

CHEST[®]

Official publication of the American College of Chest Physicians



Diagnosis and Treatment of Tuberculous Pleural Effusion in 2006

Arun Gopi, Sethu M. Madhavan, Surendra K. Sharma and Steven A. Sahn

Chest 2007;131:880-889
DOI 10.1378/chest.06-2063

The online version of this article, along with updated information and services can be found online on the World Wide Web at:

<http://chestjournals.org/cgi/content/abstract/131/3/880>

CHEST is the official journal of the American College of Chest Physicians. It has been published monthly since 1935. Copyright 2007 by the American College of Chest Physicians, 3300 Dundee Road, Northbrook IL 60062. All rights reserved. No part of this article or PDF may be reproduced or distributed without the prior written permission of the copyright holder

(<http://www.chestjournal.org/misc/reprints.shtml>). ISSN: 0012-3692.

A M E R I C A N C O L L E G E O F



P H Y S I C I A N S[®]



Diagnosis and Treatment of Tuberculous Pleural Effusion in 2006*

Arun Gopi, MBBS; Sethu M. Madhavan, MD; Surendra K. Sharma, MD, PhD; and Steven A. Sahn, MD, FCCP

Tuberculous (TB) pleural effusion occurs in approximately 5% of patients with *Mycobacterium tuberculosis* infection. The HIV pandemic has been associated with a doubling of the incidence of extrapulmonary TB, which has resulted in increased recognition of TB pleural effusions even in developed nations. Recent studies have provided insights into the immunopathogenesis of pleural TB, including memory T-cell homing and chemokine activation. The definitive diagnosis of TB pleural effusions depends on the demonstration of acid-fast bacilli in the sputum, pleural fluid, or pleural biopsy specimens. The diagnosis can be established in a majority of patients from the clinical features, pleural fluid examination, including cytology, biochemistry, and bacteriology, and pleural biopsy. Measurement of adenosine deaminase and interferon- γ in the pleural fluid and polymerase chain reaction for *M tuberculosis* has gained wide acceptance in the diagnosis of TB pleural effusions. Although promising, these tests require further evaluation before their routine use can be recommended. The treatment of TB pleural effusions in patients with HIV/AIDS is essentially similar to that in HIV-negative patients. At present, evidence regarding the use of corticosteroids in the treatment of TB pleural effusion is not clear-cut.

(CHEST 2007; 131:880–889)

Key words: adenosine deaminase; diagnosis; corticosteroids; interferon- γ ; pathogenesis; polymerase chain reaction; treatment; tuberculous pleural effusions

Abbreviations: ADA = adenosine deaminase; AFB = acid-fast bacilli; CXCR3 = receptor 3 for CXC chemokines; EPTB = extrapulmonary tuberculosis; IFN = interferon; IL = interleukin; PCR = polymerase chain reaction; TB = tuberculosis; Th1 = T-helper type 1

Tuberculosis (TB) is a leading cause worldwide of preventable morbidity and mortality from an infectious agent. The interaction of HIV with *Mycobacterium tuberculosis* has led to its resurgence in developed nations and has increased the burden of

TB cases in developing countries.¹ TB pleural effusion, considered as a form of extrapulmonary TB (EPTB), constitutes a frequent clinical problem² and is particularly important in the present era of HIV infection, when EPTB is more commonly encountered in clinical practice.³ A pleural effusion occurs in approximately 5% of patients with TB.⁴

EPIDEMIOLOGY

A total of nine million new cases and approximately two million deaths from TB were reported in 2004.¹ Although the African region has the highest estimated incidence (356 per 100,000 population per year), the majority of patients with TB live in the most populous countries of the Asian subcontinent, which accounts for nearly half of the new cases that arise yearly.⁵ The frequency of pleural involvement

*From the Division of Pulmonary and Critical Care Medicine (Drs. Gopi, Madhavan, and Sharma), Department of Medicine, All India Institute of Medical Sciences, New Delhi, India; and Division of Pulmonary, Critical Care, Allergy and Sleep Medicine (Dr. Sahn), Medical University of South Carolina, Charleston, SC.

The authors have no conflicts of interest to disclose. Manuscript received August 17, 2006; revision accepted November 3, 2006.

Reproduction of this article is prohibited without written permission from the American College of Chest Physicians (www.chestjournal.org/misc/reprints.shtml).

Correspondence to: Steven A. Sahn, MD, FCCP, Division of Pulmonary, Critical Care, Allergy and Sleep Medicine, Medical University of South Carolina, Jonathan Lucas St, Suite 812-CSB, PO Box 250360, Charleston, SC 29426; e-mail: sahnsa@musc.edu
DOI: 10.1378/chest.06-2063

in TB has been variably reported (4% in United States to 23% in Spain).^{6,7}

TB pleural effusion is the second most common form of EPTB, only less frequent than lymph node TB. TB pleural effusion is being increasingly recognized, even in developed nations,² as the incidence of EPTB has more than doubled following the HIV pandemic. The incidence of TB pleural effusions in HIV/AIDS has been variably reported from 15 to 90%,^{8,9} with an effusion being more common in patients with higher CD4+ counts.^{10,11}

PATHOGENESIS

TB pleural effusions can manifest as primary or reactivated disease. Rupture of a subpleural caseous focus in the lung into the pleural space is considered the initial event in the pathogenesis of primary TB pleural effusions.¹² The entry of mycobacterial antigens into the pleural space is followed by an interaction with predominantly CD4+ T-lymphocytes resulting in a delayed hypersensitivity reaction.¹³ The accumulation of fluid in pleural cavity results predominantly from increased capillary permeability and secondarily from impairment of lymphatic clearance of proteins and fluid from the pleural space because of occlusion of pleural stomata.^{14,15} In contrast, reactivation disease is frequently associated with parenchymal lesions.

The delayed hypersensitivity reaction responsible for the pathogenesis of TB pleural effusions is mediated by T-helper type 1 (Th1) cells that activate macrophages to switch on mechanisms responsible for the killing of mycobacteria. A strong Th1-like immunity (interferon [IFN]- γ dominant) is essential for the containment of *M tuberculosis*, while these protective effects are antagonized by T-helper type 2 cytokines, primarily interleukin (IL)-4. The predominance of Th1 immunity in TB pleural effusions is demonstrated by the significantly higher levels of IFN- γ in pleural fluid compared to peripheral blood of the same patient.¹⁶ Flow cytometry and *in vitro* polyclonal stimulation studies have also demonstrated high levels of Th1 cells, which are predominantly of memory phenotype (CD45RA⁻). The memory T cells in TB pleural effusions typically display a surface phenotype CD62L⁻ CD11a^{high} consistent with a Th1-like cytokine profile. Therefore, selective homing of IFN- γ -biased memory T cells in TB pleural effusion is evident. The mononuclear cells infiltrating the pleura are predominantly CD4⁺ CD45RO⁺ T cells expressing C-C chemokine receptor 5 and receptor 3 for CXC chemokines (CXCR3). A strong expression of their ligands was observed in the pleural tissue of patients with TB pleural effu-

sions. Intercellular adhesion molecule-1 (CD11a-ligand) was overexpressed on capillary endothelium, and chemokines like RANTES (regulated and normal T-cell expressed and secreted), macrophage inflammatory protein-1 α (C-C chemokine receptor 5 ligands), and IFN- γ -inducible protein-10 (macrophage inflammatory protein-10) [CXCR3 ligands] were detected on mesothelial cells and/or fibroblasts. A hierarchical role of CXCR3 in controlling the inflammatory reaction in TB pleural effusions was demonstrated by *in vitro* human umbilical vein endothelial cell T-cell adherence assays.¹⁷ This denotes the importance of effector cell homing at disease sites resulting in containment of infection and emphasizes that the IFN- γ response, although critical for controlling TB infection, does not always correlate with protection.^{16,17}

