The effect of different positive-end expiratory pressure on elastance of respiratory system and ventilation distribution during robot-assisted laparoscopic radical prostatectomy

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Background and Aim

Pneumoperitoneum and steep Trendelenburg position during laparoscopic surgery increase elastance of the respiratory system and impair gas distribution in the lung, resulting in hypoxia.

In this study, we investigated the effect of different PEEP on elastance of respiratory system and regional ventilation distribution using Electrical Impedance Tomography (EIT) during robot-assisted laparoscopic prostatectomy (RALP).

Methods

Patients undergoing RALP were randomly assigned to be ventilated with PEEP 5 cmH₂O (PEEP₅) or with PEEP 15 cmH₂O (PEEP₁₅) during surgery. Tidal volume was set at 6-8ml/kg/PBW throughout the study.

Time points		PEEP	Measurements
T0	before induction		Respiratory parameters
T1	after induction	5	✓ Tidal volume, SpO ₂ , PETCO ₂ , Peak inspiratory pressure, FiO ₂ , Respiratory rate, Cdyn
	Recruitment maneuver		
T2	before pneumoperitoneum and head down	5 or 15	✓ Esophageal pressure (Pes)
T3	20 min after head down	5 or 15	✓ Transplumonary pressure (Ptp)
T4	60 min after head down	5 or 15	✓ Ventilation distribution
T5	120 min after head down	5 or 15	✓ Blood gas
T6	10 min after cessation of pneumoperitoneum	5 or 15	Hemodynamics
			✓ BP, HR
			✓ Stroke volume variation
			✓ Cardiac Index

❖ Calculation of Elastances: Chest wall (E_{cw}), Lung (E_L)

$$E_{rs} = \frac{\text{Plateau pressure} - \text{PEEP}}{\text{Tidal volume}} \quad E_L = E_{rs} - E_{cw}$$
$$E_{cw} = \frac{\text{Pes at end-inspiration} - \text{Pes at PEEP}}{\text{Tidal volume}}$$

❖ Electrical impedance tomography

❖ Statistics

Independent t-tests or Mann-Whitney U tests were used for the comparisons between the groups.

Results : Demographic data (mean ± SD)

	PEEP ₅ (n = 25)	PEEP ₁₅ (n = 22)
Age (yr)	66 ± 7	68 ± 5
BMI (kg/m ²)	23 ± 2	24 ± 2
% Vital Capacity (%)	100 ± 12	99 ± 14
FEV1.0% (%)	74 ± 6	77 ± 12
Ope time (min)	382 ± 74	385 ± 90
Fluid balance (ml)	1865 ± 655	2217 ± 612
Use of phenylephrine (mg)	0.2 ± 0.2	0.9 ± 0.8*

*p<0.05 vs PEEP 5

Results : Change in lung parameters

Results : Change in distribution of ventilation

❖ Ventilation distribution at dorsal region : Layer 4

Discussion

The impact of pneumoperitoneum and steep Trendelenburg position on chest wall elastance was significant in both groups due to the cranial shift of the diaphragm. However, chest wall elastance was significantly lower and the ventilation distribution at dorsal part was maintained when PEEP 15 cmH₂O was applied compared to PEEP 5 cmH₂O. These data indicate that higher PEEP could counterbalance such cranial shift of the diaphragm and prevent lung collapse at dorsal part, leading to better oxygenation during surgery.

Conclusions

Higher PEEP could reduce the increase in chest wall elastance and keep the better ventilation distribution, which leads to maintenance of oxygenation.