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Diagnosis of Childhood Tuberculosis in Stunted Children Using Chest X-Ray and Mantoux Test: A Literature Review

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ABSTRACT

Tuberculosis (TB) is a leading cause of pediatric mortality worldwide, with malnutrition, particularly stunting, significantly increasing susceptibility and impacting diagnostic accuracy. Stunting, characterized by chronic undernutrition and zinc deficiency, compromises immune function, elevating levels of pro-inflammatory cytokines and impairing defense against Mycobacterium tuberculosis (MTB). Diagnostic tools like chest X-rays and the Mantoux test demonstrate limitations in stunted children. Chest X-rays, though widely used, lack specificity and depend on the expertise of the reader. The Mantoux test shows reduced sensitivity in malnourished children, with a higher risk of false negatives in severe cases. These findings highlight the need for a cautious interpretation of TB diagnostics in stunted populations and underscore the importance of integrating advanced diagnostic tools for improved accuracy in vulnerable groups.

Keywords: diagnosis of childhood tuberculosis; stunted; chest x-ray; Mantoux.

INTRODUCTION

TB is an infectious disease caused by MTB bacteria, primarily affecting the lungs. However, the infection can also affect other parts of the body, including the lymph nodes, bones, brain, and kidneys, leading to what is known as extrapulmonary TB. The disease spreads through airborne droplets released when an infected individual coughs, sneezes, or speaks, making it highly contagious in close-contact environments. TB remains one of the leading causes of death among children worldwide, particularly in low- and middle-income nations. WHO data suggest that there were approximately 1.2 million pediatric cases in 2021 [1].

Stunting is a nutritional condition determined using the Body Length-for-Age Index or Height-for-Age Index, assessed through anthropometric measurements to evaluate a child's nutritional status. This condition is classified as stunting when the Z-Score falls between <-2 SD and -3 SD (short/stunted) or below <-3 SD (very short/severely stunted). Stunting arises from chronic malnutrition caused by prolonged inadequate nutritional intake due to food provision that does not meet dietary requirements. Stunting occurs when children undergo growth delays and experience insufficient catch-up growth due to inadequate nutritional intake.

This condition can result from both stunted growth and growth delays that do not align with optimal growth patterns [2]. Nutrition is a key factor influencing a child's vulnerability to TB, its progression, and outcomes. Malnutrition compromises the immune system, impairing the body's ability to generate an effective defense against Mycobacterium tuberculosis infection. According to data from UNICEF, WHO, and the World Bank, approximately 148.1 million children under the age of five globally experienced stunting in 2022, representing 22.3% of the total population in this age group. In Asia, 76.6 million children, or 22.3%, are affected, with Southeast Asia accounting for 14.4 million of these cases. Africa reports 63.1 million stunted children (30%), while Latin America has 5.7 million cases, equating to 11.5 [3].

METHODS

This study utilizes sources from books and journal databases such as ScienceDirect, PubMed, Google Scholar, the World Health Organization (WHO), and the Indonesian Ministry of Health. It focuses on finding books and journal articles using keywords including "children", stunting", "malnutrition", "chest X-ray", "Mantoux", and "Tuberculin". Data Collection was obtained by collecting key takeaways from the literatures found and then organizing them into a literature review.

RESULTS AND DISCUSSION

The Impact of Stunting on the Immune System

Stunting is associated with elevated levels of pro-inflammatory cytokines such as IL-6 and IL-8 in response to bacterial antigens like lipopolysaccharide stunting significantly impacts immunity by lowering the immune system's efficacy and increasing susceptibility to infections. This effect is linked to chronic undernutrition and deficiencies in key micronutrients, particularly zinc. Stunted children were found to have significantly lower serum zinc levels compared to their non-stunted peers, a factor that plays a crucial role in immune cell function and cytokine production [4][5].

