

CT of Pulmonary Tuberculosis in Children¹

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This paper illustrates the spectrum of CT findings of pulmonary tuberculosis in children and shows the advantages and complementary nature of CT compared with conventional radiography. Common CT manifestations of pulmonary tuberculosis in children are mediastinal or hilar lymphadenopathy, air-space consolidation, atelectasis, and disseminated nodules. CT is useful in the detection of the disease in equivocal chest radiographs, in the characterization of lesions, by demonstrating caseation necrotic areas, calcification and bronchogenic spread nodules, and in defining the extent of the disease and its complications. This information will be helpful in the diagnosis and evaluation of tuberculosis in children.

Index Words : Children, respiratory system
Lung, CT
Tuberculosis, pulmonary

INTRODUCTION

Tuberculosis in children remains an important cause of morbidity and mortality worldwide. In Western countries, children represent one of the high-risk groups in the resurgence of tuberculosis and early diagnosis is the key to controlling this disease(1, 2). Because bacteriological confirmation is difficult to obtain in children, a plain radiograph along with contact screening and the tuberculin skin test, is an integral ingredient in the early diagnosis of tuberculosis in the pediatric age group. CT is not routinely used in the evaluation of pediatric patients with pulmonary tuberculosis, but unusual presentations or complications of the disease frequently occur, prompting the use of CT. Its findings in cases of pulmonary tuberculosis have been previously described, but mainly in adults with postprimary tuberculosis(3, 4). This paper illustrates the spectrum of CT findings of pulmonary tuberculosis in children and shows both the advantages and complemen-

tary nature of CT compared with conventional radiography.

Pathogenesis

In 90% of cases, the portal of entry of the tubercle bacillus in children is by inhalation. Since children produce little sputum, tuberculosis is seldom spread from child to child. Most often the child is infected by the sputum of an adult caretaker. Congenital infection is extremely rare.

There is usually a single small primary focus, located in 70% of cases in the middle, lower lobes and the subpleural region(5). Here, organisms multiply, spread to regional lymph nodes, are eventually disseminated by lymphohematogenous routes to other regions of the lung and extrapulmonary sites. In most cases, primary tuberculosis remains clinically silent, as the body contains the initial infection through the development of a delayed hypersensitivity response and granuloma formation at 1–3 weeks. Of those exposed, active tuberculosis develops in only 5–10%. It may take the form of local progression of the initial infection, uncontrolled dissemination, or as reactivation of a dormant organism at a later stage.

Primary Pulmonary Tuberculosis

Mediastinal and hilar lymphadenopathy is a radiologic hallmark of primary tuberculosis in childhood. Enlarged lymph nodes, although almost always pres-

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ent, may be difficult to identify on the chest radiograph and CT can be used to identify or confirm the adenopathy. The right paratracheal nodes are most often involved, followed by the right tracheobronchial, hilar and subcarinal nodes(Fig. 1). Multiple nodal involvement is the rule, but the manifestations of tuberculous mediastinal lymphadenitis can be only a single nodal lesion.

Characteristically, enhanced CT usually demonstrates enlarged nodes with low-attenuated centers, indicating caseation necrosis, and peripheral rim enhancement which represents inflammatory hypervascularity in granulomatous tissue(Fig. 1). Calcification within the nodes can sometimes be seen. CT can be

useful in differentiating tuberculosis from other causes of lymphadenopathy in children because these CT findings are rarely seen in other diseases such as lymphoma, metastasis, sarcoidosis, coccidioidomycosis and histoplasmosis(3). In less than 10% of cases, solid homogeneous nodes without a necrotic center can also be seen.

