Childhood pulmonary tuberculosis; Imaging characteristics

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Learning objectives

The aim of this review is to illustrate radiographic findings in childhood pulmonary tuberculosis, to point out the importance of combining symptoms, signs, history of TBC contact, tuberculin skin test, blood test, bacteriological and chest radiographic findings in making the diagnosis and to illustrate changes of radiographic picture during antituberculous therapy.
Background

In most cases, a child is infected with Mycobacterium tuberculosis after an adolescent or adult in their close environment (usually the household) with active tuberculosis expels bacilli into the shared air.

As the distribution of inhaled droplet nuclei is determined by the ventilatory pattern and volumes of the various lung lobes, the site of implantation preferentially occurs in the middle and lower lung zones, although any lobe may be affected.

Development of specific immunity is usually adequate to limit further multiplication of the bacilli, the host remains asymptomatic and the lesions heal.

Some of the bacilli remain dormant and viable for many years, and this condition is referred to as latent TB infection. Risk factor for progression from infection to active TB are co-infection with HIV and M tuberculosis, conditions that are associated with defects in T-lymphocyte and/or macrophage function, such as malnutrition, drug and alcohol abuse, and corticosteroid or other immunosuppressive therapy.

Patients who develop disease after initial exposure are considered to have primary TB.

Postprimary TB occurs in a person who has previously been infected and has retained a degree of acquired immunity. It can result from endogenous reactivation or, less commonly, exogenous reinfection.

Miliary spread of TB may also occur during either primary or postprimary stages of disease. It happens mostly within 3 months of infection and that is why some authors refer to it as early postprimary tuberculosis while other authors refer to it as a complication of a primary disease. It results when a focal collection of tubercle bacilli discharges into a blood or lymph vessel, releasing a large number of viable bacilli that embolize to capillary beds in multiple organs. The lung is the most commonly involved organ.

TB symptoms in children are very vague and common to symptoms and signs seen in children with other chronic disease: chronic cough (an unremitting cough that is not improving and has been present for more than 21 days), weight loss or failure to thrive, fever lasting many days and repeated respiratory tract infection.

Specific clinical manifestations of TB are influenced by the age and immune status of the infected person. Because of the narrower diameter of their airways, younger children are more likely to have respiratory symptoms which include cough and wheezing or rales over the involved region.

Tuberculin skin test identifies children infected with TB but not necessarily those with active disease. The test can be positive in children who are asymptomatic (TB infection) as well as those with active disease (TB disease).
TB blood test, also called an Interferon Gamma Release Assay or IGRA is a relatively new diagnostic tool for TB. There are two kinds of TB blood tests: Quantiferon-TB and T-SPOT-TB. They should not replace the existing standard diagnostic methods for the diagnosis of active TB and negative IGRA result does not exclude active TB disease.

It is always preferable to make a bacteriological diagnosis using whatever specimens and laboratory methods are available. Bacteriological methods most commonly used in diagnosing pulmonary TB are examination of sputum smears for tubercle bacilli and culture of bacilli from sputum specimens and gastric aspirates.

Radiographically, primary pulmonary tuberculosis manifests as parenchymal disease and lymphadenopathy. The primary focus is often so small that it is not visible and only the accompanying mediastinal lymph gland enlargement is seen. It can occur as dense homogenous parenchymal consolidation in any lobe, predominantly in middle and lower lobes.

Lymphadenopathy is typically unilateral and right sided as the right hilar and right paratracheal nodes drain the right lung and lower half of the left lung. TB lymph nodes resolve very slowly even with appropriate TB therapy and can be visible on the radiograph even after completion of successful therapy.

If the enlargement of lymph nodes progresses it can cause narrowing, obstructing or ulcerating into airways that manifests as unilateral hyperinflation, lobar or segmental collapse, TB expansive pneumonia and tuberculous bronchopneumonia.

If the alveolar infiltration breaks through to the pleural space, it provokes a hypersensitivity response in the pleura and a large pleural effusion.

Miliary disease is manifested as a diffuse nodular pattern on chest x ray, with nodule size 1 - 2 mm in diameter.

In postprimary TB which is mostly seen in adolescents, the earliest radiological finding is the development of patchy, ill-defined segmental, lobar or confluent consolidation with the development of cavities later in time. It usually affects the apical and posterior segments of the upper lobe or the superior segment of the lower lobe.

