
COMPUTED TOMOGRAPHY SCAN MANIFESTATIONS OF ABDOMINAL TUBERCULOSIS IN CHILDREN

JUAN MIGUEL B. ZAMORA, MD, BERNARD F. LAYA, MD, DO, AND MARVIN W. BAUTISTA, MD

ABSTRACT

Purpose. Tuberculosis (TB) is a chronic disease that may cause significant morbidity and death. Overall, one third of the world's population is infected with tuberculosis, but not all infected individuals have clinical disease. Abdominal tuberculosis (ATB) is a major health problem in many underdeveloped countries and any abdominal organ can be affected. Clinical symptoms experienced by patients with ATB are diverse and non-specific. Patients suspected to have abdominal involvement of TB are given anti-TB drugs without establishing a histological diagnosis. Various imaging studies have played an important role in the diagnosis and follow up. This study aims to describe the spectrum of computed tomography (CT) scan findings in pediatric patients with ATB and correlate these findings with the patient's clinical signs and symptoms.

Materials and Methods. Twenty seven patients aged 5 months to 17 years old diagnosed with ATB were included in this study. In the absence of biopsy or histological evidence, ATB was established given a combination of the following criteria: positive M. tuberculosis in sputum of patients with abdominal symptoms, positive tuberculin skin test, strong clinical signs and symptoms, diagnosed TB in other parts of the body, response to anti-TB medication, and radiological signs suggestive of TB. The CT scan studies were independently and retrospectively reviewed by two pediatric radiologists. These findings were itemized, tabulated, and analyzed. Medical chart review was also conducted and the clinical signs and symptoms of the patients were also itemized and analyzed.

Results. The clinical presentation of ATB in the pediatric population is multiple. Most common symptoms include increasing abdominal girth, abdominal pain, cough and fever. Common abdominal CT scan findings include bowel wall thickening, mesenteric lymphadenopathy, hepatic nodules and calcifications, and ascites.

Conclusion. Clinical signs and symptoms are diverse, nonspecific and inconclusive for ATB. Gold standard for diagnosis is biopsy and establishing histological evidence. CT scan has the capability of demonstrating the spectrum of abnormalities associated with ATB in one study. Given a strong clinical suspicion and laboratory tests, despite the absence of biopsy, CT scan plays an important role in establishing the diagnosis and characterizing the extent of the disease.

Author's Affiliations:

Tuberculosis (TB) is a chronic disease that may cause death but is curable and preventable. Overall, one third of the world population is infected with TB, but not all infected individuals have clinical disease. Each year, about 9 million people develop TB, of whom about 2 million die. Of the 9 million annual TB cases, about 1 million (11%) occur in children (under 15 years of age). Of these childhood cases, 75% occur annually in 22 high-burden countries (including the Philippines) that together account for 80% of the world's estimated incident cases. TB is the 6th leading cause of illness and the 6th leading cause of deaths among the Filipinos.

A child usually gets TB infection from being exposed to a sputum-positive adult. This exposure leads to the development of a primary parenchymal lesion (Ghon focus) in the lung with spread to the regional lymph nodes. Young children below ten years of age are at risk of becoming infected with TB bacilli. They are also at high risk of developing active tuberculosis because the immune system of young children is less developed. The chance of developing TB disease is greatest shortly after infection¹.

TB can affect virtually any organ in the body and can be devastating if left untreated². ATB is a major health problem in many underdeveloped countries. Routes of infection include; 1. Spread by means of the ingestion of infected sputum, in patients with active pulmonary TB, especially in patients with pulmonary cavitation and positive sputum smears; 2. Spread through a hematogenous route from tuberculous focus in the lung to submucosal lymph nodes; and 3. Local spread from surrounding organs involved by primary tuberculous infection^{3,4}. Diagnosis of ATB is difficult because symptoms are vague, signs non-specific and clinical tests are often non-conclusive. Clinical features include abdominal pain, weight loss, anemia, fever and night sweats but patients may also present with symptoms of obstruction or a palpable mass. The most common finding in ATB is mesenteric adenopathy, followed by solid organ involvement where multiple granulomas can be seen especially in the liver and spleen^{2,5}. The genitourinary tract can also be affected by TB and patients typically present with symptoms such as frequent voiding, dysuria, hematuria, and either back, flank, or abdominal pain⁶. Biopsy and establishing histological evidence remains the gold standard diagnostic test⁷.

