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**Advanced Concepts  
in Pediatric Tuberculosis:  
Infection Control, Source Case and  
Contact Investigation**

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## Objectives

At the end of this session, participants will be able to:

- Compare contagiousness of children of different ages with pulmonary TB, and apply this to planning investigations
- Discuss importance and indications for source case investigation
- Plan evaluation for contacts of patients with various forms of TB disease
- Discuss infection control guidelines for a child hospitalized with TB disease

## Key Terms

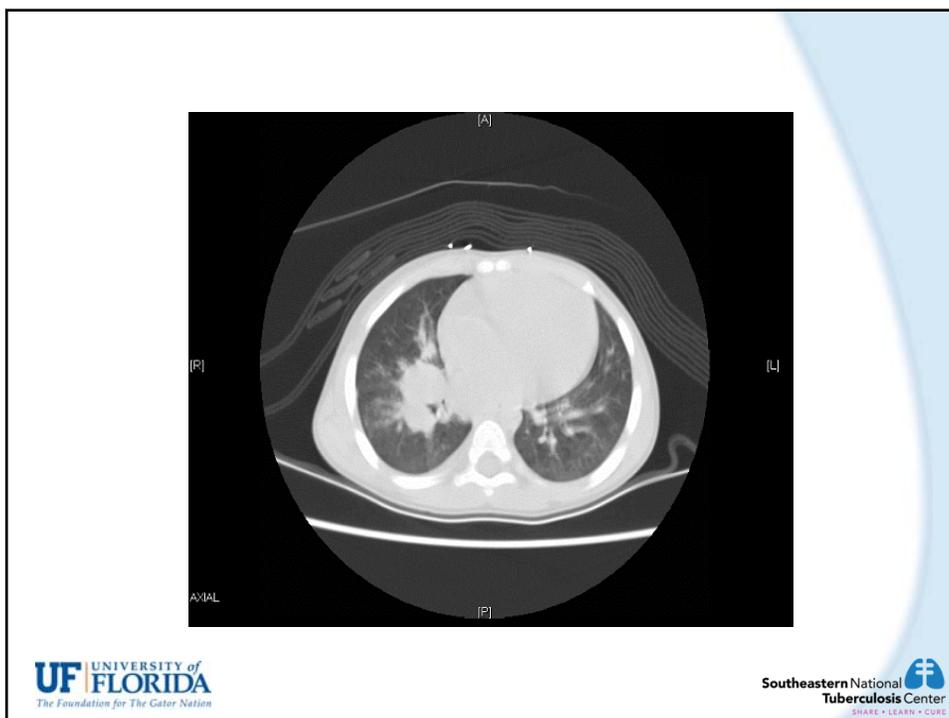
- **Case** – A particular patient with TB disease. All TB cases are reportable.
- **Contact** (AKA: Exposed person)–Someone who has been exposed to *M. tuberculosis* by sharing air space with a person with infectious TB.
- **Index case**– The first case or patient who comes to attention as indicator of a potential public health problem.
- **Source case** – The case or person who was the original source of infection for secondary cases or contacts; can be, but is not necessarily, the index case.

## Index Case

- 2 y/o AA male presented to ER with 8 day history of fever and cough. He was diagnosed with pneumonia and was prescribed amoxicillin. After 5 days, his fever was not better, so he was admitted to the hospital for IV antibiotics. He was started on ceftriaxone, and then vancomycin was added. However, fever persisted.
- PMH: no significant illness, no surgeries or hospitalizations

## Index Case

- Family/Social history: lives with mother and 2 older siblings. Has attended a Daycare Center since the age of 7 months. No travel history, no history of contacts with adults with HIV, IVDU, homeless, incarcerated.
- Physical exam was normal, with the exception of Tmax of 41 degrees.