Parenchymal abnormalities are more common in older children than in infants and are usually combined with lymphadenopathy(2). The primary parenchymal focus is often seen in the middle or lower lobes or in anterior segments of the upper lobes(Fig. 1). This differs from postprimary pulmonary tuberculosis, which is typically located in the apical or posterior segment of

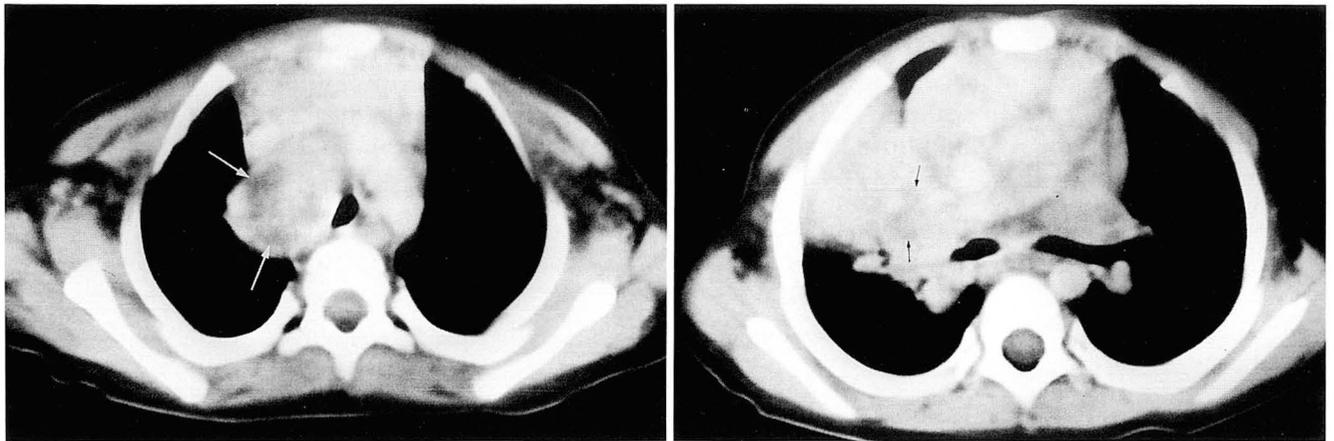


Fig. 1. Pulmonary tuberculosis causing lobar consolidation and lymphadenopathy in a 2-year-old boy.
a. CT scan shows right paratracheal lymphadenopathy with central low attenuation(arrows) and peripheral enhancement.
b. CT scan shows homogeneous dense consolidation of the anterior segment of the right upper lobe and hilar adenopathy with low-attenuation areas(arrows).

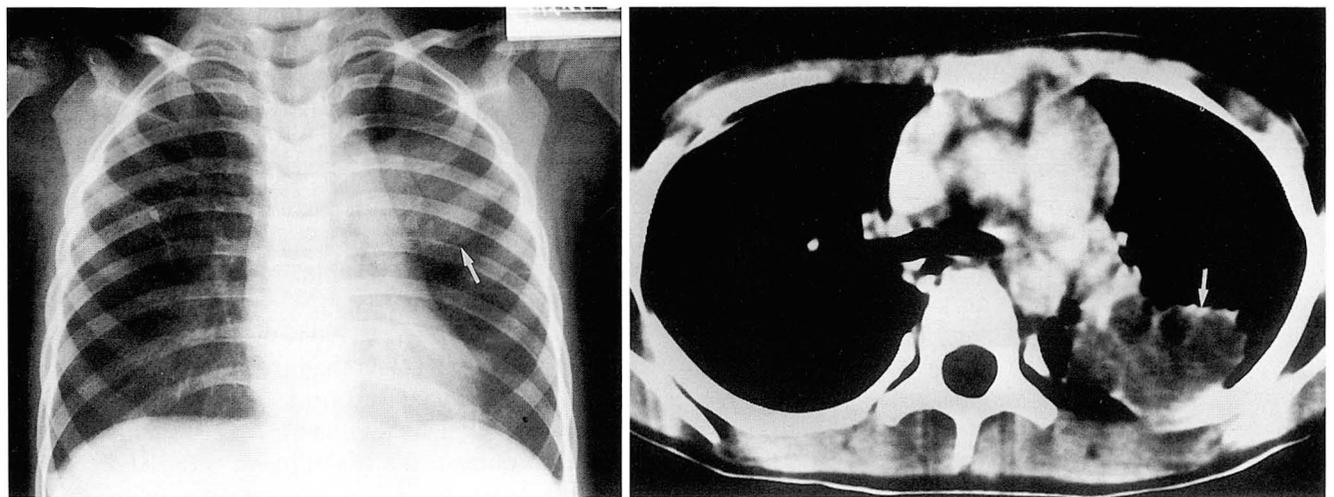


Fig. 2. Pulmonary tuberculosis appearing as a mass lesion in a 5-year-old boy.
a. Plain radiograph shows a mass-like lesion(arrow) in the left upper lobe of lung.
b. CT scan shows relatively well defined mass-like lesion(arrow) in the apicoposterior segment of the left upper lobe. The lesion is attached to the pleura and mainly composed of low-attenuation areas but has multiple thin enhancing rims.

