Usefulness of Temporal Subtraction for The Detection of Interval Changes of Interstitial Lung Diseases on Chest Radiographs

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ABSTRACT

The evaluation of interval changes between temporally sequential chest radiographs is necessary for the detection of new abnormalities or interval changes, such as pulmonary nodules and interstitial disease. For interstitial lung disease, the interval changes are very important for diagnosis and treatment. Especially, interstitial lung disease may show rapid changes in the radiographs, show changes in the entire lung field in minute detail, or show changes in multiple parts depending on the type. It is therefore difficult to have an accurate grasp of the condition of the disease only with conventional radiographs.

The temporal subtraction technique which was developed at the University of Chicago [1)2)], provides a subtraction image of the current warped image and the previous image. A temporal subtraction image, shows only differences and changes between the two images, can be very useful for a diagnosis of interstitial lung disease. However, the evaluation of the temporal subtraction technique for interstitial lung disease using receiver operating characteristic(ROC) studies has not been reported yet.

Therefore, we have evaluated the clinical usefulness of a temporal subtraction technique for detection of interval changes of interstitial lung disease by ROC analysis.

Keywords: Temporal subtraction, chest image, interstitial disease, detection.

1. MATERIALS AND METHODS

1-1 Case

34 patients with various interstitial lung diseases; 16 men (mean age of 45.7±18.6) and 18 women (mean age of 60.3±14.1), who obtained chest radiographs by Computed Radiography (CR).
Interval between the two radiographs :1-948 days(average,61.8 days).
Confirmed diagnoses by Broncho-fiber-scopy..
interstitial pneumonia (n=16),
bronchiolitis obliterans organizing pneumonia (BOOP) (n=3),
acute eosinophilic pneumonia (n=3), hypersensitivity pneumonitis (n=2),
diffuse panbronchiolitis (n=1), amyloidosis (n=2),
lymphangitis carcinomatosa (n=2), sarcoidosis (n=3) ,
rheumatic pneumonia (n=2).
Temporal subtraction images: total 4,753.
100 cases (100 pairs of temporally sequential chest radiographs):selected randomly,
63 cases (126 radiographs) with interval changes,
37 cases (74 radiographs) without interval changes,
25 cases were confirmed by CT and other 75 cases were ascertained by a radiologist with more than 20 years of experiences.

1-2 Subtraction Images

CR: FCR 9501 CR System (Fuji Medical Systems Co., Ltd., Tokyo, Japan).
Imaging plate: ST-V type. The pixel size: 0.1mm, gray level range: 1024.
Matrix size :1760 × 1760(The matrix size of the previous and current images was reduced to 586 × 586 for subsequent processing on automated subtraction.).
The temporal subtraction was performed with a Silicon Graphics O2 workstation, Those images were printed out on Pictro exclusive paper (21 cm × 30 cm) with 256 level gray-scale and 300 dpi resolution by Pictro (Fuji Xerox Co.,Ltd.,Tokyo,Japan).

1-3 ROC Studies

Four radiologists and two thoracic physicians with more than ten years of experiences visually evaluated the changes in temporally sequential CR radiographs and the changes in subtraction images and investigated the usefulness. First, the previous and current CR radiographs, placed side by side, were checked (no fixed interpretation time) and judged for the presence of any interval changes.

The subtraction image was then checked together with those CR radiographs, and similarly judged for the presence of any interval changes. The observer marked his confidence level with a pencil on a line that was 7 cm in length. The observers had also practiced the observation with two test cases before the actual observations.

The obtained observation results were analyzed using ROC analysis software developed by Metz et al at the University of Chicago. Each of the ROC data was concluded to have statistically significant difference when the level of significance was less than or equal to 5 % ($p \leqq 0.05$) using paired-t test.

Next, in order to observe the influences exerted on the detectability by interval change patterns for the lesions, we classified the shadow patterns.

reticular and particulate shadows (n=7), reticular shadows (n=8),
infiltration shadow (n=9), ground-glass (n=7), and particulate shadow (n=3).

Performed ROC analysis by each of those patterns, and investigated the usefulness of the temporal subtraction images. In this ROC analysis, the data from those six observers was classified by the interval change pattern and the pooled data was analyzed by Dr. Metz's ROC analysis software.
Each ROC data was concluded to have statistically significant difference when $p \leqq 0.05$ with paired-t test.

2. RESULTS

The average ROC curves for six observers are shown in Fig. 1. Observers showed clearly a higher detectability of interval changes for interstitial lung disease when reading paired temporally sequential CR chest radiographs in conjunction with the temporal subtraction image than when reading the CR radiographs only. The area, Az, under the average ROC curve increased from 0.78(without subtraction images) to 0.90(with subtraction images), showing a statistically significant difference with $p < 0.002$. This suggests the usefulness of temporal subtraction images to detect interval changes.

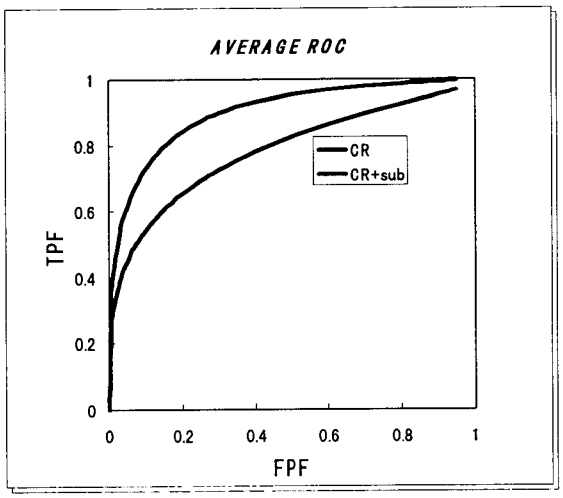

Fig. 1 Graph shows comparison of average ROC curve of those six observers for both only (CR) and with subtraction image (CR+sub) for sequential tests.

Especially for the reticular-nodular shadows and the reticular shadows, the Az with the subtraction images increased by 0.17 (20.4%) and 0.19 (18.7%) respectively. The detectability of the interval changes was largely improved by using the subtraction images.

For the infiltration and ground-glass shadows the Az increased by 0.087 (9.4%) and 0.062 (7.3%) respectively, when using the subtraction images. Even though the Az under the ROC curve for the minute-nodular shadow slightly increased from 0.52 to 0.56 , there is no the statistically significant difference.

3. CONCLUSION

Though the Az showed various values in the shadow pattern, we conclude that the temporal subtraction can assist radiologists in the detection of interval changes of interstitial lung disease on chest radiographs.

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