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Automated Assessment of Cardiothoracic Ratios on Chest Radiographs Using Deep Learning

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Introduction:

The cardiothoracic ratio (CTR) is a quantitative measure of cardiac size that can measured from chest radiography (CXR). Although radiologists using digital workstations possess the ability to calculate CTR, clinical demands prevent calculation for every case. In this study, the efficacy of a deep convolutional neural network (dCNN) to assess CTR was evaluated.

Methods:

611 HIPAA-compliant de-identified CXRs were obtained from [institution blinded] and public databases. Using ImageJ, a board-certified radiologist (reader #1) and a medical student (reader #2), measured the CTR by marking four pixels on all CXRs: the right- and left-most chest wall, the right- and left-most heart border.

The Tensorflow framework (v2.0, Google LLC, Mountain View, CA) and the Keras library (v2.3, https://keras.io) were used to train the dCNN. The images were split into training (511 images), validation (50 images), and test (50 images). U-Net network architecture with an Intersection over Union loss function was employed to predict oval masks on new CXRs and calculate the CTR.

Results:

45 test cases were analyzed. The mean absolute difference in the calculated CTR was 0.026 (stdev: 0.039) for reader 1 vs dCNN, 0.024 (stdev: 0.039) for reader 2 vs. dCNN, and 0.022 (stdev: 0.024) for reader 1 vs. reader 2. The intra-class correlation coefficient was 0.84 (95% CI: 0.73-0.91), 0.84 (95% CI: 0.72-0.91), 0.92 (95% CI: 0.822-0.958) for reader 1 vs. dCNN, reader 2 vs. dCNN, and reader 1 vs. reader 2, respectively.

Discussion:

The dCNN trained in this study outputted similar CTR measurements to the human readers with the dCNN achieving "good" reliability with the human readers and the human readers achieving "excellent" reliability among themselves. This study proves the feasibility of using a dCNN to perform automated CTR assessment from CXR. Future improvements to the algorithm can allow the dCNN to closely approach the expected limits of inter-observer human agreement.