Webinar: New developments in automated weaning systems

Dr. Dirk Schädler
Automated weaning systems

Agenda

- Modern weaning strategy
- Automated weaning systems
  - Overview and basic technology
  - Clinical studies
Automated weaning systems

→ **Mechanical ventilation is harmful!**

- Barotrauma
- Volutrauma
- Atelectrauma: cyclic closing and reopening of alveoli
- Suppression of spontaneous breathing activity
Automated weaning systems

→ Mechanical ventilation is harmful!

- Barotrauma
- Volutrauma
- Atelectrauma: cyclic closing and reopening of alveoli
- Suppression of spontaneous breathing activity

Reduce ventilation time!
Automated weaning systems

Weaning protocols reduce ventilation time

- Ely 1996 (n=300)
- Kollef 1997 (n=357)
- Horst 1998 (n=2134)
- Marelich 2000 (n=335)
- Krishnan 2004 (n=299)
Automated weaning systems

Weaning protocols reduce ventilation time

- Environment:
  - 14-bed ICU
  - 6 residents
  - 2 postdoctoral fellows
  - 2 attending physicians
  - Routine use of structured standard checklists

Ventilation time [hours]

- Ely 1996 (n=300)
- Kollef 1997 (n=357)
- Horst 1998 (n=2134)
- Marelich 2000 (n=335)
- Krishnan 2004 (n=299)
Automated weaning systems

→ Recommendations

- Task force 1 (ACCP, AARC, ACCCM)
  - Weaning protocols that are designed for nonphysician health-care professionals should be developed and implemented in the ICU [1].

Recommendations

- Task force 1 (ACCP, AARC, ACCCM)
  - **Weaning protocols** that are designed for nonphysician health-care professionals should be developed and implemented in the ICU [1].

- Task force 2 (ERS, ATS, ESICM, SCCM, SRLF)
  - **Weaning protocols** are most valuable in hospitals in which physicians otherwise do not adhere to **standardised weaning guidelines** [2].

Rationale

- A protocol for weaning patients from mechanical ventilation can be implemented into an automated ventilation system.
Automated weaning systems

→ History (1953 - today)

- 49 automated weaning systems were published
  - 27 feedback-controller
  - 8 knowledge based systems
  - 6 knowledge based systems & physiological models
  - 2 fuzzy controllers
  - 3 model based systems
  - 2 electronic protocol systems
  - 1 belief network system
## Automated weaning systems

### Commercially available systems

<table>
<thead>
<tr>
<th>Name</th>
<th>Ventilator</th>
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<td>MMV - Mandatory Minute Ventilation</td>
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<td>Servo Maquet</td>
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No system is able to control all ventilatory settings

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## Automated weaning systems

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→ ASV - Adaptive Support Ventilation

- Pressure controlled SIMV + PS mode
- Choice of optimal $f$ and $V_T$
  according to pulmonary mechanics
- Semi-automatic mode: $F_{O_2}$, PEEP, minute
  ventilation not controlled by ASV
- Automatic transfer from controlled to assisted
  ventilation

Evaluation of ASV in patients following cardiac surgery

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of patients</th>
<th>Control group</th>
<th>Ventilation time (ASV vs. control)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001 [1]</td>
<td>49 included 36 completed</td>
<td>SIMV/PS</td>
<td>3.2 vs. 4.1 [h]</td>
<td>0.02</td>
</tr>
<tr>
<td>2003 [2]</td>
<td>45 included 34 completed</td>
<td>SIMV/PS</td>
<td>2.7 vs. 3.2 [h]</td>
<td>n.s.</td>
</tr>
<tr>
<td>2008 [3]</td>
<td>50</td>
<td>Automode</td>
<td>2.8 vs. 8 [h]</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
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→ SmartCare/PS

- Precondition: pressure support (PS) mode
- Automatic change of pressure support

Automated weaning systems

→ SmartCare/PS

- Comfort zone for the patient
  - **Respiratory rate:** $15 < f < 30$ bpm
  - **Tidal volume:** $V_T > 300$ ml
  - **End-tidal CO$_2$:** $P_{etCO_2} < 55$ mm Hg

- Automatic spontaneous breathing trial

Recommendation for extubation:
   ➔ ”Consider separation”

Automated weaning systems

→ SmartCare/PS: patient example (1)
SmartCare/PS: patient example (2)
Automated weaning systems

A Multicenter Randomized Trial of Computer-driven Protocolized Weaning from Mechanical Ventilation

François Lellouche, Jordi Mancebo, Philippe Jolliet, Jean Roeseler, Frédérique Schortgen, Michel Dojat, Belen Cabello, Lila Bouadma, Pablo Rodriguez, Salvatore Maggiore, Marc Reynaert, Stefan Mersmann, and Laurent Brochard

- Number of included patients: 145
- Inclusion rate: 14%
- Comparison of local weaning protocols to automatic system
- Protocol (71) ↔ SmartCare/PS (74)
- “Weaning was conducted according to usual local practice”
- „Written guidelines were available in four of the five units”

Automated weaning systems
Experiences in today’s clinical practice

A Multicenter Randomized Trial of Computer-driven Protocolized Weaning from Mechanical Ventilation

