

## One Lung Ventilation: How can we Prevent Lung Injury after Thoracic Surgery?

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After thoracic surgery, about 2% to 5% patients develop lung injury and the mortality rate for those patients is high, 25% to 100% [1]. Therefore, it is important to prevent lung injury after thoracic surgery to improve outcomes of patients undergoing thoracic surgery. The question is “how can we do so?”

The causes for the development of lung injury are reported as surgical trauma, lung overinflation, pulmonary hypertension or hyper-perfusion, lymph drainage impairment, oxidative stress, and reperfusion injury [2,3]. Pre-existing conditions such as malignancy [4], sepsis [5], or lung diseases are other factors that may prime lungs for susceptibility to lung injury. Risk factors [6] for postoperative lung injury are evident (Table 1). Any single risk factor is less possible to cause lung injuries by itself; but combined effects of some of the factors would lead lung injury (multiple hit theory) [7].

The biophysiological etiology of postoperative lung injury is also multi factorial. Ventilator induced lung injury due to high tidal volume /high transmural pressure owing to reduced lung volume, pulmonary capillary stress failure due to reduced vascular bed, oxygen stress caused by increased inspiratory oxygen fraction during One Lung Ventilation (OLV), ischemia / reperfusion injury of the non-ventilated lungs during OLV, and surgical injury and stress [13]. In addition, recent laboratory findings suggested that tissue hypoxia of the collapsed lungs during OLV is the major cause of lung injury [14]. The authors applied 3 cm H<sub>2</sub>O of Continuous Positive End-Expiratory Pressure (CPAP) to the collapsed lungs and found that the CPAP increased perfusion of the collapsed lungs, decreased mRNA expressions of hypoxia-related genes, and reduced inflammatory cytokines.

Mechanical ventilation doesn't cause lung injury by itself; however, conventional mechanical ventilation (tidal volume of 10-12 ml/kg ideal body weight) may induce lung injury if lungs are primed by systemic inflammation or during major surgery. Tidal volume should be reduced to about 5 ml/kg ideal body weight during OLV. A brief outline of the lung protective strategies is to reduce tidal volume, apply open lung approach with Positive End-Expiratory Pressure (PEEP) and repeated lung recruitment maneuver, and avoid any lung lesion to be hypoxic.

In conclusion, OLV itself has a potential hazard to ventilator induced lung injury. Coexisting conditions including malignancy,

preoperative radiation and chemotherapies, and the ongoing major surgical injury and stress would have primed the lungs for Acute Respiratory Distress Syndrome (ARDS). Therefore, during and after the thoracic surgery, we should eliminate as many known risk factors for post-operative lung injury as possible. That includes unnecessary hyperoxia, lung overinflation, fluid overload, and lung collapse and these will be facilitated by reducing inspiratory oxygen fraction, reducing tidal volume, applying PEEP and lung recruitment maneuver to the ventilated lungs, and applying CPAP to collapsed lungs.

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Phase	Factors	Reference
Pre-operative	Chemotherapy	Parquin1996 [6]
	Radiation	Parquin1996 [6]
	Alcohol abuse	Licker2003 [7]
	Pulmonary fibrosis	Chida2008 [8]
Intra-operative	Pneumectomy	Licker2003 [7]
	Rt. pneumectomy (as compared with Lt.)	Nohl-Oser1972 [9]
	Intraoperative fluid overload (> 2L)	Parquin1996 [6]
	High tidal volume / pressure during OLV	Jeon2009 [10]
Post-operative	High insp. oxygen fraction	Grocott2008 [11]
	Perioperative fluid balance (< 1.5L)	Evans2012 [12]
	Remaining lung perfusion (<55%)	Parquin1996 [6]

**Table 1:** Risk factors for lung injury after thoracic surgery.

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