ORIGINAL ARTICLE

APPLICATION OF COMPUTED TOMOGRAPHY IN CHILDHOOD CHEST TUBERCULOSIS

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Abstract

Tuberculosis (TB) is a common and often fatal infectious disease caused by various strains of mycobacteria and in India nearly 3-4 million children have tuberculosis and another 94 million are at risk for this disease.

Aim: To compare CT and chest radiography as diagnostic tools for childhood chest tuberculosis in revealing and confirming lymphadenopathy and parenchymal lesions.

Materials and Methods: A prospective observational study was done on 50 patients aged between 2 months and 15 years of age who were clinically suspected to have TB. All 50 patients were evaluated using chest radiograph and CT Thorax and results were compared.

Results: Chest X-ray (CXR) was normal in 6 (12%) patients. CT chest detected mediastinal lymphadenopathy in 3 of them, consolidation in 2 and consolidation with mediastinal lymphadenopathy in 1 patient. The comparision between results of chest radiograph and CT showed statistically significance in detection of mediastinal lymphadenopathy (CT 70% vs CXR 56 %, p = 0.006), pleural effusion (CT 18% vs CXR 16%, p= 0.03) and consolidation (CT 48% vs CXR 36%, p = 0.030).

Conclusion: CT scan chest has advantages over conventional radiographs in diagnosing chest TB in pediatric patients and can detect the disease in patients whose chest radiographs are normal.

Introduction

Tuberculosis (TB) is a common and often fatal infectious disease caused by various strains of mycobacteria, usually mycobacterium tuberculosis (MTB) in humans. (1) World Health Organization (WHO) estimates that one-third of the world's population is infected with MTB, with the highest prevalence being in Asia. (2) The lifetime risk of developing the disease after infection is 43% in infants, 24% in children between 1 to 5 years and 15% in adolescents, compared to immunocompetent adults who have a lifetime risk of 5% to 10%. (3) Younger children also experience more severe disease like neurotuberculosis or disseminated disease. (4) In India nearly 3-4 million children have tuberculosis and another 94 million are at risk for this disease. The annual infection rate is about 3%. (5,6)

Difficulty in establishing a definitive diagnosis, presence of extra-pulmonary disease and lower public health priority are few of the challenges to estimate the burden of TB in children. Frequent radiological findings of TB in children are hilar and mediastinal lymphadenopathy with central necrosis and airspace consolidations. Chest radiographs provide important information but computed Tomography (CT) has advantages over it in diagnosing TB in pediatric patients and can detect the disease in patients whose chest radiographs are inconclusive or complications of TB are suspected. (7)

The advantage of X-ray is that it is fast, inexpensive and leaves no residual radiation, however it has its limitations because it cannot detect small lesion and lesions super-imposed on normal structures. CT scanning provides very detailed images of airways, lung- pleura, parenchyma and lymphnodes and it can detect very small lesions. However, its disadvantages lies in the fact that it is more expensive, requires IV contrast and there is always a slight chance of cancer from exposure to radiation.

We thus undertook this study to compare CT and chest radiography as diagnostic techniques in revealing and confirming lymphadenopathy or parenchymal lung lesions.

Methods & Materials

This prospective observational study was done in a tertiary health care centre of a large metropolitan city in India from January 2011 to June 2012. Approval of Institutional Ethical Committee was obtained. All hospitalized infants and children between 2 months to 14 years of age suspected to have chest TB were enrolled in the study. Patients with non-tuberculous pulmonary lesions and patients already on anti-tuberculous treatment (ATT) were excluded from the study. Patients were divided into three groups - less 5 years, 5 to 10 years and 10 to 14 years. Children less than 5 years were graded according to Indian Academy of Pediatrics classification of malnutrition and those above 5 years grouped as undernourished or not. (8) Mantoux test (MT) was performed with 0.1 ml of 5 TU PPD solution on anterior part of the forearm of patient and a test response of >10mm was considered positive. (1) Chest X-ray was done in all patients. Chest CT scans were performed after initial chest radiography for one or more of the following reasons – to evaluate unusual findings on radiographs such as mass-like lesions or widespread nodules; to find or confirm lymphadenopathy; and to detect or evaluate complications such as airway narrowing with or without atelectasis or empyema, pleural effusion, cavities and bronchiectasis. In patients with seizures or abdominal complaints additional CT scan of head and abdomen were performed. Reporting was done by a radiologist.

Zeihl Nielsen staining for acid fast bacilli (AFB) and sputum microscopy was done using gastric aspirates in younger children and sputum samples in older children. Ultrasonography of abdomen and thorax were also done respectively in patients with significant abdominal symptoms and evidence of pleural effusion. Pleural tapping was done in the patients with moderate to gross pleural effusion and sent for cytology, biochemistry and culture sensitivity.

