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The CT features of abdominal tuberculosis in children

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Abstract *Background:* The last decade has seen a resurgence in the incidence and clinical presentation of tuberculosis (TB). Little data exist in the paediatric age group regarding abdominal tuberculosis (ATB) and limited reports of its CT features have been published. *Purpose:* To elucidate the CT features of ATB in children. *Materials and methods:* The medical records of 22 patients with ATB were reviewed. Data were extracted regarding the methods of diagnosis and HIV status. The plain chest films were examined and the CT scans were assessed for adenopathy, solid organ involvement, ascites, bowel wall and omental thickening and inflammatory masses. *Results:* Ten patients had biopsy-proven ATB, 11 had extra-abdominal TB with clinical suspicion of ATB and 1 had a positive trial of therapy. Five patients were tested for HIV and one tested positive. Thirteen patients had abnormal chest radiographs. The commonest CT finding was lymphadenopathy ($n=17$), followed by solid organ involvement ($n=12$), ascites ($n=5$), bowel wall thickening ($n=5$), inflammatory masses ($n=2$) and omental thickening ($n=1$). *Conclusions:* The clinical features of ATB are protean. This usually results in a delay in diagnosis and impacts negatively on patient morbidity and mortality. On CT, the constellation of findings is highly suggestive of the diagnosis of ATB and, used in conjunction with clinical and laboratory data, should narrow the differential considerably. Unique findings include histologically proven active TB in calcified lymph nodes and a pancreatic TB granuloma.

Keywords Abdomen · Tuberculosis · Lymphadenopathy · CT · Calcification · Granuloma · Pancreas

Introduction

In 1882, when Robert Koch isolated *Mycobacterium tuberculosis*, he could not have envisaged the devastating effect that this bacillus, which has infected man since the beginning of recorded history, was to have on modern society.

The last decade has seen a resurgence in the incidence of tuberculosis (TB) due to malnutrition, increased number of immigrants with untreated TB, IV drug abuse, immunosuppression, emergence of drug-resistant mycobacteria and, most notably, the burgeoning AIDS epidemic. There has been a concurrent change in the clinical presentation of TB. Extrapulmonary forms have become more manifest, particularly in the HIV-positive population, where up to 50% of TB is extrapulmonary. In the HIV-negative population, this figure ranges from 10% to 15% [1, 2, 3]. Abdominal tuberculosis (ATB), in particular, complicates pulmonary TB (PTB) in 6–38% of cases and continues to be a major cause of morbidity and mortality in developing countries. Its presenting features are protean and present a major diagnostic challenge, despite advances in imaging techniques [4].

ATB is a well described entity in adults, but little data exist for the paediatric age group where the clinical presentation and pathological features may differ in adults [5]. Abdominal involvement is uncommon in children, occurring with an incidence of approximately 10% under the age of 10 years [6] and complicating PTB in 1–5% of cases [7].

ATB can affect the gastrointestinal tract, peritoneum, omentum, lymph nodes and solid viscera, individually or in combination. To our knowledge, there have been limited reports of the CT features of ATB in children. The aim of this study was to determine the CT appearances and frequency of the different sites of involvement in paediatric ATB.

Materials and methods

We retrospectively reviewed the clinical and radiological records of 22 children with ATB who underwent a CT scan between 1989 and 1999 at Red Cross Children's Hospital.

Inclusion criteria for a diagnosis of ATB were:

1. Histological proof of ATB
2. Combination of strong clinical suspicion and positive laboratory/histological/radiological features at extra-abdominal sites
3. Response to treatment

Patients with isolated musculoskeletal (TB spondylitis, psoas muscle) or genitourinary TB were excluded.

From the clinical notes, details were recorded concerning histologically proven ATB, presumptive diagnoses as per inclusion criteria number 2 above, and HIV testing. The plain chest radiographs were assessed for pulmonary parenchymal disease, lymphadenopathy or pleural changes suggestive of PTB.

