Nurses’ Role in Mechanical Ventilation: an International Perspective

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Why is it important to make international comparisons?
- Comparisons between countries are no only useful but essential to:
  - identify available resources in different countries
  - interpret study results
  - study the efficacy/effectiveness of critical care itself and the influence of various organizational factors
- Wunsch et al, 2007 Curr Opin Crit Care

Why is Mechanical Ventilation Important for Nurses?
- 24 hour bedside presence
- Nurses able to:
  - identify changing physiological responses and initiate interventions without delay
  - recognize weaning readiness
- Availability of RTs differs institutionally/internationally
  - RN lack of understanding for ventilatory/weaning processes may increase duration of mechanical ventilation and result in negative patient outcomes
- Patients who undergo prolonged mechanical ventilation require multidisciplinary, multi-system approach

What’s Happening in Canada…

With thanks to Ms Orla Smith
St Michael’s Hospital

ICU Profile
- Canadian ICUs admit approx 100,000 patients each year
- Conservatively consume 8% of hospital budget
- Survey of 98 Canadian ICUs in 2003:
  - median number of ICU beds ~ 14
  - median number of staff physicians ~ 5
  - median number admissions/ICU yr ~ 751
  - overnight physician coverage ~ 51% (adult ICUs)


ICU Staffing

Mechanical Ventilation in Ontario

Key epidemiological trends 1992-2000:
- >150,000 non-cardiac surgery patients received mechanical ventilation
- Incidence of mechanical ventilation increased by 9%
- 10% of all mechanically ventilated patients had >1 episode of mechanical ventilation
- 30% increase in mechanical ventilation days
  - Mechanical ventilation days consume one of every 10 hospital inpatient bed days
- Mortality increased by 22%

Needham et al. (2004). Crit Care Med. 32:1504-1509

Change in patient characteristics from 1992 to 2000
- ↑ >80 years old
- ↑ respiratory disease
- ↓ cardiovascular disease and neoplasms
- ↑ inpatient and 30-day mortality

Needham et al. (2004). Crit Care Med. 32:1504-1509

Ventilation in Ontario in 2026
- Number of mechanically ventilated patients projected to increase by 80%
  - Crude increase of >30%
  - Annual increase of 2.3%
- Mechanical ventilation days will consume 1 of every 9 hospital inpatient bed days
  - Indicative of increased inpatient acuity
- Worsening shortage of intensivists and critical care nurses


Relevant Studies: Clinician Roles in Weaning in Canada

<table>
<thead>
<tr>
<th>Role</th>
<th>BT (%)</th>
<th>Internist (%)</th>
<th>Fellow (%)</th>
<th>Attending (%)</th>
<th>Nurse (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily screening</td>
<td>31.8</td>
<td>59.1</td>
<td>41.8</td>
<td>28.6</td>
<td>20.4</td>
</tr>
<tr>
<td>Decision to conduct SBT</td>
<td>77.8</td>
<td>76.6</td>
<td>69.6</td>
<td>31.3</td>
<td>8.5</td>
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<tr>
<td>Actual SBT conduct</td>
<td>106%</td>
<td>103%</td>
<td>61%</td>
<td>29%</td>
<td>5.1</td>
</tr>
<tr>
<td>Decision to adjust settings</td>
<td>47.8</td>
<td>68.3</td>
<td>70.4</td>
<td>45.9</td>
<td>8.9</td>
</tr>
<tr>
<td>Actual adjustment of settings</td>
<td>♠</td>
<td>26.6</td>
<td>15.9</td>
<td>4.1</td>
<td></td>
</tr>
<tr>
<td>Decision to ventilate</td>
<td>41.4</td>
<td>27.9</td>
<td>67.7</td>
<td>37.4</td>
<td>15.2</td>
</tr>
<tr>
<td>Actual ventilation</td>
<td>54.3</td>
<td>27.3</td>
<td>18.2</td>
<td>12.1</td>
<td>17.2</td>
</tr>
</tbody>
</table>

