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Original Research Article

A Review on Pediatric Chest Tuberculosis

Binod Kumar Choudhary

Associate Professor, Department of Respiratory Medicine, Patna Medical College and Hospital, Patna, Bihar, India

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Corresponding Author: Binod Kumar Choudhary

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Abstract

Tuberculosis (TB) commonly affects the chest in children, with the lungs being the most commonly affected area, trailed by the pleura, chest wall, and lymph nodes. Diagnosing TB in children is challenging due to the absence of obvious indications and difficulties in acquiring samples for the microbiology validation. Therefore, various imaging techniques play a crucial role in the diagnostic process and in monitoring treatment progress. It is essential to establish standardized reporting of chest radiographs when TB is suspected in order to provide an accurate diagnosis and prevent unnecessary diagnoses. This review aims to examine the imaging characteristics of chest TB in children, based on the specific areas affected, as observed through different imaging methods.

Keywords: Chest tuberculosis, Computed Tomography, Children, Imaging, Ultrasound, MRI.

Introduction

Imaging plays a vital role in the diagnostic evaluation of pediatric chest tuberculosis (CTB). The struggle in obtaining microbiological validation arises from the paucibacillary nature of tuberculosis (TB) in pediatric patients. Thoracic tuberculosis encompasses both pulmonary tuberculosis (PTB) and extrapulmonary tuberculosis (EPTB). Extrapulmonary tuberculosis (EPTB) manifests in various anatomical sites within the thoracic region, including the pleura, chest wall, and lymph nodes. The imaging manifestations of CTB have traditionally been categorized into primary disease, progressive primary disease, and post-primary (or reactivation or adult type) patterns. The aforementioned differentiation is predicated upon the temporal progression of the ailment. Multiple studies have demonstrated a convergence in the characteristics exhibited by these various manifestations. Moreover, recent investigations have elucidated, utilizing epidemiological and genetic analyses, that the pattern is primarily regulated by the host's immunity, rather than the duration since exposure [1]. This article discusses the imaging characteristics based on the location of engagement observed across different imaging modalities, instead of distinguishing between primary or post-primary pathology.

Role of Imaging

Medical imaging plays a pivotal role not only in the initial diagnostic process, but also holds equal significance in subsequent monitoring and evaluation of treatment response. Furthermore, subsequent to the resolution of the active infection, pediatric patients may exhibit clinical manifestations that can be attributed to the sequelae of the aforementioned infection. The aforementioned symptoms may manifest during the early stages of development or, alternatively, may present themselves in the later stages of adulthood, potentially spanning several years. The clinical manifestations encompass dyspnea, hemoptysis, or productive cough. The observed clinical manifestations may indicate the re-activation of TB, but they may also arise as a result of fibrotic sequelae, either with or without a secondary infection of bacteria or fungal colonization, in the absence of active TB. The differentiation between these two conditions is of utmost importance to prevent unwarranted initiation of anti-tubercular treatment (ATT). The foundation of this differentiation once again relies on the utilization of medical imaging techniques, in conjunction with the analysis of microbiological data. The objectives of medical imaging encompass the attainment of multiple objectives, while simultaneously ensuring that the patient is subjected to minimal radiation exposure and economic strain.

Imaging Modalities

Chest Radiograph

The utilization of chest radiography (CXR) continues to be the foremost imaging modality in the assessment of pediatric individuals presenting with clinical doubt of thoracic tuberculosis. CXR, nonetheless, exhibits a diminished sensitivity of

67% when compared to cross-sectional imaging modalities like CT, or MRI. Additionally, CXR is subject to substantial interobserver variability [2].

Lymphadenopathy

The identification of lymphadenopathy holds significant importance in the diagnosis of primary TB, frequently serving as the sole radiographic indication of the disease. Multiple radiographic findings have been delineated on CXR to facilitate a more objective assessment in the identification of hilar/mediastinal adenopathy. The utilization of lateral CXR proves to be more advantageous in comparison to frontal CXR when it comes to the precise detection of subcarinal nodes. Therefore, although certain facilities may not routinely employ lateral CXR, they can serve as a valuable supplementary tool when there is suspicion of lymphadenopathy based on the frontal CXR. The subcarinal/retrocarinal lymph nodes manifest as elliptical/circular opacities of pliable tissue located posteriorly and inferiorly to the bronchus intermedius, exhibiting a configuration reminiscent of a doughnut sign.

Lung Parenchymal

Modifications The requested alterations Primary TB typically exhibits a predilection for the middle and lower lobes of the right lung, as opposed to the left lung. The CXR examination demonstrates regions of heightened opacity, which manifest as consolidation, either focal or multilobar, or as nodules that are concentrated within a specific zone or distributed diffusely in a miliary pattern. The presence of consolidation may be indicative of the occurrence of cavitation.

