Predictors for Extubation Failure for Adults

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Clinical Educator

What is extubation failure

- Necessity of reintubation within 24-48 hours of planned extubation

- Occurs 10%-20%
Consequences of extubation failure

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

Risk factors affecting reintubation

- Inadequate respiratory load and capacity
- Left ventricular dysfunction
- Older age
- Upper airway obstruction
- Ineffective clearance of respiratory secretions
- Severity of illness upon admission to ICU
- Prolonged mechanical ventilation
- Neurologic impairment
- Pre-extubation hypercapnia $\text{PCO}_2 > 44\text{mmHg}$
Causes of extubation failure-post extubation

- Increased work of breathing
- Accessory muscle use
- Hypoxia or hypercapnia
- Upper airway edema
- Inadequate muscle strength glottic incompetence
- Excessive secretions
- Residual effects of sedatives
- 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”
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

http://clincalc.com
Robriquet Study

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

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>
<thead>
<tr>
<th>Variables</th>
<th>Extubation success (n = 96)</th>
<th>Extubation failure (n = 52)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>67.3 ± 10.9</td>
<td>70.2 ± 8.5</td>
<td>.99</td>
</tr>
<tr>
<td>SAPS II</td>
<td>36.6 ± 10.9</td>
<td>42.2 ± 10.3</td>
<td>.003</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>80 (16)</td>
<td>37 (15)</td>
<td>.08</td>
</tr>
<tr>
<td>Homa oxygen</td>
<td>21 (22%)</td>
<td>16 (31%)</td>
<td>.23</td>
</tr>
<tr>
<td>Home noninvasive MV</td>
<td>3 (3%)</td>
<td>10 (19%)</td>
<td>.001</td>
</tr>
<tr>
<td>Previous MV</td>
<td>13 (14%)</td>
<td>8 (15%)</td>
<td>.75</td>
</tr>
<tr>
<td><strong>Diagnosis at admission</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute exacerbation</td>
<td>53 (55%)</td>
<td>30 (58%)</td>
<td>.77</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>21 (22%)</td>
<td>15 (29%)</td>
<td>.34</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>7 (7%)</td>
<td>2 (4%)</td>
<td>.4</td>
</tr>
<tr>
<td>Planned surgery</td>
<td>6 (6%)</td>
<td>0 (0%)</td>
<td>.06</td>
</tr>
<tr>
<td>Others</td>
<td>13 (14%)</td>
<td>7 (13%)</td>
<td>.98</td>
</tr>
<tr>
<td><strong>ICU stay</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of MV (d)</td>
<td>6.5 ± 5.5</td>
<td>8.1 ± 4.5</td>
<td>.07</td>
</tr>
<tr>
<td>Use of sedation</td>
<td>82 (85%)</td>
<td>46 (88%)</td>
<td>.6</td>
</tr>
<tr>
<td>Duration of sedative drugs (n = 128) (d)</td>
<td>3.96 ± 3.75</td>
<td>4.47 ± 2.76</td>
<td>.32</td>
</tr>
<tr>
<td>Use of NIVA</td>
<td>5 (5%)</td>
<td>2 (4%)</td>
<td>.52</td>
</tr>
<tr>
<td>Use of PSV</td>
<td>76 (79%)</td>
<td>41 (79%)</td>
<td>.96</td>
</tr>
<tr>
<td>Duration of PSV (n = 117) (d)</td>
<td>3.2 ± 2.9</td>
<td>3.4 ± 2.9</td>
<td>.7</td>
</tr>
</tbody>
</table>

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

Data are presented as n (%).
Multiple logistic regression analysis of variables predictive of extubation failure

<table>
<thead>
<tr>
<th>Predictor variables</th>
<th>Adjusted odds ratio</th>
<th>95% confidence interval</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home noninvasive ventilation</td>
<td>12.99</td>
<td>2.86-58.89</td>
<td>.0009</td>
</tr>
<tr>
<td>SAPS II &gt;35 on ICU admission</td>
<td>3.88</td>
<td>1.65-9.12</td>
<td>.001</td>
</tr>
<tr>
<td>Sterile EA on the day of extubation</td>
<td>0.23</td>
<td>0.10-0.52</td>
<td>.0005</td>
</tr>
</tbody>
</table>

