Lung Injury Related to One Lung Ventilation

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ABSTRACT BODY:
Introduction: Single lung ventilation (SLV) to facilitate surgery in the thoracic cavity, while not a new concept, is rapidly becoming popular. Thoracoscopic approach mandates that the lung on the operative side be collapsed to allow visualization of the operative field and approach to the target organ. Advantages to the thoracoscopic approach include less postoperative pain and shorter hospitalization, however little data exists examining the tissue injury that may result (1). Objective of this study is to identify the changes in lung mechanical parameters and examine histological appearance of lung parenchymal tissue resulting from a SLV in juvenile pigs.

Methods: Animal Care Committee approved the study. Three week old juvenile pigs were anesthetized initially with ketamine/azepromazine/zylazine cocktail. The internal jugular vein was canulated, followed by intubation with a 6.0 cuffed ETT. Anesthetic consisted of 1% isoflurane in 100% oxygen and sufentanyl infusion. The carotid artery was canulated for continuous arterial pressure monitoring as well as for collecting blood samples for biochemical assays. After 30 minutes of bilateral ventilation (BLV), the left lung was collapsed by placing an Arndt endobronchial blocker (5F) in the left main bronchus under direct vision. The animal was turned to the right lateral position to simulate surgical positioning , and a trochar was placed into the left thoracic cavity to simulate introduction of a thoracoscope. After 3 hrs of SLV, the bronchial blocker was deflated, BLV was resumed, and the animal was returned to a supine position. Lung mechanics and serum markers of lung injury were measured at baseline and half hourly all through the experiment, including final measurements after 30 min on BLV. At the end of the experiment, lungs were flushed with Millonig's solution and lung samples were obtained for histological and immunological analysis. Blood samples were collected for assays of TNF-α, IL-6, IL-8 baseline and every 30 min through the experiment, including 30 min after re-expansion of the collapsed lung (BLV).

Results: Serum for 1L-6 and TNF-α shows marked increase at the onset of OLV, continues to increase over duration of OLV, followed by a second surge during reexpansion (see Fig 1). Mechanical parameters and PAO_2 are given in Table 1. Data is analyzed for measurements during initial BLV vs BLV after reexpansion using Paired T-tests. IL-6 was significantly greater in the lung homogenates from the collapsed lung (mean of 30.4 VS 5.9) by paired T-test (P=.007). Fig 2. shows histological staining of lung tissue for apical non-dependent areas of the lungs from collapsed (left) vs ventilated (right) side. Histology reveals the spectrum of damage that lung is likely to sustain with the collapsed left side showing greater density and less aeration overall, along with significant wall thickening.

Table 1. Comparison of lung mechanics and PaO_2 between initial BLV and BLV after 3 Hrs of OLV

	Baseline before OLV	BLV after 3 Hrs of OLV	P Value by Paired T-Test
Peak Inflating Pressure(cm of H2O)	12 (0.6)	14.3 (1.9)	0.05
Mean Airway Pressure " "	4.6 (0.51)	5.6 (0.51)	0.01
PaO_2 (mm of Hg)	488 (46.5)	423 (57.4)	0.03
Compliance (ml/cm/kg)	9.5 (2.0)	8.6 (1.6)	0.43
Resistance (cm/L/sec)	12.4 (1.6)	14.8 (3.2)	0.24

IL-6 and TNF-alpha measured during initial BLV, during OLV, then again 30min after re-expansion

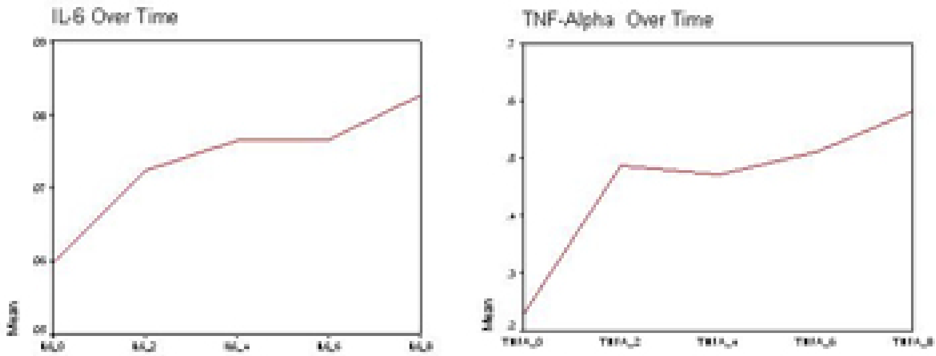
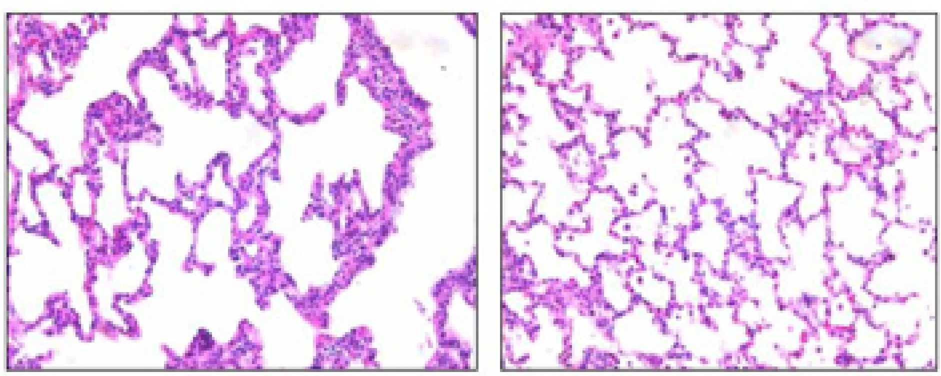


Fig 2. Comparative Histology between Lung Tissue from Collapsed Lung vs Ventilated Lung. Note: Lung tissue is harvested 30 min after bilateral ventilation was re-established. Figs attached as a separate jpg file.

H&E staining of lung tissue - Apical Nondependent Region



Lt-Collapsed Lung   Rt-Ventilated Lung

Discussion: Our data shows significant rise in inflammatory cytokines during OLV and possible further rise during reexpansion of collapsed lung. Injury during reexpansion of collapsed lung has not been well examined and provides an area where improvements can potentially be made A recent clinical paper has published data on lung injury examining the inflammatory parameters and lung mechanics during OLV in humans (2). Our animal model closely approximates this study and further adds invaluable data on lung tissue histology. Furthermore, our model of OLV allows for studying interventions to alleviate damage sustained from OLV.

Refs: Tonz M et al: Ann Thorac Surg 1998;66:542-6. (2) Michelet P et al: Anesthesiology 2006;105:911-9.