

Predictors for Extubation Failure

Terrence Shenfield MS, RRT, RPFT-NPS, AE-C



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 $\text{PCO}_2 > 44\text{mmHg}$



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

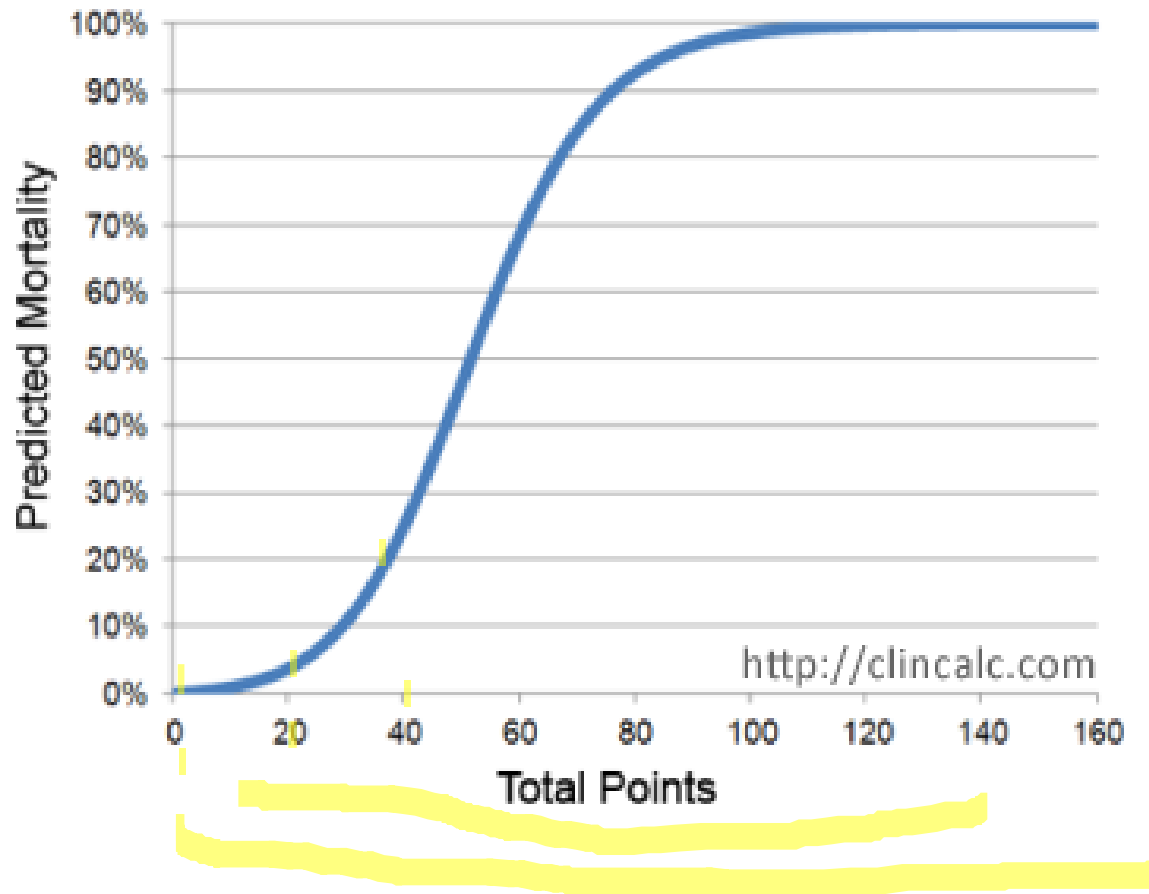


New Simplified Acute Physiology Score (SAPS2) collected first 24 hours

- 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 |
| <i>Pseudomonas aeruginosa</i> | 9 | 11 | |
| <i>Staphylococcus aureus</i> | 7 | 4 | |
| <i>Streptococcus pneumoniae</i> | 0 | 1 | |
| Enteric gram-negative bacilli | 3 | 4 | |
| <i>Haemophilus influenzae</i> | 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 | <i>P</i> |
|-------------------------------------|---------------------|-------------------------|----------|
| 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 if 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) | <u>p Value*</u> |
|--|------------------------|------------------------------------|-------------------------------|------------------------|
| 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%) | |
| Spinal trauma | 4 (4%) | 3 (6%) | 1 (2%) | |
| Other | 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 |
|-------------------------------------|------|---------|--------------|
| $f/V_T \leq 105$ | 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/V_T ratio | 5.1 | 3.1–8.4 | ≤ 0.001 |
| P/F ratio, GCS score | 4.8 | 2.9–8 | ≤ 0.001 |
| f/V_T 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_{iO_2} ; V_T = 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)