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)
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. TAITER, L. DOUGLAS CASE, MICHAEL A. LUCIA
  American Journal Respiratory Critical Care Med

APACHE Score

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

- cardiovascular: 7 variables
- respiratory: 3 variables
- renal: 3 variables
- gastrointestinal: 6 variables
- hematologic: 4 variables
- septic: 4 variables
- metabolic: 6 variables
- neurologic: 1 variable
- Add all of 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

**Glasgow Coma Scale Interpretation**

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

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

Neurosurgical patients premise

- Did not support delaying extubation when impaired neurologic status was the sole reason for prolonging intubation
Study Design (Neuro)

- Patients were assigned randomly to
  - Control
  - Intervention group

- 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
Neurosurgical patients

TABLE 1. BASELINE CHARACTERISTICS OF MECHANICALLY VENTILATED NEUROSURGERY PATIENTS

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Total (n = 100)</th>
<th>Intervention Group (n = 49)</th>
<th>Control Group (n = 51)</th>
<th>p Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age (range)</td>
<td>59 (18-91)</td>
<td>55 (18-91)</td>
<td>64 (19-88)</td>
<td>0.252</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>55 (55%)</td>
<td>24 (49%)</td>
<td>30 (59%)</td>
<td>0.323</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>79 (79%)</td>
<td>39 (80%)</td>
<td>40 (78%)</td>
<td>0.067</td>
</tr>
<tr>
<td>Other</td>
<td>21 (21%)</td>
<td>10 (20%)</td>
<td>11 (22%)</td>
<td></td>
</tr>
<tr>
<td>APACHE II score, median (interquartile range)</td>
<td>14.5 (5-21)</td>
<td>14 (5-29)</td>
<td>14.9 (8-29)</td>
<td>0.844</td>
</tr>
<tr>
<td>Acute-lung-injury score, median (interquartile range)</td>
<td>0.00 (0-3)</td>
<td>0.75 (0-3)</td>
<td>1.0 (0-2.8)</td>
<td>0.455</td>
</tr>
<tr>
<td>Chronic disease</td>
<td>18 (18%)</td>
<td>7 (14%)</td>
<td>10 (20%)</td>
<td>0.479</td>
</tr>
<tr>
<td>Mode of ventilation, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.525</td>
</tr>
<tr>
<td>Intermittent mandatory ventilation</td>
<td>22 (22%)</td>
<td>9 (18%)</td>
<td>13 (26%)</td>
<td></td>
</tr>
<tr>
<td>Pressure-support ventilation</td>
<td>25 (25%)</td>
<td>11 (22%)</td>
<td>14 (27%)</td>
<td></td>
</tr>
<tr>
<td>Both</td>
<td>52 (52%)</td>
<td>28 (57%)</td>
<td>24 (47%)</td>
<td></td>
</tr>
<tr>
<td>Assist-control ventilation</td>
<td>1 (1%)</td>
<td>1 (2%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Cause of neurosurgical admission</td>
<td></td>
<td></td>
<td></td>
<td>0.281</td>
</tr>
<tr>
<td>Head trauma</td>
<td>23 (23%)</td>
<td>12 (25%)</td>
<td>11 (22%)</td>
<td></td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>19 (19%)</td>
<td>13 (27%)</td>
<td>6 (12%)</td>
<td></td>
</tr>
<tr>
<td>Intracerebral hemorrhage/AVM</td>
<td>34 (34%)</td>
<td>15 (31%)</td>
<td>19 (37%)</td>
<td></td>
</tr>
<tr>
<td>Tumor</td>
<td>8 (8%)</td>
<td>4 (8%)</td>
<td>4 (8%)</td>
<td></td>
</tr>
<tr>
<td>Spinal trauma</td>
<td>4 (4%)</td>
<td>3 (6%)</td>
<td>1 (2%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>10 (10%)</td>
<td>2 (4%)</td>
<td>8 (16%)</td>
<td></td>
</tr>
</tbody>
</table>

