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REVIEW

A current review of infection control for childhood tuberculosis

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SUMMARY

Tuberculosis (TB) infection control recommendations in healthcare settings were developed to decrease nosocomial transmission from adults. In the absence of pediatric-specific guidelines, these infection control recommendations have been incorporated, in almost unmodified format, for childhood TB. We will review the evidence concerning the contagiousness of TB in children, scenarios in which transmission is more likely, review United States national recommendations, and consider the family unit, as opposed to the patient, to be the transmission unit for childhood TB.

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1. Introduction

Of the approximately 12,000 cases of TB disease diagnosed in the United States in 2010, 5–6% occurred in children younger than 15 years of age.[1] As case numbers decline in the U.S., infection control focus appropriately has been on adults, who are more likely to be acid-fast bacilli (AFB) smear-positive.[2] While the proportion of TB in children is much higher in developing nations,[3] resource limitations also have led to a case-finding focus on the more contagious adult. Additionally, the World Health Organization (WHO) and the United Nations' Millennium Development Goals emphasize identification of smear-positive adults.[4] These priorities have led to children being neglected in the discourse of TB diagnostics, therapeutics, and also have resulted in a lack of emphasis on infection control of childhood TB. As a result, current infection control recommendations from the Centers for Disease Control and Prevention (CDC)[5] for adult TB have limited applicability for children, particularly pre-pubertal children who rarely are contagious. This has implications both for patients and their families regarding unnecessary isolation and for healthcare facilities, many of which lack large numbers of negative-pressure rooms[6] or negative-pressure rooms in high-risk areas such as intensive care units and emergency departments.[7]

2. Risk of TB transmission from children

Childhood TB disease is quite different from adult TB disease. These differences include time from exposure to disease onset, epidemiologic differences in contagiousness, pathophysiology, bacillary load, to clinical and radiographic manifestations. Each has infection control and public health ramifications. Most cases of childhood TB disease have a short period between exposure to a contagious individual and manifestation of symptoms. In contrast, many adults with TB disease have reactivated latent TB infection [asymptomatic child with positive tuberculin skin test or interferon gamma release assay and normal physical examination and chest radiograph] from years or decades earlier; this makes it less likely that the patient is still in contact with the person from whom they acquired the bacillus. Thus, diagnosis of TB disease in a child should be a sentinel public health event, as these cases generally represent recent community transmission and often a contagious adult can be identified. This also means that a child may be accompanied to a healthcare facility by an adult with as-yet-undiagnosed TB disease,[8,9] posing another, potentially more tangible, infection control risk.

A second infection control difference relates to contagiousness. It has long been noted that children with TB disease are contagious infrequently. Early epidemiologic studies noted that when an adult in an orphanage developed TB, many children subsequently did as well; however, when one of the children developed TB, other children and caregivers did not.[10] In the modern era, a similar phenomenon has been noted when daycare center workers[11] and school bus drivers[12] have developed TB.

Recently, data on the relative contagiousness of children often have been derived from healthcare venues, where (it is presumed) any transmission to healthcare workers (HCWs) is from the child, not from accompanying adults. Studies in children's hospitals have indicated that tuberculin skin test (TST) conversion among healthcare workers (HCWs) is rare, even in HCWs who cared for as-yet-undiagnosed children with pulmonary TB and did not use

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personal protective equipment (PPE). Cincinnati Children's Hospital reviewed its TB control program from 1986 to 1994, the period during which TB rates were rising in the US. Screening 2000–4000 HCWs/year with 97% employee adherence with screening resulted in identification of 0.3% rate of TST conversion annually (2/1000 employee-years); no cases of TB disease among HCWs were identified, and no TST conversions in HCWs were seen after caring for children with TB.[13] These children were isolated in negative-pressure rooms and employees used N95 respirators. A similar study conducted in a higher prevalence area (Houston, Texas) from 1992 to 1998 showed an HCW TST conversion rate of 8/1000 employee-years.[8] However, only 3% of HCWs with TST conversion were involved in any direct patient care, and none cared for TB disease patients. The increased TST conversion rate compared to Cincinnati likely reflected higher rates of TB in the Houston community. A follow-up study in Houston from 2003 to 2009 showed that, in an infection control program with 99.7% adherence and in which there had been no changes since the earlier study, there were 1.8 TST conversions per 1000 employee-years.[9] Only one TST conversion was seen in an HCW who cared for a child with cavitary TB. This low rate of TST conversion occurred despite occasional delays in implementation of effective isolation. For hospital employees, the primary risk venue appeared to be the community, not the occupational setting.