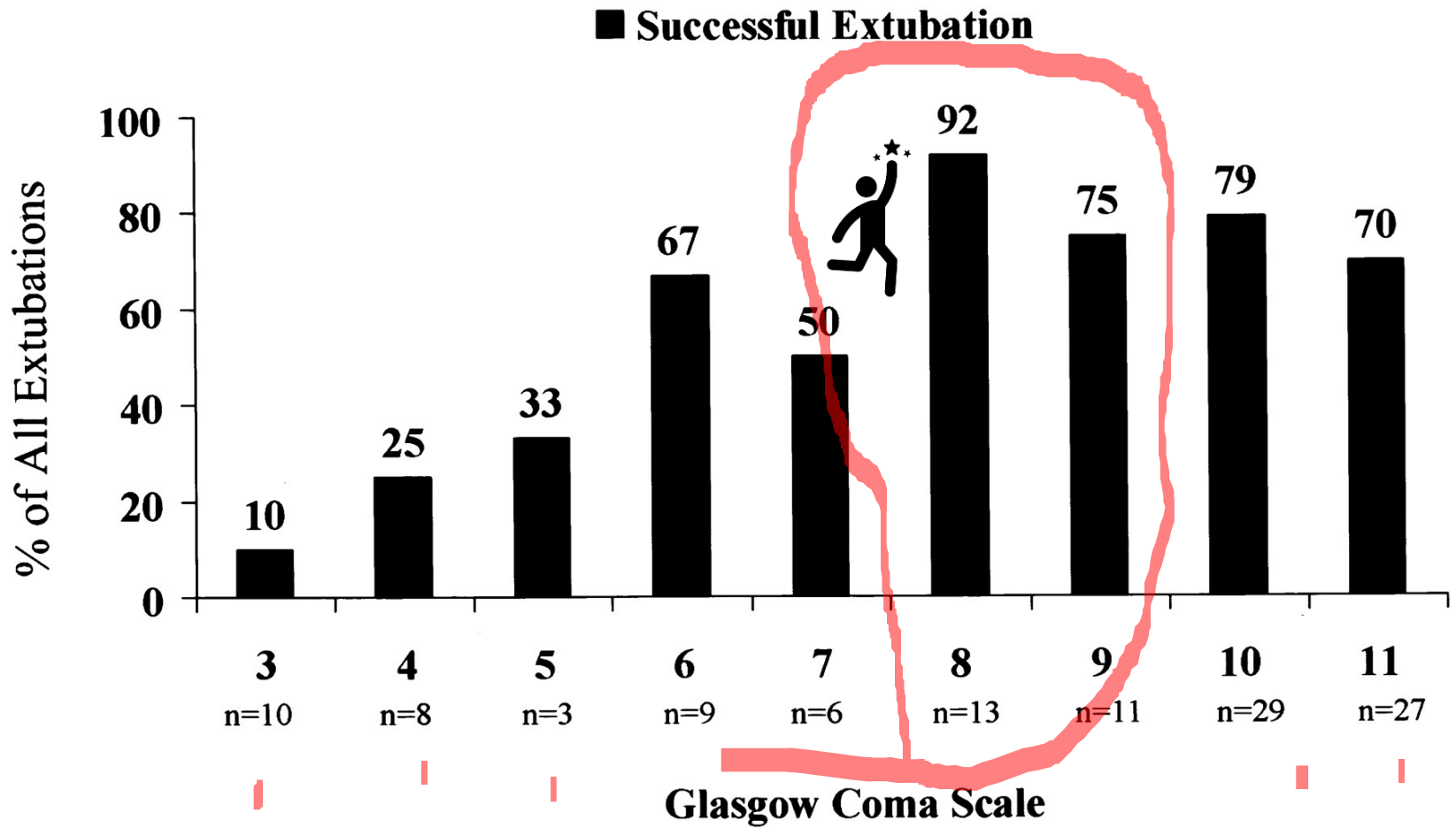


Factors Associated with Successful Extubation-Most important

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



GCS



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 Cuenca, 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% $\Delta\dot{V}_E$, min | 2.7 ± 1.2 | 10.7 ± 8.4 | 0.001 |
| RT50% Δ RR, min | 4.3 ± 4.5 | 7.3 ± 8.7 | 0.8 |