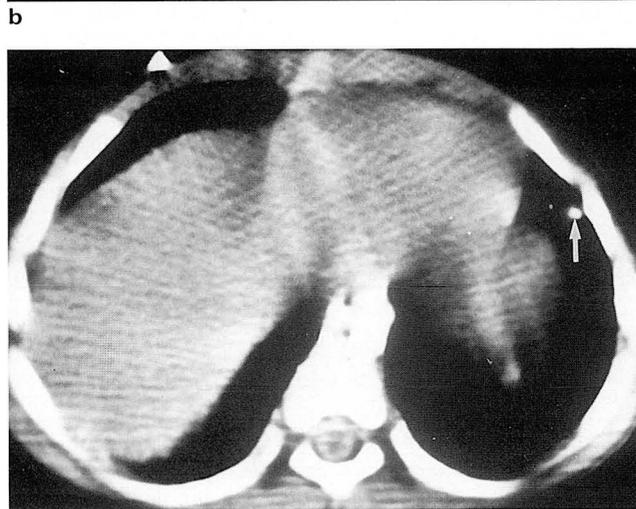
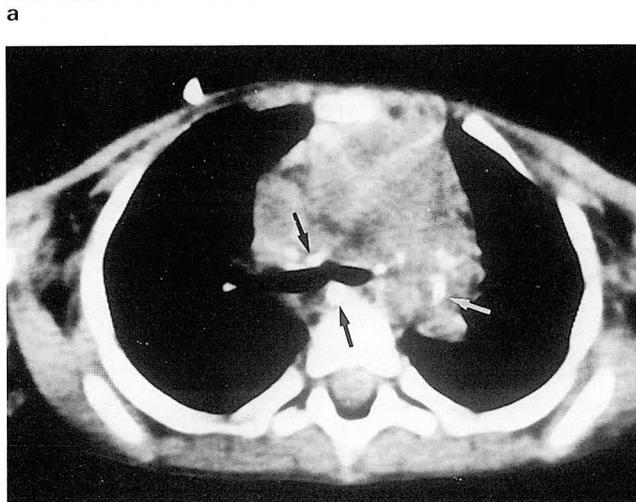
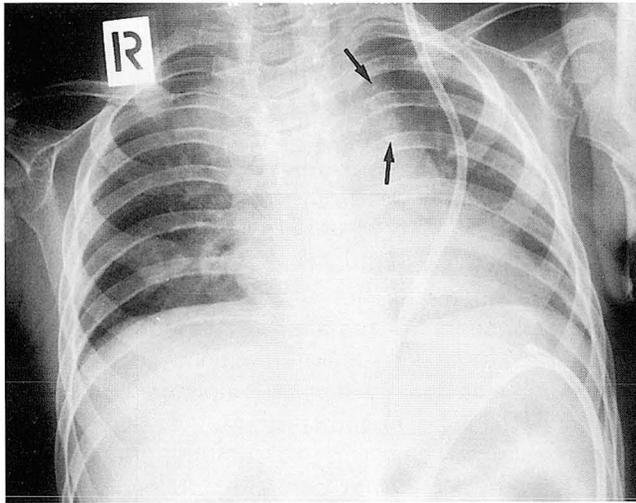


Fig. 3. Residual mediastinal lesions in a 2-year-old girl who had received 6 months' antituberculous therapy.
 a. Plain radiography shows bilateral widening of the superior mediastinum with calcifications (arrows). V-P shunt tube is for relieving hydrocephalus secondary to tuberculous meningitis.
 b, c. CT scans obtained after shunt revision show calcified small nodes in the right tracheobronchial, left hilar and subcarinal areas (arrows in b) and a small calcified nodule in periphery of the left lower lung (arrow in c).

