THE SPECTRUM OF TUBERCULOSIS PRESENTING AT A LONDON DISTRICT GENERAL HOSPITAL

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ABSTRACT

Tuberculosis has a high prevalence in people infected with human immunodeficiency virus, those who abuse drugs and alcohol, immigrants, and homeless persons. London accounts for almost 40% of all cases in the UK, with Ealing having the third highest incidence rate in the capital. Tuberculosis can affect almost any organ system, mimicking many diseases, with solely extrapulmonary involvement not uncommon. Recognition of the imaging features of its many guises can aid in its prompt diagnosis and treatment. This article reviews the pulmonary and extrapulmonary imaging features of tuberculosis, focusing on the lung, abdomen, spine and brain.

INTRODUCTION

The incidence of tuberculosis has remained stable over the past few years at 13.8 per 100000 in the UK in 2007, with London accounting for 39% of total cases and a regional rate of 43.2 per 100000. Seventy-two percent of cases were of non-UK born from South Asia and sub-Saharan Africa. The proportion of patients presenting exclusively with extrapulmonary disease is rising, approaching nearly 50% (1). Tuberculosis prevalence is especially high in people infected with human immunodeficiency virus (HIV), those who abuse drugs and alcohol, immigrants, and homeless persons (2). Ealing has a high population of immigrants and persons infected with HIV. In 2007, the incidence of tuberculosis within the Ealing Primary Care Trust catchment area was 80.2 per 100000 (3).

This article reviews the pulmonary and extrapulmonary imaging features of patients with tuberculosis, focusing on the lung, abdomen, spine and brain.

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PATHOGENESIS

Tuberculosis is acquired by inhalation of Mycobacterium tuberculosis. The initial infection (Ghon focus) may or may not be identified as a small scar or calcified nodule, located anywhere within the lungs. A Ghon focus and associated nodes are termed Ghon complex (4). Once the primary infection has been contained, the organisms lay dormant within tuberculomas. Post-primary tuberculosis is thought to be secondary to reactivation of infection as a result of a decrease in the host’s immunity, rather than re-infection. Propagation of the disease is secondary to haematogenous spread, local rupture of infected nodes or contiguous spread of disease from adjacent structures. Eventually, the chronic features predominate.

Miliary TB, which can occur in both the primary and reactivation phases of the disease, is secondary to haematogenous dissemination of mycobacteria. This results in multiple small tuberculomas within one or several organs, commonly lung, kidneys, liver, spleen and brain. Although manifestations of tuberculosis are usually limited to the chest, the disease often disseminates from its primary site and can affect any organ including the gastrointestinal tract, central nervous system and skeleton. Thus, tuberculosis can mimic a number of other disease entities.

PULMONARY

The imaging features of pulmonary tuberculosis differ according to the timing of the infection. Primary tuberculosis is characteristically a disease of childhood, although it is becoming increasingly prevalent in adults (5). It is characterized by mediastinal lymphadenopathy, typically unilateral involving the right hilar and paratracheal spaces, but in one third of cases it is bilateral. Occasionally there is no evidence of any pulmonary parenchymal abnormality, with lymphadenopathy the sole feature (6). When present, parenchymal disease manifests as subsegmental areas of atelectasis, acinar nodules and non-specific areas of air space opacification, which can involve an entire lobe (Fig. 1a). The right middle lobe, lower lobes and anterior segments of the upper lobes are preferentially affected. Reactive pleural effusions are not uncommon and are ipsilateral to the pulmonary disease. In 5% of cases, reduced host immunity results in clinically active disease occurring within a year of the primary infection, termed progressive primary tuberculosis (5-9).

Post-primary tuberculosis commonly occurs in elderly or immunocompromised individuals. Lymphadenopathy is not as bulky as in the primary infection and characteristically contains central necrosis manifesting as a low attenuation centre with an enhancing rim on CT. Parenchymal disease is typified by multiple acinar nodules (Fig. 1b) which may coalesce; and non-specific areas of airspace opacification (Fig. 1c). There is a predilection for the upper lobes and the superior segments of the lower lobes.
Segmental and subsegmental areas of atelectasis may be caused by endobronchial plugging or nodal compression of the bronchial tree (5-9).

Cavitation is an important feature, a sign that indicates active disease and results in endobronchial spread of mycobacteria secondary to caseous necrosis of bronchial walls. This is depicted on CT as multiple branching centrilobular nodules reflecting granulomatous plugging and occlusion of the distal bronchioles. This tree-in-bud pattern is very characteristic for tuberculosis (10). Cavities occur in areas of consolidation, are often multiple and of varied sizes, usually with a thickened irregular wall. If present, air-fluid levels may indicate superinfection. Other features indicative of activity include pleural effusions and miliary nodules (5-9).

