Dräger

Evolution of Weaning with SmartCare®/PS

Improving Intensive Care Unit (ICU) outcomes by reducing ventilator associated complications and ventilator days may be achieved by re-engineering the weaning process [1].

Alternative methods to assist clinicians in organizing and implementing accurate weaning processes may shorten the duration of ventilator dependence and positively impact ICU outcomes [2]. Knowledge-based weaning (KBW) provides an alternative to the traditional weaning process [3].

Different approaches have been pursued and different modes have been used to achieve these goals and some like MMV and ASV turned out to work in easy to wean postoperative patients [4, 5]. Reducing ventilator-associated complications and days on ventilator are becoming much more important when trying to improve ICU outcomes. Scarce resources and awareness that ventilator-induced lung injury may play a key role in mortality of ventilated patients has led to more attention paid to alternatives for traditional weaning processes [6].

Knowledge-based weaning (KBW) provides a promising alternative to the traditional weaning process.
Only recently, ventilation has crested the next evolutionary step (Fig. 2) [7] to make such approaches available in an ICU ventilator – with an average reduction in ventilation time by 30% in longer-term ventilated patients [8].
This article will describe the therapist driven automated weaning approach in comparison to conventional algorithm-based ventilation modes like Mandatory Minute Volume Ventilation (MMV by Dräger Medical), Adaptive Support Ventilation (ASV by Hamilton Medical) and mode enhancements like AutoMode (Maquet).

Therapist driven automated ventilatory support
Since the very early beginning of intensive care medicine, clinicians worldwide have been looking for the ideal strategy for weaning the patient off the ventilator. Due to today's medical opportunities for treatment of the severely sick patient and the enormous complexity of therapeutic strategies, it has become more challenging to clinicians to wean the patient. Developing and establishing clinical guidelines for patient treatment was seen as the necessary consequence to improve patient's outcome, to reduce the workload of ICU staff and to prevent errors in medical treatment.
Several guidelines for patient treatment, e.g. ventilation, resuscitation or blood sugar regulation have already been published. Some of them could show the reduction in costs and length of stay [9].

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QUESTION:
Since you as a clinician are experienced in using different servo controlled weaning modes (strategies) could you please tell us about the major differences of knowledge-based systems and algrithm-based weaning modes?

DR. JOLLIET:
Several studies have shown that if a weaning protocol is implemented in an ICU, its application results in a reduction of the duration of the weaning process, thereby reducing the incidence of complications associated with prolonged intubation and mechanical ventilation. This underlines the importance of focusing on a weaning strategy. The problem however is that no matter how good the written protocol is, physicians and caregivers still have to devote enough time to ensure that no opportunities to progress in weaning are lost, which is often difficult in a busy ICU where more urgent matters might take precedence. With a knowledge-based system constantly attempting to detect opportunities of moving ahead, there is a greater likelihood of reducing any waste of time, and thereby to more efficiently reduce the duration of weaning.

QUESTION:
If you review the evidence base regarding MMV, ASV and SmartCare with regard to a cut back in ventilation time, what is the order of magnitude that can be expected? How do these approaches compare?

DR. JOLLIET:
From an engineering perspective, these three modes operate at different levels of complexity associated with computer-controlled mechanical ventilation. Therefore it is probably not relevant to compare them as if they were pursuing the same goals with identical tools. ASV and SmartCare®/PS for instance have both been shown to reduce weaning time, however in very different patient populations (post-cardiac surgery for ASV, general ICU patients for SmartCare/ PS), and therefore with different overall time constants for weaning. They are also based on different philiosophies: ASV aims for automatic adaptation by the ventilator to the patient‘s respiratory mechanics and spontaneous breathing activity from onset to end of mechanical ventilation, while SmartCare/PS is designed to shorten weaning, and to that end is only initiated when patients are ready for pressure support ventilation.

QUESTION:
One disadvantage of dual controlled ventilation modes is that they fail to distinguish among improved pulmonary compliance and increased respiratory effort. Drawing more than the set tidal volume will be answered with a drop in pressure - which is the opposite of what may be required in that situation. Does this apply to MMV+AutoFlow and ASV, too? How does it compare to SmartCare/PS?

