AI Quantification of Lung Fibrosis Outperforms Visual Extent Analysis of Images

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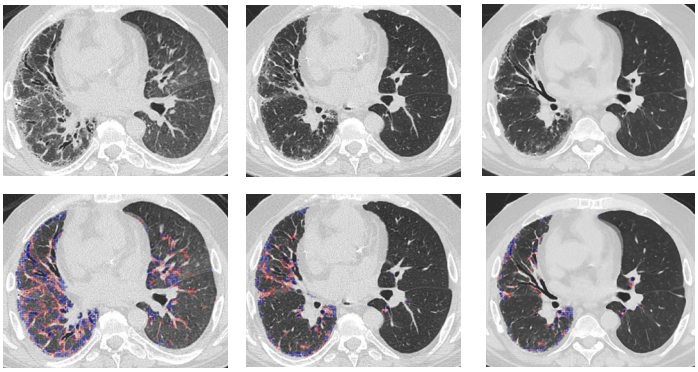
Researchers at UCLA helped to pioneer an artificial intelligence algorithm over 10 years ago that adds quantitative analysis to the visual image analysis of computed tomography (CT) images at our institution in screening patients for interstitial lung disease (ILD) and for tracking changes to lung tissue over time to help manage treatment. The Quantitative Lung Fibrosis (QLF) score was developed to bring uniformity to the interpretation of CT lung images. A significant goal of the efforts was to make the interpretation of CT images generalizable across different imaging sites and CT equipment. Once the images are normalized, the computer model analyses each voxel to determine the likelihood of fibrosis at every point in the image. A voxel represents a position in three-dimensional space just as a pixel represents a position in a two-dimensional image.



A subject with improvement over time: 62 year old male, QLF (red+blue) score in the whole lung =27% at visit 1; later QLF=7.7% at visit 2; and QLF=6.4% at visit 3. After visit 3, The percent predicted forced vital capacity improved by 22%.

Each voxel is classified using artificial intelligence according to the distinctive visual patterns characteristic of fibrotic tissue in ILD — including ground glass opacities (which indicate inflammation) and honeycomb cysts (which are the final stage of ILD). The voxel score is summed across the entire scan to arrive at the Quantitative Lung Fibrosis score. The QLF score is expressed either as a percentage or volume in milliliters of fibrotic tissue detected. At UCLA, QLF scores have supplanted quartile scores of lung fibrosis assigned by radiologists based on their visual assessment of CT scans. QLF offers advantages in sensitivity, reproducibility and traceability. It can detect smaller increments of change and enables clinicians and researchers to track where changes to tissue have occurred over time.

In clinical investigations of fibrosis treatments for example, QLF enables researchers to track physical changes over time in patients receiving different treatments regimens. Similarly, QLF provides clinicians detailed analysis of lung tissue to help guide their treatment decisions

Development of the QLF score

The QLF score was developed using support vector machine, a supervised learning principle in which experienced radiologists identified patterns of lung fibrosis to teach the model the specific texture features of lung fibrosis. Once the model was trained to characterize each voxel, it was tested to confirm that the score based on individual voxels corresponded well with evaluations of the overall lung performed by a consensus of expert radiologists. The level of concordance between QLF and the expert consensus is 0.96, with 1.00 being perfect concordance.

Following that confirmation of the model's validity, the algorithm was further assessed by applying it to other, larger populations of patients to ensure that the score was accurate across multiple patient populations and imaging manufactures. The score was compared against both visual image analysis and lung functions test data. Researchers confirmed that changes in the score were associated with other treatment outcome measures and symptom as well. In one example, skin biopsies of patients whose lung fibrosis is associated with scleroderma were evaluated to confirm that changes in scleroderma tissue in response to fibrosis treatment corresponded with changes to the QLF score. Serum biomarkers have also been used to correlate QLF score with measurable biological changes.

QLF scores can predict changes in lung function

An exciting application of QLF is its use in adjusting the medical treatment of patients with idiopathic pulmonary fibrosis (IPF). "We have learned that changes in QLF score — whether a reduction or a worsening of the fibrosis — predict by 18 to 24 months changes of the lung function in IPF patients," states Dr. Kim. "Patients can be baselined and then tested again after six months. When their scores worsen, it may be a signal to increase medication doses or to switch medication in an attempt to prevent lung function from worsening." Conversely, when QLF scores improve, pulmonologists can consider reducing doses to minimize unwanted treatment side effects.

QLF scoring is also an important tool for monitoring rheumatoid arthritis patients for the development of interstitial lung disease. An estimated one in 10 rheumatoid arthritis patients will develop ILD over the course of their disease, leading to a significantly higher risk of mortality. It is important to define a threshold for treating lung disease in this population, and QLF scores proved the sensitivity needed to determine such a threshold.

UCLA is currently the only center on the West Coast that offers QLF testing.