Recognition and understanding of the radiologic findings of extrapulmonary TB can help in diagnosis³. Medical imaging has long been utilized to aid in diag-

nosis and evaluation of the extent of disease. Ultrasound and conventional x-ray films, though primary screening imaging studies, are limited in their ability to evaluate all the intra and retroabdominal organs. CT with its multiplanar capability allows detailed evaluation of both solid and hollow organs in the various compartments of the abdomen. Intravenous administration of contrast also aids in better visualization of the abdominal vasculature, which aids in detection of abnormal lesions. There have been numerous publications on the CT imaging findings of abdominal tuberculosis in adult patients, but there have been paucity of literature in pediatric population. This study will present the spectrum of CT scan findings of pediatric patients diagnosed with ATB. The patient's clinical signs and symptoms will also be presented.

MATERIALS AND METHODS

This is a retrospective study of 27 pediatric patients aged 5 months to 17 years old (16 males and 11 females) diagnosed with abdominal tuberculosis (ATB). Diagnosis of ATB was made using a combination of the following criteria:

1. Culture or identification of *M. tuberculosis* in the sputum of a patient with abdominal signs and symptoms suggestive of TB
2. Positive TB skin test
3. Documented TB infection elsewhere in the body (lymphadenopathy, pulmonary TB, skeletal TB, etc.)
4. Response to appropriate medical therapy (anti-TB medication)
5. Radiologic findings suggestive of TB

Patients who have malignancy, other co-morbidities such as congenital malformations, or infections other than tuberculosis were not included in the study.

All the CT scans were performed in a single institution utilizing a multidetector (16, 64, or 256) Philips CT scanner. CT scans were performed prior to and following intravenous administration of non-ionic, iodinated contrast media. The amount of contrast given depends on the patient's weight (2 cc's per kilogram). Weight based CT scan parameters were utilized by the institution to reduce the radiation dose. Two pediatric radiologists retrospectively and independently reviewed the CT scans of all the 27 patients. The CT scan findings of all the patients were itemized, tabulated, and analyzed. Review of the patient's medical charts was also done. All of the patient's signs and symptoms were noted which were itemized and tabulated.

RESULTS

The most common CT findings and clinical signs and symptoms are tabulated as follows:

Table 1. CT Scan findings

LIVER	
• Calcifications	13
• Micronodules	6
• Macronodules	7
• Hepatomegaly	8
• Fatty infiltration	2
• Ductal dilatation	2
• Necrosis	1
SPLEEN	
• Calcifications	1
• Micronodules	1
• Macronodules	1
• Density change	2
• Splenomegaly	4
LYMPHADENOPATHY	
• Mesenteric	18
• Retroperitoneal	6
• Pelvic	2
• Paraaortic	9
• Gastrohepatic	6
• Calcifications	4
• Inguinal	4
• Necrosis	4
• Peripancreatic	1
• Perisplenic	2
• Porta hepatis	1
• Pararectal	2
RENAL	
• Small for size	1
• Hydronephrosis	1
• Calcifications	2
• Hypodense nodule	3
PANCREAS	
• Decrease attenuation	2
• Calcifications	1
• Enlarged	2
GASTROINTESTINAL	
• Thickening	16
• Stenosis	3
• Calcifications	1
PERITONEUM	
• Wet	8
• Dry	2
• Fibrotic	4
URINARY BLADDER	
• Thickening	2
• Hypodensity	1
ADRENALS	
• Nodules	1
MISC	
• Inflamed appendix	1
URETERS	
• Thickening	1

Table 2. Clinical Symptomatology

FINDINGS	N
Anemia	5
Fever	13
Abdominal pain	10
Anorexia	8
Vomiting	5
Cough	14
Weakness	7
Abdominal swelling	10
Malnutrition	4
Weight loss	6
Cervical lymphadenopathy	5
Hepato-splenomegaly	2
Seizures	1
Back pain	1
Difficulty of breathing	1
Jaundice	1
Diarrhea	2
Oliguria	1
Parasitism	1