## Index Case

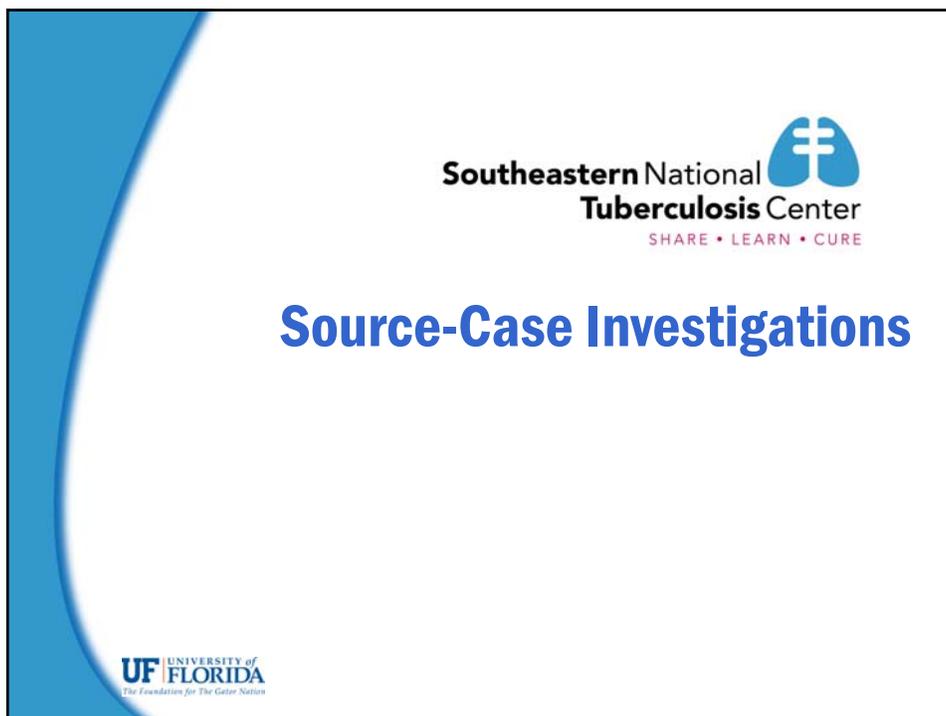
- TST was placed and read as 10 mm of induration
- Gastric aspirates x 3 were sent
- Patient was started on INH, Rif, and PZA, and fever resolved after 3 days.
- He was discharged home to continue meds under DOT.
  
- Gastric aspirate cultures were negative

## Case

2y/o AA male with a clinical case of pulmonary TB .

**What would you do next?**

- a. Obtain biopsy of hilar lymph nodes to confirm TB.
- b. Since patient is responding to anti-TB therapy, just complete 6 months of therapy
- c. Plan and conduct a contact investigation
- d. Plan and conduct a source-case investigation



## Source-case Investigations

- Seeks the source of recent *M.tuberculosis* infection
- TB in children <5 years of age typically indicates recent transmission.
- Young children usually do not transmit TB to others. The source-case is usually an adult/adolescent care-giver.
- A source-case investigation should be considered for children <5 y/o (**especially <2**) with TB.

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## Importance of Source-case Investigations

- Public health measure
  - Identify the individual who infected the child, who is probably transmitting TB to others
- Diagnostic measure
  - Isolating the organism from the source case provides likely drug susceptibility of the child's organism
  - Yield is higher than yield of diagnostic microbiology in children

## Source-case Investigation for Child with LTBI

- Search for source of infection for child with LTBI is not likely to be productive and cost-efficient
- Recommended only with **infected children <2 years of age**, and only if data are monitored to determine the value of the investigation
  - Relative recent transmission!

## Procedures for Source-Case Investigation

- Same procedure as standard contact investigation
- Patient or guardians best informants (associates)
- Focus on associates who have symptoms of TB disease
- Should begin with closest associates, and expand if appropriate

## Back to our case

Source case investigation was conducted

- All household tested negative (TST)
- Investigation was expanded to the Daycare Center (DCC)
- 3 DCC staff had +TST, but negative CXR
- One DCC worker had neg TST, but history of chronic cough, and was eventually diagnosed with Pulmonary TB (cavitary, smear positive) – **This was the source case!**

**What next?**

## Contact Investigations – A Crucial Prevention Strategy

- On average, 10 contacts are identified for each person with infectious TB in the U.S.
- 20%–30% of all contacts have LTBI
- 1% of contacts have TB disease
- Of contacts who will ultimately have TB disease, approximately 50% develop disease in the first year after exposure

## Benefits of Contact Investigations

- Finding and treating additional TB disease cases (potentially interrupting further transmission)
- Finding and treating persons with LTBI to avert future cases



## Importance of Contact Investigation

### How are pediatric cases discovered?

- Active
  - Contact investigation: 25-80%
  - Screening of high risk groups: 3-35%
- Passive
  - Symptomatic children: 15-45%

## Contact Investigation Responsibilities

- Health departments are responsible for conducting contact investigations
- Contact investigations are complicated activities that require
  - Many interdependent decisions
  - Time-consuming interventions

## Decisions to Initiate a Contact Investigation

- Public health officials must decide which
  - Contact investigations should be assigned a higher priority
  - Contacts to evaluate first
- Decision to investigate an index patient depends on presence of factors used to predict likelihood of transmission

