Chest Tuberculosis: Radiological Classification According to Current Concepts

Sun Young Jeong, Jeong Jae Kim, Gukmyung Choi, Seung Hyung Kim, and Im Kyung Hwang
Department of Radiology, Jeju National University School of Medicine, Jeju, Korea
(Received November 29, 2013; Revised December 6, 2013; Accepted December 13, 2013)

Abstract

Tuberculosis (TB) is one of the most important infectious diseases, causing high mortality and morbidity worldwide. The traditional imaging concept of primary and reactivation TB recently has been challenged on the basis of DNA fingerprinting; the radiological findings are closely related to the patient's immune status rather than the elapsed time after the infection. In this regard, we need to use new radiological classification instead of using the inappropriate previous terminologies (primary and reactivation TB). In this paper, we will classify the imaging findings of chest TB as follows: parenchymal TB (air-space consolidation, focal nodular lesion and linear density, cavity, tuberculoma, fibrosis–scar–destruction), tracheobronchial TB, miliary TB, lymph node TB, pleural TB, and pericardial TB. (J Med Life Sci 2013;10(2):163–174)

Key Words : chest tuberculosis, current concepts, radiological classification

Introduction

Tuberculosis (TB) is an airborne infectious disease caused by Mycobacterium tuberculosis and is a major cause of morbidity and mortality worldwide. In 2012, an estimated 8.6 million people developed TB and 1.3 million died from the disease. Most cases occur in Southeast Asia and Africa.

Patients with active pulmonary TB may be asymptomatic, have mild or progressive dry cough, or present with multiple symptoms including fever, fatigue, weight loss, night sweats, and a cough that produces bloody sputum.

If TB is detected early and fully treated, people with the disease quickly become noninfectious and eventually cured. The prompt diagnosis of TB is essential for community public health infection control. Unfortunately, acid-fast bacilli are found in the sputum in a limited number of patients with active pulmonary TB. Therefore, the imaging diagnosis would provide an appropriate therapy for infected patients before the definitive diagnosis by the bacteriology

New Concept of Radiologic Manifestation of Tuberculosis

Patients who develop disease after initial exposure are considered to have primary TB, and others who develop disease as a result of reactivation of a previous focus of TB or due to reinfec- 

Correspondence to: Sun Young Jeong, MD
Department of Radiology, Jeju National University School of Medicine, 102 Jeju University, 690–756, Jeju, Korea
E-mail: sy7728jeong@gmail.com

This research was supported by the 2013 scientific promotion program funded by Jeju National University.
This study was presented at 3rd World Congress of Thoracic Imaging in Seoul, Korea in June, 2013.
of the radiographic appearance is the integrity of the host’s immune response. Severe immunocompromised patients show a tendency to have the primary form of TB—lymphadenopathy, whereas immunocompetent patients tend to have the postprimary form—parenchymal granulomatous inflammation with slowly progressive nodularity and cavitiation.

The radiographic findings cannot be simply divided into primary and postprimary forms of TB, and the traditional classification of TB into primary and postprimary should be avoided.

In this regard, we need to use the accurate descriptive terminology, instead of using the inappropriate previous terminologies (primary and reactivation TB). We suggest a radiological classification of chest TB as follows:

- Parenchymal TB
  - Air-space consolidation
  - Focal nodular lesion and linear density
  - Cavity
  - Tuberculosis

- Fibrosis, scar, and destruction
- Tracheobronchial TB
- Miliary TB
- Lymph node TB
- Pleural and chest wall TB
- Pericardial TB

**Radiological Classification and Illustration of Chest Tuberculosis**

1. Parenchymal TB

1) Air-space consolidation

It is related to parenchymal granulomatous inflammation. Particularly in patients with impaired T-cell function, coalescence and enlargement of multiple foci of such inflammation lead to extensive consolidation. In immunocompetent patients, focal or patchy consolidation with surrounding nodules may be seen in the upper lobes and the superior segments of the lower lobes. (Fig. 1 & Fig. 2)