Table 3. Most common CT findings and most common clinical presentation

CT FINDINGS		CLINICAL FINDINGS	
Hepatic calcifications	41%	Cough	52%
Lymphadenopathy	56%	Fever	48%
GI thickening	56%	Abdominal pain	37%
Ascites	30%	Abdominal swelling	37%

When all the CT scans were reviewed, it was noted that most, if not all of the intraabdominal organs were affected by abdominal TB. Majority of findings involved the gastrointestinal tract, lymph nodes, liver, and the peritoneum. Gastrointestinal involvement in the form of enteric wall thickening is a common feature, and 33% had ileocecal involvement. Mesenteric lymphadenopathy is also a predominant finding with 20% demonstrating necrosis, and 13% showing calcification. Liver involvement is also common among patients with abdominal TB disease and it comes in the form of liver calcifications, liver nodules (macronodules > 1 cm, and micronodules < 1 cm), hepatomegaly, fatty infiltration, and even intrahepatic biliary ductal dilatation. Peritoneal involvement in the form of ascites is also a frequent finding, noted in 30% of the patients.

Urinary organ abnormalities were seen in only 15% of our patient population. Renal abnormalities noted include, hydronephrosis, renal nodules, renal parenchymal calcification, and scarred kidney. Urinary bladder abnormality was noted in two (2) patients, and ureteral wall thickening was seen in one patient.

Cough and fever were the two most predominant clinical complaints noted in our patient population. Abdominal pain and abdominal swelling (increase in abdominal girth) were also frequent clinical signs. Anorexia, vomiting, and diarrhea were also encountered along with hepa-

tosplenomegaly and jaundice. Generalized clinical signs including anemia, weakness, malnutrition, and weight loss were also noted.

DISCUSSION

Extrapulmonary TB is not uncommon and can affect virtually any organ in the body. Abdominal involvement in TB remains to be a major health concern especially in many underdeveloped countries including the Philippines where TB is endemic. It has been cited that ATB can be seen in one third of all TB cases⁷, although children are less commonly affected by ATB compared to adults⁸. It complicates pulmonary TB in 6-38% of cases and continues to be a major cause of morbidity and mortality in developing countries⁵. Mycobacterial infection reaches the abdomen via the following routes: 1. Spread by means of the ingestion of infected sputum, in patients with active pulmonary TB, especially in patients with pulmonary cavitation and positive sputum smears; 2. Spread through a hematogenous route from tuberculous focus in the lung to submucosal lymph nodes; and 3. Local spread from surrounding organs involved by primary tuberculous infection^{3,4}.

Rapid diagnosis is needed in this disease because ATB is associated with high morbidity and up to 50% mortality if not treated⁷. Diagnosis of ATB is challenging because the signs and symptoms are vague and non-specific, and often times, clinical tests and laboratory findings are inconclusive. Diagnosis based on clinical findings alone could be erroneous because it can have similar clinical presentation with appendicitis, Crohn's disease, lymphoma, ascites due to other pathology, pyogenic infection, acute peritonitis, intussusceptions, anemia, hepatitis, and even pancreatitis^{9,10}. Definitive diagnosis is made by biopsy with positive microbiological staining and/or culture, or by identification of caseating granulomata histologically.

In our patient population biopsy was not performed but the diagnosis of ATB was achieved because of the following: All Patients were previously diagnosed to have TB infection/disease in other parts of the body including cervical lymphadenopathy, pulmonary TB, and skeletal TB, and were also complaining of abdominal symptoms. All patients tested positive for TB skin test (Mantoux test) with an induration greater than 10 mm. There were CT scan findings suggestive for ATB and patients responded well to anti-TB regimen. In some patients, a positive culture or identification of *M. tuberculosis* in the sputum was obtained. The evidence is even made stronger given the fact that the prevalence of TB is high in the area where the study was conducted.

The clinical presentation of ATB is variable and non-specific, but commonly includes fever, abdominal distension, abdominal pain or tenderness, and abdominal mass. Other symptoms include nausea, vomiting, weight loss, anorexia, diarrhea, and night sweats. Patients with gastrointestinal TB may present with symptoms similar to inflammatory disease but some patients may not present until there is intestinal obstruction or perforation¹¹. In our patient population, cough was a common finding (52%) because a lot of the patients also have concomitant pulmonary TB. fever is also a predominant finding and was noted in nearly half of the patients (48%). Abdominal pain and distention was a common manifestation, noted in 37% of the patients. Gastrointestinal symptoms including anorexia, vomiting, and diarrhea were noted along with clinical clues pertaining to liver involvement such as hepatomegaly and jaundice. Other systemic signs including anemia, weakness, malnutrition, and weight loss were also encountered.