DR. JOLLIET:
At one point or another, most automated modes available today can misinterpret signals when faced with very complex situations that their internal algorithms don‘t have the power to analyze in depth. No mode is foolproof, but then again neither are clinicians! Having said that, the decrease in pressure support following an increase in tidal volume should only occur if the pressure-support algorithm has been modified to provide tidal volume feedback to the controller. Indeed, in classical pressure support ventilation, there is no direct tidal volume feedback. A knowledge-based mode such as SmartCare/PS receives feedback from several parameters to control the level of pressure support, and therefore should most likely avoid this pitfall.

European screen image

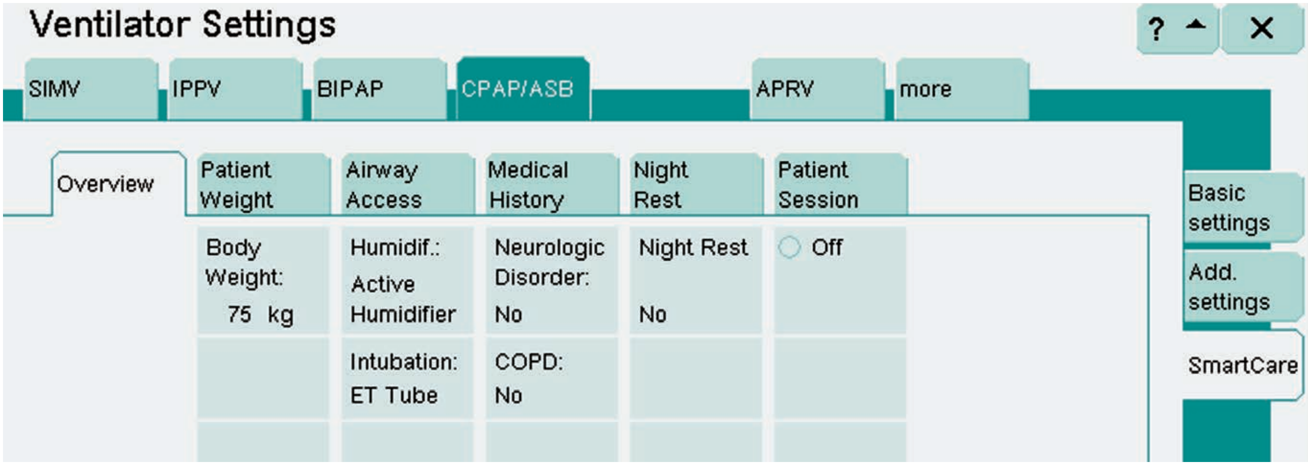

Figure 2: “Zone of Respiratory Comfort” – tailored by prestart information.

SmartCare®/PS Inside View

SmartCare/Pressure Support ventilates the patient with conventional pressure support. Before starting a patient sessionthe clinician enters a menu to tailor the “Zone of Respiratory Comfort” defined by breathing frequency, tidal volume and end-tidal CO_2 to a particular patient. Information about patient weight, airway access and medical history can be keyed in (Fig. 2).

SmartCare/PS classifies the patient every two minutes based on the afore mentioned parameters. After each assessment SmartCare/PS will put the patient in one of 8 different classifications of ventilation visible to the user all the time. Depending on the classifications, SmartCare/PS will decrease or increase the pressure support according to the patients‘ needs. Every single decision of SmartCare/PS and the values the decision are based on can be seen in the SmartCare/PS data menu (Fig. 3, 4).

The prestart information for a SmartCare/PS session will define the lowest allowed level of pressure support. SmartCare/PS will actively reduce pressure support down to this level, e.g.: 0 mbar/cm H_2O in case ATC is used. If reached, SmartCare/PS will perform a Spontaneous Breathing Trial (SBT). If successful the patient will be declared ready for separation from the ventilator – while still kept adequately ventilated until the clinician takes the actual decision.
An automatically repeated P 0.1 measurement and RSBi calculation can be trended and used as accompanying predictors of successful extubation (Fig. 4)[10].

Most importantly, SmartCare/PS doesn't control on a fixed and clinician-set MV need of the patient but adapts to the actual metabolic need of the patient by using its knowledge base. As such, SmartCare/PS is able to distinguish between improved pulmonary compliance and increased patient effort subsequent to an increased metabolic need[11].