![Figure 1. Pulmonary tuberculosis in a 24-year-old woman. Chest radiograph (A) and high-resolution CT scan (B) show extensive air-space consolidation in both upper lung zones.](image)

2) Focal nodular lesion and linear density

The centrilobular nodules and branching linear/nodular opacities (tree-in-bud pattern) are due to the presence of caseation necrosis and granulomatous inflammation within and surrounding the terminal and respiratory bronchioles and alveolar ducts. Coalescence or clustering of small nodules lead to the formation of a large nodule (so-called galaxy sign).

3) Cavity

With erosion into airways and subsequent evacuation of necrotic materials, a cavity can be formed within a parenchymal lesion (Fig. 5). The expelled necrotic material frequently spreads via the bronchi to other parts of the lung (endobronchial spread). Therefore, cavititation is an important sign of an active disease.
Figure 2. Pulmonary tuberculosis in a 35-year-old woman.
Chest radiograph(A) and high-resolution CT scan(B) show focal consolidation and surrounding small nodular lesions in the right upper lobe.

Figure 3. Pulmonary tuberculosis presenting with small nodules and branching linear structures in a 24-year-old woman.
A, Targeted view of chest radiograph shows peribronchial small nodular lesions and focal consolidation in the right upper lobe.
B–C, Lung window images of transverse high-resolution CT(1.0-mm section thickness) scans obtained at levels of trachea (B) and carina (C) demonstrate branching linear structures and small nodules (tree-in-bud sign), and lobular consolidation in the posterior segment of right upper lobe.
Figure 4. Pulmonary tuberculosis showing CT galaxy sign in a 53-year-old man.
A. Chest radiograph shows fine reticulonodular opacities in bilateral upper lung zones.
B & C. Lung window images of transverse high-resolution CT scans (1.0-mm section thickness) obtained at levels of aortic arch (B) and aygos arch (C), respectively, demonstrate lung lesions consisting of small centrilobular nodules and branching linear structures (arrows forming so-called galaxy sign) in both upper lobes. Similar lesions are observed in superior segment of left lower lobe.

Figure 5. Active pulmonary tuberculosis with cavity in a 44-year-old man.
A. Chest radiograph shows cavitary lesion in the right upper lung zone and nodular opacities in bilateral upper lung zones. B. Lung window image of transverse high-resolution CT scans (1.0-mm section thickness) obtained at level of great vessels demonstrates cavitary lesions in both upper lobes. C. Lung window image of transverse high-resolution CT scans (1.0-mm section thickness) obtained at level of subcarina demonstrates cavitary nodules in the left upper lobe and dense lobular consolidation and tree-in-bud signs in the right upper lobe.
4) Tuberculoma

"Tuberculoma" refers to a well-delimited, round or oval focus of parenchymal TB. Tuberculomas may show central necrosis, cavitation, and satellite nodules (Fig. 6). On CT, following intravenous administration of contrast, tuberculomas often show ring-like enhancement. Ring-like enhancement corresponds histologically to the granulomatous inflammatory tissue capsule, whereas the nonenhancing area corresponds to the central necrotic material. Only calcified lesions should be considered inactive.

Figure 6. Tuberculoma in a 41-year-old man. (Courtesy: Kyoung Soo Lee, MD, of Samsung Medical Center, Seoul, Korea)
A. Chest radiograph shows an oval nodule in left upper lung zone. B. Lung window image of transverse CT scan (5.0-mm section thickness) obtained at level of main bronchi demonstrates a nodule containing central cavitation (arrow). Also note surrounding satellite nodule (arrowhead). C. Photograph of surgical resection specimen demonstrates nodule consisting of central caseation necrosis (tan yellow area) and surrounding collagenous connective fibrous capsule (arrows). D. Low-magnification photomicrograph reveals typical tuberculoma composed of well-defined central focus of necrosis and surrounding inflammatory and fibrous capsule.
5) Fibrosis, scar, and destruction