The CT scans were reviewed and details recorded as follows:

1. Adenopathy – lymph nodes were assessed for enlargement and/or calcification. Specific note was made of site(s) of adenopathy.
2. Solid organ involvement – – the liver, spleen and pancreas were assessed for calcification and/or granuloma/abscess formation.
3. The presence or absence of additional features, viz. ascites, bowel-wall thickening, inflammatory masses and omental thickening.

Table 1 Method of diagnosis of abdominal TB (total number of patients = 22)

Method	Number of patients
Histopathology positive	10
Extra-abdominal TB	11
(Pulmonary TB)	(9)
(TB spine)	(2)
(Cervical adenopathy)	(2)
Response to therapy	1

Table 2 Pattern of involvement in abdominal TB (total number of patients = 22)

	Number of patients
Lymphadenopathy	17
Solid organ involvement	12
Ascites	5
Bowel-wall thickening	5
Inflammatory mass	2
Omental thickening	1

Results

In the decade reviewed (1989–1999), 22 children with ATB had CT. There were 14 boys and 8 girls, with ages ranging from 14 months to 10 years (mean 3 years, 6 months). The diagnosis of ATB was made with positive histopathological features in 10 patients, proven extra-abdominal TB and a strong clinical suspicion of abdominal involvement in 11 patients, and a positive response to therapy in a single case. Of the patients diagnosed on the basis of extra-abdominal TB, nine had PTB, two had TB spondylitis and two had cervical lymphadenopathy. These results are summarised in Table 1.

Of the 22 patients, 5 were tested for HIV. One patient was HIV positive and 4 were HIV negative. Thirteen patients had abnormal chest films with radiological features consistent with PTB. In 4 patients, the chest radiographs were normal. In 5 patients the plain radiographs had been destroyed.

On review of the CT scans, the commonest finding was lymphadenopathy ($n = 17$), followed by solid organ involvement ($n = 12$), ascites ($n = 5$), bowel-wall thickening ($n = 5$), inflammatory masses ($n = 2$) and omental thickening ($n = 1$). These findings are summarised in Table 2.

Of the 17 patients with lymphadenopathy, 8 had evidence of enlargement only, 6 had calcified adenopathy only and 3 had calcified and/or enlarged lymph nodes. Two of the patients with isolated calcified adenopathy had histologically proven TB on lymph node biopsy. Abnormal nodes were found in the para-aortic area, porta hepatis, mesentery and pelvis. In the majority of cases, more than one site was involved. Thirteen patients had evidence of para-aortic lymphadenopathy, which often co-existed with porta hepatis and mesenteric adenopathy. The porta hepatis was involved in ten cases. Only two patients had involvement of pelvic lymph nodes. These results are summarised in Table 3.

Twelve patients had solid organ involvement. Four patients had evidence of tuberculous abscesses, four had calcified tuberculomata as well as abscesses, and four had involvement by calcified tuberculomata only, one of which showed positive histology for TB. Nine patients had hepatic involvement, six had splenic lesions and a single case of pancreatic involvement was recorded. Isolated hepatic lesions were reported in five cases, while the spleen was the only involved solid viscus in three cases. These results are summarised Table 4.

Ascites and bowel-wall thickening were reported in five cases each. Only two cases demonstrated an

Table 3 Pattern of lymph node involvement in abdominal TB

	Para-aortic	Porta hepatis	Mesenteric	Pelvic
Calcified only (6)	5	5	2	0
Calcified and enlarged (3)	3	2	0	0
Enlarged only (8)	3	3	4	2
Total (17)	13	10	6	2

Table 4 Pattern of organ involvement in abdominal TB

	Liver	Spleen	Pancreas
Calcified (4)	3	3	1
Calcified and abscesses (4)	3	2	0
Abscesses (4)	3	1	0
Total (12)	9	6	1

inflammatory mass, while omental thickening was found in a single case.

