A Scale-Free Model of Ventilation-Induced Lung Injury. DC Gottman, BJ Smith (Ph.D.), Bioengineering, University of Colorado, Aurora, CO

Acute respiratory distress syndrome (ARDS) is characterized by the accumulation of pulmonary edema (PE) and atelectasis in alveoli, often leading to life-threatening hypoxemia and the need for mechanical ventilation. While mechanical ventilation is a necessary life-saving intervention, it can also exacerbate ARDS and propagate lung injury. A common practice for analyzing the progression of ventilator-induced lung injury (VILI) relies on interpretation of histological cross sections of injured lungs from mice; however, it remains a challenge as to how disparate regions of injury should be correlated with one another. To answer this question, we subjected mice to two-hit models of acute and ventilator-induced lung injury, prepared histological samples, and segmented the corresponding regions of atelectasis and PE with machine-learning software. We conceptualized the dynamics governing the progression of VILI as analogous to those governing earthquakes. We discovered that, like earthquakes, sizes of VILI regions are power-law distributed and exhibit scale-free behavior (Fig. 1). Our work also builds on previous models of VILI that demonstrate a similar pattern in the progression of alveolocapillary perforation sizes – an aptly-named "rich-get-richer" scheme that exhibits preferential attachment. Knowing that scale-free networks exhibit preferential attachment, we suggest that areas of injury act along "fault lines". That is, we can cluster areas of injury according to regional influences with varying levels of confidence (Fig 2.). The advantage of our current model is that we can correlate regions of lung injury with minimal assumptions of the actual mechanism, allowing us to build a simple model that generalizes to a variety of injuries and allows for simple inspection of their visual patterns.

Figure 1. Average Degree Distribution of Injured Regions (N = 12)

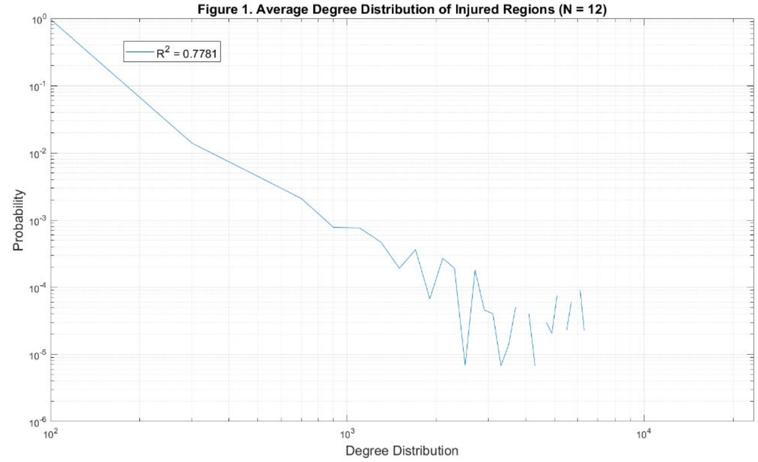

Figure 2.