MONITORING ALVEOLAR RECRUITMENT IN THE CRITICALLY ILL –

Patient studies using Electric Impedance Tomography and Volume-Dependent Compliance

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin vid Göteborgs Universitet
kommer att offentligen försvaras i hörsal Arvid Carlsson, Medicinaregatan 3, Göteborg
fredagen den 3 december 2010 kl 13.00

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Avhandlingen baseras på följande delarbeten:

I. **Positive end-expiratory pressure optimization using electric impedance tomography in morbidly obese patients during laparoscopic gastric bypass surgery.** Erlandsson K, Odenstedt H, Lundin S, Stenqvist O. *Acta Anaesthesiol Scand 2006; 50: 833-839*

II. **A prolonged moderate pressure recruitment manoeuvre results in lower optimal PEEP and plateau pressure.** Lowhagen K, Lindgren S, Odenstedt H, Stenqvist O, Lundin S. *Accepted for publication in Acta Anaesthesiol Scand*

III. **A new non-radiological method to assess potential lung recruitability – a pilot study in ALI patients.** Lowhagen K, Lindgren S, Odenstedt H, Stenqvist O, Lundin S. *Acta Anaesthesiol Scand 2010; 29 October [Epub ahead of print]*

IV. **Regional intratidal gas distribution in acute lung injury and acute respiratory distress syndrome - assessed by electric impedance tomography.** Lowhagen K, Lundin S, Stenqvist O. *Accepted for publication in Minerva Anestesiol*

2010
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ABSTRACT

Background: Acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) are associated with a high mortality rate and poor long-term outcome in terms of quality of life, for those who survive. Similarly, patients with morbid obesity are at risk for respiratory complications when subjected to anaesthesia and surgery. To improve treatment and subsequently outcome for these patient groups, new treatment strategies and bedside monitoring techniques are needed.

Methods: 31 patients were studied, of whom 15 were morbidly obese patients undergoing laparoscopic gastric by-pass surgery, and 16 ALI/ARDS patients mechanically ventilated in the early phase of the disease. Electric impedance tomography (EIT) was used to follow changes in end-expiratory lung volume (EELV), to titrate positive end-expiratory pressure (PEEP) and to monitor regional distribution of ventilation, as well as intratidal gas distribution of the inspiratory phase of the respiratory cycle. Tracheal pressure was measured and combined with volume measures to obtain tracheal pressure/volume (P/V) loops, from which were obtained alveolar P/V curves and volume-dependent compliance (VDC). Cardiac output was measured using oesophageal Doppler technique.

Results: When EIT was used to titrate PEEP in patients with morbid obesity during laparoscopic surgery, a high PEEP of 13-17 cmH_2O was needed to maintain EELV. A prolonged moderate pressure recruitment manoeuvre resulted in a slightly larger EELV increase in ALI/ARDS patients than for a vital capacity manoeuvre, both when measured at PEEP 16 cmH_2O after the recruitment manoeuvre (RM). The prolonged manoeuvre also led to a lower optimal PEEP and plateau pressure when assessed during a decremental PEEP trial post RM. The vital capacity manoeuvre caused a marked decrease in cardiac output, which was not seen with the prolonged lower pressure RM. Volume-dependent compliance appeared more sensitive for detection of lung recruitment than conventional two-point compliance. Potential lung recruitability was assessed using an extrapolation method in combination with EIT for open lung volume determination. Potentially recruitable lung volume varied widely among the ALI/ARDS patients, where patients with high recruitability seemed to benefit from higher PEEP levels than those with low recruitability. The increase in EELV following a RM was mainly distributed to the non-dependent lung areas, whereas the tidal volume gas distribution was shifted towards more dependent areas. Intratidal gas was gradually redistributed dorsally during inspiration when pressure increased.

Conclusion: Electric impedance tomography has many potential clinical applications, including monitoring of alveolar recruitment, assessment of lung recruitability when combined with volume-dependent compliance, and determining regional and intratidal distribution of ventilation. This will help to improve individualized ventilatory treatment, with the potential to decrease the incidence of ventilator induced lung injury (VILI).

Key Words: ALI, ARDS, compliance, end-expiratory lung volume, EELV, EIT, electric impedance tomography, lung recruitment, morbid obesity, PEEP, recruitment manoeuvre, regional ventilation, volume-dependent compliance

ISBN 978-91-628-8203-7 http://hdl.handle.net/2077/22938