KBWean: Control Systems for Ventilation and Weaning in the Intensive Care Unit

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Objective

Patients who require mechanical ventilation during operation, where they are deeply sedated, must slowly be weaned from ventilation after the operation to the point where they breath spontaneously. At this point the patients can be extubated, i.e., the tube placed in the trachea to ensure the proper ventilation is removed. The aim of an improved weaning process would be to make the transition from controlled ventilation to total independency (extubation) as smooth and short as possible [1-3]. KBWean (knowledge-based weaning) is a real-time, open-loop knowledge-based ventilation and weaning system encapsulating knowledge and expertise of experienced intensivists. It offers computer-assisted advice and support during the weaning and ventilation process of patients after cardiac surgery (Fig. 1,2).

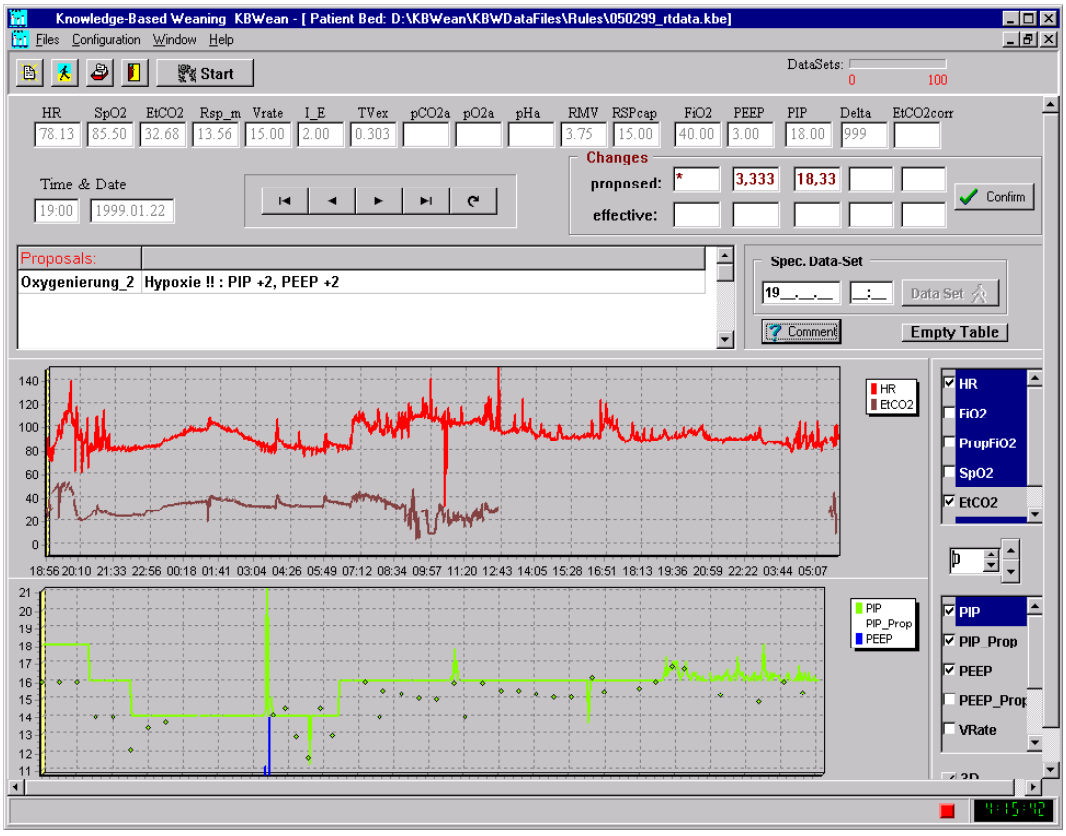

Fig. 1: KBWean proposes PIP, PEEP increasing

Material and Methods

Fuzzy knowledge bases consist of variables, values, and rules. The variables represent the physiological parameters and the respirator settings. The values are described by way of fuzzy sets and linguistic terms [4,5]. The respirator settings and physiological parameters are taken in minute intervals from the Patient-Data-Management System (PDMS) PICIS® as input. The system analyzes these data and displays suggestions for appropriate respirator setting adjustments. The attending physician is free to follow these advices or not (open loop system). KBWean contains two different knowledge bases in a parallel manner: first, a collection of crisp rules and second, a set of rules applicable for fuzzy control. These two knowledge-bases, KBWean and FuzzyKBWean, as well as various experimental versions of both are implemented as plug-in knowledge bases for the KBWean frame program [6]. The present aim is the comparison of these two approaches in practical settings. In order to generate and tune both, the crisp and the fuzzy knowledge bases, we developed a knowledge base editor KBWEdit. With this knowledge acquisition component the intensive professionals can create various experimental versions of both approaches in an easier way (cf., report on KBWEdit, page 27 in this journal issue).

