Druck, Fluss und Energie – Physik der (Be)Atmung

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Das 20-minütige Video [1] ist eine Einführung in das im Vortrag vorgestellte Beatmungskonzept (FCV = „flow controlled ventilation“).

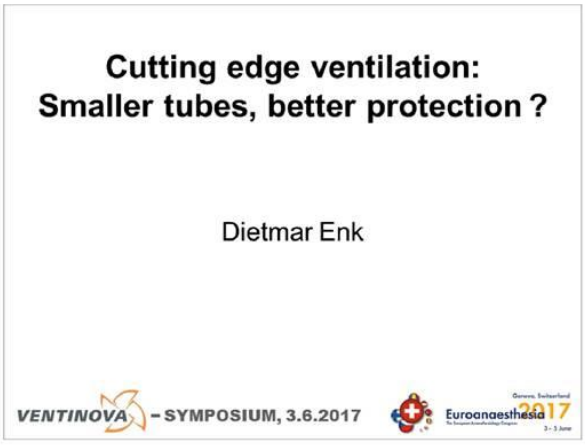
Der Artikel in *Trends in Anaesthesia and Critical Care* [2] liefert detailliertere Informationen und stellt den klinischen Bezug an Hand eines Fallberichtes her.

Die Publikation in *Medical Hypotheses* [3] bietet schließlich einen mathematischen Beleg für die Sinnhaftigkeit von FCV und vergleicht FCV mit herkömmlichen Beatmungsmodi in einem Simulationsmodell.

Unter den angegebenen Links können diese beiden („open access“) Arbeiten direkt und kostenfrei heruntergeladen werden.

Weiterführende Informationen:

1) https://www.youtube.com/watch?v=ULhgxwBgGA0



2) https://www.sciencedirect.com/science/article/pii/S2210844018301175

Barnes T, Enk D: Ventilation for low dissipated energy achieved using flow control during both inspiration and expiration

Abstract

Mechanical or thermal stresses, which cause injury, do so essentially by dissipating energy in the tissue at a rate above some threshold at which damage occurs. This principle may also

be applied to a ventilated lung. Minimizing dissipated energy is therefore a promising strategy to prevent ventilator induced lung injury (VILI) [1].

In this special interest paper, we present a qualitative argument to show that dissipated energy as determined from the area enclosed by the pressure-volume (PV) loop may be minimised during ventilation by controlling the flow to be constant during both inspiration and expiration. We then demonstrate the characteristics of the PV loop and concomitant low energy dissipation that occur with this mode of ventilation in a clinical case report. In this case, we ventilated a healthy, male, 51 year old patient undergoing elective, minor laryngeal surgery with a new, specialized ventilator, which achieves accurate control of flow during both inspiration and expiration (Evone; Ventinova Medical, Eindhoven, The Netherlands) through a small-bore (4.4 mm outer diameter), cuffed tracheal tube (Tritube; Ventinova Medical, Eindhoven, The Netherlands). This mode of ventilation is called flow-controlled ventilation (FCV). During ventilation, both inspiratory and expiratory flows were kept nearly constant at 12 ± 0.98 l/min and the I:E ratio was 1:1 with a minute volume of 6.23 ± 0.15 l/min. We recorded pressure-volume loops using pressure measured directly within the patient's trachea and calculated the energy dissipated in the patient from the hysteresis area of the PV loops.

Energy dissipation was 0.17 ± 0.02 J/l, which is close to the minimum energy dissipation achievable for this minute volume. It is lower than values quoted in the literature for spontaneous breathing (0.2–0.7 J/l) and indicative values obtained with other methods of flow control (0.32 J/l). This ventilation strategy may have implications for lung-protective ventilation.

3) https://www.sciencedirect.com/science/article/pii/S0306987718306777

Barnes T, van Asseldonk D, Enk D: Minimisation of dissipated energy in the airways during mechanical ventilation by using constant inspiratory and expiratory flows – Flow-controlled ventilation (FCV)

Abstract

It has been suggested that energy dissipation in the airways during mechanical ventilation is associated with an increased probability of ventilator induced lung injury (VILI). We hypothesise that energy dissipation in the airways may be minimised by ventilating with constant flow during both the inspiration and expiration phases of the respiratory cycle. We present a simple analysis and numerical calculations that support our hypothesis and show that for ventilation with minimum dissipated energy not only should the flows during inspiration and expiration be controlled to be constant and continuous, but the ventilation should also be undertaken with an I:E ratio that is close to 1:1.