EXTUBATION AFTER BRAIN INJURY

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Characteristics & Outcomes in Adult Patients Receiving Mechanical Ventilation


“Coma” – reason for initiation of ventilation in 17% of patients

- Independently associated with mortality
- Odds ratio 2.98 (2.44-3.63), p<0.001
Clinical Scenario

A patient is day 4 post traumatic brain injury

- Intubated and ventilated - passed a SBT and now on PS 6, PEEP 5, FiO₂ 0.4
- His level of consciousness remains depressed (localises to pain, no eye opening, intubated – 6T)
Clinical Scenario

A patient is day 4 post TBI
• Intubated and ventilated - passed a SBT and now on PS 6, PEEP 5, FiO₂ 0.4
• His level of consciousness remains depressed (localises to pain, no eye opening, intubated – 6T)

Should you extubate?
Wait (for improvement) and then extubate?
Tracheostomy now?
Comparison of three methods of gradual withdrawal from ventilatory support during weaning from mechanical ventilation

L Brochard, A Rauss, S Benito, G Conti, J Mancebo, N Rekik, A Gasparetto and F Lemaire
Medical Intensive Care Unit, Hopital Henri Mondor, Creteil, France.
Clinical Characteristics, Respiratory Functional Parameters, and Outcome of a Two-Hour T-Piece Trial in Patients Weaning from Mechanical Ventilation

IMMA VALLVERDÚ, NURIA CALAF, MIREIA SUBIRANA, ALVAR NET, SALVADOR BENITO, and JORDI MANCEBO


Intensive Care Unit, Hospital Santa Creu i Sant Pau, Barcelona, Spain
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Removal from ventilatory support is a two-step process:

1. Determine capability for unassisted breathing
2. Determine capability to tolerate removal of endotracheal tube

Both delayed extubation and extubation failure are associated with increased morbidity and mortality.
Neurologic status, cough, secretions and extubation outcomes

88 MICU Patients Passed SBT

Risk Factors:
- 4 Simple Tasks
- Cough Peak Flow < 60 L/min
- Secretions > 2.5 ml/h

Adil Salam
Lisa Tilluckdharry
Yaw Amoateng-Adjepong
Constantine A. Manthous
Risk Factors for Extubation Failure in Patients Following a Successful Spontaneous Breathing Trial*

*(CHEST 2006; 130:1664–1671)*

Fernando Frutos-Vivar, MD; Niall D. Ferguson, MD, MSc; Andrés Esteban, MD, PhD; Scott K. Epstein, MD, FCCP; Yaseen Arabi, MD, FCCP; Carlos Apezteguía, MD; Marco González, MD; Nicholas S. Hill, MD, FCCP; Stefano Narra, MD; Gabriel D’Empaire, MD; and Antonio Anzueto, MD

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**Rapid breathing shallow index**

- ≤ 57 breaths/min/L
  - 65 / 596 (11%)
  - Pneumonia as reason for mechanical ventilation
    - NO
      - 47 / 592 (9.5%)
    - YES
      - 18 / 104 (17%)
  - Positive fluid balance
    - NO
      - 20 / 154 (13%)
    - YES
      - 36 / 150 (24%)

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Reintubation rate (%)
Predictors of Successful Extubation in Neurosurgical Patients

ANDREW M. NAMEN, E. WESLEY ELY, STEPHEN B. TATTER, L. DOUGLAS CASE, MICHAEL A. LUCIA, ALLEN SMITH, SCOTT LANDRY, JOHN A. WILSON, STEVEN S. GLAZIER, CHARLES L. BRANCH, DAVID L. KELLY, DAVID L. BOWTON, and EDWARD F. HAPONIK


Randomized trial of RT-driven daily SBT protocol (similar to 1996 NEJM paper) in 100 mixed neurosurgical patients

98/100 patients had an extubation attempt

• 38 (39%) failed - ? timing

30% tracheostomy rate
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Am J Respir Crit Care Med Vol 163, pp 658-664, 2001

![Graph showing successful extubation rates by Glasgow Coma Scale](image)

- **Successful Extubation**

% of All Extubations:
- 3: 10% (n=10)
- 4: 25% (n=8)
- 5: 33% (n=3)
- 6: 67% (n=9)
- 7: 50% (n=6)
- 8: 92% (n=13)
- 9: 75% (n=11)
- 10: 79% (n=29)
- 11: 70% (n=27)

