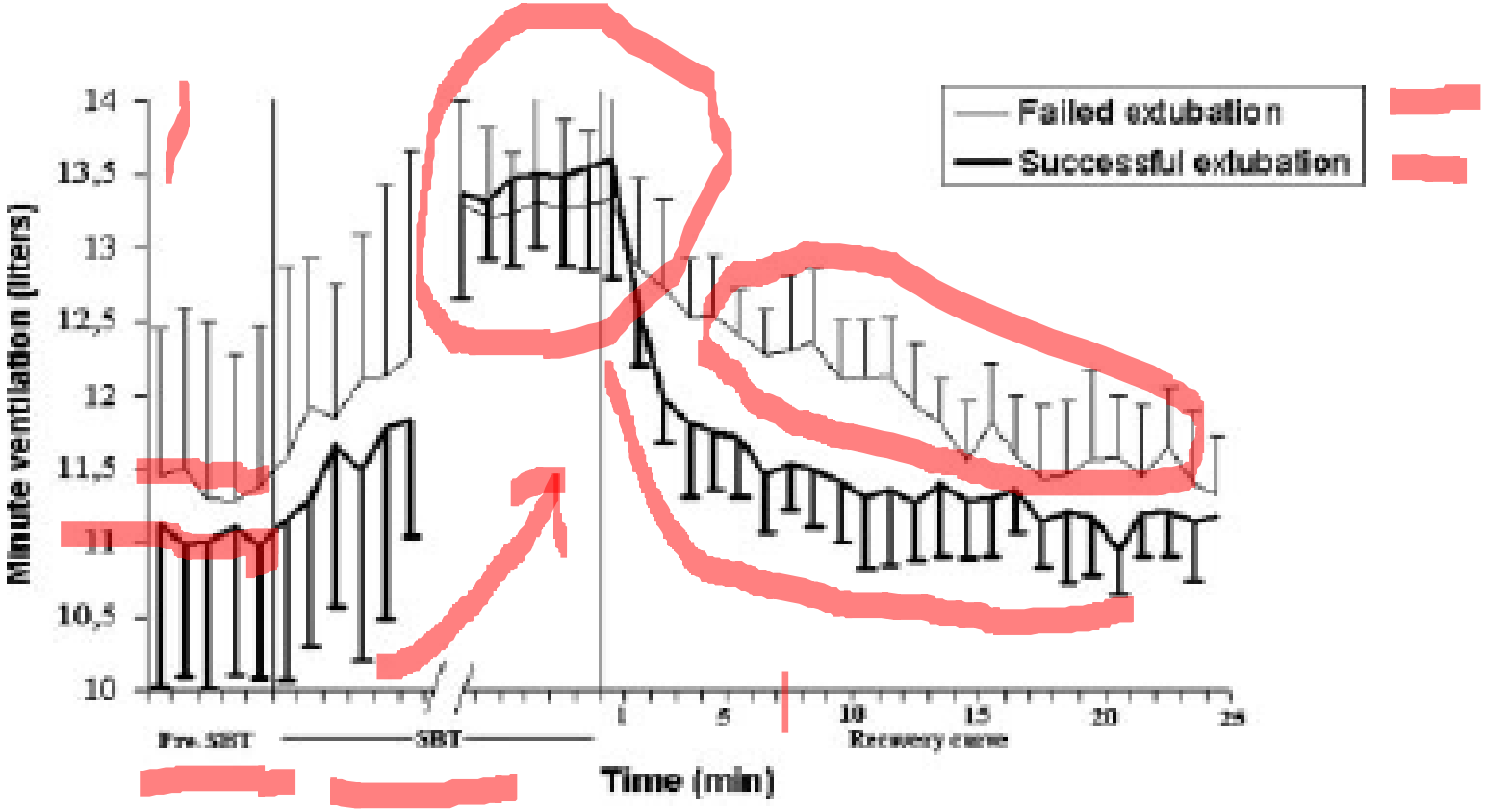


FIGURE 2. Evolution of the VE during the monitoring period.

Final Remarks

- Observe secretion clearance
- Use the WCT to determine muscle strength to generate a good cough
- Utilize the SAP2 and APACHE scores in your decision making
- Incorporate the GCS and RASS score into your practice
- Determine if there is upper airway edema
- Be aware of pre extubation PCO2 values being > 44mmHg
- Utilize the Hernandez minute ventilation recovery tool in difficult weans or second extubations
- Be careful of PS weaning methods as it may lower pre-SBT PCO2 values

References

- *“Predictors of extubation failure in patients with chronic obstructive pulmonary disease” Laurent Robriquet, Hugues Georges, Olivier Leroy, Patrick Devos, Thibaut D'escrivan and Benoit Guery Journal of Critical Care (2006) 21, 185-192*
- *The Early Phase of the Minute Ventilation Recovery Curve Predicts Extubation Failure Better Than the Minute Ventilation Recovery Time Gonzalo Hernandez, MD, PhD; Rafael Fernandez, MD, PhD; Elena Luzon, MD; Rafael Cuena, MD; and Juan Carlos Montejo, MD, PhD CHEST 2007; 131:1315–1320*
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