## Factors that Predict Likely Transmission of TB

- Anatomical site of the disease
- Positive sputum bacteriology
- Radiographic findings (cavitation)
- Behaviors/procedures that increase aerosolization of respiratory secretions
- Age
- HIV status
- Administration of effective treatment

## Characteristics of the Index Patient Associated with Increased Risk of TB Transmission

- Pulmonary, laryngeal, or pleural TB
- Acid-fast bacilli (AFB) positive sputum smear
- Cavitation on CXR
- Adolescent or adult patient
- No or ineffective treatment of TB disease

## Determining the Infectious Period

- Sets time frame for testing contacts most likely to be at risk for infection
- Information to assist with determining infectious period
  - Approximate dates TB symptoms were noticed
  - Bacteriologic results
  - Extent of disease
- Start is 3 months before TB diagnosis (recommended)
- Earlier start should be used in certain circumstances (e.g., patient aware of illness for longer period of time)

## Assigning Priorities to Contacts

- Priorities based on likelihood of infection and hazards to the contact if infected
- Factors for Assigning Contact Priorities
  - Characteristics of the index/source patient
  - Characteristics of contacts
    - Age
    - Immune status
    - Other medical conditions
  - Exposure



Patient has pulmonary, laryngeal, or pleural TB with cavitory lesion on chest radiograph or is AFB sputum smear positive

Household contact	High
Contact <5 years of age	High
Contact with medical risk factor (HIV or other medical risk factor)	High
Contact with exposure during medical procedure (bronchoscopy, sputum induction, or autopsy)	High
Contact in a congregate setting	High
Contact exceeds duration/environment limits (limits per unit time established by the health department for high-priority contacts)	High
Contact is ≥ 5 years and ≤ 15 years of age	Medium
Contact exceeds duration/environment limits (limits per unit time established by the health department for medium-priority contacts)	Medium

Any contact not classified as high or medium priority is assigned a low priority.

## Back to our case

A full scale Contact Investigation was conducted

- 52 children exposed within the previous 3 months were identified and tested (ROS, Physical exam, TST and CXR)
- 24 children had + TST
  - 5 children were diagnosed with Pulmonary TB (1 with meningitis)
  - 18 children had LTBI
- 28 children had – TST and – CXR
  - <5y/o started on window prophylaxis
  - 2 more children had +TST after 10 weeks (re-test)

## Day Care Settings: High Priority for Contact Investigation

- Children < 5 years of age
- Prolonged exposure
- Close contact
- Depending on the size of the daycare center
  - Crowding
  - Poor ventilation

## General Population vs Day Care Setting

- On average, 10 contacts are identified for each person with infectious TB in the U.S.
  - 52 exposed children identified
- 20%–30% of all contacts have LTBI
  - 38% of children had LTBI
- 1% of contacts have TB disease, half of them in the first year after exposure
  - 12% of children developed TB disease
  - All of them developed it within 6 months

## Evaluation of contacts Testing for TB Infection

- All high or medium priority contacts who do not have a documented previous positive TST/IGRA or previous TB disease should receive a TST or IGRA at the initial encounter
- TST interpretation
  - $\geq 5$  mm induration is positive for any contact
- If TST/IGRA negative
  - Repeat same test in 8-10 weeks (window period)
- If second TST is positive after initial negative
  - Contact is classified as recently infected

## Evaluation of contacts

### Medical Evaluation

All contacts with positive TST/IGRA or who report any symptoms consistent with TB disease should undergo further examination and testing for TB disease

- History & Physical
- CXR
- Other tests as indicated



## Window-Period Prophylaxis

Decision to treat contacts with a negative TST/IGRA should take the following factors into consideration

- The frequency, duration, and intensity of exposure
- Risk factors for TB disease
  - Age of the contacts
  - Medical conditions

## Management of Contacts Younger than 5 years of age

- Evaluation
  - TST
  - CXR
  - Review of symptoms and physical exam (PE)
- Primary prophylaxis (“window”)
  - If TST, CXR, and PE are neg, start INH until repeat TST in 8-10 weeks
  - If repeat TST is neg, stop INH
  - If repeat TST is pos, treat as LTBI

## Prophylactic Treatment

Prophylactic treatment (after TB disease is excluded) of presumed *M. tuberculosis* infection recommended for persons

- With HIV infection
- Taking immunosuppressive therapy for organ transplant
- Taking anti-tumor necrosis factor alpha (TNF- $\alpha$ ) agents

Since LTBI cannot be excluded, these contacts should be treated with 9 months of INH

## A story that never ends...

- Seven months later, a high school student with no risk factors was diagnosed with Pulmonary TB (cavitary, smear positive).
- Where did he get it from?
  - Grandson of a friend of the CCC source case, with occasional contact with her before her diagnosis
  - Had not been identified as a contact in the previous investigation
  - MTB isolate was genotypically identical to source case.