Discussion

The increased worldwide incidence of TB is attributed to malnutrition, overcrowding, migration of people, economic and political pressures, IV drug abuse and, most of all, to AIDS [8, 9]. AIDS accounts for about 50% of the increase in cases in the United States [6]. The clinical presentation of TB has changed to that of a less classical form and there is an increased incidence of extrapulmonary TB [1]. Unusual presentations and extrapulmonary TB are more common with AIDS [9] and may result in more severe findings on CT [6]. TB is extrapulmonary in 10–15% of HIV-negative patients [3], but up to 50% of HIV-positive adults [2]. Since our data start in a period when HIV testing was not commonly performed, we do not have sufficient information to draw conclusions about ATB and HIV-positive children.

Recent publications quote that ATB represents up to one-third of all cases of TB [10]. Other studies state that while TB peritonitis is a common disease of the peritoneum, it is still a rare manifestation of TB and only represents up to 2% of cases of extrapulmonary TB [11, 12]. In general, TB is less common in adolescents than other age groups [3]. Peritoneal TB is relatively rare in children and is considered primarily a disease of young adults [12]. In Nigeria, only 10.5% of ATB is found in children [6]. Only five case reports, comprising a total of 12 children, are found in the literature describing the CT features of ATB [11, 12, 13]. A summary of these cases is detailed in Table 5. Only two direct references to the CT findings of ATB in children are found in the recent literature [4, 14]. A large published review of cases between 1976 and 1985 involving 59 patients at our institution did not include CT findings [5].

Rapid diagnosis is necessary in this disease because ATB is associated with high morbidity and up to 50% mortality if not treated [10]. Appropriate medical therapy, which is distinct from that used for the other diseases included in the differential diagnosis of ATB, can result in a marked improvement within 24 h [15]. Diagnosis is, however, difficult and conclusive evidence may only be obtained by a positive biopsy. This is because of the protean clinical manifestations, the vague signs and symptoms in children, and the non-specific laboratory investigations [10, 11, 16]. Erroneous diagnoses based on clinical findings alone have included appendicitis, abdominal neoplasm, intestinal obstruction, Crohn's disease, lymphoma, ascites due to other pathology, pyogenic infection with acute peritonitis, intussusception, anaemia, hepatitis and pancreatitis [11, 15]. Diagnosis is made from surgical specimens by microbiological staining and/or culture of *M. tuberculosis* or suggested by the identification of caseating granulomata histologically [1, 10, 17, 18]. In the absence of the above methods, the diagnosis of ATB has been made using the following criteria in varying combinations:

1. Culture or identification of *M. tuberculosis* in the sputum of a patient with abdominal symptoms and signs suggestive of TB.
2. A positive Mantoux or Tine skin test. This is, however, only found in 50–78% of ATB cases and is considered less specific, and hence less reliable, in a population where there is a high prevalence of PTB.
3. Documented TB infection elsewhere in the body
4. Elevated ESR
5. Positive ascitic culture
6. Raised alpha-interferon and/or raised adenosine deaminase (ADA) levels in ascitic fluid
7. Response to appropriate medical therapy
8. Suggestive radiological imaging [6, 10, 15]

In our series, ten children were diagnosed on positive microbiology or histology from surgical specimens (usually obtained at mini-laparotomy). Most of the remainder were diagnosed on the basis that there was positive confirmation of TB infection elsewhere in the body. Seven children had PTB, two had tuberculous spondylitis and two with tuberculous cervical adenopathy. One child in each of the latter two groups also had PTB.

