

Detrimental factors during positive-pressure ventilation: pressure, flow, and/or volume?

Dear Editor,

During positive pressure ventilation a peak inspiratory pressure >50 – 60 cm H_2O may result in barotrauma [1]. Animal experiments have demonstrated that even a peak inspiratory pressure >30 – 40 cm H_2O may cause pulmonary interstitial edema, elevated vascular permeability and inflammation, a picture that resembles acute lung injury (ALI) or its more severe form, acute respiratory distress syndrome (ARDS) [2]. Since peak inspiratory pressure is significantly lower during pressure-control ventilation (PCV) than during volume-control ventilation (VCV), one might expect PC modes of ventilation to be superior to VC modes [3]. Nevertheless, there is ample evidence that PCV is superior to VCV in terms of clinical outcome – only one study suggested a better outcome for ARDS-patients ventilated with PCV compared with VCV [4]. Meanwhile, PCV is increasingly being used: while only 1–5% of physicians expressed preference for PCV between 1992 and 1998 [5–7], one epidemiologic study in 2004 demonstrated $>15\%$ of physicians used PCV in their daily practice [8].

Fujita et al. investigated the effect of peak inspiratory flow in a rabbit acute lung injury model [9]. In their study, animals were randomly assigned to two ventilation groups: one group ventilated with pressure-regulated volume-control ventilation (PRVC) and one group receiving VCV. In the PRVC group, peak inspiratory flow was significantly higher than in the second group, as was to be expected. After development of lung injury and start of either ventilation strategy to the end of the experiment, PaO_2 values remained significantly higher in the VC group than in the PRVC group. Wet-to-dry ratio and upper lobe tissue injury scores were higher in the PRVC group. The authors conclude from their experiments that high inspiratory flow is associated with greater deterioration in gas exchange and lung injury.

We have some concerns regarding this conclusion. First, we wonder whether solely differences in peak inspiratory flow are responsible for the findings as described. Of importance, mean airway pressures were also higher with PRVC ventilation as compared with VCV, which in itself may be partly responsible for the detrimental effects. In this context, it

can and must be noted that mammals, including humans, have a flow pattern resembling PRVC ventilation: alike the airflow pattern during PRVC ventilation, airflow during spontaneous breathing follows a “decelerating” pattern – fast contraction of the diaphragm and intercostal muscles enlarges the thorax volume, causing a negative intra-thoracic/intra-pulmonary pressure which results in a fast incline of inspiratory airflow. After reaching the peak, airflow rapidly declines until equilibration of intra-thoracic/intra-pulmonary pressure and environmental pressure. In contrast to PCV, VCV is characterized by a constant airflow during inspiration.

Secondly, the tidal volumes used in this study merit closer attention. In intensive care medicine tidal volumes over the past decades have progressively decreased from >12 – 15 ml/kg actual body weight (ABW) [10,11] to <9 ml/kg ABW (~ 10 ml/kg predicted body weight (PBW) [6,7,12,13]. This change was stimulated by clinical trials that confirmed the existence of so-called ventilator-associated lung injury [14,15]. Presently there are guidelines that strongly support the use of lower tidal volumes (i.e., 6 ml/kg predicted body weight, PBW) in patients with ALI/ARDS [16]. In the study by Fujita et al. rather large tidal volumes were used: 20 ml/kg. We wonder whether similar findings would have been obtained when using more lung-protective and/or lower tidal volumes. Of note, in the above-mentioned study comparing PC ventilation with VC ventilation by Esteban et al. [4] tidal volumes were substantially larger than 6 ml/kg PBW.

Nevertheless, the findings by Fujita et al. are remarkable, and call for additional animal studies. If confirmed, a trial comparing PCV with VCV in patients that are to be ventilated for substantial periods of time, for instance patients with ALI/ARDS, seems warranted.

Sincerely,

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