Radiologic imaging maintains an important role in the diagnosis of both pulmonary and extrapulmonary TB. Imaging plays a role in arriving at the diagnosis, evaluation of the extent of disease, and also helpful in follow up during and after treatment. An abdominal x-ray is oftentimes the primary imaging tool and may demonstrate solid organ enlargement, abnormal calcification, intestinal obstruction, and other late and more obvious signs of abdominal involvement but it remains limited especially in the evaluation of lymphadenopathy, mucosal thickening, and other subtle signs of disease. Ultrasound can be helpful especially in the assessment of ascites, solid organ abnormality, and present of mass but it is oftentimes limited in the evaluation of the gastrointestinal tract which is a common site for abdominal TB.

CT is considered by many to be superior to ultrasound because of its ability to identify all the features in a single study especially lymphadenopathy, ascites, solid organ involvement, and bowel wall thickening. It is cur-

rently considered the imaging of choice for ATB⁴. CT provides high resolution cross-sectional images of the abdominal organs, mesentery, and associated vasculature. Current multidetector CT scanners are able to generate high quality volumetric data sets required for multiplanar and three-dimensional (3D) image reconstructions. Administration of intravenous contrast improves delineation of the structures, help assess tissue vascularity, and allow CT angiography, a 3D reconstruction of the vasculature. CT has potential risks due to radiation exposure and thus, a clinical indication must be present for a patient to undergo the procedure. Imaging protocols should be adjusted to patient's age and weight while at the same time observing radiation dose reduction measures. Moreover, although current CT scanners are much faster, sedation may still be needed which is not without possible complications. Intravenous administration of contrast also poses risk for adverse reactions.

Typical CT scans findings of ATB include mesenteric lymphadenopathy, bowel wall thickening, peritoneal involvement and solid organ involvement including the liver, spleen, and kidneys were also noted in this study. Recognition and understanding of the radiologic findings of ATB can help in diagnosis.

Lymphadenopathy

Lymphadenopathy is the most common manifestation of ATB². On CT, the nodes are typically enlarged with diffuse low attenuation and enhancing rim due to inflammatory capsular and perinodal reaction which surrounds an area of central caseation or liquefaction necrosis^{10, 12, 13}. The lymph nodes maybe singular or in clusters, appearing as a conglomerate mass. This was also a predominant CT finding in our patient population (56%), and was noted in the mesenteric, omental, paraaortic, and peripancreatic regions (Figure 1). Mesenteric lymph nodes may be enlarged, matted and may caseate. Characteristic granulomas may be seen especially common in patients who

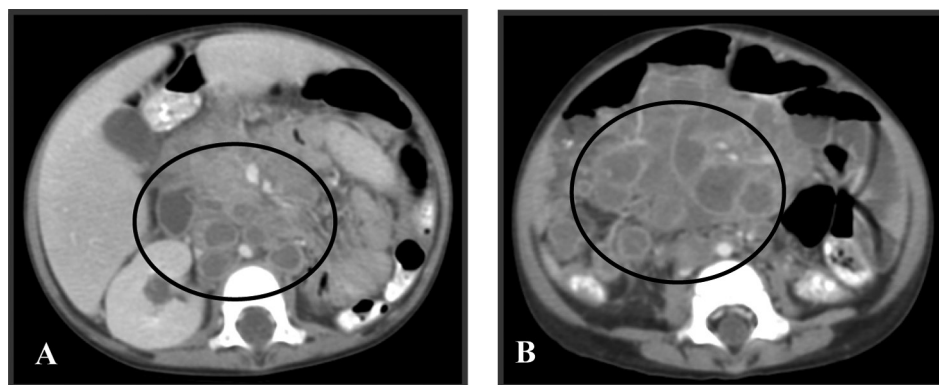


Figure 1. Lymphadenopathy. CT scan images from two different patients demonstrating lymphadenopathy (encircled) in the retroperitoneal area (Fig. 3 A) and mesentery (Fig. 3 B). The lymph nodes are clustered and enlarged with central necrosis and contrast enhancing rim.

have taken anti-TB therapy for some time. Differential diagnosis of TB adenopathy includes lymphoma, inflammatory bowel disease, AIDS and other infections, other metastatic abdominal malignancies, lymphoproliferative disorders, or reactive nodes^{13,14}.