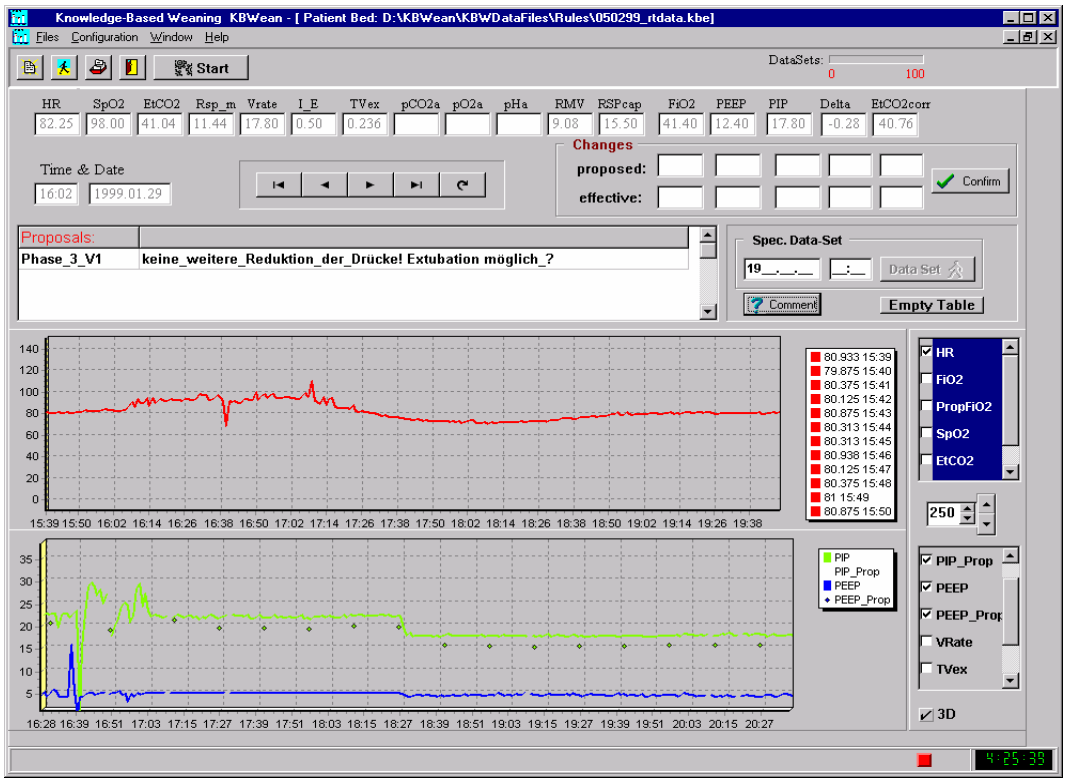

Fig. 2: KBWean proposes patient extubation

Results

Our application centers on weaning by the way of BIPhasic Airway Pressure Ventilation (BIPAP) mode, since the mode allows a very smooth and gradual change from controlled to spontaneous breathing [7,8]. The KBWean computer program has been developed as a 32 bit application with Delphi® 2.0 and runs on Windows-NT® and Windows95® platforms. It has been connected to the PICIS® PDMS in the ICU. The application is currently

being tested with actual cases. The established system indicates the applicability of KBWean to introduce medical standards in the weaning process and make weaning transparent and comprehensible.

Technical Specification

Monitoring Environment
Ventilator Draeger Evita: fraction of Inspired oxygen (FiO_2), airway pressures (PIP, PEEP), tidal volume, minute volume, respiratory rate. Oximeter Capnometer Datex Oscar: Pulsoximetry (SpO_2) endtidal CO_2 ($EtCO_2$), respiratory rate. Monitor Mennen Horizon: Heartrate, blood pressures, cardiac output, body temperature, respiratory rate.

Hardware Environment
8 bedside PCs, Pentium 166 with 32 MB Ram, Intelligent Digiboard, and Light-Pen. All PCs are connected to a server, using the hospital's tokenring network.

Software Environment
Operating System Windows-NT®4.0, PDMS PICIS CHART+ (Paris-Barcelona), Delphi® 2.0 Client/Server Suite. The KBWean program is a 32 bit application, and uses an Interbase® database for data storage and retrieval.

Conclusion

The gained results confirm the applicability of KBWean to introduce medical standards in the weaning process and make the weaning activities transparent and comprehensible. The system is widely approved of by intensive professionals, who spare no effort to tune its applicability. With their assistance and expertise we aim at finding the optimal knowledge base design for such a special real-time environment, which is the development of a closed-loop system which can be integrated into the ventilator. This would finally allow exact and continuous setting adjustments and thus improve an optimal weaning process in future.

Acknowledgement

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