In summary SmartCare/PS will permanently observe the patient and reacts according to the patient's ventilatory demands. While following a therapist driven approach with the set objective to wean the patient as fast as possible, SmartCare/PS will decrease the ventilatory invasiveness to the lowest possible level.

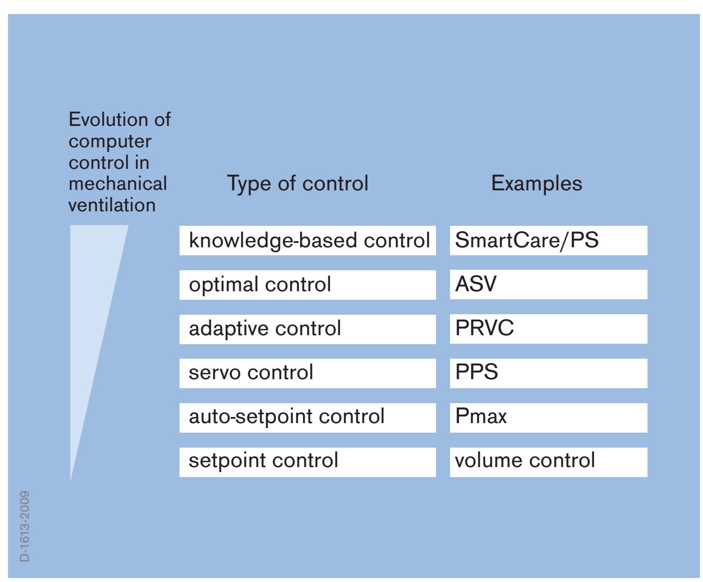

Figure 1:
Adapted from: Chatburn R Evolution of mechanical ventilation[7]

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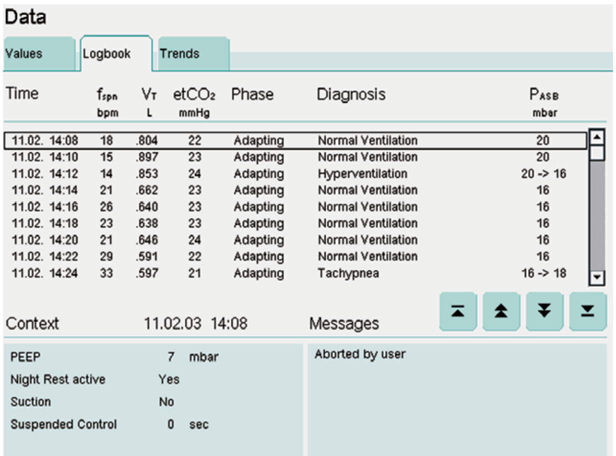

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Figure 3: SmartCare®/PS – logbook with listed classifications of ventilation.

European screen image

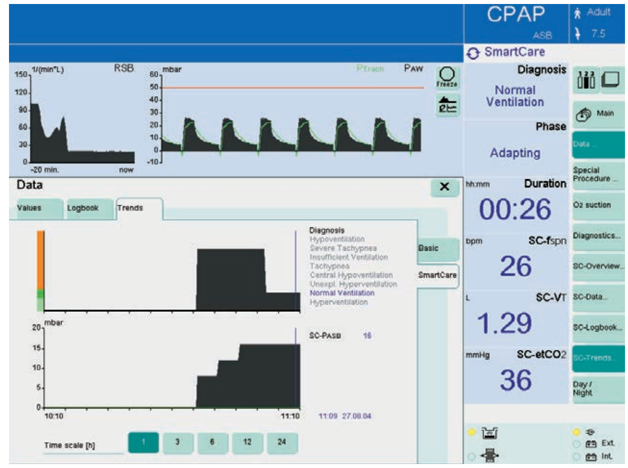

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Figure 4: SmartCare®/PS – trend with graphical information about the ongoing patient session.

Conclusion

Since the therapist-driven knowledge based approach of SmartCare/PS works differently a direct comparison of SmartCare/PS with other weaning modes and methods is difficult. The table below (Fig. 5) will provide some information. Please find information on MMV, ASV and Automode.

