International Journal of Infectious Diseases 14 (2010) e659–e666

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Review

Is spinal tuberculosis contagious?

Patricia Schirmer [a,b,*], Cybèle A. Renault [a,b], Mark Holodniy [a,b]

[a] VA Palo Alto Health Care System, 3801 Miranda Avenue (132), Palo Alto, CA 94304, USA
[b] Division of Infectious Diseases and Geographic Medicine, Stanford University, Stanford, CA, USA

ARTICLE INFO

Article history:
Received 3 July 2009
Received in revised form 18 July 2009
Accepted 4 November 2009

Corresponding Editor: William Cameron, Ottawa, Canada

Keywords:
Mycobacterium tuberculosis
Osteomyelitis
Pott's disease
Pulmonary tuberculosis
Spinal tuberculosis

SUMMARY

While pulmonary *Mycobacterium tuberculosis* infections are recognized for their public health implications, less is known about the infectiousness of extrapulmonary tuberculosis, specifically, spinal tuberculosis or Pott's disease. We present a case of spinal tuberculosis with concomitant active pulmonary tuberculosis in the absence of chest radiographic abnormalities or symptoms, and review the literature regarding infectiousness of concomitant spinal and pulmonary tuberculosis.

Published by Elsevier Ltd on behalf of International Society for Infectious Diseases.

1. Introduction

Mycobacterium tuberculosis (MTB) has infected an estimated 2 billion persons worldwide and remains a leading cause of global mortality.[1] In 2007, over 13 000 tuberculosis (TB) cases were reported in the USA.[1] Nearly 20% of patients with TB develop extrapulmonary manifestations. Skeletal TB accounts for 10–20% of all extrapulmonary TB, with spinal involvement in 50–60% of all skeletal TB cases or in <1% to 5% of all TB cases.[2–9] Pott's disease, first described by Percival Pott, is MTB infection of the vertebral spine and typically involves thoracic and lumbar anterior vertebral bodies. Complications can include vertebral collapse, paraplegia and paraspinal abscesses.[3,10–12]

Between 50% and 75% of patients with osteoarticular TB and approximately 33–50% of patients with spinal TB have an associated primary lung focus or have a reported history of pulmonary TB.[3,9,13,14] In one study of spinal TB, MTB was found elsewhere in the body in approximately 40% of cases, and 50% of those cases had pulmonary involvement.[15] Most reports suggest that spinal TB results from a primary focus outside of the spine, and spread is postulated to be via hematogenous or lymphatic dissemination.[2,7,16]

While it is common practice to obtain a chest X-ray (CXR) when a patient is diagnosed with extrapulmonary TB, sputum examination is typically reserved for those with respiratory symptoms and/or abnormal chest imaging.[17] Although TB treatment may not differ if the sputum is positive for TB, the contact investigation and isolation procedures may vary significantly.[17–21] We present a case of a patient diagnosed with spinal TB in whom sputum cultures grew MTB despite a normal CXR. We also review the literature and discuss the infection control implications and management.

2. Case report

A 62-year-old man was seen in November 2007 reporting a two-month history of lower back pain, which he attributed to lifting a heavy object. He was prescribed physical therapy. In February 2008, he reported having persistent back pain and night sweats for four months; and because he refused further workup, physical therapy alone was continued. He was seen several times in the mental health clinic over the following months where he continued to report night sweats, which were attributed to post-traumatic stress disorder. In July, he saw his primary care physician and reported approximately one month of chills, left-sided mid-abdominal pain associated with movement, a bloody bowel movement, and a 9 kg weight loss over eight months. A history of a positive tuberculin skin test (TST) was noted, although it was unknown whether he had received treatment for latent TB. An HIV ELISA test was negative. CXR findings were unremarkable except

* Corresponding author. Tel.: +1 650 852 3408; fax: +1 650 858 3978.
E-mail address: pschirme@stanford.edu (P. Schirmer).

1201-9712/$36.00 – see front matter. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases.
doi:10.1016/j.ijid.2009.11.009

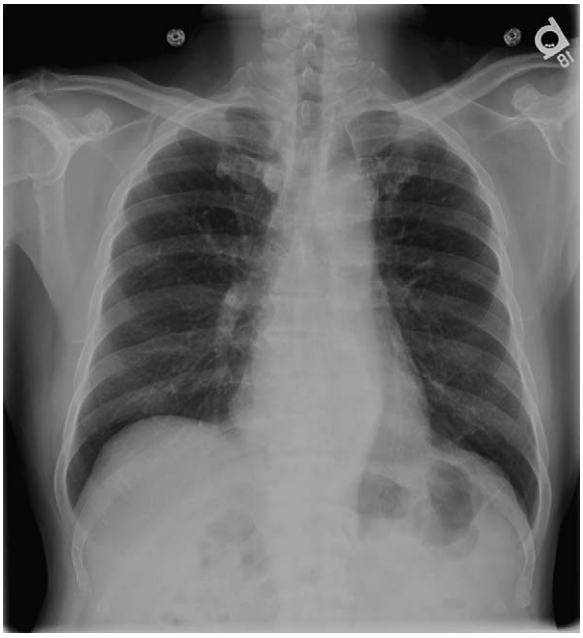

Figure 1. Chest X-ray from August 30, 2008.

for a possible T4 osteophyte. An abdominal and pelvic computed tomography (CT) scan was ordered, but the patient postponed the study until after his vacation. In August, the patient was seen in the emergency room for his abdominal pain. An abdominal and pelvic CT scan revealed a mass extending from T10 to L2, a destructive process involving the T9, L3, L4 vertebral bodies causing severe cord compression, and a large rim-enhancing fluid collection in the right psoas muscle.

