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Perspectives of Mechanical Ventilation

Authors

Salvatore Grasso

Dipartimento dell'Emergenza e Trapianti d'Organo (DETO),

Sezione di Anestesiologia e Rianimazione, Ospedale Policlinico, Bari, Italy

V Marco Ranieri

Università di Torino, Dipartimento di Anestesiologia e

Rianimazione Ospedale S. Giovanni Battista- Molinette,

Torino

Professor Ranieri and Dr Grasso review recent improvements in mechanical ventilation.

The scientific interest for mechanical ventilation is demonstrated by a PubMed search made in October 2005: since 1950, more than 44,300 articles have been published on this topic. Intensivists presently have to face the challenge of translating this tremendous volume of knowledge into real clinical advantages for patients.

Some fundamental steps have already been made in this field, principally thanks to the translational research (Zerhouni 2005). Since the mid 1980s, a large number of studies in animal models of acute respiratory distress syndrome (ARDS) have shown that mechanical ventilation can worsen pre-existing lung injury (ventilator induced

lung injury – VILI) (Matthay & Zimmerman 2005), by inducing closing and opening of collapsed alveolar units (atelectrauma), and/or alveolar overdistension at each respiratory cycle. Thanks to this knowledge, the effects of "lung protective" ventilatory strategies on VILI have been tested in clinical studies (Ranieri et al. 1999). Applied in a randomized controlled trial conducted by the ARDS Network, these strategies proved to reduce mortality of patients (ARDS Network 2000). The study by the ARDS network closed the loop between the laboratory and clinical approaches, perhaps for the first time in the field of intensive care medicine.

The last generation of mechanical ventilators presents interesting improvements in the field of partial ventilator assistance modes (Ranieri 1997). Partial ventilator support techniques are intended for patients who have normal respiratory drive, but who have difficulty sustaining adequate spontaneous ventilation. Clinical optimization of the patient-ventilator interactions requires a continuous matching between the triggering, flow delivering, and cycling functions of the ventilator and patient's ventilatory drive, spontaneous inspiratory flow demand, and neural inspiratory time. The logical development of ventilator technology has been to develop systems able to automatically interface physiologic parameters to ventilator outputs. Together with the older volume support mode, which is a peculiar form of pressure support ventilation (PSV) in which the applied pressure level is automatically targeted to a pre-set tidal volume, various forms of proportional assist ventilation (PAV) are now clinically available.

PAV is an innovative mode of partial ventilatory support in which the ventilator generates pressure in proportion to patient's effort (Younes et al. 1992). According to preliminary studies, PAV is able to near normalize patient's neuro-ventilatory coupling, making the ventilator an extension of patient's respiratory muscles and leaving the patient entirely in control of all aspects of breathing (Grasso et al. 2000). With the definitive technical implementation, PAV ventilators are able to measure continuously and non invasively the elastic and resistive properties of the respiratory system, and to continuously adapt the level of proportional assistance to the intrinsic changes in respiratory mechanics over time (Younes et al. 2001a & b).

Among the other computer driven automatic or semiautomatic algorithms recently implemented in mechanical ventilators are adaptive support ventilation (ASV) and the Knowledge Based System (KBS). ASV is a system able to deliver ventilatory assistance to obtain the "optimal" ventilatory pattern, i.e. the more favourable ventilatory pattern in terms of work of breathing (Belliato et al. 2004). KBS is an algorithm able to gradually withdraw the mechanical support and thus automatically wean the patient from mechanical ventilation. According to preliminary results, KBS reduces the "weaning time" as compared with physician-driven weaning protocols (Bouadma et al. 2005).

Another field of development for mechanical ventilators regards the devices for monitoring respiratory mechanics. Practically, all the modern intensive care mechanical ventilators are able to perform measurements of static elastance, resistance and intrinsic PEEP in ventilated patients. However, the mechanical characteristics of the respiratory system are often non-linear, and a very interesting possibility now available to clinicians is to measure quasi static volume-pressure curves of the respiratory system. The lower and upper inflection points can be identified on these curves through internal devices of the mechanical ventilator (Lu et al. 1999). In addition the possibility to measure residual functional capacity will potentially improve our understanding of the effects of positive end expiratory pressure.

In conclusion, in the last years the interplay between industrial interests and the clinician’s requests has generated a synergistic effort towards the development of the new generation of intensive care mechanical ventilators. In the next years we should be able to assess all these innovations in a correct, evidencebased, perspective.

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