Upper lobe involvement with cavitation and the absence of lymphadenopathy are helpful in distinguishing postprimary TB from primary TB.

A normal frontal and lateral chest radiograph are essential to rule out active TB. The lateral view helps us to distinguish other central shadows from lymph nodes which are spherical and can be frequently seen on both views.

Computed tomography is not indicated in the evaluation of an asymptomatic child with a normal chest radiograph and a positive tuberculin skin test but in cases when the radiograph is equivocal or when other causes of disease are to be evaluated.
A chest CT scan with contrast is particularly sensitive for detection of adenopathy. Lymph nodes, calcifications and small cavitations that are not evident on plain films can be present on CT. The associated complications of TB, such as the erosion of vessels and rupture into the pleural space are also better defined with CT scanning than with radiography.
Imaging findings OR Procedure details

Approximately 60 children have been treated from tuberculosis in our general hospital during year 2010 and 2011. We reviewed chest x-rays of 5 children and a chest CT scan of one of those children. Frontal and lateral chest radiographs were performed as well as contrast enhanced chest CT scan using dual-slice CT scanner.

Diagnosis of TB had been established by clinical and radiological findings, contact with a relative with proved TB infection, positive PPD test, positive Quantiferon test, positive culture for acid-fast bacilli and response to anti TB drugs.

CASE 1:

A 10 year old boy was admitted for treatment because of a positive tuberculin skin test (induration diameter 30 mm), a history of positive TB contact and subfebrile body temperature (37.5°C). Bacteriological tests for M. tuberculosis were negative. Chest x-ray was normal (Fig. 1).

Concerning close contact with the person who had active TB disease, subfebrile temperatures and extremely large induration of tuberculin skin test it was considered to be a subclinical primary disease and the patient went through with the treatment. Two months after the beginning of treatment, the boy was feeling well and had no clinical symptoms.
CASE 2:

A 12 year old girl was admitted for treatment because of erythema nodosum followed by moderate fever (38.6°C) and cough. Laboratory values showed anemia of chronic disease, increased CRP 30 mg/L (normal value # 5 mg/L) and ESR 32 mm/hour (normal values 3 - 13 mm/hour). TB contact was her brother. Tuberculin skin test showed induration diameter of 17 mm. Bacteriological tests for M. tuberculosis were negative. The initial chest radiograph on admission (Fig.2) was an enlarged right hilar gland.
Follow-up chest radiograph 2 and 4 months after the beginning of treatment showed no improvement (*Fig.3, Fig.4*). At the end of treatment the chest X-ray was normal (*Fig.5*). She was diagnosed with primary TB.

![Chest X-ray](image)

**Fig. 2**: Chest x-ray, PA view, on admission showing right hilar adenopathy

**References**: Radiology, Opša bolnica "Dr. Josip Benčević" - 35000/HR
**Fig. 3**: Follow-up PA chest x-ray performed two months after the beginning of treatment showing persistent right hilar adenopathy

*References*: Radiology, Opša bolnica "Dr. Josip Benčević" - 35000/HR
Fig. 4: Follow-up PA chest x-ray performed four months after the beginning of treatment showing no improvement

References: Radiology, Opat a bolnica "Dr. Josip Beno" - 35000/HR
CASE 3:

A 15 year old boy complained of chest pain when moving and taking a breath in. He also had moderate fever (38.7-39°C) that lasted for a week and was coughing productively. He is a smoker (smoking 20 cigarettes a day). Initial chest X-ray on admission showed pulmonary consolidation with central cavitation and a fluid level formation in the right upper lung lobe (Fig.6). Laboratory tests showed mildly increased CRP 11 mg/ L (normal values # 5 mg/L). Tuberculin skin test showed induration diameter of 19 mm. Sputum smear and culture for acid- fast bacilli were positive. TB contacts were the boy’s parents who had active disease several years ago. Follow-up radiographs showed regression of abnormalities (Fig.7, Fig.8). He was diagnosed with postprimary tuberculosis (pulmonary phthisis).
**Fig. 6:** Chest x-ray, PA and lateral views, on admission showing a right upper lobe pulmonary consolidation with central cavitation and a fluid level formation

**References:** Radiology, Opat bolića "Dr. Josip Benčević" - 35000/HR
Fig. 7: Follow-up PA chest x-ray performed one month after the beginning of treatment showing an inhomogenous opacity with a cavitation in the right upper lung field.

