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Role of digital tomosynthesis and dual energy subtraction digital radiography in detection of parenchymal lesions in active pulmonary tuberculosis

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ABSTRACT

Objective: To assess the role of digital tomosynthesis (DTS) and dual energy subtraction digital radiography (DES-DR) in detection of parenchymal lesions in active pulmonary tuberculosis (TB) and to compare them with digital radiography (DR).

Materials and methods: This prospective study was approved by our institutional review committee. DTS and DES-DR were performed in 62 patients with active pulmonary TB within one week of multidetector computed tomography (MDCT) study. Findings of active pulmonary TB, that is consolidation, cavitation and nodules were noted on digital radiography (DR), DTS and DES-DR in all patients. Sensitivity, specificity, positive and negative predictive values of all 3 modalities was calculated with MDCT as reference standard. In addition presence of centrilobular nodules was also noted on DTS.

Results: Our study comprised of 62 patients (33 males, 29 females with age range 18–82 years). Sensitivity and specificity of DTS for detection of nodules and cavitation was better than DR and DES-DR. Sensitivity and specificity of DTS for detection of consolidation was comparable to DR and DES-DR. DES-DR performed better than DR in detection of nodules and cavitation. DTS was also able to detect centrilobular nodules with sensitivity and specificity of 57.4% and 86.5% respectively.

Conclusion: DTS and DES-DR perform better than DR in detection of nodules, consolidation and cavitation in pulmonary TB. DTS gives better results than DES-DR, particularly in detection of cavitation and has moderate sensitivity for detection of centrilobular nodules. Thus DTS can be used for evaluation of patients of suspected pulmonary TB, thereby giving a more confident diagnosis of active disease and also in follow up.

1. Introduction

Pulmonary TB is a common worldwide infection and is a major cause of mortality and morbidity especially in developing countries. According to World Health Organisation global tuberculosis report, globally estimated new cases of tuberculosis were 8.7 million in 2011 (125 cases per 100,000 population) with 59% of the estimated cases from Asia. India had largest number of incident cases in 2011 (2.0–2.5 million cases) and accounted for 26% of all global cases [1]. Prompt diagnosis of TB is highly desirable for adequate treatment of patients and control of disease spread. However clinical features are often non specific, thereby posing difficulty in making a definitive clinical diagnosis. The gold standard for diagnosis is demonstration of mycobacteria in respiratory secretions. However, only few patients with active TB show acid fast bacilli in their sputum. Thus a radiological diagnosis of the disease can facilitate earlier treatment for patients thereby ensuring better disease control [2]. Though CT is not confirmatory for pulmonary TB, patients with high suspicion of TB on imaging can be selected, and other diseases can be excluded [3].

Abbreviations: AEC, automatic exposure control; AFB, acid fast bacilli; ATT, antitubercular therapy; BAL, bronchoalveolar lavage; CR, computed radiography; CT, computed tomography; DES-DR, dual energy subtraction digital radiography; DR, digital radiography; DTS, digital tomosynthesis; MDCT, multidetector computed tomography; FNAC, fine needle aspiration cytology; TB, tuberculosis.

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Table 1
Baseline characteristics of study population.

Demographics:	
Age	18–82 years
Male:female	33:29
History:	
1. Cough	41 (66%)
2. Fever	32 (52%)
3. Loss of appetite and weight	14 (22.6%)
4. Loss of appetite	2 (3.2%)
5. Haemoptysis	5 (8.1%)
Diagnosis:	
1. Sputum smear positivity	20 (32.3%)
2. Sputum culture positivity	17 (27.4%)
3. BAL fluid positivity	7 (11.3%)
4. Cytological diagnosis	3 (4.8%)
5. Presumptive diagnosis	15 (24.2%)
Findings on CT:	
1. Nodules	61 (98.4%)
2. Consolidation	44 (71%)
3. Cavitation	31 (50%)
4. Centrilobular nodules	40 (64.5%)

Pulmonary mycobacterial disease can give rise to various non specific radiologic abnormalities depending upon certain host factors like age, immunity and past exposure to TB [4]. Primary TB commonly manifests as mediastinal and hilar lymphadenopathy, homogenous air space consolidation and pleural effusion (usually unilateral) [4]. Post primary TB most commonly manifests as patchy or focal heterogeneous consolidation (usually in the apical and posterior segments of the upper lobes and the superior segments of the lower lobes), ill defined nodules and cavities (seen in 20–45% of patients) [4–6].

It is important to differentiate between active and inactive pulmonary TB rather than categorizing it as primary or post primary disease, as activity of the disease will decide further course of management. Consolidation (usually patchy and multifocal), cavitation and nodules (air space as well as branching centrilobular nodules) are common radiological abnormalities in active pulmonary TB. Scattered ill defined air space nodules (usually 5–10 mm in size) and branching centrilobular nodules showing tree-in-bud appearance indicate endobronchial spread of the disease and are most helpful for establishing diagnosis of active disease [7]. According to Hatipoglu et al. [8] presence of branching centrilobular nodules with tree in bud appearance is most useful radiological feature distinguishing active form inactive TB.