Some studies state that the diagnosis is more difficult in areas with a low prevalence of TB, as many patients

Table 5 Case reports of CT-scanning in pediatric abdominal TB

Reference	Age (years)	Sex	Chest X-ray	CT findings
[6]	10	M	Normal	High-density ascites, inhomogeneous enhancing omental mass
	8	M	Abnormal	Enhancing complex loculated ascitic fluid along peritoneal (*sic*) reflections around spleen and left kidney
	12	M	Abnormal	Low-attenuating adenopathy with enhancing rims in peripancreatic, periportal, coeliac, splenic and iliac regions
[7]	16	M	Abnormal	Ascites
[9]	5	F	Normal	Para-aortic adenopathy, adhesions, calcification, ascites
	10	F	Normal	Generalised lymphadenopathy with scattered calcification, hepatomegaly and ascites
[10]	2	F	Abnormal	Low-attenuation lesion in right lobe of the liver, retroperitoneal and mesenteric lymphadenopathy
	6	M	Abnormal	Diffuse lymphadenopathy involving mesenteric and retroperitoneal lymph nodes with low-density centers giving a multilocular appearance following intravenous contrast, high-density ascites and thickening of bowel wall adjacent to the mesentery
	9	M	Abnormal	Partially calcified low-attenuation lesion in right lobe of liver, diffuse lymphadenopathy involving mesenteric and retroperitoneal lymph nodes with low-density centers giving a multilocular appearance following intravenous contrast and mottled low density in the omentum
[12]	6	M	Abnormal	High- and low-density structures in the retroperitoneal and mesenteric spaces. Mottled soft-tissue densities in omental area. High-density ascites
	6	F	Not recorded	High-density ascites. Enlarged mesenteric lymph nodes. Low density masses with solid peripheral rims in right pelvis and mid-abdomen. Irregular soft-tissue densities in omental area. Right obstructive uropathy.
	14	M	Not recorded	Hydronephrotc left kidney with high-density fluid in calyces. Low-density nodes with rim enhancement in pelvic, para-aortic, peripancreatic, porta hepatic, retrocrural, coeliac axis and splenic areas.

have negative chest radiographs and skin tests. The opposing view is that the diagnosis is more difficult in areas with a high prevalence where the incidence of abnormal chest radiographs and positive skin tests is high in patients without ATB [6, 8, 18]. Chest radiographs are abnormal in only 56% of patients with ATB [5], and US and CT are thus considered more valuable in the diagnosis. This is especially so when they are used in combination with the appropriate clinical and laboratory findings. No single radiological investigation provides all the necessary information, and no CT findings are considered to be pathognomonic [1, 14, 16]. US is still valuable as an initial diagnostic tool as it does not involve ionising radiation. US is excellent in detecting ascites, but is often limited in the detection of lymphadenopathy and peritoneal involvement owing to the presence of bowel gas. CT is considered by many authors to be superior to US because of the ability to identify all the features in a single study. This is especially so in the detection of caseating lymph nodes, high-density ascites and bowel-wall thickening [1]. At present, CT is considered the diagnostic imaging modality of choice [2]. By using a combination of clinical findings, laboratory tests and appropriate radiological imaging, a rapid diagnosis can be made. Institution of appropriate medical therapy can avoid laparotomy and decrease patient morbidity and mortality.

M. tuberculosis infects the abdomen following either ingestion of infected sputum with subsequent spread from the bowel to the lymph nodes, peritoneum and contiguous organs, or by haematogenous spread from predominantly a primary lung infection to the solid organs, lymphatic system and peritoneum [1, 2]. The division of TB infection into that which affects the chest or the abdomen is considered artificial, as autopsy studies have shown that 70–80% of patients who die from PTB have abdominal involvement. However, only 56% of patients with ATB are reported to have an abnormal chest radiograph [6, 9]. In our series, 13 of 17 children who underwent chest radiography showed a radiographic abnormality. A more detailed discussion of the CT findings of ATB in children follows.