Standards for Critical Care Nursing Practice
- The critical care nurse:
  - Collects data using technological supports
  - Anticipates and/or recognizes actual or potential immediate life threatening health crises including:
    - Ineffective airway clearance, breathing patterns, and impaired gas exchange
  - Intervenes to correct an ineffective breathing pattern by:
    - Administering pharmacologic agents
    - Manually ventilating
    - Assisting with interventions
Nurses’ Role in Canada
- Little empirical data
- Not focused on manipulation of the ventilator or decision-making
- Focus directed towards care of the ventilated patient
  - ongoing assessment and surveillance
  - symptom management
  - optimizing patient for weaning

ICU Profile
- Approx 5980 ICUs
- approx 55,000 pts per day
- 4245 (71%) in non-teaching community hospitals
- 3183 (53%) have no intensivist coverage
- 20% had in-house physician coverage on weekends, 12% on week nights and 10% of week and ends
- respiratory insufficiency primary reason for admission
- nurse-to-patient ratio 1:2
- RT ratios vary across institutions
- *Angus et al. (2006) Crit Care Med. 34: 1016-1024*

Relevant Studies in the US
- Mail survey
- Participants:
  - Random sample - American Association of Critical Care Nurses (AACN) (n = 3500)
  - Inclusion criteria:
    - providing direct patient care for ≥ 8 hours/week to adult mechanically ventilated patients
  - Response rate 793/3500 (23%)

Funding University of Kentucky Faculty Research Support Award

Mechanical Ventilation in the US
- Population adjusted incidence of mechanical ventilation ≥ 11% (1995-2002)*
  - No corresponding increase in ICU beds
  - >64 years of age ≥ 9%
  - 18-64 years of age ≥ 13%
  - higher burden of co-morbidities (Charison index)
  - proportion of patients ventilated >96 hours increased from 33% to 35%
  - adjusted mean hospital charges rose 12%


What’s happening in the United States...
With thanks to Dr Susan Frazier and Sarah Kelly

Standards for Critical Care Nursing Practice
- The critical care nurse:
  - interprets diagnostic data including:
    - arterial and venous blood gases and other laboratory results
    - ventilation information
  - weaning parameters
  - intervenes to correct impaired gas exchange by managing changes in:
    - oxygenation
    - minute ventilation
    - modes of ventilation
  - intervenes to promote successful weaning from ventilatory support by ensuring adequate nutrition, pain management, rest, and alleviation from anxiety.
Use of Weaning Guidelines

Role of Nurse in Ventilator Weaning

Nurses in small hospitals less likely to assess weaning readiness (p = 0.02)

Non-physician-led Weaning Protocols

Protocol Assessment SBT Team

Proportion

SBT

Small

Medium

Large

* Significant difference in response between respondents based on hospital size, p < 0.04

RT/RN-led Weaning Protocols

Effect on Weaning Time and Incidence of Ventilator-Associated Pneumonia

A randomized, controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation

Readiness

Initiation

Monitoring

Discontinue

ICU Profile in UK

- 1-2% of total bed numbers
- 80% are "closed" units
- Majority are mixed/general ICUs
- Average ICU ~4-6 beds
  - (20+ beds in some tertiary centres)
  - 45% of hospitals also had a high dependency unit
- Throughput ~400-1800 pts/yr
- Mean APACHE II score 16.5
- Cardiovascular, GI, and respiratory admissions most prevalent


What’s Happening in the United Kingdom…

With thanks to Dr Bronagh Blackwood
Queen’s University, Northern Ireland
Staffing Profile

- 2–7 medical consultants responsible for clinical care/ICU
- Few full-time intensivists—most have anaesthetic or medical sessions in addition to ICU commitment
- Junior doctor staffing levels lower in UK than Europe
- General policy in UK is 1:1 nurse patient ratio
- 45% of nurses in UK hold ENB 100: 6–12 month qualification in critical care specialty
- No RTs