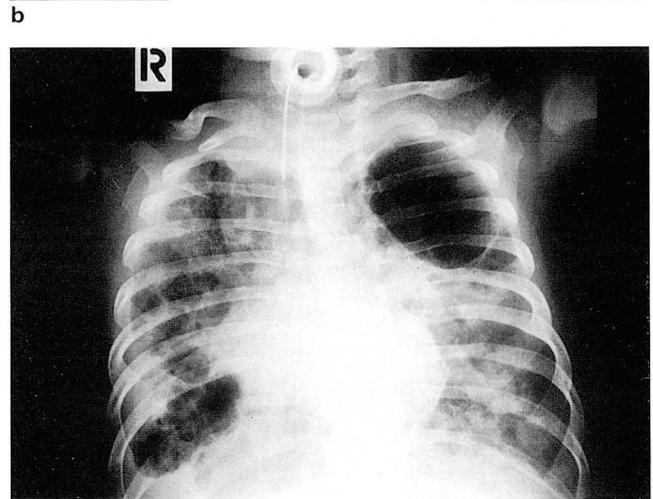
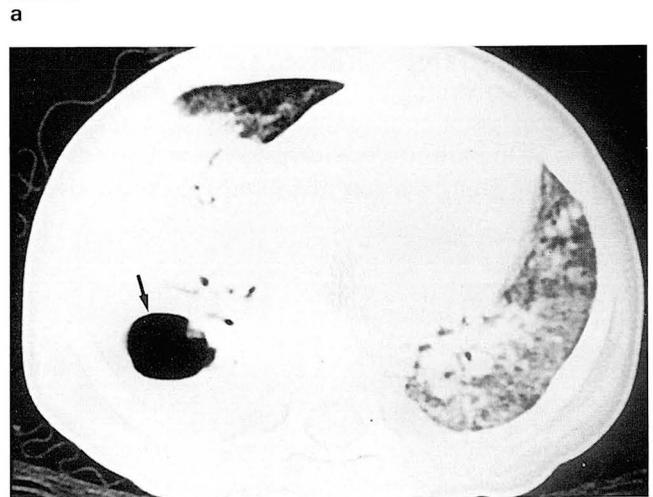
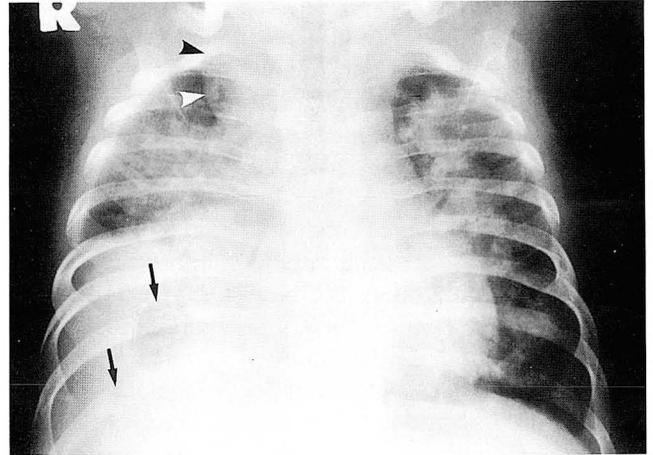


Fig. 4. Progressive primary tuberculosis in a 7-month-old infant.
 a. Plain radiograph shows bulging of the upper mediastinum (arrowheads), consolidation of the right lower lobe of lung and multifocal increased opacity in the both lungs. Multiple round radiolucencies (arrows) are seen in the right lower lobe of lung.
 b. CT scan shows air-space consolidation with a cavity (arrow) in the right lower lobe and disseminated nodules in the both lungs.
 c. Plain radiograph obtained 3 months later shows progression of the lung lesions with extensive bullae in the both lungs. Three weeks later, the infant died due to respiratory failure.

the upper lobes. CT may detect subtle parenchymal sites of primary infection that may be inconspicuous on plain radiographs. Lobar pneumonia caused by tuberculosis usually involves one lobe; the involvement of two or more lobes, or widespread disease, is uncommon. The consolidation is usually homogeneous, dense, and well defined; on CT scans, multifocal low-attenuation areas representing caseation necrosis or calcifications are occasionally seen in air-space consolidation. Cavitation of the pulmonary lesion is not common in children. Solitary or rarely multiple mass-like consolidation may be seen(Fig. 2) and needs to be differentiated from other pediatric lung tumors.

