

# OPEN AND CLOSED ENDOTRACHEAL SUCTIONING

## *Experimental and human studies*

Akademisk avhandling

som för avläggande av medicine doktorsexamen vid Sahlgrenska Akademin vid Göteborgs Universitet kommer att offentligen försvaras i Hörsal Arvid Carlsson, Academicum, Medicinare gatan 3, fredagen den 11/5 – 2007, kl. 09.00

av

**Sophie Lindgren**

Leg. Läkare

Fakultetsopponent:  
Professor i Anestesiologi  
Claes Frostell

Institutionen för Kliniska Vetenskaper, Karolinska Institutet, Stockholm

Avhandlingen baseras på följande delarbeten:

- I**        **Warning! Suctioning. A lung model evaluation of closed suctioning systems.**  
Stenqvist O, Lindgren S, Karason S, Sondergaard S, Lundin S  
*Acta Anaesthesiol Scand* 2001 45:167-172
- II**        **Effectiveness and side effects of closed and open suctioning: an experimental evaluation.**  
Lindgren S, Almgren B, Hogman M, Lethvall S, Houltz E, Lundin S, Stenqvist O  
*Intensive Care Med* 2004 30:1630-1637
- III**        **Regional lung derecruitment after endotracheal suction during volume- or pressure-controlled ventilation: a study using electric impedance tomography**  
Lindgren S, Odenstedt H, Olegård C, Söndergaard S, Lundin S, Stenqvist O  
*Intensive Care Med* 2007 33:172-180
- IV**        **Bronchoscopic suctioning may cause lung collapse: A lung model and clinical evaluation**  
Lindgren S, Odenstedt H, Erlandsson K, Grivans C, Lundin S, Stenqvist O  
*Manuscript*



The Sahlgrenska Academy  
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## *Experimental and human studies*

Sophie Lindgren

Institute of Clinical Sciences, Department of Anaesthesiology and Intensive Care,  
Göteborg University, Sweden

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**Background:** The practice of endotracheal suctioning of ventilator treated patients is necessary to remove secretions to prevent obstruction of the endotracheal-tracheal tube and lower airways. This very common procedure creates a large variety of heart-lung interferences. The closed system enables ventilation during suctioning, avoiding disconnection from the ventilator. Thus, the lesser side-effects of the closed suction system have been thoroughly evaluated rather than its effectiveness of secretion removal. Qualitative and semi-quantitative studies have indicated that the effectiveness of the closed system is inferior to the open one. Optimising the side-effects and effectiveness of the suction procedure is essential to preserve oxygenation in critically ill patients. This also requires adequate monitoring techniques. Suctioning through a fiberoptic bronchoscope (FOB) via a tight seal connector is another form of closed suctioning. The aim of this thesis was to evaluate the effectiveness and side-effects of open and closed suctioning manoeuvres, using novel lung-monitoring techniques.

**Methods:** Studies were performed in mechanical lung models, an experimental model of acute lung injury (ALI) in pigs and in ALI patients. Effectiveness of secretion removal was evaluated by weighing the suction system before and after suctioning of gel in a transparent trachea. In ALI model and patients, airway pressure and lung mechanics were measured via a tracheal catheter. A modified N<sub>2</sub> wash-out/wash-in method was used for functional residual capacity (FRC) measurements. Electric impedance tomography (EIT) was used to monitor global and regional lung volume changes during different suction manoeuvres.

**Results:** In a mechanical lung, closed suction during volume control ventilation caused high intrinsic PEEP levels at insertion of the catheter. Pressure control ventilation (PCV) produced less intrinsic PEEP. The continuous positive airway pressure (CPAP) mode offered the least intrinsic PEEP during insertion of the catheter and least sub-atmospheric pressure during suctioning. Open suctioning and closed suctioning during CPAP of 0 cmH<sub>2</sub>O was about five times more effective in regaining gel from an artificial trachea than closed suctioning during PCV or CPAP of 10 cmH<sub>2</sub>O. In lavaged lungs side-effects were considerable less during closed suction with positive pressure ventilation than during open suction. Closed system suctioning during CPAP of 0 cmH<sub>2</sub>O caused side-effects similar to open suctioning. At disconnection FRC decreased with about 50 % of baseline value and further 20 % during open suctioning. Regional compliance deteriorated most in the dorsal parts of the lavaged lung. Post-suction restitution of lung volume and compliance was somewhat slower during pressure controlled - than during volume controlled ventilation, both in experimental lung injury and in some ALI patients. Bronchoscopic suction through a tight seal connector in a mechanical lung and in ventilator treated ALI patients caused marked lung volume reduction, especially if the endotracheal tube was too small in relation to the thickness of the bronchoscope.

**Conclusions:** New monitoring strategies such as continuous, bedside FRC measurements with EIT technique and the nitrogen washout/washin method could contribute to a better understanding of the suctioning induced lung collapse and give us knowledge on how to minimize its negative effects, hence develop better clinical routines for handling them. The largest loss of lung volume takes place already at disconnection of the ventilator prior to suctioning. The dorsal regions of lavaged lungs are most affected by disconnection and suctioning. Closed system suctioning prevents lung collapse but is less efficient in removing secretions. Volume control ventilation in the post-suctioning period is a way of recruiting collapsed lung tissue. Bronchoscopic suctioning can cause severe lung collapse, although considered a closed system.

**Key words:** Suctioning, endotracheal, closed system suctioning, monitoring, lung volume, airway pressure, lung recruitment, bronchoalveolar lavage, acute lung injury