The patient was admitted with presumptive Pott's disease. Notably, he did not complain of respiratory symptoms. An admission CXR demonstrated a stable circumscribed opacity in the right paratracheal region; differential diagnosis included a prominent right costovertebral junction at the T4 level, an osteophyte, a mediastinal lymph node, or a soft tissue prominence (Figure 1). He was placed in respiratory isolation because of this abnormal CXR finding in the setting of presumptive Pott's disease. Three induced sputums for mycobacterial smear and culture were obtained over consecutive days. All acid-fast bacilli (AFB) smears were negative, and airborne isolation was discontinued. A repeat TST was negative. After a magnetic resonance imaging (MRI) scan confirmed the CT scan findings, he underwent abscess drainage and bone biopsy, performed at the local academic medical center. Samples from abscess drainage and bone biopsy were AFB smear-negative, but one week later grew pan-sensitive MTB. Bone histology demonstrated necrotizing granulomas, consistent with Pott's disease. The day after biopsy, empiric four-drug TB therapy (isoniazid 300 mg daily, ethambutol 20 mg/kg daily, pyrazinamide 25 mg/kg daily, and rifampin 600 mg daily, with pyridoxine 25 mg daily) was begun.

Three days after starting TB therapy, he developed urinary retention. A repeat MRI scan demonstrated no interval change. However, because of changed neurologic exam findings, emergent thoracolumbar decompression was performed. Spinal fusion and further debridement of necrotic bone was performed four days later. A follow-up CXR demonstrated that the previously noted right upper lung abnormality was consistent with anterior rib markings and an osteophyte. Once MTB drug susceptibilities from the psoas abscess culture were known (one month after starting treatment), ethambutol was discontinued. Two weeks later, admission sputum cultures grew pan-sensitive MTB. He was not in respiratory isolation at this time, since he had been on four-drug TB therapy for over one month and because his initial sputum AFB smears were negative. As he was nearing discharge after approximately three months of TB therapy, the local county TB control officer requested three additional mycobacterial sputum smears and cultures. Two of three sputum samples revealed rare AFB on smear. A repeat CXR and chest CT scan were not suggestive of active pulmonary disease. Although he had received directly-observed therapy, the possibility of drug-resistant MTB was entertained. He was again placed in airborne isolation until three additional sputum AFB smears returned negative. All six mycobacterial sputum cultures were negative; therefore, it was thought that the AFB smear-positive samples likely represented dead organisms. Because he was symptomatically improved, his TB regimen was not changed. Pyrazinamide was continued for four months until an MRI scan demonstrated improvement. Currently, he is clinically improved on isoniazid, rifampin, and pyridoxine.

Although infection control staff had followed the case since admission, an exposure investigation was initiated when the AFB smears returned positive. It was determined that the staff wore N-95 respirators during his abscess drainage and bone biopsy (performed at another institution). There was approximately one week when he was not in respiratory isolation prior to starting anti-TB treatment and before the MTB-positive culture results returned. A total of 69 employees and four patients were evaluated at our institution for possible TB exposure. One patient had a negative Quantiferon test result (performed because he was unable to return for follow-up reading). All others had negative symptom review, TST, and CXR with the exception of one patient, who demonstrated a new TST conversion, had a normal CXR and whose mycobacterial sputum culture grew *Mycobacterium avium* complex.

3. Discussion

Although TB has declined in the USA due to effective public health surveillance and infection control practices, the public health ramifications of undiagnosed pulmonary TB are substantial.[1] Our patient presents an interesting question about the prevalence of spinal TB and concomitant active pulmonary TB. The prevalence of both spinal and pulmonary TB (both active and inactive) occurs at a surprisingly high rate (Tables 1 and 2). A total of 29 individual cases of concomitant pulmonary and spinal TB have been presented in the literature (Table 1); unfortunately, the quality of information presented in case reports and case series varies greatly, with many lacking critical information such as mycobacterial sputum smear and culture results. Retrospective studies describing over 3000 patients with spinal TB have noted that 2–80% of these cases also have evidence of pulmonary TB (either active or inactive), indicating that further consideration of this clinical dogma should be entertained (Table 2). However, other studies suggest a low prevalence of concomitant extrapulmonary and pulmonary TB. One prospective study from Malawi reported that 1.7% of patients with extrapulmonary TB (>3% in patients with miliary disease, lymphadenitis or meningitis) had AFB smear-positive sputum.[22] Although no cases of AFB smear-positive sputum were identified in the skeletal TB patients, only 42% submitted sputum samples.[22] Unfortunately, information in many of these studies is incomplete and often does not differentiate active from inactive disease or provide information about culture positivity and radiographic findings.

