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Research article

Comparative study of DR and CT in the application of close contacts screening for tuberculosis outbreaks

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Abstract

Objective: To assess the value of direct digital radiography (DR) and CT in the screening of tuberculosis.
Methods: In a tuberculosis outbreak in May, 2014, both chest DR and CT were taken in the close contacts (n = 35 cases). The chi square test and ROC curve were used to evaluate and calculate the missed pulmonary lesions from DR and the natures of these lesions.
Results: Abnormal shadow detection rates of chest DR and CT were 22.9% (8/35) and 40% (14/35) respectively, the difference was statistically significant ($\chi^2 = 16.154$, $P < 0.01$). In the 6 missed cases from chest DR, 3 cases showed with anatomical occult or overlap, such as local area between azygos vein and esophagus (1 case), lung markings in the lower lobe (1 case) and diaphragmatic occlusion(1 case); and in the other 3 missed cases, early signs of small nodules or tree-in-bud were the major signs. ROC analysis showed that when the axis of tree-in-bud is less than 22 mm, it was prone to produce misdiagnosis by using the chest DR. The area under the ROC curve (AUC) was 0.925 with the sensitivity of 90% and specificity of 83.3%. In the 14 cases detected on CT, the lung was involved in 12 cases and the pleura was involved in 2 cases. For the 12 lung-involved cases, the lesions involving from one lung segment to five lung segments were occurred in 6 cases (50.0%), 2 cases (16.7%), 1 case (8.3%), 1 case (8.3%), and 2 cases (16.7%), respectively. Tree-in-bud signs were the main CT characteristics in close contacts, and accounted for about 91.7% (11/12). All the 4 pleura-involved cases showed pleural thickening and pleural tuberculoma after 3–4 months' anti-TB therapy. In the 14 cases detected by CT, 6 cases with micro-lesions were taken by anti-TB experimental treatment, only 2 cases was significantly absorbed of the lesions after 2 months, and all the lesions of the 6 cases absorbed after 6 months anti-TB treatment.
Conclusion: CT is more valuable in the screen of TB outbreak in school compared with DR. Subclinical cases detected by CT is recommended to take a formal anti-TB treatment.

Keywords: Tuberculosis; Pulmonary tuberculosis; Tuberculosis; Tomography; X-ray computed; Direct digital radiography

1. Introduction

With an estimated 9 million new cases and about 1.5 million associated deaths annually, active tuberculosis (TB) continues to be a major cause of morbidity and mortality worldwide [1]. In 2010, China had an estimated 1 million new tuberculosis cases, accounting for 11% of global tuberculosis incidence [2]. Recently, an outbreak of tuberculosis in school was pay attention by the local government. Although the chest X-ray and purified protein derivative (PPD) is a common method for the screening of tuberculosis in schools, some studies have shown that using the direct digital radiography (DR) to detect the small lesions is limited [3], which might lead to the misdiagnosis. This study was conducted in an outbreak of tuberculosis in a middle school in China, by contrast with CT, to evaluate the clinical value and limitation of chest DR in screening the close contacts.

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2. Materials and methods

2.1. Clinical data

In May 4, 2014, an epidemic situation of a class of tuberculosis caused by smear positive tuberculosis patients occurred in one middle school in Dalian, China. Among the totally 35 close contacted students in the class, 8 cases were diagnosed as tuberculosis by using DR screening and clinical examination, including 4 cases of pulmonary tuberculosis, 2 cases of pulmonary tuberculosis complicated with pleurisy and 2 cases of tuberculous pleurisy. Since CT has not been confirmed as a school screening method for tuberculosis in China, we try to give an evaluation by making the 35 close contacts scanned with CT within one week, under the informed consent. Among them, the abnormal pulmonary shadows were found in additional 6 cases. A total of 35 patients examined both with chest DR and CT were included in this study, including 18 male and 17 female, aged from 15 to 17 with the average age of about 15.6 + 0.5 years.