CLINICAL FEATURES

In contrast to pulmonary TB, most TB pleural effusions manifest as an acute illness, with approximately one third of patients being symptomatic for < 1 week and two thirds for < 1 month.¹⁸ The most common presenting symptoms are pleuritic chest pain (75%) and nonproductive cough (70%).¹⁹ TB pleural effusion was considered a disease of the young, with a mean age of 28 years, compared to 54 years for parenchymal tuberculosis.²⁰ However, Epstein and colleagues²¹ demonstrated a rise in the median age (56 years) at presentation of TB pleural effusions with 19% of patients having reactivation disease. Therefore, pleural tuberculosis should be considered in any adult or elderly patient with a unilateral pleural effusion.

TB pleural effusions, typically unilateral and small to moderate in size, usually occupy less than two thirds of a hemithorax.²² HIV-positive patients with TB pleural effusions tend to be older, are more likely to be pleural fluid smear and culture positive for *M tuberculosis*, have a higher propensity for positive pleural biopsy,²³ and show a higher incidence of disseminated disease.²⁴ Fever, dyspnea, night sweats, fatigue, diarrhea, marked tachypnea, hepatosplenomegaly, and lymphadenopathy are more common in HIV-infected patients. These patients tend to have a negative tuberculin skin test results, lower hemoglobin, and higher β_2 -microglobulin; their pleural fluid shows low albumin and high globulin levels.²⁴

Chronic TB empyema, an entity distinct and much less common than tuberculous pleural effusion, represents chronic, active infection of the pleural space. TB empyema can occur in several settings: (1) progression of a primary tuberculous pleural effusion

that is usually large to massive in size; (2) direct extension of infection into the pleural space from thoracic lymph nodes or a subdiaphragmatic focus; (3) hematogenous spread; (4) following pneumonectomy; and (5) following therapeutic pneumothorax that leads to lung entrapment, after Lucite ball plombage, or oleothorax. Chronic TB empyema can present as an abnormality on a routine chest radiograph or after the development of a bronchopleural fistula or empyema necessitatis.²⁵

DIAGNOSIS

The definitive diagnosis of TB pleural effusions depends on the demonstration of *M tuberculosis* in sputum, pleural fluid, or pleural biopsy specimens. Supportive evidence includes demonstration of classical TB granulomas in the pleura and elevated adenosine deaminase (ADA) and IFN- γ levels in pleural fluid.¹⁴

Sputum Examination

Traditional dogma has stated that patients with pleural TB without concomitant pulmonary disease are sputum negative and, therefore, noncontagious. However, one study²⁶ reported a remarkably high yield of mycobacterial culture (52%) in a single specimen of induced sputum with sputum smear positivity in 12% of cases. Even in patients with normal lung parenchyma on chest radiography, the yield of sputum culture in induced samples approached 55%.²⁶ Therefore, sputum induction should be pursued in resource-limited countries where invasive diagnostic procedures, such as pleural biopsy, are less accessible.

Tuberculin Skin Test

A positive tuberculin skin test result is supportive evidence in the diagnosis of TB pleural effusions in areas of low prevalence (or no vaccination); however, a negative tuberculin skin test result may occur in approximately one third of patients.²² A negative test result could result from the following: (1) anergy secondary to immunosuppression or malnourishment; (2) recent infection; (3) circulating mononuclear cells suppressing the specifically sensitized circulating T-lymphocytes in the peripheral blood^{27,28}; or (4) sequestration of purified protein derivative-reactive T-lymphocyte in pleural space.²⁸ However, results of a tuberculin skin test repeated 6 to 8 weeks later will almost always be positive.

Imaging

Chest radiography usually reveals a small-to-moderate unilateral pleural effusion. Various studies^{4,22}

report the prevalence of associated parenchymal lesions to range from 20 to 50%; although one study²⁹ reported associated parenchymal lesions in 67% of cases. Ultrasonography helps by demonstrating fibrin bands of varying lengths, mobile delicate septations, encysted pleural effusion, pleural thickening, and occasionally pleural nodules.³⁰ Contrast-enhanced CT improves the diagnostic accuracy by documenting associated parenchymal lesions and lymphadenopathy. Lung parenchymal lesions were observed in 86% of patients with TB effusion using chest CT with 37% showing features of radiologically active pulmonary TB.²⁹ CT can also detect complications associated with TB pleural effusions, such as pleural thickening, calcification, loculated effusions, empyema, empyema necessitatis, and bronchopleural fistula.³¹

THORACOCENTESIS

Pleural Fluid Examination

A TB pleural effusion is typically clear and straw colored; however, it can be turbid or serosanguinous but is virtually never grossly bloody. The effusion is virtually always an exudate.¹⁴ Pleural fluid pH is usually between 7.30 and 7.40 (rarely ever > 7.40),² although it can be < 7.30 in approximately 20% of cases.³² Pleural fluid glucose concentration is > 60 mg/dL in 80 to 85% of cases.²² Pleural fluid glucose is < 30 mg/dL in approximately 15% of cases.²¹ Although in the initial stage of illness (up to first 2 weeks), the differential cell count may reveal predominantly neutrophils,¹⁸ serial thoracenteses show a shift toward lymphocyte predominance.⁹ The older literature suggested that $> 5\%$ mesothelial cells in pleural fluid were rarely compatible with TB pleural effusions. This finding is most likely the result of chronic pleural inflammation that prevents exfoliation of mesothelial cells into pleural cavity.³³ However, there have been case reports of TB pleural effusions with numerous mesothelial cells³⁴ analogous to reports in HIV-infected individuals.³⁵ Similarly, pleural fluid eosinophilia considerably reduces the probability of TB unless the patient has a concomitant pneumothorax or a previous traumatic thoracentesis that has resulted in pleural space hemorrhage.³⁶