While physicians often use the presence of respiratory symptoms or abnormal radiographic findings in detecting those at risk for having pulmonary TB, this can be misleading. Our patient had no pulmonary symptoms and had a normal chest radiograph, despite having positive sputum cultures for MTB. Culture-positive pulmonary TB has been found in patients with extrapulmonary TB

Table 1
Individual reported cases of pulmonary tuberculosis and spinal tuberculosis in the literature

Age/sex	AFB sputum smear and culture	CXR/CT scan	Pathology	Tissue for AFB[a]		Therapy		Comments/outcome	Ref.
				Smear	Culture/PCR	Medical	Surgical/site of spinal disease		
23F	NR	Miliary TB	NR	Positive	Negative	INH, EMB, RIF (5 mo); INH, EMB (19 mo)	Anterior spinal fusion and drainage of abscess (T6)	Died of unrelated cause (heroin overdose)	10
47F	NR	Healed TB	Caseation necrosis	Positive	Negative	INH, EMB, RIF, CY (6 mo); INH, EMB (19 mo)	Debridement and drainage (T12–L1)	Minimal residual weakness	10
32M	NR	Healed TB	Caseation necrosis, granulomas	Negative	Negative	INH, EMB, RIF (4 mo); INH, EMB (18 mo)	Debridement and anterior spinal fusion, bone graft (C6–7)	Cured	10
62F	NR	Miliary TB	Granulomas	Negative	MTB	INH, EMB, SM (2 mo); INH, EMB (36 mo)	Anterior spinal fusion (T7–8)	Marked residual weakness (wheelchair bound)	10
42F	NR	Healed TB	Caseation necrosis, granuloma	Negative	MTB	INH, EMB, RIF or SM (11 mo); INH, EMB (20 mo)	Anterior spinal fusion, bone graft, debridement (T12–L1)	Cured	10
53F	NR	Healed TB	ND	ND	ND	INH, RIF (24 mo)	None	Cured	10
26M	Refused bronchoscopy and unable to provide sputum	Reticulo-nodular infiltration in RUL with right hilar enlarged	Epithelioid granulomata with Langhans giant cells and lymphohistiocytic aggregates	NR	NR	4-drug therapy – not further specified	VATS; multiple thoracic and vertebral involved	Improvement in bone lesions	2
19M	NR	Heterogeneous density increase in left apex; many nodules with smooth edges and a cavitary lesion on CT scan	Skin: micro-granuloma, many Langhans-type giant cell formation and dense mononuclear inflammatory cells	Skin lesion: negative	Skin lesion culture: negative; PCR: positive	RIF, INH, SM, EMB (18 mo)	NR; T4–T5 disease	Also with cutaneous lesions. Improved with healing of skin lesions by 5th week	59
79M	Smear: positive; culture: positive	Bilateral pseudo-tumoral infiltration with cavitation in the RUL; multiple calcified hilar lymph nodes	NR	NR	NR	NR	NR; T9 disease	NR	60
66F	NR	Miliary nodules bilaterally on CT scan	Intramedullary lesion: fibrous, diffuse chronic inflammatory cell infiltration with granulation tissue and focal abscess formation	NR	Culture: NR; PCR: positive	RIF, INH, PZA, EMB	Laminectomy of L1–L2 and subtotal laminectomy of T10–T11, myelotomies followed at T10 and T11	Intramedullary tuberculomas: spine and brain with involvement of L1–2 bone marrow and end plates. Improved movement and decreased size of tuberculomas	61
25M	NR	Left pleural effusion; repeat CXR with right pleural effusion	Pleural tissue: thickened pleural tissue, infiltration of lymphocytes; right psoas abscess caseous necrosis with Langhans giant cells and epithelioid cells	NR	Right psoas abscess: MTB	INH, RIF, SM	Debridement of T11–12; anterior spinal fusion, bone graft	Improved	11

Table 1 (*Continued*)

Age/sex	AFB sputum smear and culture	CXR/CT scan	Pathology	Tissue for AFB[a]		Therapy		Comments/outcome	Ref.
				Smear	Culture/PCR	Medical	Surgical/site of spinal disease		
25M	Bronchoscopy and sputum AFB: negative	Right hilar enlarged, perihilar infiltration and lytic expansile lesion of the left 8th rib; CT: multiple mediastinal and right hilar LAD and RUL consolidation and vertebral and rib lytic lesions	Lung and mediastinal lymph nodes: small necrotizing granulomas with multinucleated giant cells	Lung and lymph node tissue: positive	Lung and lymph node tissue: MTB	INH, RIF, PZA, EMB	VATS; L2–L3 disease	Improved	9
20M	Smear: positive	Apical lesion in RUL	ND	ND	ND	INH, EMB	No surgical intervention of T11–12 disease	Improved	15
24M	Culture: MTB	LUL infiltrate	NR	NR	MTB	INH, RIF, PZA, EMB (2 mo); INH, RIF (10 mo)	NR; T7–T9 lesion	HIV-pos; improved	62
59M	Culture: MTB	RUL cavity	NR	NR	MTB	INH, RIF, PZA, EMB (2 mo); INH, RIF (10 mo)	NR; L4 lesion	HIV-pos; improved	62
18F	Culture: MTB	NR	Lung tissue: caseating granulomas; spinal tissue: caseating granuloma	NR	Spinal tissue: MTB	NR	Laminectomy; C6, L1–L2 disease	Patient died	56
21M	Negative	Negative	Lung tissue: granulomatous cavitation with Candida and Aspergillus seen in tissue	Spinal: positive	Spinal: negative	NR	NR; T2–T3 disease	Patient died	56
26M	Negative	Mediastinal fusiform shadow and left axillary pleural thickening	Patient refused biopsy	ND	ND	INH, RIF, PZA, EMB (2 mo); INH, RIF, PZA (7 mo)	Patient refused; T7–T8 and L4–L5 disease	Improved	63
25M	NR	Retrocardiac mediastinal shadow	NR	Retro-pharyngeal abscess: positive	Retro-pharyngeal abscess culture: MTB; retro-pharyngeal abscess PCR: positive	INH, RIF, PZA, EMB (2 mo); INH, RIF (7 mo)	Abscess aspirations. C2–C3, T8–T9 disease	Improved	63
37M	Negative	Left apical thickening of the pleura		Left psoas abscess: negative	Left psoas abscess: MTB	INH, RIF, PZA, EMB (5 mo); INH, RIF (7 mo)	Psoas abscess aspiration; L2–L3 disease	Improved	63
24M	Gastric aspirate: positive	Left pleural effusion and retro-cardiac mass	NR	Spinal: positive	Spinal: MTB	INH, SM, para-aminosalicylate	NR; T8–T10 disease	Unknown	64
26M	Negative	2 cm opacity in LUL	NR	Abscess: positive	Abscess: MTB	INH, SM, para-aminosalicylate	NR; lumbar disease	Unknown	64
73F	Negative; bronchoscopy culture: positive	CT: pulmonary infiltrates and fibrosis of the right lung	Spinal: caseating granulomas with multinucleated cells	Spinal: positive	NR	INH, PZA, RIF (12 mo)	NR; mid-thoracic disease	Improved	65
51M	NR	CT: tiny nodules consistent with miliary disease	Spinal: necrotizing granulomatous inflammation; extramedullary mass: granulomatous inflammation	Spinal: positive; extra-medullary lesion: negative	Spinal: culture MTB; PCR positive	INH, ETH, RIF, SM (2 mo); INH, RIF (2 mo); INH, ETH, RIF, SM (restarted for unknown duration)	T12–L1 laminectomy.	Returned due to worse symptoms and found to have extramedullary mass, subsequently improved	66