Chest radiography has a major role in tubercular diagnosis, screening and follow up [2] and is often the first radiological investigation. It is easily available and imparts very low radiation dose, but has certain limitations due to overlap of anatomic structures, variable X-ray transmission, scattered radiation and variability in perception of abnormalities [9]. The diagnosis of TB on radiography is accurate in 49% of all cases – 34% in primary TB and 59% in reactivation TB [2]. So it cannot be always relied upon for an accurate diagnosis.

In cases with normal or inconclusive radiographs, multidetector computed tomography (MDCT) is the investigation of choice to assess for the extent and distribution of the disease. MDCT is accurate in 91% of patients for diagnosing TB [10]. However considering the young age of many patients and the socioeconomic burden of tuberculosis, especially in developing countries, both radiation dose and cost of MDCT remain the limiting factors.

Dual-energy subtraction digital radiography (DES-DR) and digital tomosynthesis (DTS) are recent advancements in digital radiography (DR) having certain advantages over conventional radiography, with a lower cost and radiation dose than computed tomography (CT). These modalities can be useful in better demonstration of pulmonary parenchymal abnormalities.

The purpose of our study was to prospectively assess the diagnostic performance of DES-DR and DTS in detection of parenchymal lesions in patients of active pulmonary TB, keeping MDCT as reference standard.

2. Materials and methods

This prospective study was carried out in a tertiary care hospital after approval from the institutional review committee. 70 patients were enrolled in the study with a clinical suspicion of active pulmonary TB. All the patients had undergone MDCT in the last one week. Informed written consent was obtained from all the patients. Clinical presentation and relevant investigations of all the patients were also noted.

The diagnosis of active pulmonary TB was confirmed by a positive sputum/bronchoalveolar lavage (BAL) culture for acid fast bacilli (AFB), demonstration of AFB on sputum/BAL smears or histopathological/cytological diagnosis. In few patients, diagnosis of pulmonary TB could not be confirmed on sputum, fluid or tissue sampling. In view of strong clinical and radiological suspicion of pulmonary TB, and failure to respond to antibiotics, these patients were started on anti tubercular therapy (ATT).

MDCT was done in 64/128 slice scanner depending upon the availability. Parameters for 64-detector CT system (Lightspeed VCT of GE Healthcare) were: detector collimation 64×0.625 mm; helical pitch 1.375; rotation time 0.6 s; tube voltage 120 kVp; AEC controlled tube current; 10 mm section thickness; and reconstruction at 2.5 mm using high spatial frequency reconstruction algorithm. Parameters for 128-detector CT system (Somatom definition flash by Siemens) were: detector collimation 128×0.6 mm; helical pitch 1.2; rotation time 0.5 s; tube voltage 120 kVp; Automatic exposure control (AEC) controlled tube current; 10 mm section thickness; and reconstruction at 2 mm with high spatial frequency reconstruction algorithm. MDCT images were analysed by a radiologist having 10 years of experience in chest radiology.

Table 2
Comparison of performance of DR, DES-DR and DTS: Table demonstrating sensitivity, specificity, positive and negative predictive values of DR, DES-DR and DTS in detection of lung nodules, consolidation and cavitation.

		Observer 1					Observer 2				
Lesion	Modality	Sensitivity	Specificity	PPV	NPV	*p* value	Sensitivity	Specificity	PPV	NPV	*p* value
Nodules	DR	82% (52/61)	100% (1/1)	100%	10%	.040	73.8% (45/61)	100% (1/1)	100%	5.9%	.101
	DES-DR	90.2% (55/61)	100% (1/1)	100%	14.3%	.005	85.2% (52/61)	100% (1/1)	100%	10%	.022
	DTS	98.4% (60/61)	100% (1/1)	100%	50%	.000	100% (61/61)	100% (1/1)	100%	100%	.000
Consolidation	DR	75% (33/44)	72.2% (13/18)	86.8%	54.2%	.001	77.3% (34/44)	77.8% (14/18)	89.5%	58.3%	.000
	DES-DR	88.6% (39/44)	72.2% (13/18)	88.6%	72.2%	.000	88.6% (39/44)	72.2% (13/18)	88.6%	72.2%	.000
	DTS	88.6% (39/44)	66.7% (12/18)	86.7%	70.6%	.000	88.6% (39/44)	66.7% (12/18)	86.7%	70.6%	.000
Cavitation	DR	67.7% (21/31)	83.9% (26/31)	80.8%	72.7%	.000	64.5% (20/31)	83.9% (26/31)	83.3%	81.3%	.000
	DES-DR	90.3% (28/31)	80.6% (25/31)	82.4%	89.3%	.000	80.6% (25/31)	83.9% (26/31)	83.3%	81.3%	.000
	DTS	100% (31/31)	90.3% (28/31)	91.2%	100%	.000	100% (31/31)	83.9% (26/31)	86.1%	100%	.000