# A Multicenter Randomized Trial of Computer-driven Protocolized Weaning from Mechanical Ventilation

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<thead>
<tr>
<th></th>
<th>Protocol</th>
<th>SmartCare/PS</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=70</td>
<td></td>
<td>n=74</td>
<td></td>
</tr>
<tr>
<td>Time till successful extubation [days]</td>
<td>5 (2-12)</td>
<td>3 (2-8)</td>
<td>0.01</td>
</tr>
<tr>
<td>Total duration of mechanical ventilation [days]</td>
<td>12 (7-26)</td>
<td>7.5 (4-16)</td>
<td>0.003</td>
</tr>
<tr>
<td>Intensive care length of stay [days]</td>
<td>15.5 (9-33)</td>
<td>12 (6-22)</td>
<td>0.02</td>
</tr>
</tbody>
</table>
The effect of automatic weaning with SmartCare/PS on ventilation time in postsurgical patients – A randomized controlled trial (ASOPI trial)

- Number of included patients: 300
- Inclusion rate: 60%
- Comparison of local weaning protocol to automatic system
- Protocol (150) ↔ SmartCare/PS (150)
Study protocol (ASOPI)

- Cerebral trauma / surgery
- Age < 18 years
- Do-not-resuscitate order
- Preventilation time > 24 hours
- Patient is currently participating in this study

Screening inclusion criterion? yes

Exclusion criteria

- Patients requiring mechanical ventilation at 9:00 am for longer than 9 hours

Exclusion

Inclusion

Randomization

## Baseline characteristics

<table>
<thead>
<tr>
<th></th>
<th>SmartCare/PS n=150</th>
<th>Protocol n=150</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age [years]</td>
<td>67 (55-75)</td>
<td>69 (60-74)</td>
<td>0.23</td>
</tr>
<tr>
<td>Male gender [n; %]</td>
<td>103 (69%)</td>
<td>106 (71%)</td>
<td>0.71</td>
</tr>
<tr>
<td>APACHE II</td>
<td>16 (12-19)</td>
<td>16 (11-19)</td>
<td>0.92</td>
</tr>
<tr>
<td>Cardiac surgery [%;n]</td>
<td>41 (61)</td>
<td>47 (70)</td>
<td>0.29</td>
</tr>
<tr>
<td>COPD [%;n]</td>
<td>13 (20)</td>
<td>15 (23)</td>
<td>0.14</td>
</tr>
<tr>
<td>Sepsis [%;n]</td>
<td>14 (21)</td>
<td>15 (23)</td>
<td>0.74</td>
</tr>
</tbody>
</table>

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Total ventilation time

Ventilated patients [%]

Total ventilation time [hours]

P=0.18
n=300

Protocol

SmartCare/PS


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→ Total ventilation time

Subgroup Cardiac Surgery

P=0.037
n=131

Protocol
SmartCare/PS

### Alarms, Manipulations

<table>
<thead>
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<th>Protocol n=150</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of alarms per hour</td>
<td>6.6±12.7</td>
<td>6.7±11.9</td>
<td>0.344</td>
</tr>
<tr>
<td>Number of manipulations per hour</td>
<td>11.7±10.7</td>
<td>15.2±73.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Number of manipulations of ventilatory settings</td>
<td>4.1±4.7</td>
<td>1.8±3.8</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>
## Study 2

### Outcome

<table>
<thead>
<tr>
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<th>SmartCare/PS n=150</th>
<th>Protocol n=150</th>
<th>P value</th>
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<tbody>
<tr>
<td>28-day-mortality</td>
<td>29 (19.3%)</td>
<td>24 (16%)</td>
<td>0.45</td>
</tr>
<tr>
<td>90-day-mortality</td>
<td>36 (24%)</td>
<td>32 (21.3%)</td>
<td>0.58</td>
</tr>
<tr>
<td>Length of stay in ICU [days]</td>
<td>3.8 (1.3-8.2)</td>
<td>3.4 (1.3-11.5)</td>
<td>0.44</td>
</tr>
<tr>
<td>Length of stay in hospital [days]</td>
<td>18.5 (10.6-37.8)</td>
<td>19.6 (10.5-34.9)</td>
<td>0.72</td>
</tr>
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Automated weaning systems

A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using SmartCare™/PS

- Number of included patients: 102
- Inclusion rate: 10%
- Comparison of local weaning protocol to automatic system
- Protocol (51) ↔ SmartCare/PS (51)
- Study period: Jan. 2006 - Dec. 2006

Automated weaning systems

Experiences in today’s clinical practice

A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using SmartCare™/PS


Louise Rose
Jeffrey J. Presneill
Linda Johnston
John F. Cade

Study 3
Automated weaning systems
Experiences in today’s clinical practice

A randomised, controlled trial of conventional versus automated weaning from mechanical ventilation using SmartCare™/PS

Weaning in the study ICU was performed by experienced and relatively autonomous nurses, the majority (70%) of whom held a graduate critical care specialty qualification, using a 1:1 nurse-to-patient ratio maintained over all shifts. Respiratory therapists are not employed in the Australian context. A team of nine intensivists directed overall patient care through twice-daily structured ICU ward rounds with an overnight on-call roster. Reporting to these intensivists, and providing 24-h in-ICU medical staff, were a team of 26 hospital medical officers representing a balanced mix of senior (Registrar) and junior (resident) levels of post-graduate training.

Automated weaning systems

Tips

- SmartCare/PS is not a fully closed-loop controller.
- Be aware of „PEEP 5 cm H₂O“ message.
- Consider dead space.
- Do not interrupt a patient session.
Automated weaning systems

Summary

• A lot of work was done to develop automatic weaning systems.
• Today, only a small number of systems are commercially available.
• ASV is a promising mode but it was evaluated only in postsurgical patients.
• Some patient populations (may) profit from automatic weaning with SmartCare/PS.
• Further multicentre trials are needed to determine the effects of SmartCare/PS in different patient populations using specific protocols.
• Further development is needed to control more ventilatory settings.