## A story that never ends...

Contact investigation conducted at the High School

- Initial: 197 contacts identified (same classrooms, sports teammates, bus-riders)
  - 1<sup>st</sup> TST: 16+ (8%)
  - 2<sup>nd</sup> TST: 18+ /103 (17%)
- Expanded: 206 additional contacts
  - TST: 8+ (4%)
- None with TB disease

## Determining When to Expand a Contact Investigation

Consideration of the following factors recommended

- Extent of recent transmission
  - Unexpectedly large rate of infection or TB disease in high-priority contacts
  - Evidence of second-generation transmission
  - TB disease in any contacts who had been assigned low priority
  - Infection in any contacts aged <5 years
  - **Contacts with change in skin test status from negative to positive**

## A story that never ends...

**It keeps going, and going...**

- One month later, a 7 m/o old male, cousin of the high school student, was diagnosed with Pulmonary TB
  - He was identified as a contact, and had been evaluated by PCP
    - Asymptomatic, TST negative
    - **No CXR, no further intervention**
  - A month later, presented with fever, wheezing and productive cough
  - CXR with right hilar adenopathy and RUL infiltrate
  - Gastric aspirates smear and cx - POSITIVE

## And it keeps going, and going...

- This baby attended a small Child Care Center
- Because of extensive disease, significant cough, and + smear, and “anxiety”, a Contact Investigation was conducted at the CCC
  - 4 workers
  - 8 infants
- All evaluations were negative

## Why not contact investigations in young children?

### Transmission

- Airborne infection
  - Inhalation of droplet nuclei produced by an adult or adolescent with pulmonary or laryngeal TB
- Infectiousness correlates with the number of organisms expelled

## Why not contact investigations in young children?

- Very low yield!
- Most children with TB are not contagious because compared to adults they are less likely to
  - Have a productive cough
  - Generate force to aerosolize the organisms
  - Have large numbers of organisms
- Children with extrapulmonary TB are not infectious unless disease of larynx or open abscesses/lesions

## When to consider contact investigations in children

- Transmission of TB from children can occur, but usually due to exceptional circumstances
  - Adult-type disease: cavitory, extensive upper lobe disease
  - Procedures creating aerosolization of bacilli
    - Bronchoscopy
    - Induced sputum

By the way, gastric aspirates are NOT associated with transmission!



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# Infection Control



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## Recommendations for Preventing *M. tuberculosis* Transmission in Health-Care Settings



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## Fundamentals of Infection Control



Administrative Controls



Environmental Controls



Respiratory Protection

## Fundamentals of Infection Control

- **Administrative controls:** reduce risk of exposure via effective IC program
  - Assign responsibility for IC in the facility
  - Conduct annual facility risk assessment by examining
  - Institute IC plan to ensure TB suspects found, isolated, evaluated, treated
  - Ensure recommended laboratory services are available
  - For HCWs, implement effective work practices and test as classification indicates
  - Ensure equipment is properly cleaned, disinfected, and sterilized
  - Educate, train, and counsel HCWs, patients, visitors about TB

## Fundamentals of Infection Control

- **Environmental controls:** prevent spread and reduce concentration of droplet nuclei
  - Primary controls: ventilation technologies
    - Natural ventilation vs mechanical ventilation
    - Use of AII room
  - Secondary controls: HEPA filters and ultraviolet germicidal irradiation (UVGI)

## Fundamentals of Infection Control

### Environmental Controls

Characteristics of AII room:

- Single-patient room with private bathroom
- Negative pressure relative to hallway
- Air sent outdoors or through HEPA filter
- Six or more air changes per hour (in some settings 12 or more air changes per hour are recommended)
- Visitors should use N95 respirator

## Fundamentals of Infection Control

- **Respiratory protection controls:** further reduce risk of exposure in special areas and circumstances
- Consists of using personal protective equipment in areas with increased risk of exposure
- Should be used by persons
  - Entering rooms of suspected/confirmed TB patients
  - Around cough- or aerosol-producing procedures
  - In settings where administrative and environmental controls will not prevent the inhalation of infectious droplet nuclei

## Respirator for Health-Care Workers



**HCW**  
**N95 Respirator**



- Designed to filter out droplet nuclei from being inhaled by the health-care worker and other individuals.
- Should properly fit different face sizes and features.
- Should NOT be worn by the patient.