Reducing pressure or frequency based on tidal volume or minute volume targets in order to simplify weaning of patients is a good and necessary step. However, changes in metabolic need and patient effort are not considered in VT or MV based systems and may lead to detrimental actions. Furthermore, clinical situations even in weaning are too complex to map them to a simple, algorithm-based ventilation mode.
SmartCare/Pressure Support is an automated standard operating procedure (SOP), taking into account metabolic information, the medical history of the patient, airway access and interventions such as suctioning. It even includes an automatically initiated spontaneous breathing trial with Pressure Support and/or ATC[10].

A Multi-Center Randomized Controlled study[8] showed reduced weaning duration from a median of 4 [2-8] days to 2 [2-6] days (P = 0.015), reduced total duration of mechanical ventilation from 9 [6-15] days to 6 [3-12] days (P = 0.020), reduced intensive care unit length of stay from 17 [9.5-33] to 12 [6.3-21.8] days (P = 0.018), and reduced need for non invasive ventilation after extubation from 36 to 19% (P = 0.0095) by using the university prototype of today's commercially available option SmartCare/Pressure Support. These results offer users the advantage of improving clinical workflows and processes benefitting patients in more efficient tretment and the opportunity to decrease complication rates, ventilator days and re-intubation rates.
A knowledge-based approach like SmartCare/PS provides the ventilator with more information than what can be considered in static, mathematical models[7].

By utilization of SmartCare/PS the clinician provides the same quality of care to every patient. This may help to prevent medical errors caused by complexity and to reduce costs in intensive care.

	SmartCare®/ Pressure Support by Dräger Medical		Adaptive Support Ventilation (ASV) by Hamilton Medical	
Therapist driven - knowledge based approach	yes	no	no	no
Algorithm-based approach	no	yes	yes	yes
Includes metabolic information ($etCO_2$)	yes	no	no	no
Automatic Tube Compensation	yes	yes	yes	no
Automatic measurement and trending of P 0.1 and RSBi	yes	yes	no	no
Spontaneous Breathing Trial	yes	no	no	no

Figure 5

LITERATUR

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MMV

MMV can be thought of as SIMV with a frequency based on a MV balance. The frequency of mandatory strokes is determined by the level of spontaneous breathing; if spontaneous breathing is sufficient, mandatory strokes are not used. If spontaneous breathing is not sufficient, intermittent mandatory strokes of the set tidal volume VT are applied. If there is no spontaneous breathing at all, the mandatory strokes are applied at the set frequency f. As patient activity increases, MMV automatically and gradually reduces the number of time cycled strokes. Therefore, it can be used well to spead up weaning of uncomplicated postoperative patients. In combination with AutoFlow™, the pressure is reduced in accordance with the contribution of the patient to the set tidal volume. MMV with AutoFlow allows automatic weaning by frequency and pressure.

ASV

ASV works on the assumption that there is such a thing as the optimal respiratory frequency in order to minimize the patient's work of breathing. The optimal frequency is estimated by measuring R and C – during spontaneous breathing. The clinician has to decide on the minute ventilation the patient needs and has to adapt this according to changes in metabolic needs in the course of treatment. From the clinician-set MV and the ideal frequency, a required tidal volume is calculated which is supplied in a dual-control (AutoFlow) fashion in both time-cycled and flow-cycled breaths. As in other dual- control modes, if MV is set inappropriately low, an increased effort of the patient leads to a decreased support[7]. The more the patient contributes spontaneously, the fewer time cycled strokes are given. No spontaneous breathing trial is executed.

Similarities to MMV: preset MV, gradual shift from time-cycled to flow-cycled breaths.
Differences from SmartCare/Pressure Support: assumed ideal frequency, assures constant MV need

Automode®

Automode® switches between time-cycled (controlled) and flow-cycled (supported) breaths depending on the patient triggering breaths. If the patient triggers a breath, Automode switches to flow-cycled breaths (support). If the patient becomes apneic, Automode switches back to time-cycled (control). The longer the patient stays in support, the longer the effective apnea time is set – up to the apnea time setting of the operator. Switching between controlled and supported breaths may lead to fall[11]. Automode works in VC, PRVC and PC and switches to PS, respectively, VS.

The pressure or volume target remains the same in flow-cycled and in time-cycled breaths.

Similarity to apnea ventilation: shift from one mode to another based on an apnea criteria.

Difference from MMV: sharp and not gradual shift from time-cycled to flow-cycled breaths.

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