*Data are presented as the mean ± SD, unless otherwise indicated. RT50% Δ RR = 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

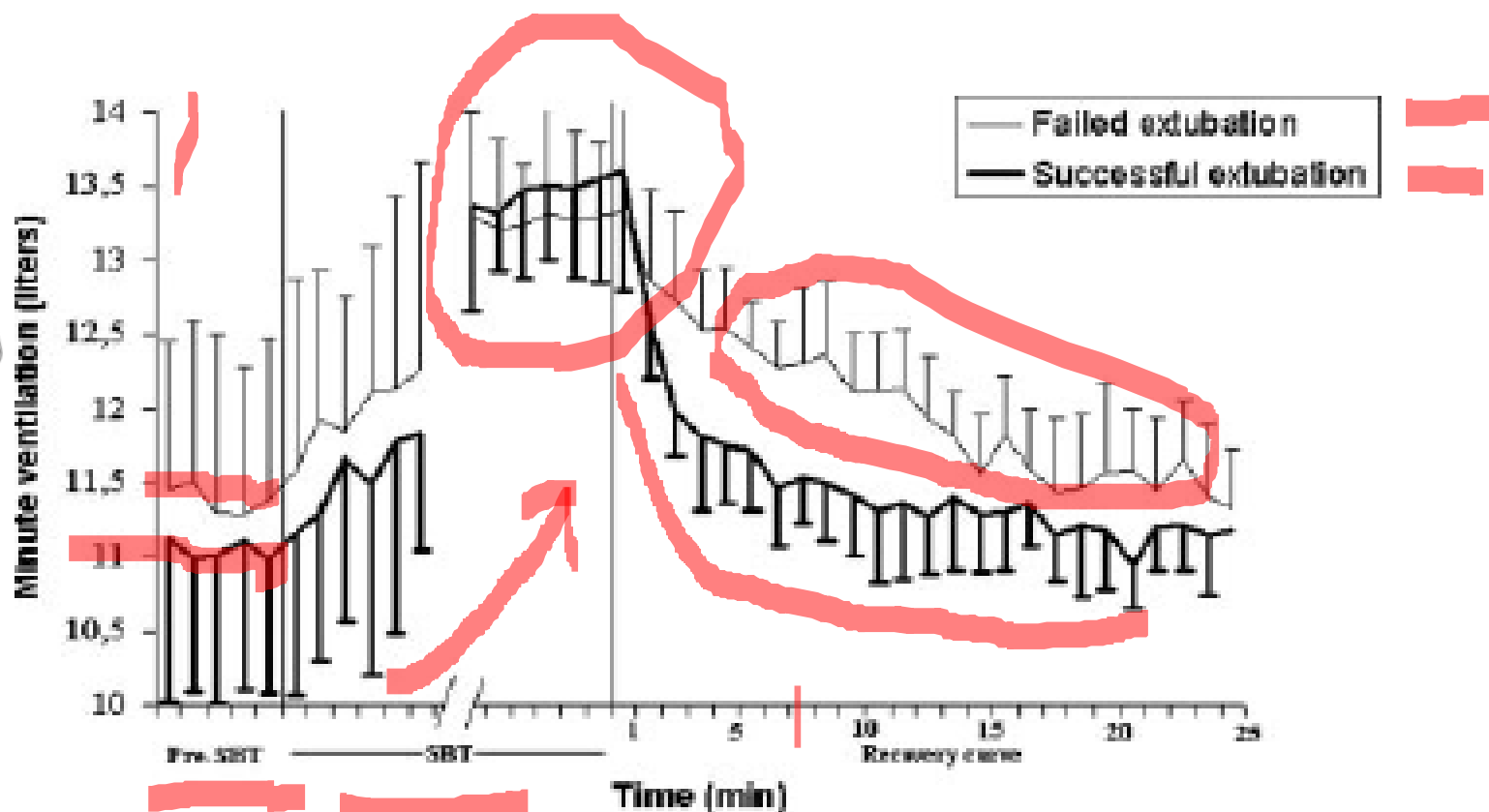


FIGURE 2. Evolution of the \dot{V}_E during the monitoring period.



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

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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 Cuenca, MD; and Juan Carlos Montejo, MD, PhD *CHEST* 2007; 131:1315–1320
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