Although resolution of radiographic abnormalities in primary tuberculosis is a protracted process, parenchymal changes and lymphadenopathy usually resolve spontaneously, leaving in most cases a residual lesion that on chest radiograph is normal or minimal. Regression of lymphadenopathy usually lags behind improvement in parenchymal consolidation and residual lymphadenopathy can be identified for up to several years(Fig. 3).

Progressive Primary Pulmonary Tuberculosis

Progressive primary pulmonary tuberculosis is a rare but serious complication of initial infection and occurs most commonly in infants and in early childhood(5). In the setting of an enlarging primary focus with surrounding pneumonitis, liquefaction of the caseous center may lead to cavitation and the bronchogenic spread of expelled material, resulting in acute tuberculous pneumonia.

CT is useful in deciphering chest radiographs when extensive disease makes interpretation difficult; common CT features are dense air-space consolidation with multiple cavities, extensive lymphadenopathy and disseminated lung nodules(Fig. 4). An emphysematous or bullous lesion and pneumothorax may also occur. Differentiation from nontuberculous disease is aided by the demonstration of characteristic necrotic nodes on CT scan.

Endobronchial Tuberculosis

Tracheobronchial tuberculosis occurs from exogenous lymph node compression or from intrinsic granuloma formation following breakdown of a lobar infec-