Chest X-Ray for Diagnosing Childhood Tuberculosis in Stunted Children

Chest X-rays remain the primary imaging modality for suspected pulmonary TB and are crucial for identifying hallmark features of active TB, such as cavitations, infiltrates, nodules, and consolidations. While these findings are valuable for raising clinical suspicion, they lack specificity and cannot independently confirm a diagnosis. To ensure accuracy, chest X-ray results must be complemented by microbiological tests such as sputum smear microscopy, nucleic acid amplification tests (NAATs), or mycobacterial cultures, which directly detect Mycobacterium tuberculosis. This combined diagnostic approach is essential for accurate identification and effective management of TB. The sensitivity of chest X-rays for detecting pulmonary TB varies widely, particularly in smear-negative cases or atypical presentations such as subtle infiltrates or non-cavitary forms.

Advances in digital radiography have enhanced the diagnostic capabilities of chest X-rays by improving image quality and enabling more precise detection of abnormalities. However, accurate interpretation still depends on the expertise of the reader. Adequate training of radiologists to recognize TB-specific patterns is critical to improving diagnostic accuracy. Despite the availability of advanced molecular diagnostics, chest X-rays remain a vital, cost-effective tool for TB detection, especially in resource-limited settings where access to sophisticated diagnostic methods is restricted. In diagnosing pediatric TB, including in stunted children, chest X-rays exhibit variability in accuracy depending on the reader's expertise. While medical and clinical officers often demonstrate higher sensitivity in detecting confirmed TB cases, their specificity is lower compared to expert radiologists and pulmonologists.

Additionally, inter-rater agreement for identifying radiological signs of TB is poor to moderate, even among experienced readers. These challenges highlight the limitations of using chest X-rays as a standalone diagnostic tool, particularly in cases where bacteriological confirmation is not feasible [6][7][8][9].

Mantoux Test for Diagnosing Childhood Tuberculosis in Stunted Children

Tuberculin, a soluble extract derived from MTB, typically uses the human strain of the bacterium [9]. It is a sterile preparation containing the growth by-products of MTB or Mycobacterium bovis and is commonly used in skin tests for diagnosing tuberculosis [10]. Tuberculin is defined as a product obtained from MTB cultures, created through the cultivation of TB bacilli [11]. The Mantoux test, or Tuberculin Skin Test (TST), demonstrates limited sensitivity for diagnosing TB in stunted children, with an overall sensitivity of 31% for clinical TB cases. Chronic malnutrition, indicated by stunted growth (HAZ < -2.14), has been associated with a higher likelihood of a positive TST, reflecting increased susceptibility to Mycobacterium tuberculosis infection. Conversely, acute malnutrition, as indicated by wasting (WHZ < -2.59), significantly reduces the likelihood of a positive TST, suggesting a diminished immune response in severely malnourished children. Interestingly, the size of the induration in Mantoux-positive cases did not vary significantly across different nutritional groups, including stunted children. This consistency in induration size implies that once the test is positive, nutritional status does not affect the extent of the reaction. However, severe malnutrition can suppress the immune response, increasing the chances of false-negative results. These findings emphasize the need for cautious interpretation of Mantoux test results, particularly in malnourished populations, as malnutrition can compromise the reliability of this diagnostic tool [10][11][12][13][14].

CONCLUSION

Stunting and malnutrition significantly affect the immune response and the reliability of TB diagnostics in children. Stunted growth, linked to chronic undernutrition and zinc deficiency, increases TB susceptibility and compromises the immune system. While chest X-rays are a vital diagnostic tool, their accuracy is limited, particularly in pediatric cases, and must be complemented by microbiological tests.

The Mantoux test shows reduced sensitivity in malnourished children, with a higher risk of false-negative results in severe malnutrition. However, induration size remains consistent in positive cases, regardless of nutritional status. These findings emphasize the need for a cautious interpretation of TB diagnostics in malnourished populations and the development of more reliable diagnostic approaches for this vulnerable group.

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