37M	NR	LLL infiltrate	Chest wall: caseating granulomas with AFB	Chest wall: positive	Chest wall: MTB	INH, RIF, PZA	Abscess aspiration around C1–4	Died of respiratory distress	[67]
31M	Smear: positive; culture: MTB	Thickened pleura, fibrotic stranding, RUL infiltrate with early cavitation	Spinal: caseating necrosis and necrotic bone	Positive	Negative	SM, INH, EMB	Debridement and fusion of L2–3	Improved	[3]
27M	Sputum and gastric aspirates smear and culture: positive (MTB)	Bilateral apical thickening and periapical fibrosis	ND	Negative	Negative	INH, RIF	NR; L3–5 disease	Improved	[3]
56F	Negative	Bilateral small pleural effusions	Spinal: fibrosis, new bone formation, multinucleated cells, plasma cell infiltrate	Negative	Negative	INH, EMB	Debridement of T8–9	Improved	[3]
36M	NR	Mediastinal widening right apical pleural thickening	Spinal: granulomas with caseation necrosis and Langhans giant cells	Positive	Negative	INH, EMB, RIF	T2–6 laminectomy	Improved	[3]

AFB, acid-fast bacilli; CXR, chest X-ray; CT, computed tomography; PCR, polymerase chain reaction; NR, not reported; ND, not done; mo, months; TB, tuberculosis; MTB, *Mycobacterium tuberculosis*; RUL, right upper lobe; LUL, left upper lobe; LLL, left lower lobe; LAD, lymphadenopathy; VATS, video-assisted thoracoscopic surgery; INH, isoniazid; EMB, ethambutol; RIF, rifampicin; SM, streptomycin; CY, cycloserine; PZA, pyrazinamide.

[a] Spinal tissue unless otherwise stated.

or with HIV infection who have normal CXR findings.[17,23–26] A recent study found a significant difference in HIV-negative versus HIV-positive patients with normal CXR findings in the setting of active pulmonary TB (5% vs. 22%).[26] HIV-infected patients with normal or atypical CXR findings in culture-positive pulmonary TB were similar to those reported in other studies (2–32%).[27–42] In one study of patients (HIV-positive and -negative) with normal CXR findings, 48 of 53 had sputum AFB smears performed, of which 21 of 48 were smear-positive.[26] Patients with normal CXR findings were also significantly less likely to report respiratory symptoms on presentation (32% vs. 13%).[26] Published series prior to the HIV epidemic, or studies not indicating HIV status, have reported a range of 1–32% of patients with normal CXR findings who were found to have MTB culture-positive sputum.[23,25,32–34,41,43–49] HIV-infected patients with pulmonary TB also have an increased probability of presenting with AFB smear-negative sputum and normal CXR findings compared to non-HIV-infected individuals.[28,50] This likely contributes to delayed TB diagnosis and treatment in HIV-infected patients.[28,50] In summary, little quality data has been published about the correlation between extrapulmonary TB, culture-positive pulmonary TB and normal CXR findings.

Importantly, respiratory transmission of TB has been documented in patients with AFB smear-negative sputum.[17,51–55] Two studies suggest that approximately 17% of transmission occurred from persons with sputum smear-negative TB.[51,52] One study found that those with extrapulmonary TB increased the TB transmission rate, suggesting that the infectiousness of extrapulmonary TB has previously been underestimated.[51] We found no evidence of transmission in our case. Although evidence of transmission (other than direct inoculation) of MTB from extrapulmonary sources is lacking in the current literature, in-depth evaluations of the infectiousness and risk of transmission from extrapulmonary TB have not been adequately documented in the literature.