Weaning from Mechanical Ventilation

- Since 1997, focus on decreasing unacceptable variations in practice
- A First Class Service: Quality in the new NHS (DOH 1998)
- 2000 – establishment of critical care nurse consultants, practice development teams
  - 22% of hospitals responding to survey used weaning protocol
  - 1% used weaning team
  - Rest clinician-led—though professional group of ‘clinician’ not specified

Rationales for Nurse-led Protocols

- Evidence from US = ↓ ventilator days
- Initiatives expanding nurse role/improving patient outcomes
  - Scope of Professional Practice, 1992
  - Comprehensive Critical Care, 2000
  - Critical to Success, 2002
- Weaning inefficient due to need for medical approval to progress weaning
- Non-uniform nursing clinical expertise to lead weaning process
- Protocols standardizing practice, guiding junior staff and optimizing patient outcome

Study Conclusions

- ICU cultures & interprofessional working practices may also influence findings.
  - Kollef protocols had least effect in unit where weaning delegated to nurses (7.9-hours longer).
  - Marelich reported no effect in unit that had a standardised multi-disciplinary approach.
- Thus, while protocols may streamline practice & reduce variability where this exists, they do not affect outcomes in units where good communication & standardised practice already exists.

ICU Profile

- 195 ICUs in Aus and NZ.
- Majority are combined units, very few specialized.
- All closed intensivist-led units.
- Aus: 1233 available beds/20325,926 population.
- Mean beds 13/ICU.
- ICU admission 2.24% of overall hospital admissions.
- Median LOS: 43 hours.
- Median APACHE II 15.57.

ICU Workforce

- 3.9 beds/intensivist.
- ICUs also staffed by senior registrars/residents.
- 1:1 nurse-to-patient ratio.
- 56% of RNs hold postgraduate specialty qualification.
- No RTs.
- Interdisciplinary team focus.

Ventilation Decisions made by Nursing Staff Independently

<table>
<thead>
<tr>
<th>Decision</th>
<th>n</th>
<th>% (95% CI)</th>
<th>Relative risk (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in FiO₂</td>
<td>49</td>
<td>91 (86-97)</td>
<td>1</td>
</tr>
<tr>
<td>Decrease in FiO₂</td>
<td>46</td>
<td>85 (73-90)</td>
<td>0.9 (0.8-1.1)</td>
</tr>
<tr>
<td>Ventilator rate</td>
<td>35</td>
<td>65 (51-77)</td>
<td>0.7 (0.6-0.9)</td>
</tr>
<tr>
<td>Decrease of pressure support</td>
<td>33</td>
<td>57 (43-71)</td>
<td>0.6 (0.5-0.8)</td>
</tr>
<tr>
<td>Increase of pressure support</td>
<td>33</td>
<td>67 (43-71)</td>
<td>0.6 (0.5-0.8)</td>
</tr>
<tr>
<td>Tidal Volume</td>
<td>26</td>
<td>48 (34-62)</td>
<td>0.5 (0.4-0.7)</td>
</tr>
<tr>
<td>Mode</td>
<td>20</td>
<td>37 (24-51)</td>
<td>0.4 (0.3-0.6)</td>
</tr>
<tr>
<td>Decrease of PEEP</td>
<td>16</td>
<td>31 (18-44)</td>
<td>0.3 (0.2-0.5)</td>
</tr>
<tr>
<td>Increase of PEEP</td>
<td>15</td>
<td>28 (16-42)</td>
<td>0.3 (0.2-0.5)</td>
</tr>
</tbody>
</table>
Adjustments by Other Groups

- Adjustments initiated solely by medical staff
  - 39% PEEP
  - 31% inspiratory pressure
  - 29% extubations
- Adjustments initiated by nurses and medical staff in collaboration
  - 68% extubations
  - 31% mode
  - 26% other