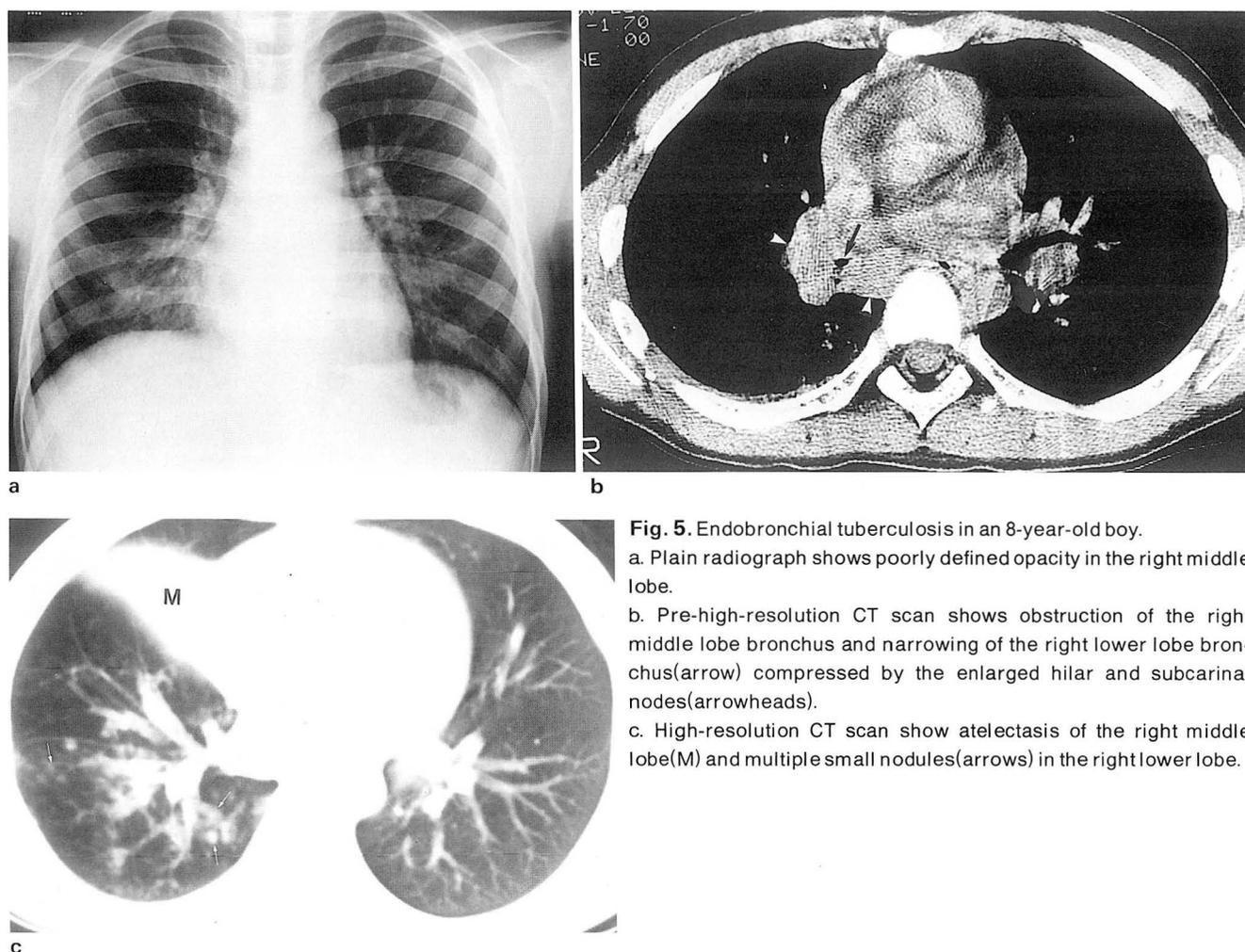


Fig. 5. Endobronchial tuberculosis in an 8-year-old boy.
 a. Plain radiograph shows poorly defined opacity in the right middle lobe.
 b. Pre-high-resolution CT scan shows obstruction of the right middle lobe bronchus and narrowing of the right lower lobe bronchus(arrow) compressed by the enlarged hilar and subcarinal nodes(arrowheads).
 c. High-resolution CT scan show atelectasis of the right middle lobe(M) and multiple small nodules(arrows) in the right lower lobe.

tion. The tracheobronchial tree of children is susceptible to compression by surrounding nodes, producing atelectasis, or less commonly, obstructive emphysema.

On CT scans, involved bronchi are stenosed or obstructed, with a peribronchial cuff of soft tissue, or peribronchial lymphadenopathy(Fig. 5). CT findings in the bronchogenic spread of tuberculosis are foci of nodular densities that vary in size. A CT scan can reveal with accuracy the extent of disseminated nodules and show subtle areas of lung involvement that are not apparent on chest radiographs. CT can be used to direct bronchoscopy and to locate appropriate sites for biopsy.

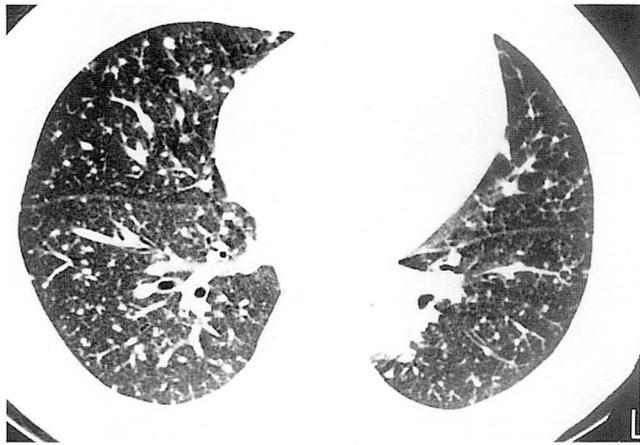


Fig. 6. Miliary tuberculosis in a 13-year-old girl. High-resolution CT scan shows well-defined 1- to 2mm nodules throughout the lungs. Plain radiograph was almost normal.

Miliary Tuberculosis

Miliary tuberculosis results when the host's defense system is overwhelmed by a massive, hematogenous dissemination of organisms. CT can detect miliary disease before it is discernible by conventional radiography. High-resolution CT scan shows poorly or well-defined nodules of 1–2 mm widely disseminated throughout the lungs(Fig. 6).

This nodular or miliary pattern is not pathognomonic of acute miliary tuberculosis because it can also be seen in histoplasmosis, cryptococcosis, viral pneumonitis, histiocytosis X, sarcoidosis, Niemann-Pick disease, lymphocytic interstitial pneumonia and metastatic neoplasm(1).



Fig. 8. Postprimary tuberculosis in a 14-year-old boy. High-resolution CT scan shows two cavities(arrows) with irregular outer margin and small peribronchiolar nodules(arrowheads) in the left upper lobe suggestive of bronchogenic spread of tuberculosis.