Outcomes

- There were no significant differences between the Intervention and Control groups
- Complications of mortality, or cost, with or without adjusting for pretreatment patient characteristics
- Basically a well balanced study
Findings

- RCP performed an SBT on 99% (199 of 201) of occasions on which Daily Screenings were passed
  - Attempt at extubation was made for only 25% of patients who passed an SBT

- Neurosurgeons’ primary reasons for not extubating such patients included concerns about
  - Patient’s level of consciousness (84%)
  - Perform tracheostomy (10%)
  - Other reasons (6%).

Factors Associated with Successful Extubation

<table>
<thead>
<tr>
<th>TABLE 3. FACTORS ASSOCIATED WITH SUCCESSFUL EXTUBATION IN NEUROSURGICAL PATIENTS AFTER FIRST EXTUBATION ATTEMPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>GCS score</td>
</tr>
<tr>
<td>f/Vr ratio</td>
</tr>
<tr>
<td>P/F ratio</td>
</tr>
<tr>
<td>VT</td>
</tr>
</tbody>
</table>

Definition of abbreviations: CI = confidence interval; F = flow; f = frequency of respiration; GCS = Glasgow Coma Scale; OR = odds ratio; P = pressure; VT = minute volume; VT = tidal volume.
Factors Associated with Successful Extubation of neurosurgical patients

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

<table>
<thead>
<tr>
<th>Parameters</th>
<th>OR</th>
<th>95% CI</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f/\text{VT} \leq 105$</td>
<td>10.3</td>
<td>1.2–87</td>
<td>0.02</td>
</tr>
<tr>
<td>P/F ratio $\geq 200$</td>
<td>3.3</td>
<td>1.8–6</td>
<td>0.0001</td>
</tr>
<tr>
<td>GCS score $\geq 8$</td>
<td>4.9</td>
<td>2.8–8.3</td>
<td>$\leq 0.001$</td>
</tr>
<tr>
<td>P/F ratio, GCS score, $f/\text{VT}$ ratio</td>
<td>5.1</td>
<td>3.1–8.4</td>
<td>$\leq 0.001$</td>
</tr>
<tr>
<td>P/F ratio, GCS score</td>
<td>4.8</td>
<td>2.9–8</td>
<td>$\leq 0.001$</td>
</tr>
<tr>
<td>$f/\text{VT}$ ratio, GCS score</td>
<td>4.9</td>
<td>2.9–8.5</td>
<td>$\leq 0.001$</td>
</tr>
</tbody>
</table>

Definition of abbreviations: CI = confidence interval; $f$ = frequency of respiration; GCS = Glasgow Coma Scale; OR = odds ratio; P/F = $\text{PaO}_2/\text{F}O_2$; VT = tidal volume.

Factors Associated with Successful Extubation

- Successful extubations were associated with higher GCS score
- Higher P/F ratio
- Lower minute ventilation
- The $f/\text{VT}$ 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

![Glasgow Coma Scale Chart]

- Successful Extubation
- % of All Extubations
- Glasgow Coma Scale

<table>
<thead>
<tr>
<th>GCS</th>
<th>% of All Extubations</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>33</td>
</tr>
<tr>
<td>6</td>
<td>67</td>
</tr>
<tr>
<td>7</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>92</td>
</tr>
<tr>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>10</td>
<td>79</td>
</tr>
<tr>
<td>11</td>
<td>70</td>
</tr>
</tbody>
</table>

n=10  n=8  n=3  n=9  n=6  n=13  n=11  n=29  n=27
Take home messages

Integrate GCS into weaning of neurosurgical patients

Tool for determining on the edge patients

- 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**

- Hypothesis was that 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?)