Pleural Fluid Smear and Culture

Direct examination of pleural fluid by Zeihl-Neelsen staining requires bacillary densities of 10,000/mL³⁷ and, therefore, detects acid-fast bacilli (AFB) in $< 10\%$ of cases.^{2,19,21,22,38,39} However, in patients with HIV coinfection, the yield of pleural

fluid microscopy is > 20%.²³ Culture requires a minimum of 10 to 100 viable bacilli and, therefore, is more sensitive with a yield ranging from 12 to 70%,¹⁹ with the majority of series showing diagnostic yields of < 30%.^{2,19,21,22,38,39} Sensitivity of mycobacterial culture can be improved by bedside inoculation of pleural fluid and by using liquid culture media or BACTEC system.⁴⁰ Moreover, the use of radiometric mycobacterial culture systems (BACTEC-460; Becton Dickinson; Rockville, MD) yields results more rapidly than the conventional method (18 days vs 33 days).^{40,41}

ADA

ADA is an enzyme in the purine salvage pathway that catalyzes the conversion of adenosine and deoxyadenosine to inosine and deoxyinosine with the release of ammonia. Although ubiquitous in distribution, it plays an important role in differentiation of lymphoid cells and is most abundant in lymphocytes (predominantly active T-lymphocytes) whose concentration is inversely related to the degree of differentiation.⁴² Piras and colleagues⁴³ for the first time in 1978 reported high levels of ADA in patients with TB pleural effusions. Subsequently, several studies⁴³⁻⁵⁷ (Table 1) have explored the usefulness of estimation of ADA activity in the diagnosis of TB pleural effusions. It was determined that a pleural fluid ADA level > 70 IU/L is highly suggestive of TB, while a level < 40 IU/L virtually excludes the diagnosis.^{14,38} A metaanalysis⁵⁸ of 40 studies published from 1966 to 1999 concluded that the test performance of ADA (sensitivity range 47.1 to 100%, and specificity range 0% to 100%) in diagnosing TB pleural effusions is reasonably good (adequate to avoid pleural biopsy in young patients from areas with high prevalence of TB).

The discrepancies in the results among the reported studies can be attributed to the use of different methods of ADA analysis, with the most frequent being the calorimetric assay by Guisti and Galanti.⁵⁹ The specificity is increased when the lymphocyte/neutrophil ratio in pleural fluid (> 0.75) is considered in conjunction with an ADA concentration > 50 IU/L.⁶⁰ When the prevalence of disease is low (*ie*, < 1%), as in developed countries, the positive predictive value may be as low as 15%, although the negative predictive value increases.⁶¹ In contrast, in areas of high prevalence, ADA measurement is an inexpensive, minimally invasive, rapid, and readily accessible test that has gained popularity because the sensitivity and specificity reach 95% and 90%, respectively.⁴¹ However, elevated ADA in lymphocyte-rich pleural effusions has been reported in other diseases, such as rheumatoid arthritis, bronchoalveolar carcinoma, mesothelioma, mycoplasma and chlamydia pneumonia, psittacosis, paragonimiasis, infectious mononucleosis, brucellosis, mediterranean fever,⁴² histoplasmosis, coccidioidomycosis,⁶¹ and in most patients with empyema.^{14,41} The levels of ADA in HIV/AIDS and postrenal transplant patients are comparable to immunocompetent individuals.^{62,63} Two isoenzymes, ADA1 and ADA2, based on their selective affinity for deoxyadenosine as a substrate, are known.⁶⁴ ADA1 is found in all cells, with the highest activity observed in lymphocytes and monocytes; whereas ADA2 isoenzyme is predominantly found in monocytes/macrophages. A study⁶⁵ has found ADA2 isoenzyme to be primarily responsible for the increased ADA activity in TB pleural effusions with a median contribution of 88%. Therefore, pleural effusion with high ADA level and ADA1/total ADA ratio of < 0.45 makes the diagnosis

Table 1—Utility of Pleural Fluid ADA in the Diagnosis of Tuberculous Pleural Effusion

Study	Year	No. of Patients	Threshold, IU/L	Sensitivity, %	Specificity, %
Piras et al ⁴³	1978	54	30	100	100
Ocana et al ⁴⁴	1983	182	45	100	97
Segura et al ⁴⁵	1989	600	71	100	92
Valdes et al ⁴⁶	1993	405	47	100	95
De Olivera et al ⁴⁷	1994	276	40	91	88
Burger et al ⁴⁸	1995	462	50	90	89
Valdes et al ⁴⁹	1996	350	47	100	91
Villena et al ⁵⁰	1996	228	33	90	85
Perez-Rodriguez et al ⁵¹	1999	103	40	89	92
Villegas et al ⁵²	2000	140	45.5	88	86
Sharma et al ⁵³	2001	75	35	83	67
Sharma et al ⁵³	2001	75	100	40	100
Reechaipichitkul et al ⁵⁴	2001	132	48	80	81
Lima et al ⁵⁵	2003	45	40	68	72
Diacon et al ⁵⁶	2003	51	50	95	89
Tahhan et al ⁵⁷	2003	62	40	91	89

of TB highly likely,⁶⁶ suggesting that isoenzyme estimation could increase the diagnostic utility of ADA in pleural effusion.

INF- γ

INF- γ , produced by T-lymphocytes, is capable of activating macrophages, increasing their bactericidal capacity against *M tuberculosis* and is involved in granuloma formation. Several studies (Table 2) have found elevated concentrations of INF- γ in TB pleural effusions, which is related to increased production at the disease site by effector T cells. The sensitivity of an elevated level varies from 78 to 100% and specificity from 95 to 100%.^{52,67-75} Comparison between different studies is not possible, as the method of estimation and units used differed. Other diseases that can cause elevated INF- γ levels in pleural fluid include hematologic malignancies⁷² and empyema.^{71,73} Immunosuppressed patients (HIV or after renal transplant) had INF- γ levels similar to immunocompetent individuals retaining its efficacy as a diagnostic test.⁷²

A metaanalysis⁷⁶ that reviewed articles from 1978 to 2000 concluded that both ADA and IFN- γ appeared to be reasonably accurate in detecting TB pleural effusions with a maximum joint sensitivity and specificity of 93% for ADA and 96% for IFN- γ . Although a few studies^{76,77} have shown IFN- γ levels to be more sensitive and specific than ADA, it is less preferred in resource-limited settings as it is more expensive and less readily available compared to ADA.⁷⁸ Two new blood tests (T-SPOT.TB [Oxford Immunotec; Oxford, UK] and QuantiFERON-TB Gold [Cellestis Limited; Carnegie, Australia]) based on detection of IFN- γ in blood have been found to be more accurate than the tuberculin skin test in the diagnosis of latent TB infection. Future research should focus on the potential efficacy of quantification of specifically activated lymphocytes in pleural fluid and blood using IFN- γ release assay in the diagnosis of pleural TB.

Polymerase Chain Reaction

Polymerase chain reaction (PCR) is based on amplification of mycobacterial DNA fragments. As TB pleural effusion is paucibacillary disease, the sensitivity could be improved by PCR, as it can detect as few as 10 mycobacteria.⁷⁹ Advantages of PCR include rapid diagnosis, improved specificity and sensitivity, and no requirement of intact immunity. Numerous studies^{52,55,80-87} (Table 3) evaluating the efficacy of PCR for diagnosis of pleural tuberculosis have shown a sensitivity ranging from 20 to 90% and specificity from 78 to 100%. The sensitivity of the nucleic acid amplification technique depends on the number of mycobacteria, their homogenous distribution in the sample, the presence of amplification inhibitors, the type of primer used, and the genomic sequence amplified.