Lymphadenopathy

This was the commonest finding in our series, with 11 patients showing enlarged nodes and 9 showing calcified nodes. In children with ATB, lymphadenopathy has most commonly been reported in the para-aortic and

mesenteric regions, but the periportal, omental, peripancreatic and pararenal node groups can also be involved (Fig. 1). The upper para-aortic and mesenteric groups are more often involved in TB than in lymphoma. In our series, the most common nodes involved were the para-aortic and porta hepatis groups. TB nodes typically have a low-density centre with a contrast-enhancing rim (Fig. 2). They may, however, be multiloculated, non-enhancing or show areas of calcification. Calcification does not imply inactivity. Two of our cases with calcified nodes had active TB histologically. Lymph nodes with a low-density centre and a contrast-enhancing rim correlate with the histological features of central caseation surrounded by reactive inflammation [5, 8, 14].

Solid organ involvement

Hepatic and splenic abscesses and granulomata are seen with miliary spread but are rare following ingestion of *M. tuberculosis*.. This was the next most common finding, after lymphadenopathy, in our series ($n = 12$). Solid organ lesions in our study were either calcified or of low density, and in four cases both types of lesions co-existed. The low-density lesions may be single or multiple, may show ring enhancement with IV contrast medium and may calcify (Figs. 3, 4). The single case of pancreatic involvement has, to our knowledge, not previously been reported in children, but has been reported in adults where it is associated with other findings of ATB [2, 16].

Inflammatory masses

Poorly defined inflammatory masses commonly involve the ileocaecal region. These are formed by matted lymph nodes, inflamed thickened omentum and adherent bowel (Fig. 5) [1, 16]. We demonstrated only two such masses in our study.

Omental and mesenteric involvement

Omental thickening with nodules may be seen and has been termed omental 'caking' or 'rolling up'. We recorded only one such case (Fig. 6). Focal nodular

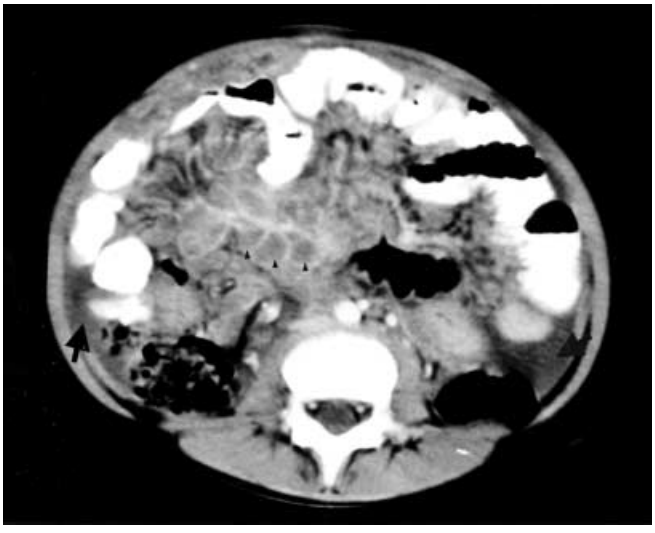

Fig. 2 Contrast-enhanced CT shows multiple, low-density, ring-enhancing mesenteric lymph nodes (*arrowheads*) displacing the contrast-filled bowel peripherally. A small amount of ascites is present (*arrows*)

Fig. 1 Contrast-enhanced CT shows low-density periportal and para-aortic lymph nodes (*arrowheads*)

