**Project Title**  
Assessment of Endotracheal Tube Position Relative to the Carina Using A Cascaded Convolutional Neural Network Approach

**Problem Statement**  
Rapid and accurate assessment of endotracheal tube (ETT) position from chest radiograph is a critical need in the acute care setting.

**Hypothesis or Design Goals**  
A serial cascade of deep learning CNNs can be used to determine the distance of an ETT from the carina with high accuracy.

**Materials**  
- MacBook Pro - Google Colaboratory - MIMIC-III CXR dataset

**Procedure**  
Using the MIMIC-III CXR dataset, an open-source critical care database, a natural language processing technique based on regular expressions was used to parse 227,835 patient reports (corresponding to 377,110 images). From this initial cohort, a subset of 16,000 individual patients were identified with exams that indicated a high probability of either presence or absence of ETT (8,000 patients in each category). Each of the 8,000 patients with an ETT were confirmed via manual inspection, and the coordinate locations of both the carina and distal ETT tip annotated. A total of three different CNN algorithms were created (Figure 1). The first algorithm comprised of a regression network designed to output the estimated (y, x) coordinate of the carina. From this information, a 256 x 128 crop was generated of the upper airway. Using this input, a second CNN binary classifier network was used to predict the presence or absence of ETT. Finally, if an ETT was detected, a third CNN regression network was designed to output the estimated (y, x) coordinates of the distal ETT tube.

**Results**  
Upon five-fold cross validation, carina coordinate location was estimated within 0.33 cm (0.21-0.46 cm) of ground-truth annotations. The subsequent bounding-box crop based on this anchor point properly included the airway and ETT 99.8% of the time. Classification accuracy of presence or absence of ETT demonstrated an accuracy of 94.0% (sensitivity of 92.45%, specificity of 94.96%, positive predictive value of 92.34%, and negative predictive value of 95.03%). Final prediction of distance from the ETT tip to carina was estimated within 0.36 cm (0.24-0.48 cm) of ground-truth measurements.

**Conclusions or Evaluation**  
A serial multi-step CNN approach implemented via a custom VGG derived architecture, trained on 16,000 patients, demonstrates high accuracy for localization and assessment of ETT position. Rapid and accurate assessment of ETT location via a deep learning system may significantly expedite patient care in the ICU setting, particularly in the event of a misplaced ETT where even slight delays in physician notification can result in severe patient morbidity and mortality.