PCR findings are positive in 100% of culture-positive TB pleural fluids and in only 30 to 60% of culture-negative pleural fluids.^{38,86} Systems amplifying DNA sequences present in multiple copies in the mycobacterial genome may be more sensitive than those that amplify targets present in a single copy.⁸⁵⁻⁸⁷ Causes of false-positive results include DNA contamination or presence of nonviable organisms. PCR of pleural biopsy tissue has 90% sensitivity and 100% specificity, the overall accuracy being similar to biopsy culture.⁸⁷ The disadvantages of PCR include high cost, risk of contamination, and the technology involved in the procedure does not permit routine diagnostic use at present.

Pleural Biopsy

Since its first description in 1955, biopsy of parietal pleura has become the most sensitive diagnostic test for TB pleural effusions. Histologic examination of tissue from the pleural biopsy may demonstrate granulomatous inflammation, caseation necrosis, or AFB. In patients with TB pleural effusions, pleural biopsy reveals granulomas in 50 to 97% of patients

Table 2—Utility of IFN- γ in the Diagnosis of Tuberculous Pleural Effusion*

Study	Year	No. of Patients	Assay Method	Threshold	Sensitivity, %	Specificity, %
Ribera et al ⁶⁷	1988	80	RIA	2 IU/mL	100	100
Shimokata et al ⁶⁸	1991	40	RIA	3.48 IU/mL	100	95
Aoki et al ⁶⁹	1994	39	ELISA	Not detectable	100	100
Wongtim et al ⁷⁰	1999	66	ELISA	240 pg/mL	95	96
Villegas et al ⁵²	2000	140	ELISA	6 IU/mL	78	97
Villena et al ⁷¹	2003	595	RIA	3.7 IU/mL	98	98
Wong et al ⁷²	2003	66	ELISA	60 pg/mL	100	100
Sharma and Banga ⁷³	2004	101	ELISA	138 pg/mL	90	97
Poyraz et al ⁷⁴	2004	45	ELISA	12 pg/mL	87	95
Gao and Tian ⁷⁵	2005	190	ELISA	61.7 pg/mL	84	96

*RIA = radioimmunoassay; ELISA = enzyme-linked immunosorbent assay.

Table 3—Utility of PCR in the Diagnosis of Tuberculous Pleural Effusion

Study	Year	No. of Patients	DNA Sequence Amplified	Sensitivity, %	Specificity, %
De Wit et al ⁸⁰	1992	84	336 base-pair sequence	81	78
De Lassance et al ⁸¹	1992	24	IS6110 insertion sequence	60	100
De Lassance et al ⁸¹	1992	24	65XD mycobacterial gene	20	100
Querol et al ⁸²	1995	107	IS6110 insertion sequence	81	98
Verma et al ⁸³	1995	67	150 base-pair sequence	63	93
Kuwano et al ⁸⁴	1995	19	16SrRNA gene (nested) Bovine tb MP 1370 gene (nested)	30 20	100 100
Villegas et al ⁵²	2000	140	IS6110 insertion sequence	74	90
Martins et al ⁸⁵	2000	73	MPB64 gene (nested)	70	88
Nagesh et al ⁸⁶	2001	60	150 base-pair sequence	70	100
Hasaneen et al ⁸⁷	2003	45	IS986 based primer	90	100
Lima et al ⁵⁵	2003	45	IS6110 insertion sequence	31	96

and culture yields mycobacteria in 39 to 80%; when both methods of diagnosis are used, the diagnostic yield is 60 to 95%.^{4,19,21,22,37,38,88,89}

Even when granulomas are not visualized, the biopsy specimen should always be examined for AFB (in 10%, only organisms may be seen in the biopsy).^{19,37} Other causes of granulomatous pleuritis, such as fungal disease, sarcoidosis, rheumatoid arthritis, and nocardial infection, need to be excluded.

Thoracoscopy

Thoracoscopy has been used extensively for the diagnosis of pleural TB and malignancy. Now with the advent of video-assisted thoroscopic surgery, there has been a renewed interest in use of thoracoscopy. Thoracoscopy may show yellow-white tubercles on the parietal pleura, reddening of pleura, and numerous adhesions. Thoracoscopy also allows targeted biopsy of suspicious lesions, which are most concentrated in the costovertebral angles. In a study⁵⁶ that compared various diagnostic modalities for TB pleural effusions, thoracoscopy was the most accurate, yet most expensive, tool for establishing the diagnosis with a diagnostic accuracy of 100% on histology and 76% positivity on culture.

Other Diagnostic Tests

Immunodiagnosis: The utilization of immunodiagnosics is hindered by its low sensitivity. Table 4 lists

the details regarding various studies^{90–95} using immunologic markers in the diagnosis of TB pleural effusions. Further studies are required to address the clinical utility of these markers.

Cytokines: Cytokine-producing cells and various cytokines have been demonstrated in pleural fluid from patients with TB pleural effusions. The emerging role of IFN- γ has been discussed (*vide supra*). Significantly higher levels of IL-6 have been demonstrated in TB effusions compared to parapneumonic and malignant pleural effusions. Furthermore, the serum/pleural fluid IL-6 ratio was significantly higher in TB pleural effusions, making it a novel marker in the differential diagnosis of exudative pleural effusions.⁹⁶ IL-1 α and tumor necrosis factor- α , produced predominantly by mononuclear phagocytes, have been shown to be present in TB pleural effusions, malignant effusions, and parapneumonic effusions with considerable overlap of its cut-off levels among these diseases.^{96,97} Levels of soluble IL-2 receptors, IL-18, immunosuppressive acidic protein, and IL-12p40 are all significantly elevated in TB pleural effusions with a decreasing order of sensitivity, with soluble IL-2 receptors being a more sensitive marker than ADA (although without statistical significance).⁹⁸

Miscellaneous Tests: Levels of pleural fluid lysozyme, a bacteriolytic enzyme, have been found to

Table 4—Immunodiagnosis of Tuberculous Pleural Effusion

Study	Year	No. of Patients	Pleural Fluid/Serum	Sensitivity, %	Specificity, %
Murate et al ⁹⁰	1990	31	Anti-purified protein derivative antibody	23	95
Caminero et al ⁹¹	1993	30	IgG anti-A60 antibody	50	100
Banchuin et al ⁹²	1990	26	Bacille Calmette-Guérin antigen	12	100
Yew et al ⁹⁴	1991	74	Tuberculostearic acid assay	68	52
Samaik et al ⁹³	1993	413	Anti-tuberculophospholipid antibody	87	100
Caminero et al ⁹⁵	1991	30	IgG anti-A60 antibody	55	100

be higher in patients with TB pleural effusions. However, a pleural fluid to serum lysozyme ratio > 1.2 has been found to be a better tool for the diagnosis of TB pleural effusions.⁹⁹ Likewise, a cut-off value for pleural fluid C-reactive protein ≥ 30 mg/dL was shown to have a sensitivity of 72% with 93% specificity, and the pleural fluid to serum ratio of C-reactive protein with a cut-off value of 0.45 had a sensitivity of 60% and 89% specificity for the diagnosis of TB pleural effusion.¹⁰⁰ Pleural fluid neopterin levels with a threshold value of 30 mmol/L had a sensitivity and specificity of 85% and 93%, respectively, for the diagnosis of TB pleural effusions.¹⁰¹