Glasgow Coma Scale
Predictors of Successful Extubation in Neurosurgical Patients

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- Randomized trial of RT-driven daily SBT protocol (similar to 1996 NEJM paper) in 100 mixed neurosurgical patients
- 98/100 patients had an extubation attempt
- 38 (39%) failed - ? timing
- 30% tracheostomy rate
- 44 total extubation failures (44/117 - 38%) - followed by reintubation in half, others withdrawal of LST
Implications of Extubation Delay in Brain-Injured Patients Meeting Standard Weaning Criteria

WILLIAM M. COPLIN, DAVID J. PIERSON, KATHY D. COOLEY, DAVID W. NEWELL, and GORDON D. RUBENFELD

Division of Pulmonary and Critical Care Medicine and the Departments of Neurology, Neurological Surgery, and Respiratory Care. Harborview Medical Center, University of Washington, Seattle, Washington

136 patients with isolated brain injuries

- 78 TBI
- 26 SAH
- 24 Stroke
- 8 Other

Exclusions:

Chest trauma (30); Abdo Inj/Surg (17);
Impending brain death (12);
Parameters not met before death/extubation (15);
Parameters met but died or trach before extubation (10);
ALI (2); MODS (1)
## Implications of Extubation Delay in Brain-Injured Patients Meeting Standard Weaning Criteria

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*Am J Respir Crit Care Med Vol 161. pp 1530–1536, 2000*

### CRITERIA USED TO DETERMINE READINESS FOR DISCONTINUATION OF VENTILATORY SUPPORT*

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic status</td>
<td>Physical examination not deteriorating</td>
</tr>
<tr>
<td></td>
<td>ICP &lt; 20 mm Hg (when ICP measured)</td>
</tr>
<tr>
<td></td>
<td>CPP ≥ 60 mm Hg (when ICP measured)</td>
</tr>
<tr>
<td>Cardiovascular status</td>
<td>Systolic BP &gt; 90 and &lt; 160 mm Hg</td>
</tr>
<tr>
<td></td>
<td>HR &gt; 60 and &lt; 125 beats/min</td>
</tr>
<tr>
<td></td>
<td>No acute dysrhythmia</td>
</tr>
<tr>
<td>Arterial oxygenation</td>
<td><strong>Extubation Delay – &gt;48 hrs</strong></td>
</tr>
<tr>
<td>(on ≤ 5 cm H$_2$O PEEP)</td>
<td></td>
</tr>
<tr>
<td>Spontaneous ventilatory mechanics</td>
<td>MIP &gt; 20 cm H$_2$O</td>
</tr>
<tr>
<td></td>
<td>RSBI (f/Vt) &lt; 105</td>
</tr>
<tr>
<td></td>
<td>Spontaneous $V_e$ ≤ 12 L/min</td>
</tr>
<tr>
<td></td>
<td>Spontaneous $V_e$ ≥ 80% of ventilator spontaneous $V_e$</td>
</tr>
<tr>
<td>Absence of specific indication for mechanical ventilation</td>
<td>Surgery requiring general anesthesia not planned within 72 h</td>
</tr>
<tr>
<td></td>
<td>No deliberate hyperventilation</td>
</tr>
<tr>
<td></td>
<td>Cervical-spine status cleared</td>
</tr>
</tbody>
</table>
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Am J Respir Crit Care Med Vol 161, pp 1530-1536, 2000

Reintubation required in 17/99 (17%) prompt vs. 7/37 (19%) of delayed patients

- 39/49 (80%) of GCS $\leq$ 8 and 10/11 (91%) of GCS $\leq$ 4 were successfully extubated
- Spontaneous cough and lower suction frequency associated with successful extubation

Pneumonia: 21% vs. 38%
ICU LOS: 3 vs. 8 days
Mortality: 12% vs. 27%

All favouring the non-delayed group
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16 pneumonias

9 pneumonias

10 pneumonias

A

B

C

Admission

Meet readiness criteria

Extubated

Endpoint
Ready for Extubation?
Causes & Consequences of Extubation Failure in Neurosurgical ICU Patients

ND Ferguson, JA Lorente, DA Margel, KPW Chan, WL Lee, W Demajo, TE Stewart

AJRCCM 2004 169:A123
Included Patients

- 2380 Intubated Admissions 1998-2002
  - 278 Repeat Admissions

- 2102 Individual Patients
  - 654 Deaths
  - 111 Trachs.