Gastrointestinal findings

Gastric involvement of tuberculosis is rare and colonic involvement is often segmental, usually affecting the ascending and transverse colon. The most com-

mon area of involvement is the ileocecal region due to the abundance of lymphoid tissue^{3, 15}. The most common imaging finding on CT shows circumferential wall thickening of the cecum and terminal ileum associated with adjacent mesenteric lymphadenopathy (Figure 2). These findings were also frequently noted in our patient population. Bowel dilation, obstruction, or perforation may occur from severe enteritis, stricture, or adjacent adenopathy, inflammatory mass, or abscess¹⁵.

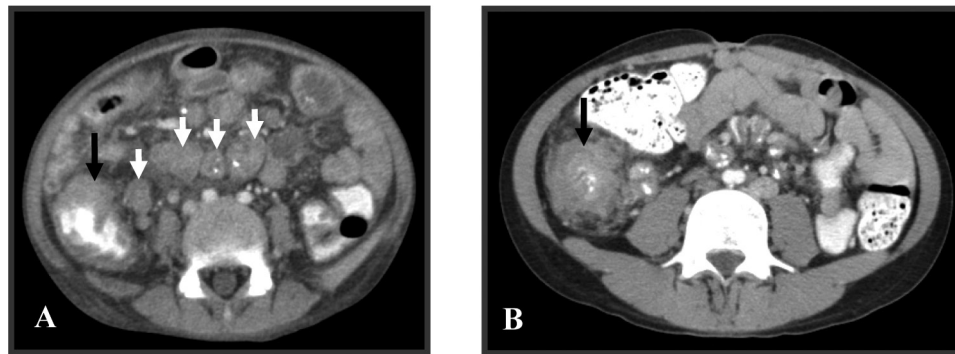


Figure 2. Ileocecal abnormality. Fig 2 A shows a diffuse and irregular thickening of the intestinal tract predominantly around the ileocecal junction (black arrow). Enlarged lymph nodes (short white arrows) are also detected adjacent to the involved segment and mesentery. Fig. 2 A demonstrates a circumferential and asymmetric thickening of the cecal region (black arrow) with haziness of the surrounding mesentery is seen. Few subcentimeter non necrotic lymph nodes are also observed in the mesentery.