TREATMENT

Antituberculosis Drugs

The natural history of an untreated tuberculous pleural effusion is characterized by spontaneous resolution in 4 to 16 weeks with subsequent development of active pulmonary TB or EPTB in 43 to 65% of cases over the next several years.^{102,103} These data emphasize the importance of proper diagnosis and treatment of tuberculous pleural effusions. According to the directly observed treatment short-course guidelines, severely ill patients with extensive or bilateral pleural effusions and sputum positivity are given treatment under category I (treated during intensive phase with four drugs: isoniazid, rifampin, pyrazinamide, and ethambutol for 2 months followed by continuation phase of 4 months with isoniazid and rifampin). Those with a solitary TB pleural effusion should be treated with isoniazid, rifampin, and pyrazinamide for 2 months followed by 4 months of two drugs, isoniazid and rifampin.¹⁰⁴ Especially in loculated TB pleural effusions, there can be delayed resorption of pleural fluid even after completion of 6 months of treatment.¹⁰⁵

Patients with HIV/AIDS and tuberculous pleural effusion are treated similarly to those who are HIV negative. The clinician should be aware of drug interactions between highly active antiretroviral therapy and antituberculosis therapy, adverse drug reactions, and paradoxical reactions, or the immune reconstitution inflammatory syndrome; the latter is manifested by worsening symptoms, an increase in the volume of existing pleural fluid, or the development of pleural effusion during treatment.¹⁰⁶

The emergence of multidrug-resistant TB has posed a significant threat to the treatment of all forms of TB. The judicious use of second-line drugs, supervised treatment, focused clinical, radiologic and bacteriologic follow-up, and surgery at the appropriate juncture are key factors in the successful man-

agement of these patients. Innovative approaches, such as DOTS-Plus, show promise for the management of patients with multidrug-resistant TB under program conditions and appear to be hopeful for the future.¹⁰⁷

Corticosteroids

A hypersensitivity reaction to *M tuberculosis* results in granulomatous pleuritis. Corticosteroids through their antiinflammatory action may hasten fluid resorption and prevent pleural adhesions during healing. Three randomized trials^{108–110} have investigated the possible role of adjunctive oral corticosteroids in TB pleural effusion. A dose of 0.75 to 1 mg/kg/d was used for a period ranging from 4 to 12 weeks. Early resolution of clinical symptoms and signs including fever, chest pain, and dyspnea was observed.¹¹⁰ Although there was a trend toward less residual pleural fluid at the end of treatment, there was no difference in the development of residual pleural thickening or adhesions on follow-up. Residual lung function was similar between steroid and control groups at completion of treatment. All three studies^{108–110} had insufficient power to examine death as an outcome; nevertheless, no deaths occurred in the study groups. The Cochrane review stated that there was insufficient evidence to determine whether steroids are effective in treatment of TB pleural effusions.¹¹¹ There are concerns regarding the use of steroids in HIV-positive individuals due to the possibility of increased risk of opportunistic infections. On the contrary, suppression of lymphocyte activation and viral replication by steroids may slow the rate of progression of HIV disease. Because there is a lack of survival benefit and increased risk of Kaposi sarcoma, the use of steroids in HIV associated TB pleural effusions is not currently recommended.¹¹²

UNRESOLVED ISSUES AND CONCLUSIONS

There have been significant advances in the understanding of pathophysiology of TB pleural effusions. The more frequent use of imaging modalities, such as CT, and bronchoscopic techniques, such as BAL, has led to detection of underlying pulmonary TB in a larger proportion of patients. However, the implication of these findings in the treatment of patients with TB pleural effusion is unclear. Likewise, the estimation of ADA and IFN- γ in pleural fluid has gained wide acceptance in the diagnosis of TB pleural effusion. However, the use of these investigations may be limited because of availability and quality control, especially in developing nations. Porcel and Vives¹¹³ found effective prediction mod-

els to differentiate tuberculous from malignant pleural effusions based on readily available clinical (age, temperature, history of malignancy) and pleural fluid (RBC, protein, ADA, pleural to serum lactate dehydrogenase ratio) data, although further validation is needed. The proper use of corticosteroids in the treatment of TB pleural effusions remains unresolved. It is hoped that further research to clarify these issues will result in better diagnostic and therapeutic approaches to TB pleural effusions.