Diagnostic criteria for definite diagnosis of TB in the children were designed based on observing at least 3 of 5 following characteristics. (9)

1. Clinical signs and symptoms of TB
2. History of close contact with a patient having TB
3. Positive radiological findings – consolidation,

mediastinal lymphadenopathy, pleural effusion, calcification, miliary TB.
4. Positive tuberculin test
5. Positive bacteriological findings for tuberculosis.

Statistical analysis was carried out using IBM SPSS statistical software. p- value was computed using Pearson Chi-Square test, Continuity Correction and Fischer's Exact test to document the significance of association for various imaging observations of CT and X-ray.

Results

Total 50 children were included in the study of which 12 (24%) were less than five years, 24 (48%) were between five and ten years and 14 (28%) were between 10 to 14 years of age. Male: female ratio was 1:1.38. Most frequent presenting complaint was fever of more than one week in 28 (56%) patients. Other clinical symptoms at the time of presentation were poor appetite in 25 (50%), cough more than two weeks in 18 (36%), weight loss in 12 (24%), breathlessness in 9 (18%), abdominal complaints in 9 (18%), cough with expectoration in 5 (10%), chest pain in 3 (6%) and seizures in 2 (4%) patients. Twenty two (44%) patients were exposed to household members suffering from pulmonary tuberculosis. In children < 5 years, 1 (8%) had no malnutrition, 4 (33.3%) had Grade I protein energy malnutrition (PEM), 5 (42.5%) had Grade II PEM, 1 (8%) had Grade III PEM and 1 (8%) had Grade IV PEM. In children 5 years or older, 35 (92%) were found to be underweight. BCG scar was present in 31 (62%) cases. Eleven patients (22%) had cervical lymphadenopathy. MT was positive in 39 (78%) patients. Of the 11 patients with negative MT test, 9 (81.1%) had mediastinal lymphadenopathy on CT chest and chest X-ray showed lymphadenopathy in 6 of them, consolidation in 2, consolidation with lymphadenopathy in 2 and miliary nodules in 1 patient. One patient was HIV infected. Two patients were sputum positive for AFB but cultures were negative. Chest X-ray findings are depicted in Table 1. Chest X-ray was normal in 6 (12%) patients but all had positive mantoux test with TB contact. Among those with normal chest X-ray, CT chest detected mediastinal lymphadenopathy in 3 (6%), consolidation in 2 (4%) and consolidation with mediastinal lymphadenopathy in 1 (2%) patient. In the present study CT scan proved to be more accurate in detecting post-primary tuberculosis such as cavitation, bronchial wall thickening, collapse, centrilobular nodules and a tree-in-bud appearance as compared to chest X-ray. X-ray detected such findings in 32.4% patients but CT scan detected it in 78% patients. CT scan detected vertebral involvement in 3 patients in form of erosion, collapse of vertebrae and paravertebral abscess. Table 2 depicts CT findings.

Table 1: X-ray findings by age

AGE (years)	Consolidation	Mediastinal widening	Pleural Effusion
< 5	5 (41.7%)	6 (50%)	2 (16.7%)
5-10	6 (25%)	15 (62.5%)	4 (16.7%)
10-14	7 (50%)	7 (50%)	2 (14.3%)

Table 2: CT thorax finding by age

AGE (years)	Consolidation	Mediastinal Lymphadenopathy	Pleural Effusion	Calcification	Necrotic nodes	Systemic Dissemination
< 5	7 (58.3%)	7 (58.3%)	1(8.3%)	4 (33.3%)	2 (16.7%)	3 (7.1%)
5-10	7 (29.2%)	19 (79.2%)	4 (16.7%)	5 (12.5%)	3 (12.5%)	6 (25%)
10-14	10 (71.4%)	9 (64.3%)	4 (28.6%)	1 (14%)	1 (7.1%)	1 (7.1%)

Chest X-ray showed consolidation in 18 patients which was confirmed on CT in 16 (88.9%). Of the remaining two, one had mediastinal lymphadenopathy and other had calcification. CT revealed consolidation in 8 (25%) other patients which was not picked up on X-ray (p=0.030). Mediastinal lymphadenopathy was confirmed in 24 (85.7%) out of 28 patients on CT, the remaining 4 had additional findings such as randomly distributed air space nodules with a "tree in bud" appearance, collapse, consolidation, mild emphysematous changes and necrotic lymphadenopathy. In 11 patients mediastinal enlarged nodes were not detected in chest x ray, but were revealed on CT scan (p= 0.0006). Out of the 28

patients in which X-ray has detected lymphadenopathy, most frequently involved nodes were hilar in 27 (96%), followed by right paratracheal in 6 (21%) and subcarinal in 1 (3%). On CT, hilar lymphnodes were most frequently involved in 21 (60%), followed by right paratracheal in 20 (57%), pretracheal in 19 (54%), subcarinal in 16 (46%), prevascular in 6 (17%), left paratracheal in 5 (14%), and para-esophageal in 3 (8%). Pleural effusion seen in chest X-ray of 8 patients which was confirmed on CT scan in 7 cases. In 2 patients, additional information about presence of empyema was obtained (p =0.031).