2.2. Diagnosis and treatment of tuberculosis

Sputum smear, culture and Gene Xpert were carried out for the 8 cases which were detected by chest DR, among which it showed that all were negative of sputum smear, 1 case was positive for sputum culture, and 3 cases were positive for Xpert Gene. All the 8 cases were given the combined treatment of 2HEZE/4HR. Additional 6 cases detected by CT which were missed by DR, didn't have obvious clinical symptoms, while sputum smear, sputum culture and Xpert Gene detection were all negative. Via the clinical consultation, they were finally considered as tuberculosis infection, and were given the combined treatment of 2HEZE/4HR. All patients were follow-up by CT scanning.

2.3. Radiological examination and analysis

All the contacts were taken the postero-anterior chest DR, by using the Philips DIGITAL DIAGOSIS digital camera. CT examinations were carried out by using GE-lightspeed 16 multislice spiral CT scanner with scanning range from the thoracic inlet to the bottom level of the chest, and the scanning parameters included tube voltage of 100–120 kV, tube current mA of 75–100; layer thickness of 5.0 mm, and layer spacing of 5.0 mm.

In our study, Xiwei Lu's [4] standards were used to classify the pulmonary tuberculosis signs, which were divided into the type of cavity with spread, consolidation, nodules, and interstitial lesions. Two experienced senior radiologists were employed to analysis images of the chest DR and CT of the 35 contact students by using double blind method. A third doctor was employed to statistic the misdiagnosis rate of DR.

2.4. Statistical analysis

Statistical analyses were performed using SPSS 17.0 for Windows OS. Continuous variables with the normal distribution were reported with mean ± standard deviation; Count data was described by rate or constituent ratio, and compared using chi square test, and $P < 0.05$ was considered as statistically significant. As the misdiagnosis rate of DR was state value and pulmonary lesion size was observed, receiver operating curve (ROC) method was used to calculate the cutoff value of DR missed diagnosis.

3. Results

3.1. Comparison of abnormal shadows detection rate between chest DR and CT

Among those close contacts (35 cases), the abnormal shadows detection rate of chest DR and CT were 22.9% (8/35) and 40.0%(14/35), respectively, with the significant difference (χ^2 value was 16.154, $P < 0.01$). Those 14 cases detected by CT included 10 case of pulmonary tuberculosis (PTB), 2 case of PTB complicated with tuberculous pleurisy and 2 case of only tuberculous pleurisy. Compared with CT, there were 6 cases missed by using chest DR 42.9% (6/14), due to anatomical conceal sites, such as local area between azygos vein and esophagus (Fig. 1), thickening of the blood vessels (lung markings) in the lower lobe and the diaphragmatic occlusion (Figs. 2 and 3), or due to other reasons, of which the early tree-in-bud signs were the major signs in the missed cases (Fig. 3B).

3.2. CT features of this tuberculosis outbreak

In the 12 cases with abnormal pulmonary shadow detected by CT (except for the 2 cases of only pleurisy), lesions involving from one lung segment to five lung segments were visible in 6 cases (50.0%), 2 cases (16.7%), 1 case (8.3%), 1 case (8.3%), and 2 cases (16.7%), respectively. Lesions involving upper lobe, the mid-lingual lobe and lower lobe were in 8 cases (8/12, 66.7%), 2 cases (2/12, 16.7%) and 6 cases (6/12, 50.0%) respectively. It was obvious that the frequency of lower lobe involvement was dominant in our study.

The major CT feature of the first onset TB was tuberculosis cavity, and accompanied with smear-positive. The other CT features included “tree-in-bud” sign and fusion nodules (see Fig. 4). In the 12 cases of the close contacts, the CT features of lung lesions were disseminated foci, accounting for 11 cases (91.7%), which manifested as tree-in-bud sign, patchy, nodules and fusion nodules (Fig. 5). Tree-in-bud was the main CT sign in this outbreak of TB (Figs. 2 and 3B), and all the close contacts had homogeneity CT signs.

In the 4 cases of pleural abnormal changes, 3 cases were with right pleural effusion and 1 case was with bilateral pleural effusion. CT showed a small amount of fluid with uniform density. But after the anti-TB treatment of 3–4 months, all the cases of pleural effusion turned into pleural tuberculoma with a high degree of nodular opacities (Figs. 6–9).