REFERENCES

- 1 Global tuberculosis control: surveillance, planning, financing. Geneva, Switzerland: World Health Organization, 2006; 242
- 2 Sharma SK, Mohan A. Extrapulmonary tuberculosis. *Indian J Med Res* 2004; 120:316–353
- 3 Harries AD. Tuberculosis and human immunodeficiency virus infection in developing countries. *Lancet* 1990; 335: 387–390
- 4 Siebert AF, Haynes J Jr, Middleton R, et al. Tuberculous pleural effusion: twenty-year experience. *Chest* 1991; 99: 883–886
- 5 Dye C. Global epidemiology of tuberculosis. *Lancet* 2006; 367:938–940
- 6 Reider HL, Snider DE Jr, Cauthen GM. Extrapulmonary tuberculosis in the United States. *Am Rev Respir Dis* 1990; 141:347–351
- 7 Vidal R, de Garcia J, Ruiz J, et al. Estudio controlado de 637 pacientes con tuberculosis: diagnostico y resultados terapeuticoscon esquemas de 9 y 6 meses. *Med Clin (Barc)* 1986; 87:368–370
- 8 Lababidi HMS, Gupta K, Newman T, et al. A retrospective analysis of pleural effusion in human immunodeficiency virus infected patients [abstract]. *Chest* 1994; 106:86S
- 9 Batungwanayo J, Taelman H, Allen S, et al. Pleural effusion, TB and HIV-1 infection in Kigali, Rwanda. *AIDS* 1993; 7:73–79
- 10 Jones BE, Young SMM, Antoniskis D, et al. Relationship of the manifestations of TB to CD4 cell counts in patients with human immunodeficiency virus infection. *Am Rev Respir Dis* 1993; 148:1292–1297
- 11 Ferrer JS. Pleural tuberculosis: incidence, pathogenesis, diagnosis and treatment. *Curr Opin Pulm Med* 1996; 2:327–334
- 12 Stead WW, Eichenholz A, Staus H-K. Operative and pathologic findings in twenty-four patients with syndrome of idiopathic pleurisy with effusion, presumably tuberculous. *Am Rev Respir Dis* 1955; 71:473–502
- 13 Barnes PF, Mistry SD, Cooper CL, et al. Compartmentalization of a CD4+ T lymphocyte subpopulation in tuberculous pleuritis. *J Immunol* 1989; 142:1114–1119
- 14 Light RW. Tuberculous pleural effusions. In: Light RW, ed. *Pleural diseases*. Philadelphia, PA: Williams and Wilkins, 2001
- 15 Wang NS. The preformed stomas connecting the pleural cavity and the lymphatics in the parietal pleura. *Am Rev Respir Dis* 1975; 111:12–20
- 16 Sharma SK, Mitra DK, Balamurugan A, et al. Cytokine polarization in miliary and pleural tuberculosis. *J Clin Immunol* 2002; 22:345–352
- 17 Mitra DK, Sharma SK, Dinda AK, et al. Polarized helper T cells in tubercular pleural effusion: phenotypic identity and selective recruitment. *Eur J Immunol* 2005; 35:2367–2375
- 18 Levine H, Szanto PB, Cugell DW. Tuberculosis pleurisy: an acute illness. *Arch Intern Med* 1968; 122:329–332
- 19 Berger HW, Mejra E. Tuberculous pleurisy. *Chest* 1973; 63:88–92
- 20 Aho K, Brander E, Patiala J. Studies for primary drug resistance in tuberculosis pleurisy. *Scand J Respir Dis* 1968; 63S:111–114
- 21 Epstein DM, Kline LR, Albelda SM, et al. Tuberculosis pleural effusions. *Chest* 1987; 91:106–109
- 22 Valdes L, Aivarez S, San Jose E, et al. Tuberculous pleurisy: a study of 254 patients. *Arch Intern Med* 1998; 158:2017–2021
- 23 Heyderman RS, Makunike R, Muza T, et al. Pleural tuberculous in Harare, Zimbabwe: the relationship between HIV, CD4 lymphocyte count, granuloma formation and disseminated disease. *Trop Med Int Health* 1998; 3:14–20
- 24 Richter C, Perenborn R, Mtoni I, et al. Clinical features of HIV seropositive and HIV seronegative patients with tuberculous pleural effusions in Dar es Sabam, Tanzania. *Chest* 1994; 106:1471–1475
- 25 Sahn SA, Iseman MD. Tuberculous empyema. *Semin Respir Med* 1999; 14:82–87
- 26 Conde MB, Loivos AC, Rezenda VM, et al. Yield of sputum induction in diagnosis of pleural tuberculosis. *Am J Respir Crit Care Med* 2003; 167:723–725
- 27 Ellner JJ. Pleural fluid and peripheral blood lymphocytes function in tuberculosis. *Ann Intern Med* 1978; 89:932–933
- 28 Rossi GA. Pleural effusions: evidence for selective presence of PPD specific T lymphocytes at site of inflammation in the early phase of infection. *Am Rev Respir Dis* 1987; 136:575–579
- 29 Kim HJ, Lee HJ, Kwon S-Y, et al. The prevalence of pulmonary parenchymal tuberculosis in patients with tuberculous pleuritis. *Chest* 2006; 129:1253–1258
- 30 Alchan O, Demirkazik FB, Balkanci F, et al. Tuberculous pleural effusions: ultrasonic diagnosis. *J Clin Ultrasound* 1992; 20:461–465
- 31 Choi JA, Hong KT, Chung MH, et al. CT manifestations of late sequelae in patients with tuberculous pleurisy. *AJR Am J Roentgenol* 2001; 176:441–445
- 32 Good JT, Taryle DA, Maulitz RM, et al. The diagnostic value of pleural pH. *Chest* 1980; 78:55–58
- 33 Spriggs AI, Boddington MM. Absence of mesothelial cells from tuberculous pleural effusions. *Thorax* 1960; 15:169–171
- 34 Lau KY. Numerous mesothelial cells in tuberculosis pleural effusion. *Chest* 1989; 96:438–439
- 35 Jones D, Lieb T, Narita M, et al. Mesothelial cells in tuberculous pleural effusions of HIV infected patients. *Chest* 2000; 117:289–291
- 36 Adelman M, Albelda SM, Gottliels J, et al. Diagnostic utility of pleural fluid eosinophilia. *Am J Med* 1984; 77:915–920
- 37 Bueno CE, Climente G, Castro BC, et al. Cytologic and bacteriologic analysis of fluid and pleural biopsy specimens with Copes needle. *Arch Intern Med* 1990; 150:1190–1194
- 38 Aggarwal AN, Gupta D, Jindal SK. Diagnosis of tuberculosis pleural effusion. *Indian J Chest Dis Allied Sci* 1999; 41:89–100
- 39 Sibley JC. A study of 200 cases of tuberculous pleurisy with effusion. *Ann Rev Tuberc* 1950; 62:314–323
- 40 Maartens G, Bateman ED. Tuberculous pleural effusions increased yield with besides inoculation of pleural fluid and poor diagnostic value of adenosine deaminase. *Thorax* 1991; 46:96–99
- 41 Ferrer J. Pleural tuberculosis. *Eur Respir J* 1997; 10:942–947