Miliary TB is secondary to haematogenous dissemination and is characterized by numerous small 1-2 mm centrilobular nodules distributed throughout both lungs. Pleural effusions are exudative and may progress to form an empyema (Fig. 2a), the CT features of which are a thickened enhancing pleural rind surrounding a pleural collection (11). Pleural disease may also rarely show multifocal areas of nodularity, mimicking mesothelioma (12) (Fig. 2b). Extension of the infection through the chest wall into the subcutaneous tissues results in a subcutaneous abscess, the so-called empyema necessitans (13). Other complications include a bronchopleural fistula (14).

After prolonged antituberculous therapy or longstanding infection, the chronic features of the disease are evident. The disappearance of the tree-in-bud pattern and pleural effusion on HRCT and the presence of fibrotic change appear to be indications of the effectiveness of treatment (15). Healing is by fibrosis resulting in thickened pleura, walled off and often calcified pleural collections and parenchymal fibrosis. This usually affects the upper lobes, with interstitial thickening, traction bronchiectasis, linear atelectasis and scarring. Tuberculomas are often present, frequently calcified. Old cavities may be visible and become susceptible to aspergilloma colonization. An apical pleural cap is formed, predominantly composed of an increased layer of extrapleural fat filling the space caused by the underlying volume loss (16).

EXTRAPULMONARY

The incidence of extrapulmonary tuberculosis continues to increase, with 44% of all UK cases in 2007 demonstrating extrapulmonary disease (1). In their review of 57 cases with abdominal tuberculosis, Tan et al reported a 53% rate of isolated abdominal tuberculosis, the remainder with disseminated involvement (17). The prevalence of extrapulmonary tuberculosis is increased in patients with co-existent HIV secondary to their decreased immunity (6). In a study by Small et al (18), 38% of HIV patients with tuberculosis had pulmonary involvement only, 30% had extrapulmonary involvement only, and 32% had both pulmonary and extrapulmonary involvement.
LYMPHADENITIS

Peripheral lymphadenopathy continues to remain one of the commonest extrapulmonary manifestations of tuberculosis, particularly in children. Cervical nodes are most commonly involved often manifesting as bilateral painless cervical lymphadenitis, known as scrofula (5, 19). Initially there are multiple nodes showing non-specific reactive hyperplasia, later becoming fixed due to surrounding periadenitis, with subsequent progression to abscess and sinus tract formation (19) (Fig. 3). Diagnosis is by lymph node aspiration and culture or biopsy.

ABDOMINAL

Abdominal tuberculosis encompasses the gastrointestinal tract, peritoneum, nodes and solid organs. Intra abdominal spread of tuberculosis is commonly secondary to haematogenous spread or rupture of an infected mesenteric lymph node, with dissemination of mycobacteria throughout the peritoneum. However, it may also be secondary to ingestion (20). The intestinal tract is frequently involved, with the ileocaecal region most commonly affected. Lymphadenopathy is the commonest manifestation.

The CT features of tuberculous peritonitis (Fig. 4) are nonspecific and include free intra abdominal fluid, mesenteric infiltration, granulomatous deposits and lymph nodes (5, 6, 21, 22). Ascitic fluid can show high attenuation due to the increased protein content and often becomes loculated demonstrating an enhancing rim. Generalised mesenteric fatty stranding is a common feature; more focal omental deposits and omental thickening are also frequent findings. Multiple mesenteric and retroperitoneal lymph nodes are invariably present commonly with central necrosis, manifesting as low attenuation centre nodes on CT. The differential diagnosis includes disseminated peritoneal malignancy, nontuberculous peritonitis, and mesothelioma (5, 6) and can be confirmed with culture of ascitic fluid, omental biopsy or nodal biopsy.

The CT appearances of ileocaecal tuberculosis can mimic a colitis or malignancy, with focal or generalised enhancing bowel wall thickening and soft tissue infiltration into the mesentery (Fig. 5a). Adjacent mesenteric and regional nodes are usually enlarged (23). Involvement of terminal ileal loops can result in either mechanical small bowel obstruction or adhesive obstruction secondary to the mesenteric infiltration (Fig. 5b). Features which help to differentiate tuberculosis from Crohn’s disease include greater bowel wall thickening, a lack of vascularisation (comb sign) and absence of fibrofatty mesenteric proliferation. In caecal carcinoma, the ileocaecal valve is rarely involved; in lymphoma, aneurysmal bowel wall dilatation may be present (24, 25).

Renal tuberculosis is one of the commonest extrapulmonary sites. Approximately 75% of renal tuberculosis is unilateral, with renal calcification
being the most common CT finding. Tubercle bacilli can remain latent within cortical granulomas for many years following initial infection, before reactivation and spread into the collecting system. Imaging features include “moth-eaten” calyces with progression to papillary necrosis, renal parenchymal cavitation and dilated calyces (hydrocalicosis) secondary to infundibular strictures. End-stage disease results in tuberculous autonephrectomy, a shrunken diffusely calcified kidney (26-28).

