Manifestations of pulmonary tuberculosis: radiographic findings

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Learning objectives

The aim of this study is to highlight the radiographic aspects found at patients with pulmonary tuberculosis.
**Background**

Tuberculosis is an infectious disease mainly caused by *Mycobacterium tuberculosis*, that is transmissible with high contagion rate and with high mortality.

Only 10-20 % of the infected patients make the disease, especially those with improper immune system, and approximately 80% is pulmonary tuberculosis while the rest of 20% is extrapulmonary (pleural, osteoarticular, genitourinary, gastrointestinal system).

The source of tuberculosis are the patient with the active disease, untreated and they spread it by sneezing, coughing or spitting. The spreaded Flugge droplets dehydrate and the become nucleosome that can stay on the floor, on clothes or different objects.

If the tuberculosis bacillus are inhaled into the alveoli the macrophages are the first responsible of the elimination, but the bacillus can remain in a dormant (inactive) phase. It can also spread through the lymphatic vessels to the lymphatic nodes.

After the first exposure the patient can develop Primary Tuberculosis and there are specific manifestations because they don't have any specific immunity. Secondary Tuberculosis (Postprimary Tuberculosis) develop in patients with previous exposure.

Characteristic in TB is the polymorphism of the lesions:

- exudative
- proliferative-epitheloid granuloma (nodule)
- caseous necrosis - destruction
- fibrosis-sequelae

In the alveoli, around the bacillus, the immune system cells form a granulomatous proliferative inflammation (epithelioid granuloma).

**Primary Tuberculosis**

PrimoInfection is the first phase when the bacillus enter into the alveoli and where a infiltrate develops.

The focus of infection it is known as Ghon Lesion (focus). Usually it develops in the most ventilated part of the lung (upper lobe, middle lobe or basal segments of the inferior lobe).
It can be so small that it cannot be found on a chest X-ray (CXR). Usually found on a CXR is a nodular omogenous opacity 0.2-2 cm.

If the bacillus spread through the lymphatic vessel to the lymphatic nodes on the radiography appears the lymphangitis and the lymphatic adenopathy (hilar or paratracheal most frequent).

The initial focus, the lymphangitis and the adenopathy form the Ranke or Ghon Complex. It is not necessary to appear all 3, sometimes only initial focus can be seen or only the adenopathy.

Primary Tuberculosis can heal without any signs visible on CXR or it can complicate.

The complication of the primary tuberculosis are local-regional and general.

The local-regional complication refers at the complication that can appear in the pulmonary parenchyma:

- perifocal congestion (epituberculosis)
- caseous pneumonia
- bronhopneumonia
- caverna of the initial focus or the adenopathy
- bronchial fistulisation or stenosis
- lobar atelectasis
- pleural efussion

The general complication refers at the dissemination through the lymphatic vessels, bronchial three and the hematogenous dissemination:

- caseous pneumonia
- caseous bronhopneumonia
- miliary tuberculosis

At the end stage of primoinfection there is an atypical local-regional limfatic-hematogenous dissemination in the upper part of the lung (apical):

- Simon nodules: round calcar micro-opacities, lung apical zone (primoinfection in childhood)
- Aschoff-Puhl nodules: incapsulated caseous foci, bigger than Simon nodules, retroclavicular
- Malmross-Hedwall "initial apical foci": nodular calcar opacities (primoinfection in young adult)

This type of lesions are very important because they can constitute the initial place of tuberculosis reactivation.
Postprimary Tuberculosis (Secondary Tuberculosis)

Postprimary Tuberculosis appears at patients with improper immune system that had previous contact with the bacillus. The immune response is different and the disease appears because of the reactivation of previous healed lesions that contain dormant bacillus or by a second exogenous reinfection.

Typically it is the early infiltrates (precocious infiltrate) that appears and it is a caseous alveolitis with a perifocal congestion ring. The place where it is found is where the primary tuberculosis was:

- Simon nodules
- Aschoff-Puhl nodules
- Malmross-Hedwall "initial apical foci"
- Ghon focus
- Adenopathy

The pulmonary common sight were the reactivation appears is in the apical-posterior segment of the upper lobes and the apical segments of the lower lobes (best ventilated segments).

There are several aspects of the early tuberculosis infiltrates:

- **early infiltrate of Assmann**: homogenous, low intensity, ill defined, round-oval form opacity, 2-3 cm diameter
- **round infiltrate of Fleischner**: like Assmann infiltrate but with sharp margins
- **nebulous infiltrate of Redeker**: it is a mixture of elements and on a patchy, diffuse, low intensity, inhomogeous area it can be seen a few nodules ill defined; compared with an astral nebula.

The difference from the primary tuberculosis is the fact that there is no adenopathy like in Ranke complex. Although, when the Postprimary tuberculosis it is caused by a reinfection, not by reactivation, the adenopathy can appear (with the condition that primary tuberculosis has previous totally healed).

Tuberculosis can spontaneously heal in a small amount of 10% without any radiographic findings or can heal by fibrosis leaving fibrotic scars (fibrosis lesions). On the chest x ray the most common found are pulmonary dense nodules well defined and with sharp margins, that eventually can calcify (granulomas).