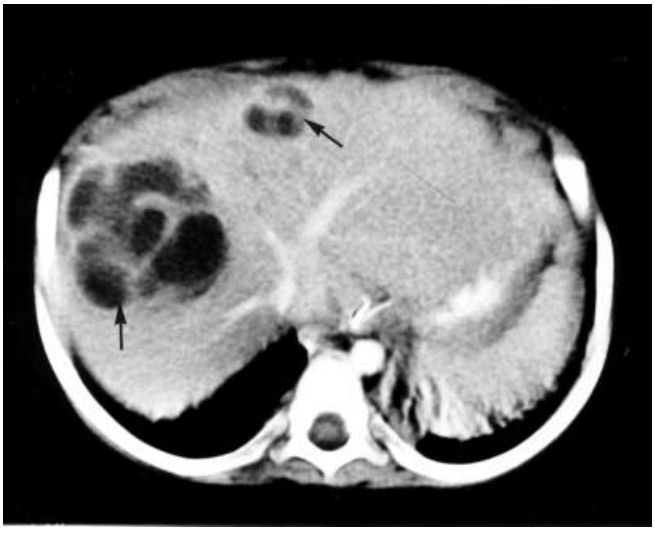

Fig. 3 Contrast-enhanced CT demonstrates multifocal, low-density, hepatic tuberculous abscesses that show rim enhancement and thick irregular septations (*arrows*)

peritoneal implants are, however, uncommonly seen on CT. The mesentery may also be thickened and may have a 'stellate' appearance with lymphadenopathy lining the vessels [2, 9, 10] (Fig. 2).

Bowel involvement

Bowel loops with thickened walls are found in ATB, as shown in five of our cases. These are usually in the ileocaecal region (Figs. 5, 6). This type of involvement is considered less common in children than in adults [2, 5].

Ascites

High-density (20–45 HU) ascites has been reported as being characteristic, but not pathognomonic of ATB and may exist in varying amounts (Figs. 2, 6). Ascites of water density has also been reported and may represent an earlier transudative phase of the disease [2, 10, 11]. We identified ascites in five cases on CT but could not evaluate the density retrospectively.

Complications and associations

Complications and associated features that may be identified include intestinal obstruction, perforation, abscesses, fistulae and hepatic fatty infiltration. The latter is a non-specific finding [6, 16]. Of these, only the latter was identified in our series.

Our results show that the above findings may co-exist in varying combinations. We therefore agree with those authors who regard the traditional division of ATB into 'wet', 'dry', 'plastic' and 'mass formation' as artificial. Isolated extraintestinal involvement is believed to only occur in about one-third of patients. Lymphadenopathy is the commonest finding in both adults and children. Some authors state, however, that

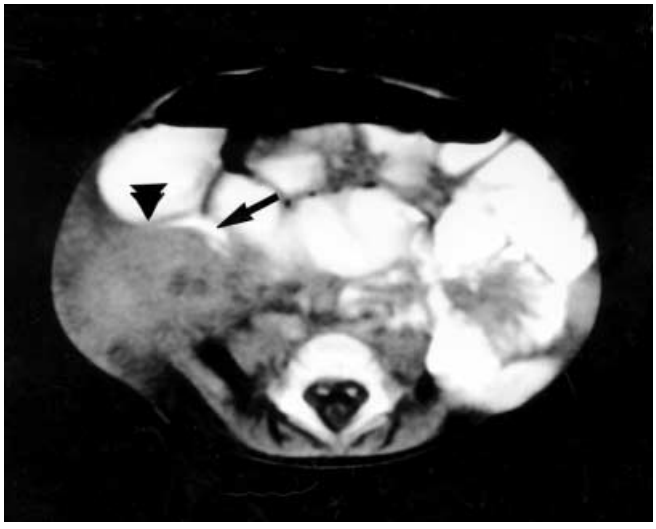

Fig. 5 Contrast-enhanced CT demonstrates an ill-defined right-iliac-fossa mass displacing bowel (*arrowhead*) with overlying induration of the abdominal wall. The crescent of contrast medium superomedial to the mass (*arrow*) suggests bowel involvement