Hepatic and splenic tuberculomas demonstrate non-specific low attenuation on CT (Fig. 6). They may be multiple and micronodular as in miliary tuberculosis or larger, less numerous tuberculomas in the rarer macronodular form (29). Pancreatic tuberculosis (Fig. 7) manifests as low attenuation pancreatic masses or peripancreatic nodes, which may mimic carcinoma or pancreatitis (30). Fine needle aspiration of the nodes can establish the diagnosis.

SPINAL

Haematogenous dissemination of tuberculosis to the spine, most commonly from the lungs or kidneys, is also a common presenting feature. Spinal tuberculosis (Potts disease) is the most frequent site for musculoskeletal tuberculosis (19, 31). There is often extensive vertebral destruction and large adjacent cold abscesses (Fig 8). The initial infection involves the vertebral body, with extension through the subchondral bone into the disc the most common sequelae. Infection can also spread as a prevertebral abscess (Fig. 9) beneath the anterior longitudinal ligament, for several levels causing multifocal tuberculous osteomyelitis, with normal intervening discs (19). Noncontiguous spinal tuberculosis has a reported incidence of 16-36% and a higher incidence of associated neurology (32, 33). A sagittal STIR sequence of the whole spine is useful to detect involved vertebrae distant from the initial site of infection. Occasionally, the vertebral body alone is affected, with sparing of the disc, an appearance that is indistinguishable from metastasis or lymphoma (19).

In tuberculous discitis, destruction and fragmentation of the disc and adjacent vertebral endplates occurs. Bony destruction with collapse of the anterior endplates can result in the characteristic gibbus deformity (Fig. 10). Epidural abscesses may cause significant compression of the spinal cord, thecal sac and cauda equina nerve roots. Extension into the surrounding paravertebral, erector spinae and psoas muscles occurs either haematogenously through the lumbar venous plexus or by direct extension along fascial planes. Large abscesses, frequently bilateral, containing pea-green thick pus extend for several centimetres, often all along the iliopsoas muscle to its insertion into the greater trochanter.

The MR appearances of spinal tuberculosis are of high signal intensity on T2 and STIR sequences and low signal on T1 weighted sequences. On T1
weighted gadolinium enhanced sequences the abscess walls enhance uniformly and brightly; central necrosis is depicted as low signal intensity (6, 19, 34). MRI can aid in evaluating the response to treatment by showing improvement or resolution of the abnormal bony signal and surrounding abscesses. Although the majority of patients will have a normal spine MR one year following treatment, signal abnormalities can persist despite clinical recovery (35).

MRI has been shown to be accurate for differentiating tuberculous spondylitis from pyogenic spondylitis (36). Jung et al showed a thin and smooth abscess wall, subligamentous spread to three or more vertebral levels, a well-defined paraspinal abnormal signal and multiple vertebral or entire body involvement to be more suggestive of tuberculous spondylitis than pyogenic spondylitis. Other discriminating findings are a pattern of bone destruction with relative disc preservation and heterogeneous enhancement for tuberculous spondylitis; a discitis pattern (disc destruction) with peridiscal bone destruction and homogeneous enhancement for pyogenic spondylitis (37).

CRANIAL

Neurological tuberculosis is invariably secondary to haematogenous spread. It manifests as tuberculous meningitis or an intraparenchymal tuberculoma. HIV infected patients account for over 50 per cent of cases of tuberculous meningitis in developed nations (38). Neurological involvement is also five times more frequent in HIV-positive patients.

The rupture of a subependymal tuberculoma (Rich focus) results in the release of mycobacteria into the subarachnoid space and a subsequent tuberculous meningitis (39). MRI is more sensitive in detecting meningeal involvement and intraparenchymal abnormalities compared to CT (40). Meningeal involvement on unenhanced CT is iso- or hyperattenuating relative to the basal cisterns. It demonstrates intense, smooth or nodular enhancement on contrast enhanced CT and MR studies, extending into the hemispheric fissures and over the cortical surfaces of the brain (6, 19). Characteristically, there is involvement of the basal cisterns, which may result in an obstructive hydrocephalus secondary to the inflammatory exudate and later meningeal thickening. Usually, however, the hydrocephalus is communicating and the obstruction is in the arachnoid granulations. Further complications include encephalitis, abscess formation and vasculitis of the small perforating arteries, leading to infarction (40, 41). Small infarcts are common in the basal ganglia and brainstem where they can lead to mental retardation, stroke and blindness.