Pleural/ Chest Wall Involvement

Furthermore, the detection of pleural effusion and the presence of bone destruction, specifically involving the ribs or vertebrae, can be observed on a CXR. Tuberculous pleural effusion is commonly characterized by the presence of a free pleural effusion accompanied by an ascending fluid level. The identification of loculations, as indicated by the convexity of the medial border of the effusion, in conjunction with observed volume reduction, is indicative of the potential development of empyema.

Standardization of CXR Report

Numerous standardized methodologies for documenting the CXR have been put forth, albeit lacking universal consensus. The utilization of the subsequent nomenclature is advocated by the authors [3]:

The term 'probable' is recommended when the radiographic findings on chest X-ray are nonspecific but may align with tuberculosis, accompanied by one of the following: a history of documented exposure, positive tuberculin skin sensitivity (TST), or a positive response to ATT.

The term 'possible' is indicated when the findings on chest X-ray are comparable to those in the probable category, but there is no documented exposure, no response to anti-tuberculosis treatment, and the tuberculin skin test is negative. If the CXR results do not align with TB, it is necessary for at least one of the following characteristics to be present: documented exposure, positive TST, or a positive response to ATT. In such cases, there is a possibility of tuberculosis [4].

Ultrasonography

The assessment of the lung using ultrasonography (USG) is a relatively recent development in medical practice, and it has become increasingly significant, particularly in the field of critical care. The presence of a thin chest wall and non-calcified costal cartilages renders USG a viable modality for assessing pleura, lung parenchyma, and lymph nodes in pediatric patients. This technique is not only cost-effective but also eliminates the need for radiation exposure, making it an appropriate choice for evaluation in this population. The incorporation of USG into CXR serves to augment the diagnostic certainty, potentially eliminating the necessity for a CT scan of the chest in numerous pediatric cases.

Mediastinal Nodes

The recent literature has demonstrated the usefulness of USG in the assessment of mediastinal nodes. Several studies have showed a higher sensitivity rate (up to 67%) when compared to CXR in the detection of mediastinal lymph nodes [5]. Any standard USG machine equipped with linear, convex/microconvex, and endocavitary probes can be utilized for this purpose. The utilization of a linear probe over the parasternal regions is recommended for the purpose of visualizing the right and left paratracheal nodes. The utilization of a suprasternal approach employing an endocavitory probe may also be considered as a viable option. The utilization of a microconvex probe is deemed most suitable for the examination of the prevascular and subcarinal nodes. Ultrasound typically does not provide visualisation of lower mediastinal and posterior mediastinal nodes. In addition to the thoracic region, a prompt abdominal USG screening has the potential to unveil periportal and other lymph nodes, as well as liver and splenic granulomas. These findings can provide valuable support in confirming the detection of TB. Hypoechoic nodes are observed as round to oval lesions in close proximity to mediastinal vessels. These findings may exhibit hyperechoic foci of calcifications or occasionally internal anechoic regions. The presence of anechoic areas within the observed structures is indicative of necrotic tissue. USG for the evaluation of mediastinal lymph nodes is subject to limitations stemming from operator dependence and a relatively protracted learning curve.

Pleural Collections

USG has been extensively employed in the assessment of pleural fluid accumulations for the purposes of identification, quantification, and guided drainages. USG aids in the identification of anechoic fluid within the pleural cavity, devoid of any pleural thickening or septations, indicative of free effusion. Alternatively, it may reveal the presence of multiple echoes, septations, and loculations accompanied by pleural thickening, characteristic of empyema. Therefore, its significance in making a determination pertaining to drainage is immeasurable.

Parenchymal Lesions

In conjunction with the examination of lymph nodes and pleura, a thorough examination of the complete chest can be performed in a systematic manner to evaluate the lung parenchyma. This evaluation aims to identify areas of consolidation or sizable nodules that are in close proximity to the pleural margin. USG has the capability to depict these regions as areas of hypoechoic nature, characterized by the presence or absence of air bronchograms. Multiple clinical indicators are additionally delineated to ascertain pulmonary irregularities pertaining to consolidation or collapse as observed through USG. The aforementioned signs encompass the "tissue-like sign," "shred sign," "loss of curtain sign", and "static or dynamic air bronchogram sign." USG is capable of identifying potential complications, including the presence of cavities or the development of lung abscesses within consolidated regions.

Computed Tomography (CT)

Notwithstanding the apprehensions surrounding radiation, CT continues to uphold its preeminence as the favored cross-sectional imaging modality for assessing intricate thoracic pathologies in both pediatric and adult populations. The aforementioned phenomenon can be attributed to the inherent capacity of CT to perform comprehensive imaging of the entire thoracic region within a single breath-hold. It is noteworthy that vendors have made substantial advancements in dose reduction techniques throughout the years.