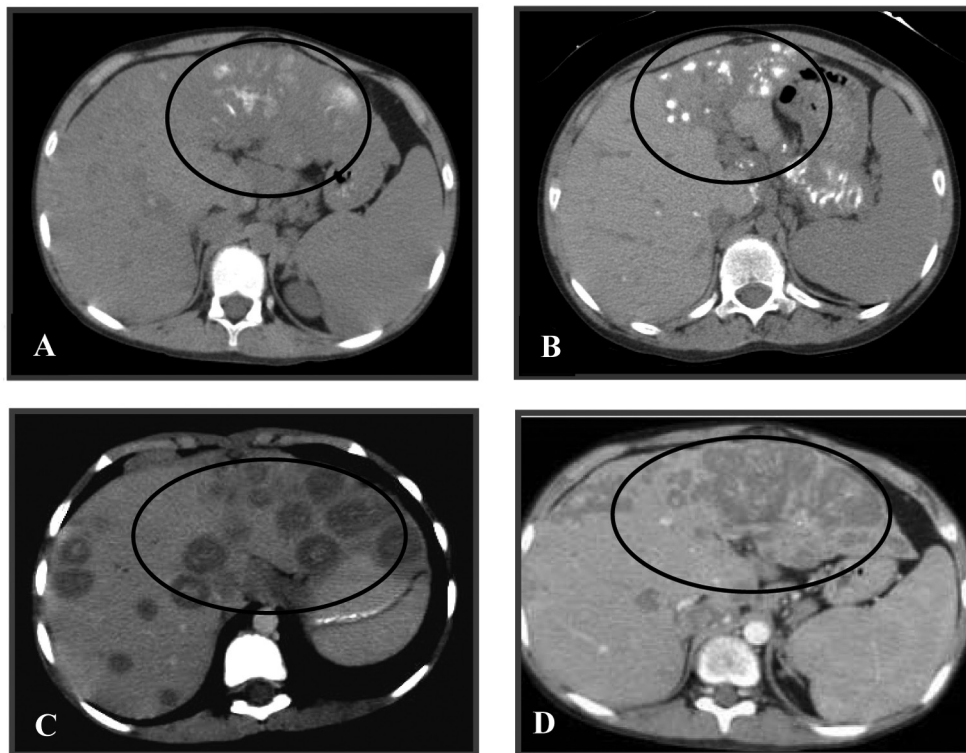


Figure 3. Liver involvement. Spectrum of abnormal liver findings include hepatomegaly with amorphous calcifications (Fig. 3 A), small rounded calcifications (Fig. 3 B), round hypodense nodule (Fig. 3 C), and large irregular nodules with mass-like configuration (Fig. 3 D).

Solid organ involvement

The liver and spleen is involved secondary to haematogenous dissemination and even a small number of tubercle bacilli can gain access to the circulation through the lymphatics and disseminate to sites such as the liver and spleen which have rich vascular supply and good oxygenation¹⁶. In our study, the liver was the most commonly affected solid organ manifesting as nodules, enlargement, or with abnormal calcifications. Micronodular hepatic lesions (< 1 cm) manifest as multiple tiny, low-attenuation foci and is seen in 6 of 27 patients. The macronodular form (> 1 cm) of hepatic lesions manifest as diffuse hepatic enlargement with multiple low-attenuation lesions or a single tumor-like mass. Hepatic macronodules were detected in 7 of 27 patients in the study (Figure 3). Advanced lesions demonstrate calcifications², however, miliary tuberculosis is usually not detected at imaging, and hepatomegaly may be the only radiologic abnormality¹⁷. Other solid abdominal organs noted to be involved in our patient population includes the spleen in nine patients, and the pancreas in 5 patients (Figure 4).

Peritoneum

Peritoneal TB occurs in three forms: wet type with ascites, dry type with adhesions, and fibrotic type with omental thickening and loculated ascites (Figure 5). TB peritonitis has been reported to occur in 5-13% of children with abdominal TB. Peritoneal involvement in TB is usually associated with widespread abdominal disease involving lymph nodes or bowel but it may occur without gastrointestinal involvement or other intraabdominal manifestation. Peritoneal involvement may be preceded by infection in the pleural space resulting in spread along the pleural reflections and through the diaphragm via lymphatics¹¹. The ascites associated with tuberculous peritonitis is exudative and contains elevated protein and white blood cells which frequently results in increased attenuation on CT. Ascites of low density of water density has also been reported and may represent an earlier transudative phase of the disease^{7,9}. Thickened mesentery, peritoneal enhancement, and a nodular appearance of the peritoneum, mesentery, or omentum has also been described¹¹.

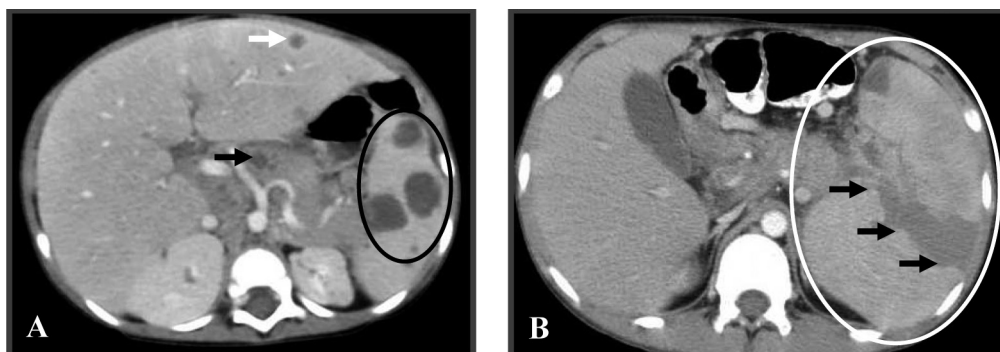


Figure 4. Splenic involvement. Fig. 4 A is an axial CT image demonstrating liver abscesses (encircled). Incidentally, there is also a small nodule in the liver (white arrow) and in the pancreas (black arrow). Fig. 4 B is an axial CT scan image demonstrating an enlarged spleen (encircled) with a large area of infarction (arrows).