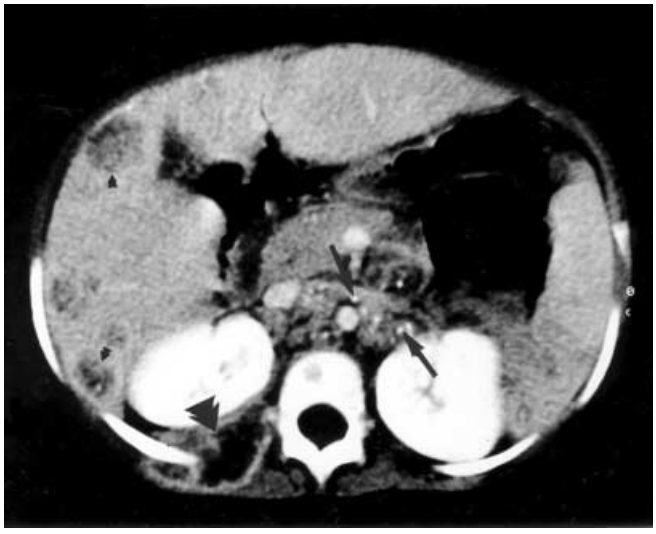

Fig. 4 Contrast-enhanced CT demonstrates hepatic abscesses (*small arrowheads*) and a cold abscess in the right paraspinal muscles (*large arrowhead*). Punctate calcification of paraaortic lymph nodes (*arrows*) was better seen on unenhanced CT

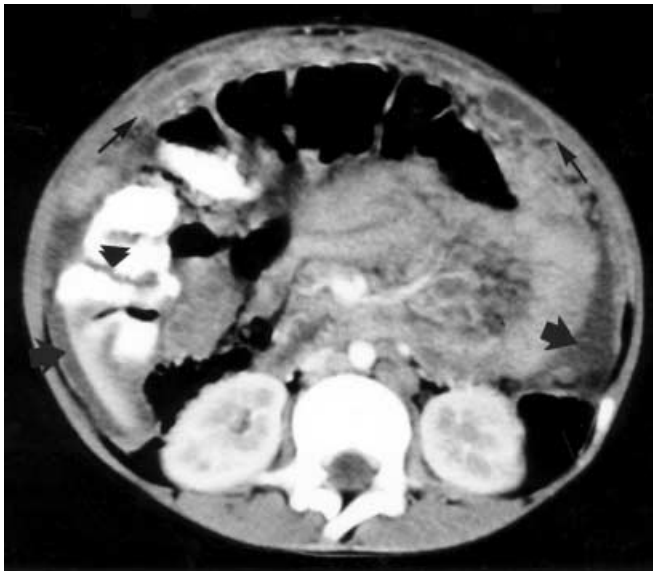

Fig. 6 Contrast-enhanced CT shows a thick 'rolled-up' omentum with visible low-density, ring enhancing omental 'cakes' (*arrows*). Bowel-wall thickening is present on the right (*arrowhead*) and there is a small amount of ascites (*thick arrow*)

ascites is commoner in adults, as it is found in up to 97% of cases [2, 10].

The differential diagnosis of ATB in children includes lymphoma, inflammatory bowel disease (e.g. Crohn's disease), pyogenic peritonitis, Kaposi sarcoma and *M. avium intracellulare* in AIDS patients, appendicitis, post-surgical starch granulomata and gastrointestinal infestation by giardiasis, amoebiasis, Yersinia and fungi. A further differential, which is commoner in adults and rare in children, includes mesothelioma, peritoneal carcinomatosis from ovarian, testicular and head and neck malignancy, carcinoma of the caecum, Whipple's disease, pancreatitis and hepatitis [10, 12]. Lymphoma resembles TB the most, but more often involves the pelvic lymph-node groups and less commonly the paraortic and porta hepatis groups. Calcification of lymph nodes in lymphoma only occurs after treatment [8].

This series of cases concentrated on a group of patients who were already diagnostic problems. This explains why they had CT and why ten patients underwent surgery for diagnosis. In our institution, only about one in ten cases of ATB undergo CT. In the remainder, the findings on US, together with other clinical features discussed above, lead to a diagnosis of ATB (unpublished data). To the best of our knowledge there are only 12 cases in the literature in which the CT features of paediatric ATB are recorded. This study therefore concentrates on documenting the local experience in this regard.

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