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„SmartCare™ – Optimizing Workflow Processes in Critical Care through Automation“

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SmartCare™ – Optimizing Workflow Processes in Critical Care through Automation

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Introduction. Improving the quality and efficiency of health care delivery are important objectives in critical care. Process engineering approaches to identify, organize and standardize health care workflows have been employed to meet these goals. Evidence-based clinical guidelines (CGs) for critical care are among these approaches. Their impact on outcome measures have been investigated and quantified in several clinical studies, e.g. [1]. Outcome measures that were studied include the reduction of hospital stay, mortality, human errors, medical device induced complications and workload of clinical staff. A logical next step is now the implementation of standardized health care processes into medical technology by allowing CGs to be executed by medical devices. This could provide automated standardized workflow process support. Dräger Medical's SmartCare™ technology is a platform that allows the implementation and automatic execution of various CGs within a wide range of medical devices. The SmartCare™ expert system comprises a universal engine and a set of executable knowledge bases that each reflects a certain critical care process, as described by a CG. An expert system construction suite (Solvatio, iisy AG, Rimpar, Germany) is used to facilitate efficient, visual-oriented knowledge modeling as well as the transition to the runtime environment. It seamlessly combines process-, knowledge- and software-engineering tasks. The core paradigm is that if a medical device allows for reading access to its measurements, settings, and contextual information as well as for writing access to its settings, then every clinical guideline for that medical device is potentially automatable [2].

Currently the automation of a specific process for weaning patients from mechanical ventilation has been implemented in a commercial product. SmartCare™/PS as an add-on for EvitaXL (Dräger Medical, Germany) provides automated control in pressure support ventilation. It implements a weaning CG clinically developed by Dojat and Brochard [3].

Methods. A multi-center, randomized controlled study was carried out in five university hospitals. 144 medico-surgical ICU patients were enrolled in this study. Approximately half of the patients (n=70) were randomized to be weaned following the conventional weaning protocol used in the respective hospital, the other half were weaned using the automated SmartCare™ approach (n=74).

Results. In comparison with manual implementation of conventional weaning CGs used in these intensive care units, SmartCare™/PS reduced weaning duration by 50%, total duration of mechanical ventilation by more than 30% and the ICU length of stay by almost 30 % [4].

Conclusion. The automated execution of CGs by medical devices is a logical and beneficial progression of workflow support in health care. The implementation of additional CGs is expected to demonstrate the efficiency of SmartCare™ technology throughout the complex development process from knowledge acquisition to knowledge execution.

References.

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SmartCare™

Daily practice with SmartCare™ in a difficult to wean patient

CASE STUDY

Biotrauma and goals for weaning

The advances in critical care medicine have resulted in more patients surviving calamitous diseases. A considerable amount of these patients require mechanical ventilation for extended periods. Patients requiring respiratory support more than fifty days are still not a rarity, even today, in our ICU.

Weaning procedures continue to gain more importance in the Intensive Care, combined with increasing knowledge about the detrimental effects of mechanical ventilation and iatrogenic lung injury resulting in a so-called biotrauma. Apart from the pulmonary effects of ventilator induced lung injury, the systemic effects, eventually, resulting in the multiorgan dysfunction syndrome become more and more evident today. The trend, therefore, in modern respiratory therapy is increasingly moving towards assisted forms of mechanical ventilation.

The main goal for treatment of patients with respiratory failure and the necessity for ventilatory support is to minimize the potential lung injury induced by ventilation itself. Therefore, as the saying goes, weaning begins with intubation. It's a training-process for respiratory muscles, much like athletes do in training to improve their performance. If you rest the weaning of your patient he / she will become lazy.

In consideration of the current pathophysiologic understanding of the acute lung injury,

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spontaneous breathing modes should be used as much as possible in the course of critical illness.

Adjusting the ventilator settings frequently, according to the changing demands and needs of the patient, is a major problem in the daily routine of almost every ICU.

What is "Smart Care"?

With SmartCare, Dräger Medical introduced a new weaning technique integrated into their EvitaXL ventilator, developed from a knowledge based weaning system resulting from a protocol developed by Brochard and Coworkers. This approach includes a special innovation of a derived pressure support mode that let's the ventilator react to the patient's demand for an adjusted ventilatory support every two to five minutes. It's the first ventilator with an integrated circuit that includes the patient and his ventilator. SmartCare is not only a computer

Specifications

Time	0:00	2:00	5:00	8:50	9:10	10:30	11:45	13:30	18:00	21:20	23:40
Setting	BP 12	BP 12	BP 10	BP 10	BP 12	BP 14	SC	SC	SC	SC	BP 12
FiO_2	35	35	30	30	45	40	40	40	40	40	40
pmax	24	24	24	23	25	25	30	36	36	36	28
PEEP	5	5	5	5	5	5	5	5	5	5	5
f	40	37	44	40	40	47	34	35	32	36	27
I:E	1:2	1:2	1:2	1:2	1:2	1:2					
MV		17.6	19.3			12.3	18.5	21.3	22.9	17.2	12.3
Vt		0.65	0.6			0.65	0.78	0.6	0.57	0.75	0.65
PaO_2	101	101	77.1	50.4	65.9	103	112	126	122	127	144
PaO_2/FiO_2	288.6	288.6	257.0	168.0	146.4	257.5	280.0	315.0	305.0	317.5	360.0
$PaCO_2$	39.6	38.7	37.5	36.4	36.0	38.1	37.0	38.0	36.0	33.0	36.4
pH	7.4	7.4	7.44	7.44	7.44	7.4	7.44	7.39	7.44	7.46	7.42
SaO_2	98.6	98.5	96.7	88.3	94.3	98.6	99.1	99.3	97.6	99.6	99.7
HCO_{3-}	24.1	24.2	25	24.5	24.8	23.2	24.5	23.3	24.6	24.2	25
BE	-0.1	0.1	1.2	0.9	0.4	-0.8	0.9	-1.3	-0.1	-0.3	-0.7

Table 1: Patient ventilator settings and results of blood gases in the course of a day with SmartCare (BP=BIPAP; SC=SmartCare)

system but, also, a reliable bedside-tested clinical protocol for weaning that aims for comfortable recovery from respiratory failure.