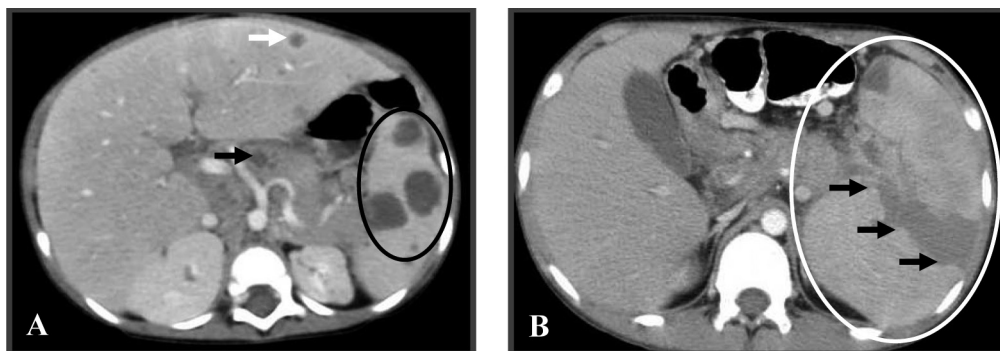


Figure 5. Ascites. Fig. 5 A high attenuating fluid surrounds the intestinal loops compatible with dry type of ascites (encircled). Fig. 5 B shows massive amount of low attenuating fluid compatible with wet ascites (asterisks) with centralization of the intestinal segments (black arrows).

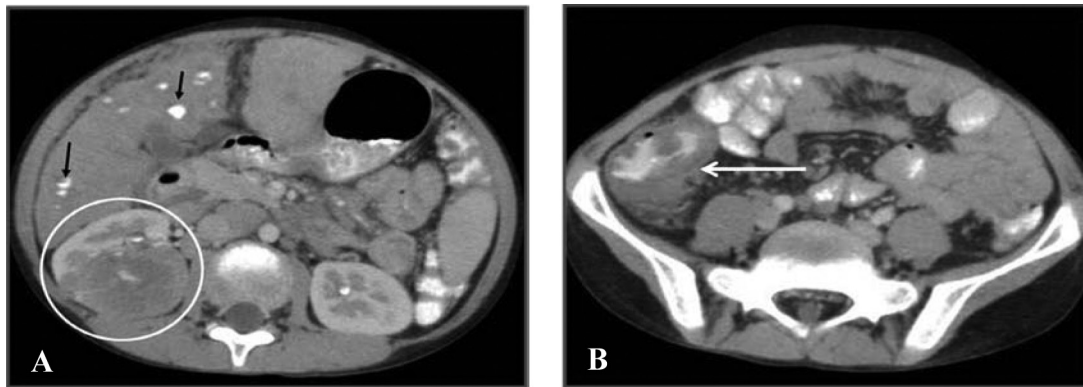


Figure 6. Renal involvement in a 9 year old boy diagnosed with abdominal TB. Fig. 5 A demonstrates abnormal appearance at the posterior aspect of the right kidney with a large nodule of mass-like configuration (encircled). Note that the liver demonstrates numerous small calcifications (small black arrows). Fig. 5 B is an axial CT scan image of the lower abdomen from the same patient demonstrating a significantly thickened wall of the cecum (arrow).

Urinary involvement

The genitourinary system is one of the most common sites of involvement by extrapulmonary tuberculosis, accounting for 15%–20% of infections outside the lungs. Renal TB is mainly a disease of adults but it is uncommon in children, with a late clinical presentation of occasional dysuria or haematuria. The radiological changes that occur are poor definition of a minor calyx followed by local cavitation into the adjacent renal parenchyma leading to renal destruction and nonfunction^{8,18}. In our series, renal involvement was noted in 7 of 27 patients in the form of calyceal irregularity, renal parenchymal nodules, and calcification (Figure 6). Patterns of renal calcification noted in TB maybe amorphous, granular, curvilinear, or lobar. The ureter and urinary bladder can also be involved in the form of wall thickening and adjacent inflammatory changes. The most common finding in tuberculous cystitis is reduced bladder capacity which manifests as a shrunken bladder with wall thickening. Three patients were noted to have urinary bladder abnormality in our series and one patient demonstrated ureteral abnormality.