- 1337 Patients Extubated Prior to Death / Trach
  - 50 Self-extubation
  - 7 Tube exchanges

- 1280 Elective Extubations Included
Timing of Extubation Failure

Proportion Remaining Extubated

Time (hrs)

Neuro vs. Med-Surg

p=0.63 by log rank test
Conclusions

- Extubation failure rates and times are similar between med-surg and neuro patients in our centre
- Causes of extubation failure differ
- Different approaches to identifying extubation readiness may be needed for this patient population
NEUROLOGICAL ICU EXTUBATION STRATEGY UTILIZATION AND REINTUBATION OUTCOMES (NEURO) PILOT STUDY

ND Ferguson, NKJ Adhikari, DC Scales, RA Fowler, M Chapman, AJ Baker, DJ Cook, and MO Meade for the Canadian Critical Care Trials Group

Interdepartmental Division of Critical Care Medicine, University of Toronto
Methods

Prospective observational study enrolling consecutive ventilated brain-injured patients

3 University of Toronto hospitals

• Toronto Western Hospital
• Sunnybrook Health Science Centre
• St. Michael’s Hospital

April – November 2005

REB approved with waiver for consent
**Figure 1 – Patient Enrolment and Follow-up**

### Active Observation for Readiness to Extubate
- GCS ≥ previous day
- Intracranial pressure < 20
- CPP > 60 mm Hg
- PaO₂/FiO₂ > 200 mm Hg
- PEEP ≤ 5 cmH₂O
- Temperature < 38.5 °C
- MAP > 60, no inotropes
- No surgery planned
- No hyperventilation order
- Tolerates minimal ventilatory support

### Observation for Clinical Suspicion of Pneumonia
- Temp >38.5°C + WBC >12
- Positive respiratory cultures
- New antibiotics
- Need for FiO₂ > 0.5 x 6hrs
- Reintubation
- ICU Readmission

### Patients meet criteria for active observation:
- Acute brain injury*
- Mechanical ventilation for ≥ 24 hrs via endotracheal tube
- Age > 16 years
- Not previously in study cohort

### Patients meet cohort exclusion criteria:
- Unplanned extubation in ICU
- Death prior to extubation
- Extubation for withdrawal of life-sustaining treatment

### Patients meet cohort inclusion criteria:
- Elective extubation or primary tracheostomy

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* New subarachnoid haemorrhage, traumatic brain injury, ischemic stroke, intracerebral bleed, subdural haematoma, epidural haematoma, post-craniotomy, global cerebral ischemia, status epilepticus, meningitis, encephalitis, or abscess

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**Abbreviations:** GCS=Glasgow coma score; CPP=cerebral perfusion pressure; PaO₂=arterial oxygen pressure; FiO₂=fraction of inspired oxygen; PEEP=positive end-expiratory pressure; MAP=mean arterial pressure; WBC=white blood cells
# Baseline Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>N = 238</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>51 (36-66)</td>
</tr>
<tr>
<td>Male Sex</td>
<td>155 (65%)</td>
</tr>
<tr>
<td>APACHE II</td>
<td>18 (14-23)</td>
</tr>
<tr>
<td>GCS (max 10T)</td>
<td>5.5 (3-7)</td>
</tr>
<tr>
<td>Location prior to admission</td>
<td></td>
</tr>
<tr>
<td>Home:</td>
<td>140 (59%)</td>
</tr>
<tr>
<td>Other acute hospital</td>
<td>70 (29%)</td>
</tr>
</tbody>
</table>
# Admitting Diagnoses

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Count (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traumatic Brain Injury</td>
<td>65 (27%)</td>
</tr>
<tr>
<td>Subarachnoid Bleed</td>
<td>50 (21%)</td>
</tr>
<tr>
<td>Intracranial Bleed</td>
<td>37 (16%)</td>
</tr>
<tr>
<td>Subdural Bleed</td>
<td>34 (14%)</td>
</tr>
<tr>
<td>Post-craniotomy</td>
<td>16 (7%)</td>
</tr>
<tr>
<td>Extradural Bleed</td>
<td>10 (4%)</td>
</tr>
<tr>
<td>Other / Missing</td>
<td>26 (11%)</td>
</tr>
</tbody>
</table>
Results – Extubation Timing

147 Elective Extubations

Days from Readiness to Extubation:

- Prior to Readiness
- Prompt: 3.6 (1.3-5.9)
- Delayed
Results – Extubation Failure

147 Elective Extubations

- 47 (32%) Reintubated
  - 33 within 72 hours
  - Extubation Failure Rate (95%CI): 22 (16-30)%

- Median time to reintubation:
  - 0.63 (0.08 – 2.41) days
# Predictors of Extubation Failure

