Applying Deep Learning and Radiomics to Determine Biological Lung and Heart Age from Chest Radiographs

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Purpose

Age is an important risk factor for disease. The study goal is to establish a mean value of the size of lung parenchyma (SLP) and the cardiothoracic ratio (CTR) of healthy population in Southern China using a large-scale chest radiograph (CXR) dataset as baseline for different ages and genders. The result is used to generate prediction models for biological lung or heart age to monitor aging processes and early detect lung or heart diseases.

Material and methods

A large PA/AP CXR dataset was acquired from six sources in Southern China, from 2012 to 2018, including 249,858 and 222,011 CXRs for SLP and CTR, respectively. All cases were confirmed by at least one radiology report, EKG, or other clinical report to exclude abnormal SLP and pre-existing heart conditions.

CXR image was first resized and converted into PNG format. An adaptive histogram equalization was applied to improve the contrast. A deep learning artificial intelligence (AI) technique was trained and applied to automatically segment the left and right lung, and the heart area with a very high accuracy

(DICE value<0.017). The left and right SLP was calculated for different ages and genders. The CTR was calculated for each age and gender by dividing the transverse cardiac diameter by the maximum internal thoracic diameter.

Results

The mean right and left SLP increased with age until it peaked at gender specific maturity age. Figures 1 and 2 show the SLP and CTR profiles for each age, referred as lung and heart age, with a 95% confidence level. The mean SLPs of the study population were 399, 368, and 435 cm^2, and the mean CTRs of the study population were 0.417, 0.420, and 0.413, for general, female, and male population, respectively.

Conclusion

This is the first large-scale study on radiological lung and heart age measured using PA/AP CXR images. The study generated prediction models and obtained the averaged biological lung and heart age using deep learning AI and radiomics. The trend of lung and heart age profiles are similar to various reported disease risks and growth trends.

Key Words: Deep Learning Convolutional Neural Network, Artificial Intelligence, Chest Radiograph, Lung Age, Heart Age, Biological Age

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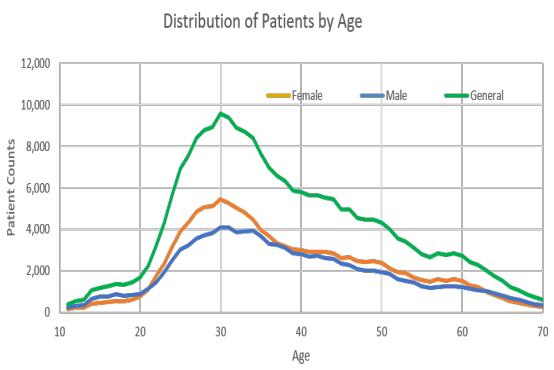
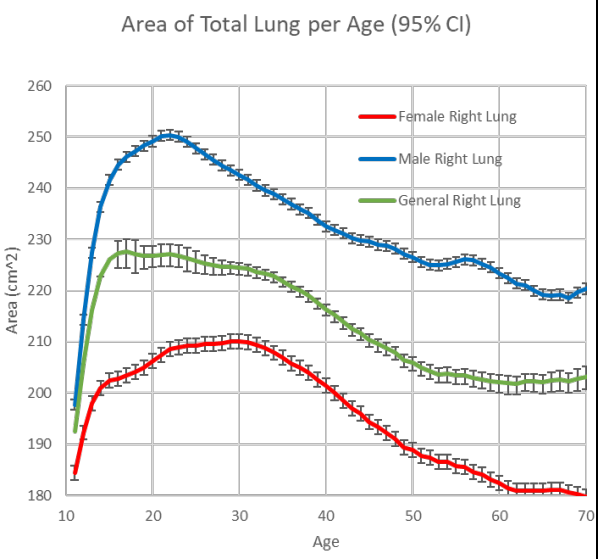
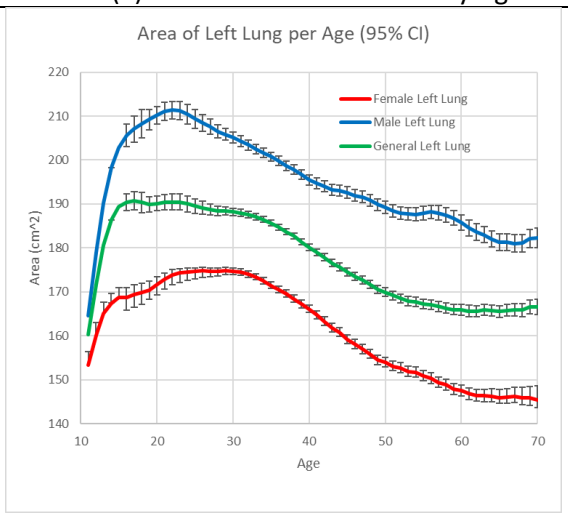
Figure 1. Distribution of patients by age (a) used to generate SLP; Total SLP distribution by age (b); Left SLP distribution by Age (c); and Right SLP distribution by Age (d). The mean SLP increased gradually from Age 12 till Age 24, with females having less values than males. The right SLP is greater than the left SLP.



