

Recruitment of small size lungs - experimental studies

Angela Hanson

Department of Anesthesiology and Intensive Care Medicine,
Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Sweden

ABSTRACT

Background: Patients - both children and adults - undergoing anesthesia and mechanical ventilation rapidly develop atelectasis. Even more severe problems occur in patients with acute lung injury/acute respiratory distress syndrome. To prevent the lung from further injury use of lung protective ventilation including a recruitment maneuver (RM) and a positive end-expiratory pressure (PEEP) titration are parts of the treatment. Children differ from adults not only in size but also in physiology. Studies in pediatric size animals should precede clinical studies.

Methods: 52 pediatric size piglets, weighing about 10 kg were surfactant depleted using a lung injury model with saline lavage. In the first two of four studies tidal elimination of CO₂ (V_TCO₂) was evaluated as a marker of optimal recruitment and dynamic compliance (C_{dyn}) was evaluated as a marker of incipient collapse during a RM and downward PEEP titration respectively. In all four studies the titrated PEEP was used during different follow-up-ventilation periods.

Aeration, airway pressures including driving pressure (DP), C_{dyn} and oxygenation were recorded. Iterated CT scans were taken at every change of ventilation for measurement of aeration during the first two studies and during the follow-up-ventilation in three studies.

The effect of a RM and PEEP titration for a prolonged (3 h) follow-up-ventilation was compared with a group with elevated PEEP (PEEP10-group) but without a foregoing RM. Ventilation after a RM was also compared with a control group ventilated with standard ventilation without a prior RM.

In a final study continuous cardiac output (CO) was measured during the RM and PEEP titration for detailed information of central hemodynamics in eight piglets.

Results: During the different follow-up-ventilation periods; 5, 15, 60 and 180 min, ventilation performed with the titrated PEEP resulted in improved aeration as assessed by repetitive CT scans, higher C_{dyn}, lower DP and better oxygenation compared with ventilation before the RM.

V_TCO₂ peaked or levelled off during the recruitment and corresponding CT scans showed a recruited lung. In addition minimally improved aeration was found when airway pressure was increased above the V_TCO₂ peak/plateau. The first decline of C_{dyn} during PEEP titration corresponded to an increasing amount of lung collapse according to CT scans.

CO and blood pressure decreased at the highest airway pressure during the RM. CO remained at a lower level but blood pressure recovered entirely. PEEP elevation in the PEEP10-group resulted in improved aeration, higher C_{dyn} and oxygenation and lower DP but not as much as in the RM-group. The control group did not improve in aeration, C_{dyn} or oxygenation but was stable.

Conclusion: Ventilation after a RM and PEEP titration results in improved aeration, improved lung mechanics and lower airway pressures compared with baseline and compared with control groups ventilated without a foregoing lung recruitment. V_TCO₂ peak/plateau indicates a recruited lung and C_{dyn} is a good indicator of increasing derecruitment during the PEEP titration. CO was persistingly and blood pressure temporarily decreased during the RM.

Key Words: lung recruitment, PEEP titration, V_TCO₂, C_{dyn}, computed tomography, cardiac output, atelectasis, lung aeration, driving pressure

Recruitment of small size lungs – experimental studies

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska akademien vid Göteborgs universitet kommer att offentligen försvaras i hörsal Tallen, Drottning Silvias barn- och ungdomssjukhus, Rondvägen 10, Göteborg, tisdagen 5 juni 2012 kl 09.00

av
Angela Hanson
Leg. Läkare

Fakultetsopponent:
Universitetslektor Hanne Berg Ravn
Department of Anesthesiology and Intensive Care, Aarhus University Hospital, Danmark

Avhandlingen baseras på följande delarbeten:

- I. **V_T CO₂ and dynamic compliance-guided lung recruitment in surfactant-depleted piglets: A computed tomography study.** Hanson A, Göthberg S, Nilsson K, Larsson LE, Hedenstierna G. *Pediatr Crit Care Med* 2009; 10: 687-692
- II. **Lung aeration during ventilation after recruitment guided by tidal elimination of carbon dioxide and dynamic compliance was better than after end-tidal carbon dioxide targeted ventilation: A computed tomography study in surfactant-depleted piglets.** Hanson A, Göthberg S, Nilsson K, Hedenstierna G. *Pediatr Crit Care Med* 2011; 13; e362-368
- III. **Recruitment and PEEP level influences long-time aeration in saline-lavaged piglets: an experimental model.** Hanson A, Göthberg S, Nilsson K, Hedenstierna G. *Pediatr Anesth* 2012; Febr 20 [Epub ahead of print]
- IV. **Hemodynamic effects during lung recruitment: an experimental study in pediatric size piglets.** Hanson A, Göthberg S, Nilsson K, Hedenstierna G. *Manuscript*

2012

Department of Anesthesiology and Intensive Care Medicine,
Institute of Clinical Sciences, Sahlgrenska Academy
University of Gothenburg
Göteborg, Sweden