**Table 1—Patient Characteristics**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Successful Exubation (n = 74)</th>
<th>Failed Exubation (n = 10)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>58 ± 15</td>
<td>62 ± 12</td>
<td>0.03</td>
</tr>
<tr>
<td>Male sex</td>
<td>67</td>
<td>65</td>
<td>6.4</td>
</tr>
<tr>
<td>APACHE II score</td>
<td>22 ± 8</td>
<td>24 ± 8</td>
<td>0.6</td>
</tr>
<tr>
<td>Previous length of MV, d</td>
<td>8.4 ± 6.2</td>
<td>6.7 ± 5.5</td>
<td>0.7</td>
</tr>
<tr>
<td>GCS score (motor + ocular components only)</td>
<td>9 ± 1</td>
<td>9 ± 1</td>
<td>0.3</td>
</tr>
<tr>
<td>PSV level, cm H2O</td>
<td>14 ± 2.3</td>
<td>14 ± 2</td>
<td>0.8</td>
</tr>
<tr>
<td>PEEP, cm H2O</td>
<td>5 ± 1</td>
<td>5 ± 1.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>12</td>
<td>21</td>
<td>0.5</td>
</tr>
<tr>
<td>Hypertension</td>
<td>40</td>
<td>42</td>
<td>1</td>
</tr>
<tr>
<td>Diabetes</td>
<td>23</td>
<td>11</td>
<td>0.5</td>
</tr>
<tr>
<td>COPD</td>
<td>14</td>
<td>31</td>
<td>0.04</td>
</tr>
<tr>
<td>OSAS</td>
<td>7</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Medical diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>22</td>
<td>21</td>
<td>0.8</td>
</tr>
<tr>
<td>Neurological</td>
<td>29</td>
<td>37</td>
<td>0.8</td>
</tr>
<tr>
<td>Other</td>
<td>20</td>
<td>16</td>
<td>0.9</td>
</tr>
<tr>
<td>Surgical diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thorax/abdomen</td>
<td>37</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Neurosurgery</td>
<td>11</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

*Values are given as the mean ± SD or %. OSAS = obstructive sleep apnea syndrome. Medical and surgical diagnoses may coexist in some patients.
Hernandez Study

**Figure 2.** Evolution of the $V_E$ during the monitoring period.

### Table 2—Univariate Analysis of Ventilatory Variables*

<table>
<thead>
<tr>
<th>Variables</th>
<th>Successful Exubation (n = 74)</th>
<th>Failed Exubation (n = 19)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal $V_E$, L</td>
<td>$11.2 \pm 3$</td>
<td>$10.9 \pm 2.9$</td>
<td>0.7</td>
</tr>
<tr>
<td>Basal RR, breaths/min</td>
<td>$20 \pm 6$</td>
<td>$19.6 \pm 6.2$</td>
<td>0.8</td>
</tr>
<tr>
<td>Basal $V_R$, mL</td>
<td>$557 \pm 263$</td>
<td>$580 \pm 249$</td>
<td>0.7</td>
</tr>
<tr>
<td>RT of $V_E$, min</td>
<td>$5.4 \pm 5.2$</td>
<td>$14.5 \pm 9.7$</td>
<td>0.001</td>
</tr>
<tr>
<td>RT of RR, min</td>
<td>$9.2 \pm 8.8$</td>
<td>$10.2 \pm 9.4$</td>
<td>0.8</td>
</tr>
<tr>
<td>RT50%Δ$V_E$, min</td>
<td>$2.7 \pm 1.2$</td>
<td>$10.7 \pm 8.4$</td>
<td>0.001</td>
</tr>
<tr>
<td>RT50%ΔRR, min</td>
<td>$4.3 \pm 4.5$</td>
<td>$7.3 \pm 8.7$</td>
<td>0.8</td>
</tr>
</tbody>
</table>

*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.
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

Questions???

The End
References

- 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

New slides for failed extubations

- Working on now
Predictors of respiratory mechanics

- New info

Assessing airway protection

- Working on new slides
Management of failed extubations

- Working on now