Healing of parenchymal TB is associated with more marked fibrosis and calcification (Fig. 7). Cicatrization, atelectasis is common after cavitary disease, and manifests as atelectasis of the upper lobe, retraction of the hilum, compensatory lower lobe hyperinflation, and mediastinal shift toward the fibrotic lung. Apical pleural thickening associated with fibrosis may reveal proliferation of extrapleural fatty tissue and peripheral atelectasis on CT. Complete destruction of a whole lung or a major part of a lung is not uncommon in the end stages of tuberculosis. Such damage results from a combination of parenchymal and airway involvement (Fig. 8).

![Figure 7. Healed TB lesion in a 38-year-old woman.](image)

Chest radiograph shows multiple parenchymal calcifications and linear fibrotic bands in the left upper lung zone.

![Figure 8. Chronic destructive TB lesion mainly involving right upper lobe in a 70-year-old man.](image)

A. Chest radiograph shows marked volume decrease in right upper lung zone with upward elevation of the right hilum and tracheal deviation. Note the right apical pleural thickening and right costophrenic angle blunting. Focal pleural thickening in the left apex and several nodular opacities in the left upper lung zone are also noted. B. Lung window image of transverse high-resolution CT scan (1.0-mm section thickness) obtained at level of great vessels demonstrates traction bronchiectasis with volume decrease in the right upper lobe. C. Coronal reformatted CT scan (2.0-mm section thickness) demonstrates extrapleural fat proliferation in the right apex.
2. Tracheobronchial TB

Tracheobronchial TB has been reported in 10–20% of patients with pulmonary TB. Long segmental circumferential wall thickening and luminal narrowing of the central airways can be seen in both active and fibrotic stages. However, in patients with active disease, CT scans show irregular and thick-walled airways, a pattern that is reversible (Fig. 9), whereas patients with fibrotic disease generally had smooth narrowing of airways and minimal wall thickening, a pattern that is not reversible (Fig. 10).

Figure 9. Active stage of tracheobronchial TB in an 18-year-old girl.
A & B. Mediastinal window images of transverse enhanced CT scans (3.5-mm section thickness) obtained at levels of great vessels (A) and main bronchi (B), respectively, demonstrate irregular wall thickening in distal trachea and right main bronchus.
C. Coronal reformatted mediastinal window image demonstrates irregular wall thickening in distal trachea.

Figure 10. Fibrotic stage of bronchial TB involving left main bronchus in a 23-year-old woman.
A & B. Mediastinal window images of transverse unenhanced CT scans (2.5-mm section thickness) obtained at levels of main bronchi (A) and right upper lobar bronchi (B), respectively, demonstrate concentric wall thickening of left main bronchus. Also note obliterated bronchial lumen in distal portion of left main bronchus.
C. 3D volume-rendering image discloses marked luminal narrowing and obliteration of left main bronchus.
3. Miliary TB

Miliary TB refers to widespread dissemination of TB by hematogenous spread. The characteristic radiographic and high-resolution CT findings consist of innumerable, 1- to 3-mm diameter nodules randomly distributed throughout both lungs (Fig. 11).

![Figure 11. Miliary TB in a 40-year-old woman.]
A. Chest radiograph shows diffuse granular or ground-glass opacity in both lungs. B. Targeted view of chest radiograph shows more clear small nodules of 2-3 mm in diameter, miliary nodules. C & D. Lung window images of transverse high-resolution CT scans (1.0-mm section thickness) obtained at level of bronchus intermedius (C) and targeted view obtained at level of right middle lobar bronchus (D) demonstrate miliary nodules of random distribution; nodules distributed in centrilobular oration (arrows), along pleura (arrowheads), and along fissure (curved arrows).