Discussion

Most pulmonary TB cases seen in infants are due to primary infection. It begins when the respiratory secretion from a patient with TB is inhaled and reaches the lung alveoli which then causes parenchymal inflammation. This primary focus of TB is usually not visible on chest X-ray but may progress to involve a segment or an entire lobe. (10,11) Infection then spreads to the central lymph nodes from the primary focus via draining lymphatic vessels (appearing as a linear interstitial pattern on chest radiographs) and results in regional lymphadenopathy. In most cases, these parenchymal lesions and the accompanying lymphadenopathy resolve spontaneously. (12) In some cases, especially in young infants, the involved lymph nodes continue to enlarge. Some studies report that mediastinal lymphadenopathy with or without parenchymal abnormality is a hallmark of primary tuberculosis in childhood. (10,11) In our study, X-ray appeared normal in 6 patients but they all had positive mantoux test with TB contact and CT scan showed mediastinal lymphadenopathy in 3 patients, consolidation in 2 and consolidation with mediastinal lymphadenopathy in 1 patient. In a retrospective study by Kim et al in South Korea in 1997, 41 children with TB, diagnosed with bacteriologic findings and chest x-ray were evaluated. Results of the lung CT-scan with contrast revealed hilar and mediastinal involvement in 90% of patients. (13) Computed tomography was performed by Delacourt et al (1993) in 15 children with tuberculous infection and a normal chest radiograph to measure the size of their mediastinal lymph nodes. Ten control children without tuberculosis were also evaluated. When compared with controls it was found that nine of 15 (60%) infected children had enlarged lymph nodes. (14) Thus, it appears that many infected children with normal chest radiography have unrecognized active disease.

In our study 2 patients had positive sputum smear examination, one had mediastinal lymphadenopathy with calcification on CT scan thorax and other had bronchiectasis with cavitation. X- ray picked up mediastinal lymphadenopathy in the former, but reported the latter case as normal. In a study by Khalilzadeh et al in 2003 in 20% of children, bacteriological studies of gastric fluid or sputum were positive and in 46% children radiological findings were positive. Chest x-ray was helpful in only 5% of cases and in 41% of children pulmonary CT along with simple chest x-ray showed positive results of tuberculosis involvement. (9) Thus even in bacteriological negative TB, CT chest may be useful to pick up TB.

In our study, 22% patients were MT negative but X-ray chest and CT scan confirmed the findings in all of them. Similarly in the study by Baghaie et al (2005), 38.2% cases had a negative mantoux test while CT scan indicated pulmonary involvement. (15) Therefore, tuberculin test alone cannot be an accurate diagnostic criteria.

In the present study CT scan proved to be more accurate in detecting post-primary tuberculosis such as cavitation, bronchial wall thickening, collapse, centrilobular nodules, vertebral access and tree-in-bud appearance as compared to chest X-ray. Similarly in a study by Karam et al (2002) cavitation was seen in chest radiography in 40% to 87% patients. The most common complication of tuberculous cavitation is endobronchial spread which was detected radiographically in 19% to 58% and by CT in up to 98% of cases. (16)

Though CT chest is a better diagnostic imaging technique as compared to X-ray chest, the ionizing radiation doses delivered by CT are higher than convention radiography and are in ranges that have been linked to an increased risk of cancer. The projected lifetime attributable risks of solid cancer were higher for younger patients, girls and for patients who underwent CT scans for abdomen/pelvis. Estimates show that 4,870 future cancers could be caused by the 4 million pediatric CT scans performed each year. Reducing the highest 25 percent of doses to the median (midpoint) may prevent 43 percent of these cancers. (17)

Conclusion

CT scan chest have advantages over conventional radiographs in diagnosing chest TB in pediatric patients and can detect the disease in patients whose chest radiographs are normal or equivocal. High resolution computed tomography is the most sensitive tool currently available to detect endobronchial spread, lymphadenopathy, empyema, bronchiectasis and fibrosis better than chest radiograph.

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