## Table 3. Multivariable Regression Model for Predictors of Successful Extubation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Extubation Success</th>
<th>95% Wald Confidence Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (10 year increase)</td>
<td>0.77</td>
<td>0.59 - 1.01</td>
</tr>
<tr>
<td>Spontaneous cough present</td>
<td>2.85</td>
<td>1.11 - 7.31</td>
</tr>
<tr>
<td>Positive fluid balance'</td>
<td>0.69</td>
<td>0.52 - 0.92</td>
</tr>
<tr>
<td>Hemoglobin Level (10 g/L increase)</td>
<td>0.76</td>
<td>0.58 - 0.99</td>
</tr>
</tbody>
</table>
GCS & Extubation Failure

GCS at Extubation for Successful vs. Failed Extubation

Number of Patients

GCS at Extubation (Max 10T)

- # Successful extubation
- # Failed extubation

Interdepartmental Division of Critical Care Medicine
GSC & Tracheostomy

GCS for tracheostomy patients

GCS at the time of tracheostomy (Max 10T)

Number of Patients

2 3 4 5 6 7 8 9 10

5 4 3 4 5 5 5 5 5
### Outcomes

<table>
<thead>
<tr>
<th></th>
<th>ICU Mortality</th>
<th>p-value</th>
<th>Hospital Mortality</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prompt Extubation</strong></td>
<td>2 (3%)</td>
<td>0.62</td>
<td>3 (5%)</td>
<td>0.097</td>
</tr>
<tr>
<td><strong>Delayed Extubation</strong></td>
<td>2 (4%)</td>
<td></td>
<td>7 (13%)</td>
<td></td>
</tr>
<tr>
<td><strong>Extubation Success</strong></td>
<td>1 (1%)</td>
<td>0.004</td>
<td>8 (7%)</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Extubation Failure</strong></td>
<td>4 (15%)</td>
<td></td>
<td>4 (16%)</td>
<td></td>
</tr>
<tr>
<td><strong>Primary Tracheostomy</strong></td>
<td>8 (20%)</td>
<td>0.75*</td>
<td>9 (24%)</td>
<td>0.64*</td>
</tr>
</tbody>
</table>

*c/w extubation failure*
Conclusions

Extubation failure was common in this group of patients

Extubation delay did not appear to be associated with adverse outcomes

- Extubation failure
- Mortality

Mortality rates appeared similar between primary tracheostomy and extubation failure
<table>
<thead>
<tr>
<th>Related Studies in Non-Brain-Injured Populations</th>
<th>Studies in Brain-Injured Populations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicting extubation failure after successful SBT (NF)(^1)</td>
<td>Prior Work: Observational study of prompt or delayed extubation (GR)(^2)</td>
</tr>
<tr>
<td>Treating extubation failure with non-invasive ventilation (NF)(^2)</td>
<td>Pilot Work: Single-centre observational study on causes of extubation failure(^4)</td>
</tr>
<tr>
<td>Observational study of tracheostomy timing (DS)(^5)</td>
<td>Future Research: Multi-centre RCT</td>
</tr>
<tr>
<td>Observational study of variability in tracheostomy use (AN)(^8)</td>
<td>Future Research: Secondary analyses of RCT dataset</td>
</tr>
<tr>
<td>RCT of early vs. later tracheostomy (BC)(^9)</td>
<td>Future Research: Knowledge translation implementation</td>
</tr>
<tr>
<td>Editorials &amp; commentary on tracheostomy timing (NF, DS, BH)(^10-13)</td>
<td>Vanguard/Pilot RCT</td>
</tr>
</tbody>
</table>

NF=Niall Ferguson; DS=Damon Scales; BC=Brian Cuthbertson; AN=Avery Nathens; GR=Gordon Rubenfeld; AA=Aziz Alali
NEURO-ETT Study Question

Does extubation vs. tracheostomy lead to better clinical outcomes or improved cost-effectiveness for patients with acute severe brain injury who pass a SBT but have persistent decreased level of consciousness?
Primary Research Question

What is the effect of tracheostomy vs. a trial of extubation on
(1) ventilator-free-days to day 28
(2) cost-effectiveness
among patients receiving minimal mechanical ventilatory support for severe and persistent brain injury?
Study Overview

Design: Individual Patient RCT

Patients:
Acute brain injured patients, > 96 hrs
Weaned to minimal settings, but persistent decreased LOC

Intervention:
Early tracheostomy vs. prompt extubation

Outcomes:
VFDs
Costs (cost-effectiveness)
n.ferguson@utoronto.ca

leading science, leading practice

October 29 – November 1, 2014
Sheraton Centre Hotel, Toronto

www.criticalcarecanada.com