- 42 Sharma SK, Mohan A. Adenosine deaminase in diagnosis of tuberculosis pleural effusion. *Indian J Chest Dis Allied Sci* 1996; 38:69–71
- 43 Piras MA, Gakis C, Badroni M, et al. Adenosine deaminase activity in pleural effusion: an aid to differential diagnosis. *BMJ* 1978; 4:1751–1752
- 44 Ocana I, Vazquez JM, Sequra RM, et al. Adenosine deaminase in pleural fluids: test for diagnosis of tuberculous pleural effusion. *Chest* 1983; 84:51–53
- 45 Segura RM, Pascaual C, Ocana I, et al. Adenosine deaminase in body fluids :a useful diagnostic tool in tuberculosis. *Clin Biochem* 1989; 22:141–148
- 46 Valdes L, San Jose E, Alvarez D, et al. Diagnosis of tuberculous pleurisy using the biologic parameters adenosine deaminase, lysozyme, and interferon- γ . *Chest* 1993; 103:458–465
- 47 De Oliveira HG, Rossatto ER, Prolla JC. Pleural fluid adenosine deaminase and lymphocyte proportion: clinical usefulness in the diagnosis of tuberculosis. *Cytopathology* 1994; 5:27–32
- 48 Burger LJ, Maritz FJ, Le Roux I, et al. Use of adenosine deaminase as a diagnostic tool for tuberculous pleurisy. *Thorax* 1995; 50:672–674
- 49 Valdes L, San Jose E, Alvarez D, et al. Adenosine deaminase (ADA) isoenzyme analysis in pleural effusions: diagnostic role and relevance to the origin of increased ADA in tuberculous pleurisy. *Eur Respir J* 1996; 9:747–751
- 50 Villena V, Navarro-Gonzalez JA, Garcia-Benayas C, et al. Rapid automated determination of adenosine deaminase and lysozyme for differentiating tuberculous and nontuberculous pleural effusions. *Clin Chem* 1996; 42:218–221
- 51 Perez-Rodriguez E, Perez Walton IJ, Sanchez Hernandez JJ, et al. ADA1/ADAp ratio in pleural tuberculosis: an excellent diagnostic parameter in pleural fluid. *Respir Med* 1999; 9:816–821
- 52 Villegas MV, Labrada LA, Saravia NG. Evaluation of polymerase chain reaction, adenosine deaminase, and interferon- γ in pleural fluid for the differential diagnosis of pleural tuberculosis. *Chest* 2000; 118:1355–1364
- 53 Sharma SK, Suresh V, Mohan A, et al. A prospective study of sensitivity and specificity of adenosine deaminase estimation in the diagnosis of tuberculosis pleural effusion. *Indian J Chest Dis Allied Sci* 2001; 43:149–155
- 54 Reechaipichitkul W, Kawamatawong T, Teerajetgul Y, et al. Diagnostic role of pleural fluid adenosine deaminase in tuberculous pleural effusion. *Southeast Asian J Trop Med Public Health* 2001; 32:383–389
- 55 Lima DM, Colares JK, da Fonseca BA. Combined use of the polymerase chain reaction and detection of adenosine deaminase activity on pleural fluid improves the rate of diagnosis of pleural tuberculosis. *Chest* 2003; 124:909–914
- 56 Diacon AH, Van de Wal BW, Wyser C, et al. Diagnostic tools in tuberculous pleurisy: a direct comparative study. *Eur Respir J* 2003; 22:589–591
- 57 Tahhan M, Ugurman F, Gozu A, et al. Tumour necrosis factor- α in comparison to adenosine deaminase in tuberculous pleuritis. *Respiration* 2003; 70:270–274
- 58 Goto M, Noguchi Y, Koyama H, et al. Diagnostic value of adenosine deaminase in tuberculosis pleural effusion: a meta-analysis. *Ann Clin Biochem* 2003; 40:374–381
- 59 Guisti G, Galanti B. *Methods in enzymatic analysis*. New York NY: Academic Press, 1974; 1092–1096
- 60 Burgess LJ, Mautz FJ, Le Roux I, et al. Combined use of pleural adenosine deaminase with lymphocyte/neutrophil ratio: increased specificity for the diagnosis of tuberculous pleuritis. *Chest* 1996; 109:414–419
- 61 Galborini RL. Adenosine deaminase in the diagnosis of tuberculous pleural effusion: is it really an ideal test; a word of caution. *Chest* 2005; 127:417–418
- 62 Riantawan P, Chaowalit P, Wongsangiem M, et al. Diagnostic value of pleural fluid adenosine deaminase in tuberculous pleuritis with reference to HIV co-infection and a Bayesian analysis. *Chest* 1999; 116:97–103
- 63 Chung JH, Kim SY, Kim IS, et al. The diagnostic value of the adenosine deaminase activity in the pleural fluid of renal transplant patients with tuberculous pleural effusion. *Yonsei Med J* 2004; 45:661–664
- 64 Hirschhorn R, Ratech H. Isoenzymes of adenosine deaminase. In: Rataai MC, Scandalia JG, Whitts GS, eds. *Current topics in biological and medical research*. New York, NY: Alan R. Liss, 1980; 132–157
- 65 Ungerer JPP, Oosthuizen HM, Retief JH, et al. Significance of adenosine deaminase activity and its isoenzymes in tuberculous effusions. *Chest* 1994; 106:33–37
- 66 Gakis C. ADA1 and ADA2: diagnostic and biological role. *Eur Respir J* 1996; 9:632–633
- 67 Ribera ER, Ocana I, Vazquez JM, et al. High level of interferon γ in tuberculous pleural effusion. *Chest* 1988; 93:308–311
- 68 Shimokata K, Saka H, Musate T, et al. Cytokine content in pleural effusion. *Chest* 1991; 99:1103–1107
- 69 Aoki Y, Katoh O, Nakanishi Y, et al. A comparison study of IFN- γ , ADA and CA-125 as the diagnostic parameters in tuberculous pleuritis. *Respir Med* 1994; 88:139–143
- 70 Wongtim S, Silachamram U, Running K, et al. Interferon γ for diagnosing tuberculous pleural effusions. *Thorax* 1999; 54:921–924
- 71 Villena V, Lopez A, Pozo F, et al. Interferon γ levels in pleural fluid for diagnosis of tuberculous. *Am J Med* 2003; 115:365–370
- 72 Wong CF, Yew WW, Leung SK, et al. Assay of pleural fluid interleukin-6, tumour necrosis factor- α and interferon- γ in the diagnosis and outcome correlation of tuberculous effusion. *Respir Med* 2003; 97:1289–1295
- 73 Sharma SK, Banga A. Diagnostic utility of pleural fluid IFN- γ in tuberculosis pleural effusion. *J Interferon Cytokine Res* 2004; 24:213–217
- 74 Poyraz B, Kaya A, Ciledag A, et al. Diagnostic significance of γ -interferon in tuberculous pleurisy. *Tuberk Toraks* 2004; 52:211–217
- 75 Gao ZC, Tian RX. Clinical investigation on diagnostic value of interferon- γ , interleukin-12 and adenosine deaminase isoenzyme for tuberculous pleurisy. *Chin Med J* 2005; 118:234–237
- 76 Greco S, Girardi E, Masciangelo R, et al. Adenosine deaminase and interferon γ measurements for the diagnosis of tuberculous pleurisy: a meta-analysis. *Int J Tuberc Lung Dis* 2003; 7:777–786
- 77 Aoe K, Hiraki A, Murakami T, et al. Diagnostic significance of interferon- γ in tuberculous pleural effusions. *Chest* 2003; 123:740–744
- 78 Sharma SK, Banga A. Pleural fluid interferon- γ and adenosine deaminase levels in tuberculosis pleural effusion: a cost-effectiveness analysis. *J Clin Lab Anal* 2005; 19:40–46
- 79 Manjunath N, Shankar P, Rajan L, et al. Evaluation of a polymerase chain reaction for the diagnosis of tuberculosis. *Tubercle* 1991; 72:21–27
- 80 De Wit D, Maartens G, Steyn L. A comparative study of the polymerase chain reaction and conventional procedure for the diagnosis of tuberculous pleural effusion. *Tuberc Lung Dis* 1992; 73:262–267
- 81 De Lassance A, Lecossier D, Pierre C, et al. Detection of mycobacterial DNA in pleural fluid by means of PCR: comparison of two protocols. *Thorax* 1992; 47:265–269