Unfortunately, current guidelines offer no clear guidance on whether or not all patients with extrapulmonary TB should be evaluated for concurrent pulmonary involvement nor is there an appropriate infection control strategy delineated for these patients. Several sources suggest a conservative approach, such as obtaining cultures from all body fluids and tissues that are suspected of being involved with MTB.[56] The Centers for Disease Control and Prevention recommends that "persons diagnosed with extrapulmonary TB disease should be evaluated for the presence of concurrent pulmonary TB disease"; however, further description of the extent of that evaluation is lacking.[57] According to Mandell's *Principles and practice of infectious diseases*, a CXR should be routinely obtained in Pott's disease since abnormal radiographs can have important health ramifications.[58]

The cost of respiratory isolation and obtaining mycobacterial sputum cultures on all patients with extrapulmonary TB would not be trivial. However, cost could be minimized by appropriately identifying patients who are at risk of having pulmonary TB. At our institution, routine isolation and subsequent AFB sputum examination from extrapulmonary TB cases does not always occur unless pulmonary symptoms or abnormal CXR findings are noted. From our literature review and weighing public health considerations of TB transmission, we suggest that airborne isolation of patients with suspected extrapulmonary TB, including spinal TB, is justified until CXR and AFB sputum smear results are known and cultures have been obtained. Even though there is documentation of AFB smear-negative transmission of pulmonary TB, it is customary to discontinue isolation once negative AFB sputum smear results are known.

Advantages of taking an aggressive approach to isolation and documentation of active pulmonary TB include minimizing healthcare worker and patient exposure to a potentially infectious

Table 2
Studies noting concomitant pulmonary and spinal tuberculosis

Study location	Number of patients with spinal TB	Number of patients also with a form of pulmonary TB (%)	Based on CXR	Based on positive sputum cultures	No further details on lung disease	Active vs. inactive vs. combined pulmonary TB	Comments	Ref.
England	500	284/500 (57)	XX			Active	Known cases of active pulmonary TB (sputum-positive) were excluded	68
England	914	175/914 (19)			XX	Active	443 with additional active TB focus	69
France	103	16/103 (16)			XX	Combined	28 extraskeletal TB	70
India	15	1/15 (7)	XX			Inactive	Primarily intramedullary TB; one of these patients with Pott's (not the one with pulmonary disease); no sputum AFBs sent	71
India and Iran	48	9/48 (19)	XX			Combined	No definition of 'a primary pulmonary focus'	72
Iran	100	18/100 (18)	XX	XX		Combined	All patients got a CXR and sputum smear and culture	73
Korea	244	116/244 (48)	XX			Combined	69 (28%) active disease; 47 (20%) inactive	74
Nigeria	34	9/34 (27)			XX	Active		75
Philippines	88 children	88/88 (100)			XX	Active	All had to have spinal TB associated with active pulmonary TB to be included; 2 miliary disease, 3 pleural effusion, 8 had residue of acute pleuritis	16
Saudi Arabia	39	12/39 (31)	XX			Combined	TB of the nervous system; 8 with bony disease (unclear if any of these had pulmonary disease as well); 7 with abnormal CXR: 4 old TB, 3 miliary TB	76
Tanzania	22 children	2/22 (9)	XX	XX		Active	AFB sputums were done and positive only on the 2 with positive CXR findings	77
Turkey	694; 35 with multifocal disease	16/694 (2)			XX	Combined	Of the 35 with multifocal TB 45% had pulmonary involvement	8
USA	70	10/70 (14)			XX	Active	9 active; 1 pleurisy; inner city patients	78
USA	12	6/12 (50)			XX	Combined	Inner city patients	14
USA	62 (48 with CXR; 56 with cultures)	40/48 (83) based on CXR; 20/56 (37) based on AFB	XX	XX		Combined	5 with miliary; combination of sputum and gastric aspirates 37%	56
USA (immigrants from Asia and Central America)	19	8/19 (42)	XX			Combined	3 inactive, 3 miliary, 1 diffuse infiltrates, 1 pleural effusion; 15 AFB smear/cultures done but the source of specimen is unclear	79
USA	20	10/20 (50)	XX			Combined	7 with calcified adenopathy and pleural thickening, 3 had pulmonary infiltrates; 1 with a positive AFB sputum (unclear if others were tested)	80
USA	26	2/26 (8)	XX	XX		Active	1 with a left upper lobe infiltrate and the other with right upper lobe cavity. HIV-pos patients. Sputum AFBs only reported on 2 patients with abnormal CXR	62
USA	230 skeletal TB patients (138 with spinal TB)	139/230 (60)			XX	Combined	Patients were chosen from a sanatorium; 117 (51%) active; 22 (10%) inactive; unclear how many of these had spinal involvement	81

TB, tuberculosis; CXR, chest X-ray; AFB, acid-fast bacilli.

patient, as well as providing an additional source for MTB culture and susceptibility testing . Future investigations and publications require clear definitions of a pulmonary primary focus as well as active versus inactive pulmonary TB to help guide appropriate infection control practices. Finally, better guidance with respect to isolation practices and appropriate evaluation of extrapulmonary TB cases, particularly spinal TB, is needed.

Conflict of interest: No conflict of interest to declare.