CONCLUSION

ATB is a serious disease and carries a high degree of morbidity and mortality if not recognized promptly and treated appropriately. Diagnosis is challenging because clinical manifestations are vague, nonspecific and inconclusive. Definitive diagnosis is thru biopsy and histological evaluation but is sometimes not performed for several reasons. In patients with positive laboratory tests and with high degree of clinical suspicion, CT scan of the abdomen could be helpful in establishing diagnosis. This is even

more important in areas of high TB prevalence. CT scan can provide an overview of the entire abdomen, demonstrating both solid and hollow organs, including the vasculature, peritoneum and the mesentery. More commonly noted abnormalities associated with ATB include terminal ileal involvement, lymphadenopathy, hepatic calcifications and ascites as also noted in our series. These findings though consistent with TB are still non-specific and can be seen in other disease entities. The radiologist must maintain a high degree of suspicion for the presence of ATB particularly in immunosuppressed children and in endemic areas.

REFERENCES

- Engin G, Acunas B, Acunas G, *et al.* Imaging of Extrapulmonary Tuberculosis. *Radiographics*. 20: 471-488
- Harisinghani MG, McLoud TC, Shepard JO, *et al.* Tuberculosis from Head to Foot. *Radiographics*. 20: 449-470
- Balthazar E, Gordon R, Hulnick D. Ileocecal tuberculosis: CT and radiologic evaluation. *American Journal of Roentgenology*. 154: 499-503
- Sun S, Gupta S, Suri R. Computed tomography in abdominal tuberculosis. *Br J Radiol* 1999; 72: 92-98
- Andronikou S, Welman CJ, Kader E. The CT features of abdominal tuberculosis in children. *Pediatr Radiol* 2002; 32: 75-81
- Gibson M, Puckett M, Shelly M. Renal Tuberculosis. *Radiographics*. 24: 251-256
- Smzmigielski W, Venkatraman B, Ejeckam GC, *et al.* Abdominal tuberculosis in Qatar: a clinic-radiological study. *Int J Tuberc Lung Dis* 1998; 2: 563-568
- Andronikou S, Wieselthaler N. Modern imaging of tuberculosis in children: thoracic, central nervous system and abdominal tuberculosis. *Pediatr Radiol* 2004; 34: 861-875
- Al-Fadel Saleh M, Al-Quorain A, Larbi E, *et al.* Tuberculous peritonitis in children: report of two cases and literature review. *J Pediatr Gastroenterol Nutr* 1997; 24:222-224

10. Pombo F, Rodriguez E, Mato J, *et al.* Patterns of contrast enhancement of tuberculous lymph nodes demonstrated by computed tomography. *Clin Radiol* 1992; 46: 13-17
11. Ablin DS, Jain KA, Azouz EM. Abdominal TB in Children. *Pediatr Radiol* 1994; 24: 473-477
12. Denath FM. Abdominal tuberculosis in children: CT findings. *Gastrointest Radiol* 1990; 15: 303-306
13. Epstein BM, Mann JH. CT of abdominal tuberculosis. *AJR* 1982; 139: 861-866
14. Hulnick DH, Megibow AJ, Naidich DP, *et al.* Abdominal Tuberculosis: CT evaluation. *Radiology*; 157: 199-204
15. Bhansali SK. Abdominal tuberculosis. Experience with 300 cases. *Am J Gastroenterol* 1977; 67: 324-337
16. Sharma SK, Mohan A. Extrapulmonary Tuberculosis. *Indian Journal of Medical Research*; 120: 316-353
17. Mortelet K, Segatto E, Ross P. The infected liver: Radiologic-pathologic correlation. *Radiographics*; 24: 937-955
18. Cremin BJ. Radiological imaging of urogenital tuberculosis in children with emphasis on ultrasound. *Pediatr Radiol* 1987; 17: 34-38

Copyright 2011 © by St. Luke's Medical Center