Individualized PEEP-adjustment in obese and non-obese patients und undergoing laparoscopic abdominal surgery

Philipp Simon, M.D.^{1,2}, Susann Schulz, M.D.¹, Gunther Hempel, M.D.¹, Alessandro Beda, Ph.D.³, Andreas W. Reske, M.D., Ph.D.^{4,5}, Hermann Wrigge, M.D., Ph.D.^{1,2,6}

¹Department of Anesthesiology and Intensive Care Medicine, University of Leipzig, Leipzig, Germany. ²Integrated Research and Treatment Center (IFB) AdiposityDiseases, University of Leipzig, Leipzig, Germany. ³Department of Electronic Engineering and Postgraduate Program of Electrical Engineering, Federal University of Minas Gerais, Belo Horizonte, Brazil. ⁴Department of Anesthesiology, Intensive Care Medicine, Emergency Medicine and Pain Management, Heinrich-Braun-Klinikum Zwickau, Zwickau, Germany. ⁵Innovation Center Computer Assisted Surgery, Leipzig, Germany. ⁶Anesthesiology and Intensive Care Medicine, BG Clinic Bergmannstrost, Halle (Saale), Germany

Introduction:

Induction of anesthesia frequently causes atelectasis, which, in obese patients, reduces end-expiratory lung volume by about 50% ¹ and may increase other pulmonary complications after surgery.² During mechanical ventilation, tidal recruitment and collapse may occur due to insufficient positive end-expiratory pressure (PEEP) and may promote lung injury. Following a recruitment maneuver (RM), individualized setting of positive end-expiratory pressure (PEEP) can be performed by Electric Impedance Tomography (EIT)-based regional ventilation delay index (RVD_i).³ We hypothesized that individualized PEEP_{EIT}+RM will improve respiratory system function compared to a standard PEEP (5 cmH₂O) in both obese and non-obese patients during general anesthesia for laparoscopic abdominal surgery.

Methods:

- IRB approval was granted and written informed consent was obtained
- body mass index (BMI) $18.5 \leq \text{BMI} < 30 \text{ kg} \cdot \text{m}^{-2}$ or $\text{BMI} \geq 35 \text{ kg} \cdot \text{m}^{-2}$
- mechanical ventilation with tidal volume (V_T) of 8 mL/kg PBW:
 - (1) a RM followed by titrated PEEP_{EIT}
 - (2) no RM and PEEP of 5 cmH₂O (PEEP₅).
- measurement of gas exchange, lung mechanics at 5 timepoints

Figure 1a+b: Points represent means and whiskers 95% confidence intervals from the data at that given time point. P-value compare the two arms from a repeated measures ANOVA.

Literature:

- ¹ Nestler C et al. Individualized positive end-expiratory pressure in obese patients during general anaesthesia: a randomized controlled clinical trial using electrical impedance tomography. Br J Anaesth. 2017 Oct 16. doi: 10.1093/bja/aex192. [Epub ahead of print]
- ² Serpa Neto A et al. Association between use of lung-protective ventilation with lower tidal volumes and clinical outcomes among patients without acute respiratory distress syndrome: a meta-analysis. JAMA 2012; 308: 1651-59.
- ³ Muders T et al. Tidal recruitment assessed by electrical impedance tomography and computed tomography in a porcine model of lung injury. Crit Care Med 2012; 40:903-911.

Results:

- n=90 (25 each obese group; 20 each non-obese group)
- before intubation:*
 - decreased PaO₂/F_iO₂ in obese patients (p<0.001; figure 1a)
- during surgery:*
 - PEEP_{EIT}: obese: mean $18.5 \pm 5.6 \text{ cmH}_2\text{O}$
non-obese: mean $14.5 \pm 3.4 \text{ cmH}_2\text{O}$
 - PaO₂/F_iO₂ 122 mmHg higher in the PEEP_{EIT} arms (95%CI 82 to 162 mmHg; p<0.001)
 - significant higher driving pressure with PEEP₅ (p<0.001; figure 1b)
- after extubation:*
 - significant lower PaO₂/F_iO₂ in obese patients (p<0.001)
 - differences between treatment groups vanished

	PEEP _{EIT} (n=45)						PEEP ₅ (n=45)						
	Obese (n=25)			Normal weight (n=20)			Obese (n=25)			Normal weight (n=20)			P-value
	after intubation	PNP	before extubation	after intubation	PNP	before extubation	after intubation	PNP	before extubation	after intubation	PNP	before extubation	
PEEP (cmH ₂ O)	5.0 (0.0)	18.6 (4.8)	18.6 (4.8)	5.0 (0.0)	14.7 (3.3)	14.7 (3.3)	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	5.0 (0.0)	<0.001
Peak pressure (cmH ₂ O)	25.9 (5.3)	34.3 (6.4)	31.9 (6.8)	23.5 (5.4)	34.9 (3.9)	30.0 (3.7)	24.1 (3.4)	27.8 (2.9)	24.2 (2.8)	24.2 (4.3)	30.7 (4.4)	25.5 (4.0)	<0.001
Plateau pressure (cmH ₂ O)	18.8 (3.9)	28.3 (5.3)	25.7 (5.2)	15.8 (2.3)	26.4 (4.4)	22.2 (3.8)	17.4 (2.7)	21.9 (2.8)	18.8 (2.7)	16.5 (2.9)	22.5 (3.0)	17.3 (2.6)	<0.001
Driving pressure (cmH ₂ O)	13.8 (3.9)	9.6 (1.7)	7.1 (1.3)	10.8 (2.3)	12.1 (2.8)	7.7 (1.8)	12.3 (2.7)	16.9 (2.8)	13.8 (2.7)	11.5 (2.9)	17.5 (3.0)	12.3 (2.6)	<0.001
Compliance (ml cmH ₂ O)	44 (12)	64 (16)	88 (20)	72 (17)	63 (18)	108 (29)	46 (12)	35 (8)	44 (11)	67 (10)	38 (6)	60 (14)	<0.001
PaO ₂ /F _i O ₂ (mmHg)	256 (119)	502 (71)	521 (75)	478 (59)	481 (95)	517 (96)	290 (135)	341 (130)	357 (125)	416 (100)	391 (102)	418 (80)	<0.001

Table 1: Respiratory and blood parameters at three time points during mechanical ventilation. Entries are mean (standard deviation) and p-values compare the two arms from a repeated measures ANOVA; PNP=pneumoperitoneum

Conclusion:

In patients undergoing laparoscopic abdominal surgery, inhomogeneity of lung inflation can be reduced by RM and PEEP-titration guided by EIT. This requires higher PEEP values than commonly recommended, especially in obese patients, and improved oxygenation with reduced driving pressures.