The radiographic findings lesions are characterized by the productive, exudative, caseous and fibrous lesions that can coexist together in the same patient chest x ray.
The radiographic findings are:

- **ulcero-caseating type**: exudative lesions - patchy inomogenous/omogenous ill defined opacities of different sizes and aspects, that can cavitate, predominant in the 1/3 upper part of the lungs.
- **ulcero-fibrosis type**: it is found especially when the ulcero-caseous type starts healing with fibrotic lessions and scar nodules.
- **chronic fibro-caseous (fibro-cavitary) type**: exudative lessions, nodular opacities, fibrotic scars with the retraction of the surrounding structures. On this, it overlaps a mosaic formed of hiperluncency images (cavitation-caverna) sometimes with air-fluid level.
- **caseous - circumscribed type**: caseous focuses,primary focus or an early infiltrate could be encysted by a fibrous tissue, well defined from 1-3 cm up to 6 cm diameter (tuberculoma). Somethimes the middle of the tuberculoma can have inomogenous calcifications.

As a complication with haematogenous dissemination through pulmonary vesselsss is the **Miliary tuberculosis**. Radiologically it is described as multiple small round opacities, with reduced intensity, bilateral, simetrically distributed.

The **cavity** is the "trademark" of the active, highly contagious tuberculosis, due to the deposit of bacillus found in it. The radiographic aspect of the tuberculosis cavity depends on it's stage. It starts like a patchy mass that is filled with caseom (formed by caseating necrosis of the middle zone of the infiltrates) that stars draining ussualy in a bronchia. The cavity appears on chest x ray as a lucency/hiperluncency ill defined without a wall, after that a thin wall, well defined can be observed. An old cavity has a thick wall. Somethimes when the cavity is partially drained an air-fluid level is observed. The cavity and the brochia in which has drained,together form an aspect that looks like a "tenis rachet".

The **fibrothorax** is the consequence of a healed tuberculosis and refers at a fibrous sclerosis of the pleura, whith pleural thickening and calcification; the hemitorax of the affected side has an important loss of volume and the lung has an important functional loss among with fibrotic lung scar lessions.
Findings and procedure details

Below is a CXR of a 67 years male patient with healed Primary tuberculosis.

![CXR of a 67 years male patient with healed Primary tuberculosis.](image)

**Fig. 1**: Yellow: fibro-nodular lesions, TB sequelae Red: healed primary complex of Ranke

**References**: Radiology and Medical Imaging Clinic, SCJU Cluj-Napoca/RO

Below is a CXR of a 45 years of a heavy smoker male with hemoptysis. The radiography is suggestive for a post primary tuberculosis (fibro-cavitary type) with bronchogenic dissemination. **Fig. 2** on page 16
Fig. 2: Red: ill defined opacities with tendency of confluence with cavitary images
Yellow, Blue: different dimensions nodules suggestive for bronchogenic dissemination
Right small pleural effusion

References: Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO

Bellow is a CXR of a 28 years male recently diagnosed with type I diabetes. The radiography shows a postprimary tuberculosis (fibro-cavitary type). Fig. 3
**Fig. 3:** Red: Cavity with the drainage bronchia ("tennis racket" aspect) Blue: ill defined fibro-nodular lesions, consolidation

**References:** Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO

Bellow there are the PA and the LL CXR of a 43 years male with postprimary tuberculosis and the evolution within a week. **Fig. 4** on page 18 and **Fig. 5** on page 19
Fig. 4: Red: 2 cavities containing air-fluid level Green: ill defined fibro-nodular lesions Blue: consolidation near cavities

References: Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO

Fig. 5: Red: no air fluid level Blue: greater consolidation

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Bellow there are the PA and the LL CXR of a 65 years women and the evolution within 40 days. It is a postprimary tuberculosis with cavity, bronchogenic dissemination and hydropneumothorax. Fig. 6 on page 20 and Fig. 7

**Fig. 6**: Red: cavities Yellow: ill defined fibro-nodular lesions Blue: patchy ill defined areas Black: small pleural effusion

**References**: Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO
**Fig. 7:** Red: cavity  Blue: infiltrative lesions, consolidation  Black arrow: air-fluid level (hidropneumothorax)

**References:** Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO

Bellow there is a CXR of a 24 years female with post primary tuberculosis complicated with miliary dissemination. **Fig. 8**

**Fig. 8:** Red- cavity  Green- ill defined fibronodular lesion  Blue- ill defined nodules  Miliary pattern

**References:** Radiology and Medical Imaging Clinic,SCJU Cluj-Napoca/RO

Bellow there is a CXR of a 86 years male with left fibrothorax. **Fig. 9**
Fig. 9: Left thorax volume loss. Left shifted mediastinum. Left pleural thickening calcification

References: Radiology and Medical Imaging Clinic, SCJU Cluj-Napoca/RO

Below there is a CXR of a 65 years patient with healed tuberculosis presenting multiple tuberculosis sequelae. Fig. 10
Fig. 10: Yellow: well defined fibro-nodular lesions Red: round well defined opacity - Tuberculoma.

References: Radiology and Medical Imaging Clinic, SCJU Cluj-Napoca/RO

Bellow there is a PA and LL CXR of a 53 years patient with healed tuberculosis presenting multiple tuberculosis sequelae and pneumothorax. Fig. 11
Fig. 11: Red: fibro-nodular lesions well defined Blue arrow: partial right lateral pneumothorax White arrow: small right pleural effusion Yellow arrow: diaphragmatic symphysis Apical pleural thickening Small calcifiate nodular opacities.

References: Radiology department, "Leon Daniello" Pulmonology and Tuberculosis Care Clinics, Cluj-Napoca/RO
Images for this section:

![Image of chest x-ray with annotated lesions]

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Conclusion

The pulmonary tuberculosis diagnosis requires a multidisciplinary collaboration, and the positive diagnosis it is made on sputum culture that can last 3-4 up to 8 weeks.

Because of the multiple lesions that can be found on a CXR, the radiologist has a major role in the interpretation of the active or the inactive pulmonary tuberculosis in order to isolate the patient and prevent the contamination of others.
References

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