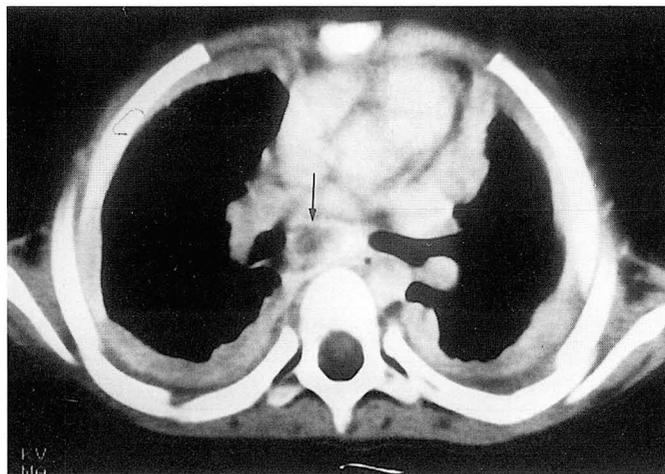
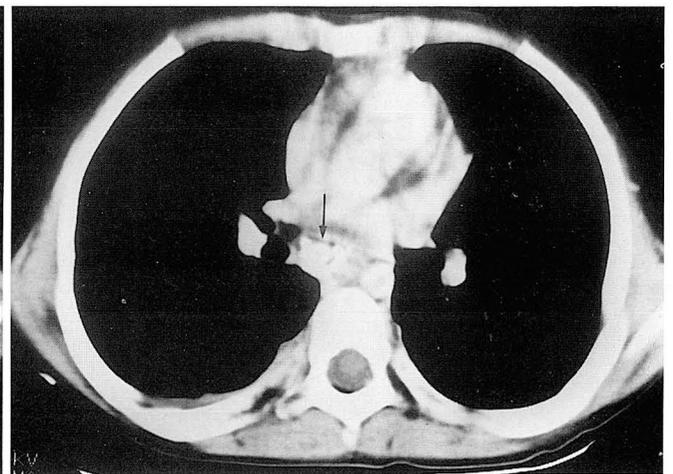


Fig. 7. Pleural tuberculosis in a 5-year-old girl.
a. CT scan shows pleural thickening and enhancement in both entire pleural space and enlarged nodes with central low attenuation(arrow) and peripheral enhancement in the subcarinal area.



b. CT scan obtained after 2 years' antituberculous therapy shows normalized pleura and calcified subcarinal node(arrow).

Pleural Tuberculosis

Pleural effusion is not a common feature of primary pulmonary tuberculosis in young children and is more likely to be observed in adolescents. It develops when subpleural foci of infection rupture into the pleural space.

A CT scan can demonstrate parenchymal tuberculosis foci abutting the pleura and mediastinal lymphadenitis(Fig. 7). Loculated pleural effusion may mimic a lung lesion and CT can differentiate a pleural mass from a lung lesion. In a case where pleural thickening is shown on a plain radiograph, CT is quite useful to determine whether it represents pleural thickening or chronic loculated effusion, which usually needs decortication.

Postprimary Pulmonary Tuberculosis

Postprimary pulmonary tuberculosis is not common in childhood. Adolescents are most commonly affected. Lymphadenopathy is less common in postprimary pulmonary tuberculosis.

CT appearance is very similar to that of adult tuberculosis ; apical location, cavity formation, bronchogenic spread nodules and scar formation(Fig. 8). CT can be useful in the detection of small cavities and in evaluation the nature of pulmonary damage.

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소아 폐결핵의 다양한 CT소견을 기술하고 CT검사의 유용성을 단순촬영과 비교하고자 한다. 소아 폐결핵의 흔한 CT소견은 종격동 또는 폐문부 임파절 비대, 폐실질 병변, 무기폐, 미만성 결절등이며, 병변내의 건락성괴사를 나타내는 저음영, 석회화, 기관지를 따라 전파된 결절등은 특징적이다. CT검사는 단순촬영에서 불명확한 병변의 발견, 특징적 소견에 의거한 진단, 병변의 범위 및 합병증등의 평가에 유용하다.