## Surgical Mask for Persons with Infectious TB Disease



**Patient  
Surgical mask**



- Designed to stop droplet nuclei from being spread (exhaled) by the patient.
- Should NOT be worn by the health-care worker.

## Risk Factors for Infectiousness

- Presence of productive cough
- Cavitation or extensive upper lobe disease
- Positive AFB smear of sputum
- Involvement of larynx
- Failure to cover mouth/nose with cough
- Cough-inducing or aerosol-generating procedures (bronchoscopy, sputum production, aerosolized medications)

## Isolation of the Hospitalized Adult Patient with TB or suspected TB

- Airborne infection isolation
  - HCW and visitors wear at least N95 mask
- Discontinuation of isolation
  - Suspected TB
    - Another diagnosis excludes TB **or**
    - 3 negative AFB sputum smear results
  - Confirmed TB
    - Effective therapy **and**
    - Clinical improvement **and**
    - 3 negative AFB sputum smear results

## Isolation of the Hospitalized Pediatric Patient with TB or suspected TB

- Children with TB, especially <10 y/o, are rarely infectious
  - Nosocomial transmission in pediatric setting rare
- Adults accompanying children into the hospital may be the source case and potentially infectious
  - Emphasis on infection control should be on these adults
- Isolate children until infectiousness excluded in patient and adults accompanying patient
  - CXR is critical component of evaluation
  - Until evaluation is complete, limit visitation or visitors should wear masks in common areas

## TB among Adult Visitors of Children with Suspected TB at a Children's Hospital

- Adult caretakers accompanying admitted children
  - Screening for TB prior to admission
  - CXR as part of screening
  - Isolation if child potentially contagious or of delay in obtaining accompanying adults' CXR
- 59 children enrolled
  - 8 required isolation
- 105 adults screened
  - 15% had abnormal CXR compatible with TB

Infect Control and Hosp Epidemiol 2002; 23:568-72

## Management of the Newborn whose Mother has LTBI

- Mother has reactive TST or IGRA and normal CXR
  - If mother is asymptomatic, **no separation**
    - Mother should be treated for LTBI after the initial postpartum period
- Newborn needs no further evaluation
- Other household members should be evaluated for TB infection or disease
  - This should not delay newborn's discharge from the hospital
- Mother can breastfeed the infant

## Management of the Newborn whose Mother has Suspected TB

Mother has clinical signs/symptoms or abnormal CXR c/w TB disease

- Evaluate mother ASAP (e.g. sputum for AFB, etc)
- **Separate mother and infant until evaluation complete**
- If TB suspected/confirmed, separate them until
  - mother receiving adequate therapy
  - she wears a mask, and
  - she understands and follows infection-control measures
- Mother can breastfeed the infant after at least 2 weeks of adequate treatment **AND** when considered not contagious

## Management of the Newborn whose Mother has Suspected TB

Mother has clinical signs/symptoms or abnormal CXR c/w TB disease

- If mother has TB disease, evaluate infant for **congenital TB**
- If excluded, begin INH
- Repeat TST when infant is 3-4 mo old
  - If negative, discontinue INH
  - If positive, re-evaluate for TB disease
  - If no disease, complete 9 mo of INH
- Once INH started for infant, separation no longer necessary unless there is suspicion for MDR TB

## Management of the Newborn whose Mother has Suspected TB

Mother has clinical signs/symptoms or abnormal CXR c/w TB disease

- If mother has TB disease, and **MDR is suspected/proven**
  - Separate mother and infant until mother considered no longer contagious
  - Consider BCG vaccination for infant (if HIV negative) if separation from mother is not possible

## Management of the Newborn whose Mother has Suspected TB

- Mother has abnormal CXR findings but no evidence of TB disease
  - Separation not necessary
  - Mother should receive LTBI treatment
  - Household should be investigated for TB

## Prevention of Transmission in the Community

- **Child care**
  - Children with TB can attend child care if they are receiving appropriate therapy
  - If source case child care worker, other children in center should be evaluated
  - Child with TB not contagious unless adult-type disease
- **School**
  - Children can attend school if receiving appropriate therapy
  - School contacts of children with adult-type disease should be investigated by Health Department

## Take-Home Messages

- The diagnosis of TB in a child is a sentinel event representing recent transmission of TB in the community
- A source case investigation should be considered when a young child is diagnosed with TB
  - Do not forget non-family care-givers
- Contact investigations are an essential component of TB prevention
- Daycare centers represent a high priority for contact investigation
- Young children are rarely contagious, but the source-case is
- Use window prophylaxis in young children

## Main References

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- Centers for Disease Control and Prevention. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. *MMWR* 2005; 54 (No. RR-17).

## Questions?