References: Radiology, Opša bolnica "Dr. Josip Benčević" - 35000/HR
Fig. 8: Follow-up PA chest x-ray performed four months after the beginning of treatment showing residual thin walled cavity in the right upper lung field

References: Radiology, Opatbolnica " Dr. Josip Benević" - 35000/HR

CASE 4:

An 18 year old girl had a productive cough lasting 2 months. She lost 15 kg in the past year and complained of fatigue. Her father had TB disease one year before she was admitted for treatment. Sputum smear and culture were positive. Tuberculin skin test showed induration diameter of 9 mm. Chest X-ray showed bilateral inhomogeneous opacities and parenchyma destruction (Fig. 9). A chest CT scan showed patchy, ill-defined
consolidations with multiple nodules and cavitations predominantly in the upper lung lobes (Fig. 10). She was diagnosed with postprimary TB.

Fig. 9: Initial PA chest x-ray showing bilateral inhomogenous opacities and parenchyma destruction

References: Radiology, Dom zdravlja Županja - 32270 / HR
Fig. 10: Chest CT, pulmonary window, showing patchy, poorly defined consolidations with multiple nodules and cavitations in both upper lung lobes

References: Radiology, Opša bolnica "Dr. Josip Beneš" - 35000/HR

CASE 5:

A 16 year old boy, a smoker (smoking 10 cigarettes a day) was coughing for two months, had fever and felt very tired. He lost weight (5-6 kg in 5 months). On admission his chest X-ray showed confluent opacities in both upper lobes (Fig. 11). Laboratory values showed increased CRP 55 mg/L (normal values # 5mg/L). Tuberculin skin test showed induration diameter of 20 mm. Quantiferon test was positive. Sputum smear and culture were positive. His parents had TB disease several years ago. One month after the beginning of treatment chest radiograph showed incomplete regression of abnormalities (Fig. 12).

He was diagnosed with postprimary tuberculosis.
Fig. 11: Chest x-ray, PA and lateral views showing confluent opacities in both upper lung lobes

References: Radiology, Opat'ja bolnica " Dr. Josip Ben'ević" - 35000/HR
Fig. 12: Follow-up PA chest x-ray performed one month after the beginning of treatment showing incomplete regression of confluent opacities in both upper lung fields.

References: Radiology, Opća bolnica "Dr. Josip Benčević" - 35000/HR
Fig. 1: Normal PA chest x-ray

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Fig. 2: Chest x-ray, PA view, on admission showing right hilar adenopathy

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**Fig. 3:** Follow-up PA chest x-ray performed two months after the beginning of treatment showing persistent right hilar adenopathy

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Fig. 4: Follow-up PA chest x-ray performed four months after the beginning of treatment showing no improvement

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**Fig. 5:** Follow-up PA chest x-ray performed at the end of treatment showing regression of right hilar adenopathy

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Fig. 6: Chest x-ray, PA and lateral views, on admission showing a right upper lobe pulmonary consolidation with central cavitation and a fluid level formation

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Fig. 7: Follow-up PA chest x-ray performed one month after the beginning of treatment showing an inhomogenous opacity with a cavitation in the right upper lung field

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**Fig. 8:** Follow-up PA chest x-ray performed four months after the beginning of treatment showing residual thin walled cavity in the right upper lung field

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Fig. 9: Initial PA chest x-ray showing bilateral inhomogenous opacities and parenchyma destruction

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Fig. 10: Chest CT, pulmonary window, showing patchy, poorly defined consolidations with multiple nodules and cavitations in both upper lung lobes

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Fig. 11: Chest x-ray, PA and lateral views showing confluent opacities in both upper lung lobes

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Fig. 12: Follow-up PA chest x-ray performed one month after the beginning of treatment showing incomplete regression of confluent opacities in both upper lung fields

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Conclusion

Radiographic findings are just one step in making the diagnose of tuberculosis in children.

Radiographic lesion does not confirm the etiology of TB, as there are no pathognomonic radiological signs of tuberculosis.

A normal chest X-ray does not rule out the disease and on the other hand chest X-ray abnormalities can show the severity of the disease.

Diagnosis cannot rely on a single factor but on a constellation of symptoms, signs, and close contact with an infectious index patient, tuberculin skin test, blood test, bacteriological and radiographic findings.

During therapy, radiographic picture does not always improve, it can sometimes stay the same or even worsen at the beginning of treatment but by the end of treatment most of these radiographic pictures become normal.
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