References

1. Trends in tuberculosis—United States, 2007. Morb Mortal Wkly Rep 2008; 57:281–5.
2. Ozol D, Koktener A, Uyar ME. Active pulmonary tuberculosis with vertebra and rib involvement: case report. *South Med J* 2006;**99**:171–3.
3. Gorse GJ, Pais MJ, Kusske JA, Cesario TC. Tuberculous spondylitis. A report of six cases and a review of the literature. *Medicine (Baltimore)* 1983;**62**:178–93.
4. Goldblatt M, Cremin BJ. Osteo-articular tuberculosis: its presentation in coloured races. *Clin Radiol* 1978;**29**:669–77.
5. Griffiths DL. The treatment of tuberculosis of bone and joint. *Trans R Soc Trop Med Hyg* 1978;**72**:559–63.
6. Tull SM, Kumar S. Early results of treatment of spinal tuberculosis by triple drug therapy. *Clin Orthop Relat Res* 1971;**81**:56–70.
7. Sankaran B. Tuberculosis of bones and joints. *Indian J Tuberc* 1993;**40**:109–18.
8. Turgut M. Spinal tuberculosis (Pott's disease): its clinical presentation, surgical management, and outcome. A survey study on 694 patients. *Neurosurg Rev* 2001;**24**:8–13.
9. Kaya A, Topu Z, Fitoz S, Numanoglu N. Pulmonary tuberculosis with multifocal skeletal involvement. *Monaldi Arch Chest Dis* 2004;**61**:133–5.
10. Shivaram U, Wollschlager C, Khan F, Khan A. Spinal tuberculosis revisited. *South Med J* 1985;**78**:681–4.
11. Okuyama Y, Nakaoka Y, Kimoto K, Ozasa K. Tuberculous spondylitis (Pott's disease) with bilateral pleural effusion. *Int Med* 1996;**35**:883–5.
12. Garg RK. Tuberculosis of the central nervous system. *Postgrad Med J* 1999;**75**:133–40.
13. Daniel TM, Debanne SM. The serodiagnosis of tuberculosis and other mycobacterial diseases by enzyme-linked immunosorbent assay. *Am Rev Respir Dis* 1987;**135**:1137–51.
14. Schlesinger N, Lardizabal A, Rao J, Rao J, McDonald R. Tuberculosis of the spine: experience in an inner city hospital. *J Clin Rheumatol* 2005;**11**:17–20.
15. Panayotopoulos P, Diennis D, Vomvoyiannis A, Galazis D. Extensive asymptomatic spinal tuberculosis in a patient with active pulmonary disease. *Practitioner* 1980;**224**:1298–300.
16. De Tavera MP, De Leon EP. Tuberculosis of the lymphatics in children; its relation to spinal tuberculosis. A clinico-radiological study. *Dis Chest* 1967;**52**:469–77.
17. Parimon T, Spitters CE, Muangman N, Euathrongchit J, Oren E, Narita M. Unexpected pulmonary involvement in extrapulmonary tuberculosis patients. *Chest* 2008;**134**:589–94.
18. Marks SM, Taylor Z, Qualls NL, Shrestha-Kuwahara RJ, Wilce MA, Nguyen CH. Outcomes of contact investigations of infectious tuberculosis patients. *Am J Respir Crit Care Med* 2000;**162**:2033–8.
19. Shaw JB, Wynn-Williams N. Infectivity of pulmonary tuberculosis in relation to sputum status. *Am Rev Tuberc* 1954;**69**:724–32.
20. Underwood BR, White VL, Baker T, Law M, Moore-Gillon JC. Contact tracing and population screening for tuberculosis—who should be assessed? *J Public Health Med* 2003;**25**:59–61.
21. Reichler MR, Reves R, Bur S, Thompson V, Mangura BT, Ford J, et al. Evaluation of investigations conducted to detect and prevent transmission of tuberculosis. *JAMA* 2002;**287**:991–5.
22. Kwanjana IH, Harries AD, Hargreaves NJ, Van Gorkom J, Ringdal T, Salaniponi FM. Sputum-smear examination in patients with extrapulmonary tuberculosis in Malawi. *Trans R Soc Trop Med Hyg* 2000;**94**:395–8.
23. Schmidek HH, Hardy MA. Pulmonary tuberculosis with normal chest radiographs: report of eight cases. *Can Med Assoc J* 1967;**97**:178–80.
24. Husen L, Fulkerson LL, Del Vecchio E, Zack MB, Stein E. Pulmonary tuberculosis with negative findings on chest X-ray films: a study of 40 cases. *Chest* 1971;**60**:540–2.
25. Miller WT, MacGregor RR. Tuberculosis: frequency of unusual radiographic findings. *AJR Am J Roentgenol* 1978;**130**:867–75.
26. Pepper T, Joseph P, Mwenya C, McKee GS, Haushalter A, Carter A, et al. Normal chest radiography in pulmonary tuberculosis: implications for obtaining respiratory specimen cultures. *Int J Tuberc Lung Dis* 2008;**12**:397–403.
27. Perlman DC, el-Sadr WM, Nelson ET, Matts JP, Telzak EE, Salomon N, et al. Variation of chest radiographic patterns in pulmonary tuberculosis by degree of human immunodeficiency virus-related immunosuppression. The Terry Beirn Community Programs for Clinical Research on AIDS (CPCRA). The AIDS Clinical Trials Group (ACTG). *Clin Infect Dis* 1997;**25**:242–6.
28. Palmieri F, Girardi E, Pellicelli AM, Rianda A, Bordi E, Rizzi EB, et al. Pulmonary tuberculosis in HIV-infected patients presenting with normal chest radiograph and negative sputum smear. *Infection* 2002;**30**:68–74.
29. Post FA, Wood R, Pillay GP. Pulmonary tuberculosis in HIV infection: radiographic appearance is related to CD4+ T-lymphocyte count. *Tuber Lung Dis* 1995;**76**:518–21.
30. Swaminathan S, Paramasivan CN, Kumar SR, Mohan V, Venkatesan P. Unrecognised tuberculosis in HIV-infected patients: sputum culture is a useful tool. *Int J Tuberc Lung Dis* 2004;**8**:896–8.
31. Greenberg SD, Frager D, Suster B, Walker S, Stavropoulos C, Rothpearl A. Active pulmonary tuberculosis in patients with AIDS: spectrum of radiographic findings (including a normal appearance). *Radiology* 1994;**193**:115–9.
32. Long R, Maycher B, Scalcini M, Manfreda J. The chest roentgenogram in pulmonary tuberculosis patients seropositive for human immunodeficiency virus type 1. *Chest* 1991;**99**:123–7.
33. Aderaye G, Bruchfeld J, Assefa G, Feleke D, Källenius G, Baat M, et al. The relationship between disease pattern and disease burden by chest radiography, *M. tuberculosis* load, and HIV status in patients with pulmonary tuberculosis in Addis Ababa. *Infection* 2004;**32**:333–8.