Decisions

- Nurses initiated weaning in 249/306 (81%) patients who underwent weaning
- Exclusively nursing decisions
  - 896 (75%) all decisions prior to weaning
  - 1642 (60%) during weaning
- 4638 changes to ventilator from 3986 decisions
  - Nursing staff made 3905 (98%)

Setting Changes According to Professional Group

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Nursing</th>
<th>Medical</th>
<th>Collaborative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode</strong></td>
<td>1238</td>
<td>613 (49)</td>
<td>244 (20)</td>
<td>381 (31)</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>296</td>
<td>223 (75)</td>
<td>45 (15)</td>
<td>28 (10)</td>
</tr>
<tr>
<td><strong>Vt</strong></td>
<td>80</td>
<td>62 (77)</td>
<td>10 (13)</td>
<td>8 (10)</td>
</tr>
<tr>
<td><strong>Pip</strong></td>
<td>60</td>
<td>39 (66)</td>
<td>19 (32)</td>
<td>11 (18)</td>
</tr>
<tr>
<td><strong>PS</strong></td>
<td>536</td>
<td>347 (64)</td>
<td>112 (21)</td>
<td>57 (11)</td>
</tr>
<tr>
<td><strong>PEEP</strong></td>
<td>341</td>
<td>159 (47)</td>
<td>136 (40)</td>
<td>47 (14)</td>
</tr>
<tr>
<td><strong>FiO2</strong></td>
<td>1725</td>
<td>1480 (86)</td>
<td>147 (8.5)</td>
<td>98 (5.7)</td>
</tr>
<tr>
<td><strong>Extubation</strong></td>
<td>307</td>
<td>4 (1)</td>
<td>92 (30)</td>
<td>211 (69)</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>55</td>
<td>22 (40)</td>
<td>22 (40)</td>
<td>11 (20)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4638</td>
<td>2960</td>
<td>826</td>
<td>852</td>
</tr>
</tbody>
</table>

Three-month prospective study
Bedside nurses serially documented each ‘decision episode’
any event that resulted in adjustment to ventilator settings
Exclusively Nursing Decisions

- Exclusively nursing decisions, prior to and during weaning, associated with:
  - post operative respiratory failure or coma
  - duration of ventilation ≥ seven days
- Nursing decisions were less common for:
  - respiratory disease (pneumonia, ARDS, COPD)
  - multiple organ dysfunction (higher SOFAmax score)
- Nursing decisions more common in all patient categories
- Exception was COPD (collaborative)
- More medical decision-making was observed in patients with higher SOFAmax scores


Conclusions

- Nurses were majority of changes
  - ranged in complexity from commencement of weaning to FiO₂ titration
  - pre/post weaning
  - across spectrum of severity of illness
- Collaborative decisions more frequent in patients with higher severity of illness and predominantly respiratory disease
  - extubation decisions collaborative in nature
- Exclusively medical decisions infrequent

Univariate Hazard Ratios for reaching “Separation Potential”

<table>
<thead>
<tr>
<th>Reference</th>
<th>Univariate</th>
<th>Hazard ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartCare/PS</td>
<td>Control</td>
<td>0.79 (0.52-1.20)</td>
<td>0.27</td>
</tr>
<tr>
<td>Age ≥ median</td>
<td>&lt; Median</td>
<td>0.85 (0.68-1.04)</td>
<td>0.06</td>
</tr>
<tr>
<td>Male gender</td>
<td>Female</td>
<td>1.63 (1.04-2.56)</td>
<td>0.05</td>
</tr>
<tr>
<td>APACHE II ≥ median</td>
<td>&lt; Median</td>
<td>0.89 (0.77-1.06)</td>
<td>0.21</td>
</tr>
<tr>
<td>SOFAmax</td>
<td>per 5 points</td>
<td>0.77 (0.62-0.77)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NMBs</td>
<td>No NMBs</td>
<td>0.76 (0.51-1.15)</td>
<td>0.20</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>No corticosteroids</td>
<td>0.73 (0.57-0.93)</td>
<td>0.04</td>
</tr>
<tr>
<td>Glucose (maximum) (mmol/L) ≥ overall median</td>
<td>&lt; overall median</td>
<td>0.68 (0.51-0.91)</td>
<td>0.008</td>
</tr>
<tr>
<td>Coma</td>
<td>No coma</td>
<td>1.40 (0.84-2.33)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Multivariate Hazard Ratios for reaching “Separation Potential”