Cerebral tuberculomas vary in diameter from a few millimetres to three to four centimetres. Solitary tuberculomas are more frequent than multiple lesions. Tuberculomas in patients under the age of 20 years are usually infratentorial, with supratentorial lesions predominating in adults (6, 19, 41). The imaging features of tuberculomas depend on their stage of maturation.
The solid granuloma usually appears as a homogeneous soft tissue mass on CT, with uniform enhancement, and a moderate amount of adjacent oedema. On MRI, granulomas are of isointense signal intensity to grey matter on T1 weighted images. On T2 weighted sequences their appearance depends on the presence of central necrosis; thus, solid granulomas show homogeneous iso-to-low signal intensity and non-caseating granulomas manifest as central hyperintensity and a low signal rim which demonstrates ring-enhancement (42, 43). Calcification may occur. The differential diagnosis includes cystercicosis, abscess, lymphoma, primary or secondary malignancy. Intramedullary spinal cord tuberculomas are rare and show similar signal characteristics as intracranial tuberculomas (44).

SUMMARY

Tuberculosis can affect almost any organ system and mimics many diseases. Extrapulmonary involvement is increasing. There is an increased prevalence in HIV infected individuals, in which it is the leading cause of mortality (45). Recognition of the imaging features of its many guises can aid in its prompt diagnosis and treatment.

REFERENCES

10. Collins J, Blankenbaker D, Stern EJ. CT patterns of bronchiolar disease:
Figure Legends

**Figure 1: Pulmonary manifestations.** (a) Tuberculous pneumonia. Extensive left upper lobar consolidation with several areas of necrosis, necrotic mediastinal nodes and adjacent pulmonary nodules.

(b) Endobronchial tuberculosis. Widespread acinar nodules of 2-5mm in size with a tree-in-bud pattern and more focal areas of segmental consolidation in the left upper lobe and superior segment of the lower lobe.
(c) Miliary tuberculosis. Multiple slightly ill-defined acinar nodules.

**Figure 2: Pleural manifestations.** (a) Bilateral empyemas showing a thickened enhancing pleural surface. Note small precardiac nodes.
(b) Nodular multifocal pleural thickening, with small loculated pleural collections.

**Figure 3. Lymphadenitis.** (a) Enlarged left cervical necrotic nodes with central low attenuation. There is periadenitis and an inflammatory nodal mass (scrofula). Note a calcified node (arrow).
(b) Ultrasound image of a collar-stud supraclavicular abscess.

Figure 4. Tuberculous peritonitis. (a) and (b) Wet type - high attenuation ascites with an enhancing rim, mesenteric nodes and interloop fluid. Omental infiltration is demonstrated beneath the left abdominal wall in (a).
Omental thickening below the anterior abdominal wall in (b) with ascites, mimicking ovarian malignancy.

(c) Dry type - omental thickening and multiple mesenteric nodes but no ascites.
Figure 5. Intestinal tuberculosis. (a) Terminal ileal tuberculosis. There are segmental areas of terminal ileal bowel wall thickening, with infiltration into the mesentery resulting in an adhesive small bowel obstruction. Note the right external iliac venous thrombosis secondary to nodal compression (arrow).

(b) Caecal tuberculosis mimicking carcinoma, with circumferential wall thickening, adjacent mesenteric infiltration and nodes (arrows).
Figure 6: Hepatic and splenic granulomas. Several small non-specific low attenuation lesions (arrows).

Figure 7: Pancreatic tuberculosis manifesting as necrotic low attenuation peripancreatic lymph nodes (black arrows). There is loculated ascites around the liver (white arrows).
Figure 8: Large multiloculated left psoas abscess with extension through the posterior abdominal wall into the erector spinae muscles. Note the extensive bony destruction within the vertebra.

Figure 9: Sagittal T2-weighted image of the thoracolumbar spine showing a gibbus deformity at T11/T12 secondary to a discitis and anterior endplate collapse. Note the prevertebral abscess, mild cord compression and multilevel involvement, with intervening normal discs and vertebrae.
Figure 10: Sagittal T2-weighted image of the cervical spine. Gross bony destruction of C6 and C7 with a large surrounding vertebral abscess extending along the prevertebral space. There is compression of the oesophagus anteriorly and the spinal cord posteriorly. Note the complete dislocation of the upper cervical spine from the lower spine.

Figure 11. Tuberculous discitis and adjacent abscesses. Axial gadolinium enhanced T1-weighted images. (a). Large multiloculated lumbar pre and paravertebral abscess. Note the smooth and intense enhancement of the abscess wall, the central non-enhancing necrosis (*) and the epidural component compressing the thecal sac (white arrows).
(b) Mid thoracic discitis with bony destruction, epidural extension and pre and paravertebral abscesses tracking along the left extrapleural space, through the chest wall into the erector spinae musculature.

![Figure 12. Tuberculoma. a) CT appearances. There is a slightly thick walled ring enhancing mass within the left occipital deep white matter with moderate surrounding oedema.](image-url)
(b) MRI appearances. Axial gadolinium enhanced T1-weighted image showing multiple ring enhancing lesions.