The utilization of CT is deemed advisable prior to the initiation of immune suppression in patients presenting with radiographs that yield inconclusive results. The discrimination between latent and active TB poses a considerable challenge when examining a CT, and CXR demonstrates superior analytic precision in this regard as well [6].

Contrast-enhanced CT is recommended as the early imaging modality for people, unless contraindicated due to specific medical conditions or allergies. This facilitates a thorough assessment of the scope and affected areas of the infection. During the subsequent evaluation, if the sole objective is to evaluate parenchymal changes, a non-contrast computed tomography (NCCT) scan with high-resolution computed tomography (HRCT) reconstruction will be sufficient.

Pleural Involvement

Pleural effusion manifests as a crescent-shaped, unconfined accumulation of fluid within the pleural cavity, exhibiting minimal or absent pleural thickening [7]. Empyema, conversely, manifests as loculated pleural effusion characterized by the presence of thickened and enhanced pleura. The presence of loss of volume and calcification is also observed.

Chest Wall Involvement

The dorsal spine, along with the sternoclavicular joint, pre or paravertebral abscess, costochondral junctions, and ribs, are frequently affected regions of the chest wall.

Airway Involvement

The presence of active tuberculosis can lead to the engagement of the trachea and major bronchi, resulting in various manifestations such as smooth or irregular thickening of the airway walls, the formation of polypoidal endoluminal ulcerated masses, or the development of peribronchial soft tissue that causes external constriction of the trachea or bronchi [8]. Bronchiectasis is a frequently encountered consequence of resolved TB, typically observed in the upper lobes due to the destruction of lung tissue and subsequent fibrosis, or as a consequence of infection within the bronchial walls resulting in their impairment.

Magnetic Resonance Imaging (MRI)

The utilization of MRI in thoracic examinations has been constrained by various factors, encompassing its financial implications and restricted accessibility. The predominant constraining elements, nevertheless, are of a technical nature. MRI exhibits considerably lengthier acquisition durations in comparison to CT, thereby rendering respiratory and cardiac motion as substantial contributors to image deterioration. Additionally, diminished proton density within the pulmonary region leads to a concomitant decline in MR signal. Nevertheless, it is imperative to acknowledge that MRI exhibits two prominent advantages in the realm of medical diagnostics. Firstly, it boasts an unparalleled contrast resolution, enabling healthcare professionals to discern minute discrepancies with utmost precision. Secondly, it is crucial to highlight the absence of radiation exposure associated with MRI, thus ensuring the safety and well-being of patients [9]. In recent years, notable advancements have been made in the field of medical imaging, resulting in substantial reductions in imaging durations. These improvements have been achieved through the introduction of breath-hold sequences, allowing for enhanced efficiency and convenience during the imaging process. There has been a notable proliferation of literature investigating the utilization of this modality in pediatric patients necessitating recurrent chest imaging [10].

In the case of TB, its possible utilization is observed in pediatric patients presenting with drug-resistant infection necessitating extended treatment courses involving second line therapeutic interventions. The utilization of interim, periodic assessment via MRI provides a reasonable evaluation of the patient's response. Furthermore, it is noteworthy to mention that the presence of contrast is not deemed indispensable in the process of detecting and accurately evaluating the size of nodes. The MRI modality has shown to exhibit a optimistic predictive value of 100% in the identification of lymph nodes with a size exceeding 7 mm, as reported in reference [11]. The administration of contrast, however, leads to enhanced detection of necrosis. Additionally, it exhibits a heightened level of sensitivity in the identification of pulmonary and pleural manifestations.

18F FDG PET-CT

Numerous studies have elucidated the efficacy of 18F FDG PET-CT in illustrating the functional areas affected by tuberculosis [12]. Nevertheless, a significant constraint of PET-CT, in addition to its associated costs and limited accessibility, pertains to the substantial radiation exposure it entails. Despite the implementation of more recent minimal dose procedures, the radiation dose continues to fall within the spectrum of 9.6 to 29.8 mSv [13]. Therefore, PET-CT is not incorporated into the standard detection algorithm for TB in pediatric patients.

Conclusions

The lungs, lymph nodes, pleura, and chest wall are the most prevalent sites of tuberculosis (TB) in children. TB in children is hard to detect due to the deficiency of symptoms and the trouble of obtaining microbiological samples. Thus, imaging methods are essential for diagnosis and treatment monitoring. When TB is suspected, chest radiograph reporting must be standardized to ensure accuracy and prevent erroneous diagnoses.

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