<table>
<thead>
<tr>
<th>Reference</th>
<th>Multivariate</th>
<th>Hazard ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SmartCare/PS</td>
<td>Control</td>
<td>0.00 (0.00-1.00)</td>
<td>0.12</td>
</tr>
<tr>
<td>Age ≥ median</td>
<td>&lt; Median</td>
<td>0.69 (0.46-1.00)</td>
<td>0.06</td>
</tr>
<tr>
<td>Male gender</td>
<td>Female</td>
<td>1.81 (1.05-3.19)</td>
<td>0.04</td>
</tr>
<tr>
<td>APACHE II ≥ median</td>
<td>&lt; Median</td>
<td>0.90 (0.69-1.19)</td>
<td>0.90</td>
</tr>
<tr>
<td>SOFAmax</td>
<td>per 5 points</td>
<td>0.55 (0.52-0.77)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>NMBs</td>
<td>No NMBs</td>
<td>0.78 (0.61-1.00)</td>
<td>0.003</td>
</tr>
<tr>
<td>Corticosteroids</td>
<td>No corticosteroids</td>
<td>0.73 (0.57-0.95)</td>
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<tr>
<td>Glucose (maximum) (mmol/L) ≥ overall median</td>
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<td>0.68 (0.55-0.86)</td>
<td>0.008</td>
</tr>
<tr>
<td>Coma</td>
<td>No coma</td>
<td>1.53 (0.82-2.87)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Multivariate Cox proportional hazards model adjusted for all other variables. Test of proportional hazards assumption: P = 0.97 (Schoenfeld residuals)
Conclusions

- Weaning with SmartCare/PS comparable to weaning by qualified and ventilation-experienced ICU nurses working with trained intensivists
- Advantages of SmartCare/PS may vary according to ICU clinical organisation

Complications

<table>
<thead>
<tr>
<th>Characteristic n (%)</th>
<th>SmartCare/PS</th>
<th>Usual weaning</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reintubation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within 48 hours</td>
<td>5 (10)</td>
<td>6 (12)</td>
<td>1.0</td>
</tr>
<tr>
<td>NIV post extubation</td>
<td>8 (16)</td>
<td>6 (12)</td>
<td>0.8</td>
</tr>
<tr>
<td>Self extubation</td>
<td>0</td>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>6 (12)</td>
<td>8 (16)</td>
<td>0.8</td>
</tr>
<tr>
<td>Duration of ventilation &gt;21 days</td>
<td>2 (4)</td>
<td>3 (6)</td>
<td>1.0</td>
</tr>
<tr>
<td>Death</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On protocol</td>
<td>2 (4)</td>
<td>1 (2)</td>
<td>0.4</td>
</tr>
<tr>
<td>In ICU</td>
<td>7 (14)</td>
<td>1 (2)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

* Fisher exact tests

Final Words

- Nursing role in mechanical ventilation and weaning differs internationally
- RT role decreases RN direct involvement in ventilation decision-making
- Care of the ventilated patient is not just about the ventilator
- Need to consider:
  - Ongoing assessment and coordination of care activities
  - Symptom management: sedation, agitation, delirium, pain, dyspnea
  - Optimizing patient outcome: nutrition, mobility, sleep
  - Safety: prevention of adverse and nosocomial events