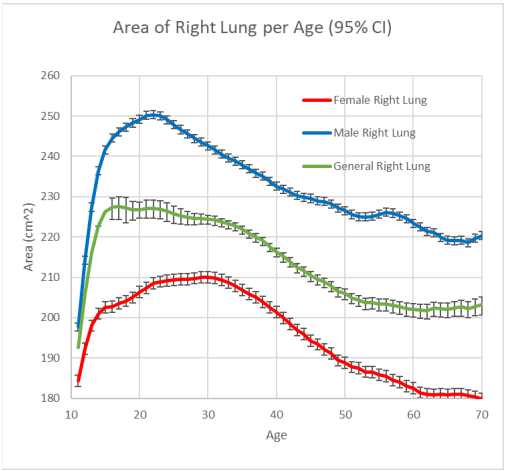
(a) Distribution of Patients by Age



(b) Total SLP Distribution by Age

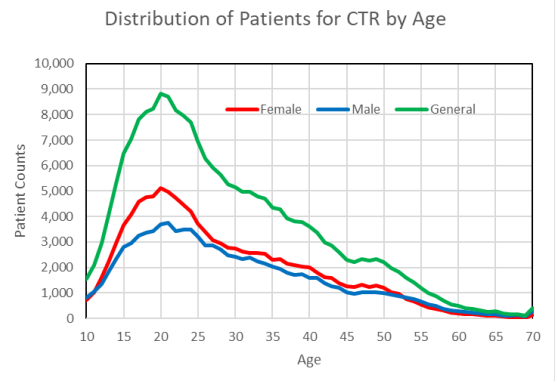


(c) Left SLP by Age

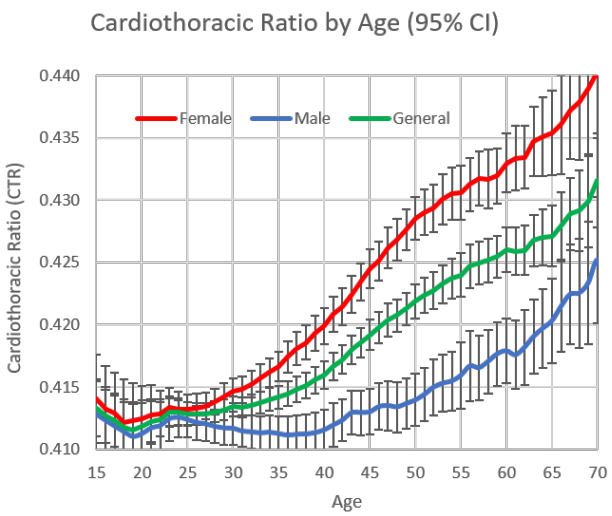


(d) Right SLP by Age

Figure 2. Distribution of patients by age (a) used to generate CTR profile and average CTR distribution by age (b). The mean CTR increased with age, with females having greater values than males, and the CTR for males staying relatively flat until after Age 35.



(a) Distribution of Patients by Age



(b) CTR Distribution by Age.

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