Quantifying Lung Shape At FRC In Normal Old And Young Subjects

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1. Rationale

Lung aging and disease tend to overlap in producing similar signs and symptoms.

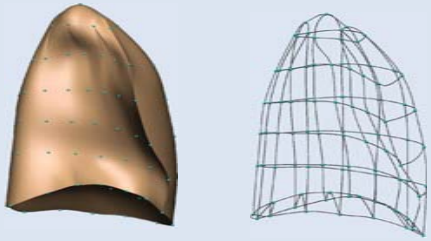
It is useful to understand and quantify "normal" changes in structure and function of the lung that occur with age.

Age-dependant geometric changes in the pulmonary lobes may be a novel imaging biomarker for measurement variability of lung structure and function.

2. Methods

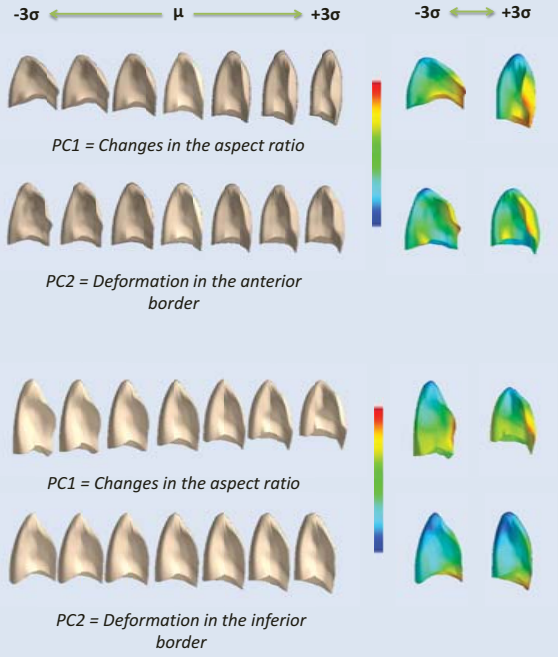
A principal component analysis (PCA) was used as a quantitative approach to describe mean lung shape and its variation. For the sake of simplicity, we used pseudo landmarks, in addition to anatomical landmarks, on the shape surface (total 87 landmarks).

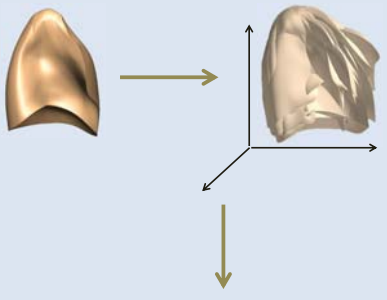
To test the feasibility of this approach in revealing age-dependent differences, a PCA was performed on data from never-smoking subjects with normal lung function (17 aged 20-30 years, and 20 aged >50 years). Data was acquired under a previous study (ethics approval granted by the University of Iowa Institutional Review Board).

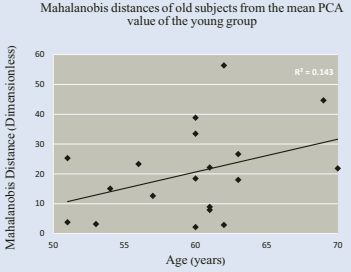


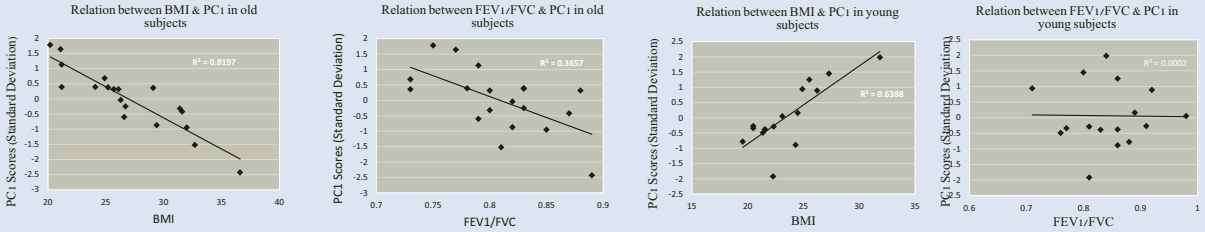
To define lung shape, volumetric CT images acquired supine at FRC were segmented and digitised, and three-dimensional finite element (FE) meshes were constructed to represent the lung surface. All nodes were uniformly distributed and spaced to create the set of pseudo landmarks. All meshes were scaled to unit volume and aligned by their apices to remove the effects of lung volumes and movements.

3. Results









4. Summary

- First few PCs demonstrated more than 70% of total variation in the populations;
- A major variation was observed in the aspect ratio of the lung;
- The aspect ratio changes were opposite in old and young populations;
- Other major variations were associated with changes in the anterior and inferior borders, rotation about the cranio-caudal axis, and changes in the cardiac impression;
- Strong correlations were observed between PC1 values and BMI in both old and young populations, and between PC1 values and FEV1/FVC ratio only in old population;
- A metric (called the Mahalanobis distance), which takes into account the correlation structure of data, was used to measure distances of old subjects from the young population's mean PCA;
- A moderate correlation was observed between the ages of old subjects and their Mahalanobis distances from the mean of the young population's PCA.

5. Future Directions

- Normative model adaptation to subject-specific parameterization and simulation;
- Tissue density distribution analysis:
  - Subjects' density and LAA mapping to the normative model.

6. Acknowledgements

- MBIE NERF: Soft tissue mechanics for breast & lung;
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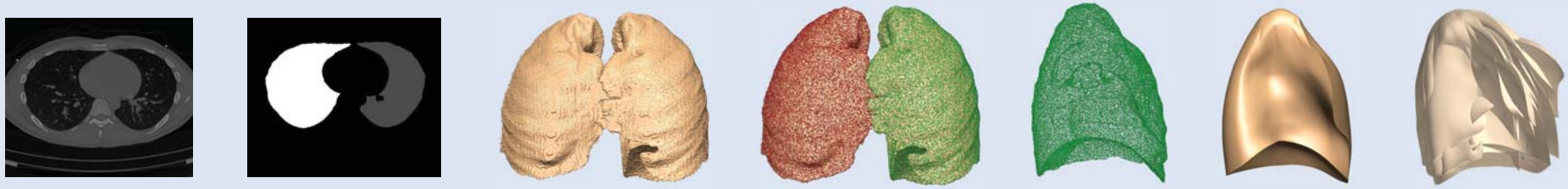

The workflow: lung CT segmentation → image digitization → data cloud creation → FE mesh construction → mesh transformation for alignment → training data set construction → data decomposition for PCA

PCA via SVD