34. FitzGerald JM, Grzybowski S, Allen EA. The impact of human immunodeficiency virus infection on tuberculosis and its control. *Chest* 1991;**100**:191–200.
35. Pitchenik AE, Rubinson HA. The radiographic appearance of tuberculosis in patients with the acquired immune deficiency syndrome (AIDS) and pre-AIDS. *Am Rev Respir Dis* 1985;**131**:393–6.
36. Pedro-Botet J, Gutierrez J, Miralles R, Coll J, Rubies-Prat J. Pulmonary tuberculosis in HIV-infected patients with normal chest radiographs. *AIDS* 1992;**6**: 91–3.
37. Pablos-Mendez A, Sterling TR, Frieden TR. The relationship between delayed or incomplete treatment and all-cause mortality in patients with tuberculosis. *JAMA* 1996;**276**:1223–8.
38. Leung AN. Pulmonary tuberculosis: the essentials. *Radiology* 1999;**210**:307–22.
39. Leung AN, Brauner MW, Gamsu G, Mlika-Cabanne N, Ben Romdhane H, Carette MF, et al. Pulmonary tuberculosis: comparison of CT findings in HIV-seropositive and HIV-seronegative patients. *Radiology* 1996;**198**:687–91.
40. Kramer F, Modilevsky T, Waliany AR, Leedom JM, Barnes PF. Delayed diagnosis of tuberculosis in patients with human immunodeficiency virus infection. *Am J Med* 1990;**89**:451–6.
41. Marciniuk DD, McNab BD, Martin WT, Hoeppner VH. Detection of pulmonary tuberculosis in patients with a normal chest radiograph. *Chest* 1999;**115**:445–52.
42. Small PM, Hopewell PC, Schecter GF, Chaisson RE, Goodman PC. Evolution of chest radiographs in treated patients with pulmonary tuberculosis and HIV infection. *J Thorac Imaging* 1994;**9**:74–7.
43. Barnes PF, Verdegem TD, Vachon LA, Leedom JM, Overturf GD. Chest roentgenogram in pulmonary tuberculosis. New data on an old test. *Chest* 1988;**94**:316–20.
44. Choyke PL, Sostman HD, Curtis AM, Ravin CE, Chen JT, Godwin JD, et al. Adult-onset pulmonary tuberculosis. *Radiology* 1983;**148**:357–62.
45. Gatner EM, Burkhardt KR. Correlation of the results of X-ray and sputum culture in tuberculosis prevalence surveys. *Tubercle* 1980;**61**:27–31.
46. Hadlock FP, Park SK, Awe RJ, Rivera M. Unusual radiographic findings in adult pulmonary tuberculosis. *AJR Am J Roentgenol* 1980;**134**:1015–8.
47. Korzeniewska-Kosela M, Krysl J, Mäller N, Black W, Allen E, FitzGerald JM. Tuberculosis in young adults and the elderly. A prospective comparison study. *Chest* 1994;**106**:28–32.
48. Miller WT. Tuberculosis in the normal host: radiological findings. *Semin Roentgenol* 1993;**28**:109–18.
49. Woodring JH, Vandiviere HM, Fried AM, Dillon ML, Williams TD, Melvin IG. Update: the radiographic features of pulmonary tuberculosis. *AJR Am J Roentgenol* 1986;**146**:497–506.
50. Elliott AM, Namaambo K, Allen BW, Luo N, Hayes RJ, Pobee JO, et al. Negative sputum smear results in HIV-positive patients with pulmonary tuberculosis in Lusaka, Zambia. *Tuber Lung Dis* 1993;**74**:191–4.
51. Hernandez-Garduno E, Cook V, Kunimoto D, Elwood RK, Black WA, FitzGerald JM. Transmission of tuberculosis from smear negative patients: a molecular epidemiology study. *Thorax* 2004;**59**:286–90.
52. Behr MA, Warren SA, Salamon H, Hopewell PC, Ponce de Leon A, Daley CL, et al. Transmission of *Mycobacterium tuberculosis* from patients smear-negative for acid-fast bacilli. *Lancet* 1999;**353**:444–9.
53. Tudo G, Gonzalez-Martin J, Obama R, Rodriguez JM, Franco JR, Espasa M, et al. Molecular epidemiology of tuberculosis in the Bata and Malabo districts of Equatorial Guinea. *Int J Tuberc Lung Dis* 2004;**8**:1458–63.
54. Grzybowski S, Allen EA. The challenge of tuberculosis in decline. A study based on the epidemiology of tuberculosis in Ontario, Canada. *Am Rev Respir Dis* 1964;**90**:707–20.
55. Rose CE, Zerbe GO, Lantz SO, Bailey WC. Establishing priority during investigation of tuberculosis contacts. *Am Rev Respir Dis* 1979;**119**:603–9.
56. Baydur A. The spectrum of extrapulmonary tuberculosis. *West J Med* 1977;**126**:253–62.
57. Jensen PA, Lambert LA, Iademarco MF, Ridzon R. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care settings, 2005. *MMWR Recomm Rep* 2005;**54**(RR-17):1–141.
58. Mandell GL, Bennett JE, Dolin R, (Eds.), Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases 6th edition. Philadelphia: Elsevier Churchill Livingstone; 2005, p. 1329–1330.
59. Saral Y, Coskun BK, Ozturk P, Bulut Y, Cobanoglu B. Multiple metastatic tuberculosis abscesses in a patient with Pott disease and lung tuberculosis: a case report. *J Cutan Pathol* 2005;**32**:629–33.
60. Bennink R, Drieskens O, Drieskens L, Kebooms L. Tc-99m tetrofosmin uptake in pulmonary tuberculosis with Pott's disease. *Clin Nucl Med* 1998;**23**:851–3.
61. Park HS, Song YJ. Multiple tuberculoma involving the brain and spinal cord in a patient with miliary pulmonary tuberculosis. *J Korean Neurosurg Soc* 2008;**44**:36–9.
62. Leibert E, Schluger NW, Bonk S, Rom WN. Spinal tuberculosis in patients with human immunodeficiency virus infection: clinical presentation, therapy and outcome. *Tuber Lung Dis* 1996;**77**:329–34.
63. Alame T, Dierckx P, Ninane V, Sergysels R. Spinal tuberculosis: a report of five cases and a review. *Monaldi Arch Chest Dis* 1996;**51**:362–8.
64. Marcq M, Sharma OP. Tuberculosis of the spine: a reminder. *Chest* 1973;**63**: 403–8.
65. Dass B, Puet TA, Watanakunakorn C. Tuberculosis of the spine (Pott's disease) presenting as 'compression fractures'. *Spinal cord* 2002;**40**:604–8.