- 82 Querol JM, Minquez J, Garcia Sanchez E, et al. Rapid diagnosis of pleural tuberculosis by PCR. *Am J Respir Crit Care Med* 1995; 152:1977–1981
- 83 Verma A, Das Gupta N, Aggarwal AN, et al. Utility of a *Mycobacterium tuberculosis* GC-rich repetitive sequence in the diagnosis of tuberculous pleural effusion by PCR. *Indian J Biochem Biophys* 1995; 32:429–436
- 84 Kuwano K, Minamide W, Kusunoki S, et al. Evaluation of nested polymerase chain reaction for detecting mycobacterial DNA in pleural fluid. *Kansenshogaku Zasshi* 1995; 69:175–180
- 85 Martins LC, Paschoal IA, Von Nowakowski A, et al. Nested-PCR using MPB64 fragment improves the diagnosis of pleural and meningeal tuberculosis. *Rev Soc Bras Med Trop* 2000; 33:253–257
- 86 Nagesh BS, Sehgal S, Jindal SK, et al. Evaluation of polymerase chain reaction for detection of *Mycobacterium tuberculosis* in pleural fluid. *Chest* 2001; 119:1737–1741
- 87 Hasaneen NA, Zaki ME, Shalaby HM, et al. Polymerase chain reaction of pleural biopsy is a rapid and sensitive method of the diagnosis of tuberculous pleural effusion. *Chest* 2003; 124:2105–2111
- 88 Kumar S, Seshadri MS, Koshi G, et al. Diagnosing tuberculous pleural effusion comparative sensitivity of mycobacterial culture and histopathology. *BMJ* 1981; 283:20
- 89 Prakash UBS, Reiman HM, Comparison of needle biopsy with cytologic analysis for the evaluation of pleural effusion: analysis of 414 cases. *Mayo Clin Proc* 1985; 60:158–164
- 90 Murate T, Mizoguchi K, Amano H, et al. Antipurified-protein-derivative antibody in tuberculous pleural effusions. *Chest* 1990; 97:670–673
- 91 Caminero JA, deCastro FP, Carrila T, et al. Diagnosis of pleural tuberculosis by detection of specific IgG anti-antigen 60 in serum and pleural fluid. *Respiration* 1993; 60:58–61
- 92 Banchuin N, Wongurajana S, Pumprueg U, et al. Value of an ELISA for mycobacterial antigen detection as a routine diagnostic test of pulmonary tuberculosis. *Asian Pac J Allergy Immunol* 1990; 8:5–11
- 93 Sarnaik RM, Sharma M, Kate SK, et al. Serodiagnosis of tuberculosis: assessment of kaolin agglutination test. *Tuberc Lung Dis* 1993; 74:405–406
- 94 Yew WW, Chen CY, Kwan SY, et al. Diagnosis of tuberculous pleural effusion by the detection of tuberculostearic acid in pleural aspirates. *Chest* 1991; 100:1261–1263
- 95 Caminero JA, deCastro FR, Carillo T, et al. Antimycobacterial antibody in tuberculous pleural effusions: reliability of antigen 60. *Chest* 1991; 99:1315–1316
- 96 Shimokata K, Saka H, Musate T, et al. Cytokine content in pleural effusion. *Chest* 1991; 99:1103–1107
- 97 Xirouchaki N, Tzanakis N, Bouros D, et al. Diagnostic value of interleukin-1 α , interleukin-6, and tumor necrosis factor in pleural effusions. *Chest* 2002; 121:815–820
- 98 Akio H, Keisuke A, Ryosuke E, et al. Comparison of six biological markers for the diagnosis of tuberculous pleuritis. *Chest* 2004; 125:987–989
- 99 Fontan-Bueso J, Veera H, Perez J, et al. Diagnostic value of simultaneous determination of pleural adenosine deaminase and pleural lysozyme/serum lysozyme ratio in pleural effusion. *Chest* 1988; 93:303–307
- 100 Nitipatana CL, Apichart K, Angkana C, et al. A simple C-reactive protein measurement for the differentiation between tuberculous and malignant pleural effusion. *Respirology* 2004; 9:66–69
- 101 Tozkoparan E, Deniz O, Cakir E, et al. The diagnostic values of serum, pleural fluid and urine neopterin measurements in tuberculous pleurisy. *Int J Tuberc Lung Dis* 2005; 9:1040–1045
- 102 Patiala J. Initial tuberculous pleuritis in Finnish armed forces in 1939–1945 with special reference to eventual post pleuritic tuberculosis. *Acta Tuberc Scand* 1954; 36:1–57
- 103 Roper WH, Waring JJ. Primary serofibrinous pleural effusion in military personnel. *Am Rev Respir Dis* 1955; 71:616–634
- 104 Maher D, Chaulet P, Spinaci S, et al. Treatment of tuberculosis: guidelines for national programmes. Geneva, Switzerland: World Health Organization, 1997
- 105 Han DH, Song JW, Chung HS, et al. Resolution of residual pleural disease according to time course in tuberculous pleurisy during and after the termination of antituberculosis medication. *Chest* 2005; 128:3240–3245
- 106 Al-Majed SA. Study of paradoxical response to chemotherapy in tuberculous pleural effusion. *Respir Med* 1996; 90:211–214
- 107 Sharma SK, Mohan A. Multidrug-resistant tuberculosis: a menace that threatens to destabilize tuberculosis control. *Chest* 2006; 130:261–272
- 108 Wyser C, Walz G, Smedema JP, et al. Corticosteroids in the treatment of tuberculous pleurisy: a double-blind, placebo-controlled, randomized study. *Chest* 1996; 110:333–338
- 109 Galarza I, Canete C, Granados A, et al. Randomised trial of corticosteroids in the treatment of tuberculous pleurisy. *Thorax* 1995; 50:1305–1307
- 110 Lee CH, Wang WJ, Lan RS, et al. Corticosteroids in the treatment of tuberculous pleurisy: a double-blind, placebo-controlled, randomized study. *Chest* 1988; 94:1256–1259
- 111 Matchaba PT, Volmink J. Steroids for treating tuberculous pleurisy. *Cochrane Database System Review*. 2000 (2): CD001876
- 112 Elliott AM, Luzzi H, Quigley MA, et al. Trial of the use of prednisolone as an adjunct to treatment in HIV-1-associated pleural tuberculosis. *J Infect Dis* 2004; 190:869–878
- 113 Porcel JM, Vives M. Differentiating tuberculous from malignant pleural effusions: a scoring model. *Med Sci Monit* 2003; 9:CR227–CR232

Diagnosis and Treatment of Tuberculous Pleural Effusion in 2006
Arun Gopi, Sethu M. Madhavan, Surendra K. Sharma and Steven A. Sahn
Chest 2007;131;880-889
DOI 10.1378/chest.06-2063

This information is current as of April 26, 2007

Updated Information & Services	Updated information and services, including high-resolution figures, can be found at: http://chestjournals.org/cgi/content/full/131/3/880
References	This article cites 96 articles, 46 of which you can access for free at: http://chestjournals.org/cgi/content/full/131/3/880#BIBL
Permissions & Licensing	Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: http://chestjournals.org/misc/reprints.shtml
Reprints	Information about ordering reprints can be found online: http://chestjournals.org/misc/reprints.shtml
Email alerting service	Receive free email alerts when new articles cite this article sign up in the box at the top right corner of the online article.
Images in PowerPoint format	Figures that appear in CHEST articles can be downloaded for teaching purposes in PowerPoint slide format. See any online article figure for directions.

A M E R I C A N C O L L E G E O F



P H Y S I C I A N S[®]