Weaning before knowledge-based weaning at our SICU

Our previous weaning technique was based on periodical clinical judgements of the patient's respiratory status, reduction of sedoanalgesics, early use of pressure support ventilation, CPAP and ventilator independence, including spontaneous breathing trials with T-piece.

The main problem today with the consuming weaning technique is very obvious: the requirement for considerable staff in a frequently understaffed ICU environment. Nevertheless, our surgical ICU is comparatively well staffed, in contrast to many other Intensive Care Units, especially in smaller sized hospitals.

Therefore, like other ICU teams we appreciate a knowledge-based weaning system, like SmartCare, for daily clinical use.

A challenge to wean the patient

This report outlines the application of SmartCare in a difficult to wean patient:

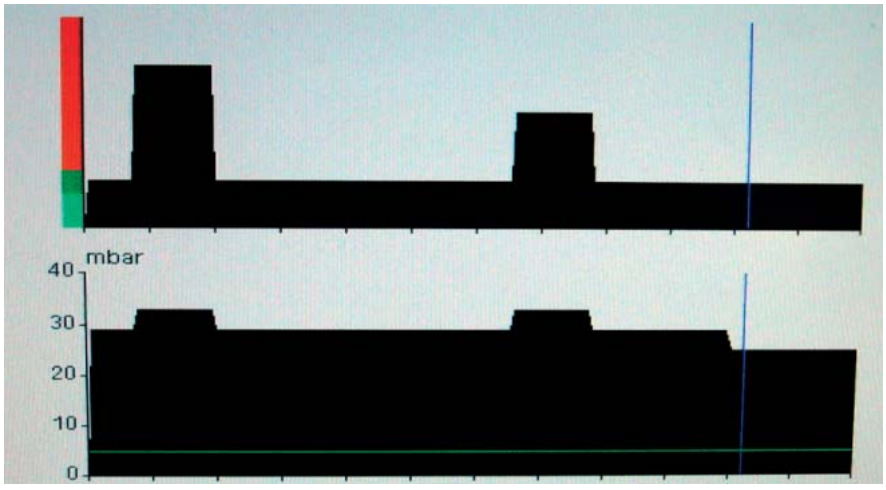

Fig. 1: The challenge to wean a patient in the comfort zone (green marked)

A 50 year old man, suffering from severe protracted ARDS, which resulted from aspiration of gastric secretion and subsequent pneumonia. The aspiration occurred after oesophageal perforation, following dilation and stenting of a stenosis, resulting from an achalasia.

The clinical course of the patient was complicated by recurrent phases of a severe candida and staphylococcus sepsis despite the use of adequate antifungal and antibiotic therapy with periodical microbiological testing at regular intervals. He was ventilator dependant with high PEEP-levels and high FiO_2, requiring positioning therapy using the prone position and kinetic therapy over a period of about 60 days.

Frequent dramatic deteriorations of his respiratory situation with repeated phases of septic shock combined with a multiple organ dysfunction syndrome and the need for catecholamines, renal replacement therapy and liver dialysis prolonged his ICU stay considerably.

First attempts to wean the patient were commenced after 60 days of invasive ventilation. The patient had comparatively high respiratory rates starting the weaning process resulting from respiratory muscle weakness. Nevertheless, during the SmartCare period, the respiratory

CASE STUDY

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rates varied in the range of those with BIPAP ventilation – with a slight trend to lower frequencies.

Tidal volumes stayed within the same range after the change and $paCO_2$ remained nearly unchanged. Despite of the change from BIPAP to SmartCare there seemed to be no relevant increase of respiratory workload for the patient. We even saw a slight increase of the oxygenation-index during the SmartCare period. While using SmartCare, the patient remained breathing, for the most part, in the so-called "respiratory zone of comfort" (Fig. 1).

In summary, it can be said that in this patient, who previously needed a long time interval of mechanical ventilation with strong ventilator settings SmartCare appeared to work without any detrimental effect on oxygenation and $paCO_2$. Also, the respiratory workload of the patient seemed not to increase. Furthermore, the patient remained in the "respiratory zone of comfort" for a long time.

Our impressions about SmartCare

Weaning should be considered a process in which the goals are to promote ventilator independence under preservation of the functional status. The choice of weaning technique is an important decision in the convalescence of the respiratory muscles and reconditioning.

Traditional methods of weaning, like progressive reductions in the number of fully supported breaths [SIMV], continuous positive airway pressure [CPAP] or spontaneous breathing trials [SBT] lack the continuous feedback of the ventilator to the patient's needs – they are mechanical and not adjustable to the patient.

From our experience, SmartCare seems to meet all requirements for a knowledge-based weaning system, even in long-term ventilated patients. It saves considerably time in the strenuous weaning process. The outstanding advantage of this ventilator-integrated weaning system is its less demand for fewer ICU staff. Even if the staff of an ICU makes every endeavour possible to wean a patient from the ventilator, the respiratory therapist can not be at the patient's bedside every minute of the day as SmartCare can.

Therefore, SmartCare can minimize the momentous consequences of mechanical ventilation to the lung and contribute to the reduction of systemic effects of ventilator induced lung injury and, thus, the biotrauma.