66. Luo L, Pino J. An intradural extramedullary tuberculoma of the spinal cord in a non-HIV-infected patient: case report and review of the literature. *Lung* 2006;**184**:187–93.
67. Wurtz R, Quader Z, Simon D, Langer B. Cervical tuberculous vertebral osteomyelitis: case report and discussion of the literature. *Clin Infect Dis* 1993;**16**:806–8.
68. Mann K. Lung lesions in skeletal tuberculosis: review of 500 cases. *Lancet* 1946;**248**:744.
69. Dobson J. Tuberculosis of the spine: an analysis of the results of conservative treatment and of the factors influencing the prognosis. *J Bone Joint Surg Br* 1951;**33B**:517–31.
70. Pertuiset E, Beaudreuil J, Liote F, Horusitzky A, Kemiche F, Richette P, et al. Spinal tuberculosis in adults. A study of 103 cases in a developed country, 1980–1994. *Medicine (Baltimore)* 1999;**78**:309–20.
71. Ramdurg SR, Gupta DK, Suri A, Sharma BS, Mahapatra AK. Spinal intramedullary tuberculosis: a series of 15 cases. *Clin Neurol Neurosurg* 2009;**111**:115–8.
72. Kumar K, Saxena MB. Multifocal osteoarticular tuberculosis. *Int Orthop* 1988;**12**:135–8.
73. Khorvash F, Javadi AA, Izadi M, Jafari NJ, Ranjbar R. Spinal tuberculosis: a major public health hazard in Isfahan. *Pakistan J Biol Sci* 2007;**10**:3400–4.
74. Chung SM, Kim NH, Kim YA, Kang ES, Park BM. Clinical studies of tuberculosis of the spine. *Yonsei Med J* 1978;**19**:96–104.
75. Ikem IC, Bamgboye EA, Olasinde AA. Spinal tuberculosis: a 15 year review at OAUTHC Ile-Ife. *Nigerian Postgrad Med J* 2001;**8**:22–5.
76. Bahemuka M, Murungi JH. Tuberculosis of the nervous system. A clinical, radiological and pathological study of 39 consecutive cases in Riyadh, Saudi Arabia. *J Neurol Sci* 1989;**90**:67–76.
77. Sayi EN, Mlay SM. Tuberculosis of the spine in children at Muhimbili Medical Centre, Dar es Salaam. *East Afr Med J* 1995;**72**:46–8.
78. Smith AD. Tuberculosis of the spine. Results in 70 cases treated at the New York Orthopaedic Hospital from 1945 to 1960. *Clin Orthop Relat Res* 1968;**58**:171–6.
79. Omari B, Robertson JM, Nelson RJ, Chiu LC. Pott's disease. A resurgent challenge to the thoracic surgeon. *Chest* 1989;**95**:145–50.
80. Alvarez S, McCabe WR. Extrapulmonary tuberculosis revisited: a review of experience at Boston City and other hospitals. *Medicine (Baltimore)* 1984;**63**:25–55.
81. Lafond EM. An analysis of adult skeletal tuberculosis. *J Bone Joint Surg Am* 1958;**40–A**:346–64.