There are a number of reasons why children with TB disease may be less contagious than adults. First, children often have paucibacillary disease,[14] leading to low rates of AFB-positive specimens. Second, young children are less likely to have cavitary lesions,[15] in part due to less mature immune responses. Third, prepubertal children have a less forceful cough than adults and the cough is less likely to be productive,[16] leading to decreased aerosolization. Fourth, childhood TB is more likely to be extrapulmonary in nature than TB in immunocompetent adults.[17] Finally, children may be less contagious, on a public health level, simply because they have more circumscribed social networks than adults.[18]

3. Circumstances in which children with TB disease should be considered contagious

To determine which children with TB disease should be considered contagious, available data come from two sources: community transmission and nosocomial transmission. Identifying the proportion of TST conversions due to a childhood case in the community is difficult because many children with TB disease live with the person from whom they acquired the bacillus,[19] and determining individual contributions to infectivity is challenging. Therefore, some data come from school-based studies and other areas where only a child, and not the adult with TB, were in contact with children. In 1999, a cluster of TST conversions in North Dakota, USA, was attributed to a 9-year-old boy with cavitary disease and AFB-positive sputum smears; 20% of his contacts had positive TSTs.[20] In this very low prevalence area of the United States, no additional active cases were discovered. More recently, a nine-year-old boy in England had extensive pulmonary lesions but AFB-negative smears; the rate of TST positivity in his classmates was statistically higher than among other students at his school (79% vs. 35%, $p < 0.01$).[21] These cases are noteworthy because these children had radiographic features often associated with adult-type TB disease.

Nosocomial transmission of TB from infants and children has been reported. These cases have often been associated with several common variables: older adolescents, any child with cavitary or other high-inoculum pulmonary disease (including children who are AFB smear-positive), and children undergoing airway instrumentation procedures. There are several case reports of HCW TST conversion after exposure to a congenitally infected infant with miliary TB.[22,23] These infants often have very high organism burden and TB often is not initially suspected, resulting in delay in isolation. As a general rule, *any* child with radiographic or symptomatic features of adult-type TB should be treated as contagious (Table 1). One study identified several predictors of AFB smear-positivity in adolescents: cough of >4 weeks duration (adjusted odds ratio (aOR): 13.8), involvement of the superior segment of the lower lobes (aOR: 12.6), and cavitary lesions (aOR: 7.7).[24]

However, nosocomial transmission from HCWs and adults to children in healthcare facilities is more common than transmission from children to adults. For example, TST conversions have been seen in patients of pediatricians with smear-positive TB[25,26] and a newborn nursery nurse,[27] and from breastfeeding mothers[28] or other hospital visitors.[29] An alternative nosocomial route of TB transmission has been reported for children receiving chemotherapy solutions that were cross-contaminated with the BCG vaccine used for bladder cancer.[30]

4. National infection control recommendations

The CDC and Occupational Safety and Health Administration (OSHA) have issued recommendations for preventing nosocomial transmission of TB.[5] These guidelines offer an integrated package of interventions to decrease nosocomial transmission from the patient to other patients and HCWs through early recognition and isolation, and from HCW to patients and other HCWs through identification and treatment of HCWs with latent TB infection (LTBI) and identification of HCWs with symptoms consistent with TB.

Recommendations are broken down into administrative, environmental, and respiratory protection. Administrative measures reduce HCW risk of exposure to persons who potentially have TB disease. This is done by screening for TB risk factors, delineating factors requiring isolation, integrating the laboratory and local health departments into the infection control team, training HCWs on TB prevention and transmission, and appropriate cleaning of equipment. Environmental measures use ventilation and high efficiency particulate air (HEPA) filters and ultraviolet light to decrease spread and reduce the concentration of bacilli in the air. Respiratory protection measures minimize the number of areas in which exposure can occur, decrease the risk in these areas, and provide appropriately sized PPE and training to HCWs.

Table 1
Clinical, radiographic, microbiologic, and environmental features indicative of potentially contagious tuberculosis in children.

Category	Feature
Clinical	Presence of cough
	Productive cough
	Draining skin/soft tissue lesion
	Lack of appropriate treatment for TB, or only having been started on TB medications for a short duration
	Undergoing airway instrumentation
Radiographic	Cavitary lesions
	Apical involvement
	Miliary disease in children undergoing airway instrumentation
	Laryngeal involvement
Microbiologic	Acid-fast bacilli (AFB) smear-positivity
Environmental	Exposure in enclosed indoor spaces with insufficient ventilation
	Recirculating of air with droplet nuclei
	Inadequate cleaning of equipment or handling of specimens

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