4. Lymph node TB

During the stage of active disease, TB organisms frequently spread to the regional lymph nodes, where the ensuing granulomatous inflammatory reaction results in lymph node enlargement. Thoracic lymphadenopathy is most commonly unilateral and located in the hilum or paratracheal region. On CT, the enlarged nodes frequently have low attenuation and show peripheral (rim) enhancement. The former corresponds to the central necrotic portion of the node, and the latter, to the surrounding inflammatory tissue (Fig. 12). In TB infection, there is considerable difference in the prevalence of radiologic findings in infants and children compared with those in adults. The most common abnormality in infants and children consists of lymph node enlargement, which is seen in 90% to 98% of cases.
Chest Tuberculosis: Radiological Classification According to Current Concepts

Figure 12. Tuberculous lymphadenitis in a 28-year-old woman.
A. Chest radiograph shows bilateral superior mediastinal widening.
B. Mediastinal window image of transverse enhanced CT scan (5-mm section thickness) demonstrates enlarged lymph nodes in the right upper para-tracheal area and bilateral prevascular areas with central necrotic low attenuation and peripheral enhancing rim.

5. Pleural and chest wall TB

Pleural effusion, typically unilateral, occurs in 15–20% of TB patients. Although pleural effusion is usually associated with parenchymal abnormalities, it may be the only radiologic manifestation of TB. Pleural effusion can be caused by rupture of a tuberculous cavity into the pleural space. This may result in the formation of tuberculous empyema and, occasionally, a bronchopleural fistula with pleural air-fluid level (Fig. 13 & Fig. 14). Empyema necessitatis result from leakage of TB empyema through the parietal pleura with discharge of its contents into the subcutaneous tissues of the chest wall (Fig. 15).

Figure 13. Loculated empyema in a 51-year-old man.
A. Chest radiograph shows moderate pleural effusion with convex border in the right hemithorax, representing empyema.
B. Mediastinal window image of transverse enhanced CT scan (2.0-mm section thickness) shows loculated pleural effusion with diffuse pleural thickening in the right hemithorax, representing empyema.
Sun Young Jeong, Jeong Jae Kim, Gookmyung Choi, Seung Hyung Kim, and Im Kyung Hwang

Figure 14. Bronchopleural fistula in a 62-year-old woman.
A. Chest radiograph shows air-fluid level in the left hemithorax, which suggests the possibility of bronchopleural fistula. Right upper lung zone shows multiple small peribronchial nodular opacities. Also note volume decrease with fibrocalcified parenchymal change in the left upper lung zone and circumferential pleural thickening or effusion in the left upper hemithorax. B. Mediastinal window image of transverse enhanced CT scan (2.0-mm section thickness) shows loculated pleural effusion with diffuse pleural thickening and air-fluid level in the left hemithorax, representing empyema with bronchopleural fistula.

Figure 15. Empyema necessitatis in a 30-year-old woman.
A. Lung window images of transverse enhanced CT scan (5.0-mm section thickness) obtained at ventricular level demonstrates parenchymal tuberculous lesion, consisting of nodules and tree-in-bud signs, in right lower lobe. B. Mediastinal window image of transverse enhanced CT scan (5.0-mm section thickness) obtained at level of supra-hepatic inferior vena cava demonstrates low-attenuation lesion with rim enhancement (arrows) having both intrathoracic and chest wall components of disease (empyema necessitatis).
6. Pericardial TB

Tuberculous pericarditis develops secondary to contiguous spread from mediastinal nodes, lungs, spine, or sternum, or during miliary dissemination. Pericardial TB presents as pericardial effusion, thickening, or calcification on CT scans(Fig.16).

Figure 16. Constrictive pericarditis as a sequelae of tuberculous pericarditis.
A & B. Posteroanterior (A) and lateral (B) chest radiographs show thick pericardial calcification (arrows) along the anterior and diaphragmatic surface of the heart.
C. Nonenhanced transverse CT scan (5.0-mm section thickness) demonstrates circumferential pericardial calcification.
Sun Young Jeong, Jeong Jae Kim, Gukmyung Choi, Seung Hyung Kim, and Im Kyung Hwang

References


