TB Intensive
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TB Infection Control in Healthcare Settings
Robert Petrossian
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Robert Petrossian has the following disclosures to make:

• No conflict of interests

• No relevant financial relationships with any commercial companies pertaining to this educational activity
Chain of Infection (Infection Control 101)

- Source of Infection
- Mode of Transmission
- Susceptible Host

Source of Infection

- Active TB Case
- Persons suffering from pulmonary and respiratory tract tuberculosis are the most common source of infection.
- Extrapulmonary Tuberculosis is not infectious unless a draining sinus tract is present.
Measures Against Source of Infection

- Identifying active cases
- Adequate treatment
- LTBI Treatment

Transmission Pathway

- Airborne Droplet Nuclei (1 to 5 microns in diameter)
- Inhaled into pulmonary alveolae and are taken up by alveolar macrophages.
- Usually takes 2 to 10 weeks to develop demonstratable primary lesion or significant tuberculin reaction.
Measures Against Transmission Pathways

- Environmental Controls
- Isolation
- Personal Respiratory Protection

Susceptible Hosts

- Everyone (humans, elephants, cattle, pigs and a few unlucky monkeys)
- High Risk for Developing Disease
  - Children under 3
  - Immunosuppressed
  - Elderly Population
  - Injectable Drug Users
  - Malnourishment
  - Diabetics
Measures Against Host Susceptibility

- Curbing high risk behavior
- ART (anti-retroviral therapy)
- BCG (in children under 5)
- Adequate nutrition
- LTBI Treatment

Objectives

- TB incidence in community & hospitals decreasing, but Risk to health care workers persists
- CDC Guidelines 2005 update reviewed
  - Administrative, Environmental, Respiratory Controls
  - Implementation
  - Extended to include many non-hospital settings
- Re-evaluation of TST screening
TB Among Health Care Workers

- Occupational risk to HCW recognized in 1950s Resource-rich countries ⇒ Infection Control Measures that ↓ Nosocomial TB
- US: Resurgence of Nosocomial TB in 1990s
  - Poor implementation of Infection Control
  - HIV Epidemic
  - MDRTB
- Recent Public Health Threat will impact HCW: XDRTB

Occupational Risk in HCW

- HCW at increased risk for LTBI & TB disease
  - Risk correlates directly to regional TB incidence
- TB infection control measures protect HCW
  - Potential protection magnitude ~ correlates directly w/ regional TB incidence
    - Up to 27% in Low TB Incidence Regions
    - Up to 49% in Intermediate
    - Up to 81% in High

Baussano I, et al: TB Among HCW. Emerg Infec Dis 2011; 17:468-
FIGURE 1. Rate* of tuberculosis (TB) cases, by state/area — United States, 2008†

* Per 100,000 population.
† Data updated as of February 18, 2009. Data for 2008 are provisional.
TB rate (case rate) was based on controls. 17 states had TB case rates of <2.0 (range: 0.00–1.90) per 100,000, 17 states had TB case rates of 2.0–4.0 (range: 2.63–3.42) per 100,000, and 15 states and the District of Columbia had TB case rates of >4.0 (range: 4.02–9.58) per 100,000.

FIGURE 2. Number and rate* of tuberculosis (TB) cases among U.S.- and foreign-born persons, by year reported — United States, 1985–2006†

* Per 100,000 population.
† Data are updated as of February 18, 2009. Data for 2008 are provisional.
What is the most dangerous type of TB to Health Care Workers?

The Unsuspected Case!!

What Factors Determine TB Infectiousness?

Transmission of Tuberculosis
Part 1

• Aerosol (airborne droplet nuclei) only transmits infection
• 21-23% of close contacts become infected
• Patient factors
  – Disease in lung, airway, and/or larynx
  – Coughing or cough inducing procedure
  – Concentration of droplet nuclei (cavitary > non-cavitary)
    Sputum smear:
    • Positive: transmission occurs
    • Negative, but culture positive: transmission less often
      (see Figure)
Transmission of Tuberculosis
Part 2

- Environmental factors
  - Duration of contact
  - Small enclosed space
  - Poor ventilation or recirculation of room air

- Other factors
  - Susceptibility of the host
  - Poorly understood bacteria characteristics

- Infection rate drops rapidly with treatment initiation

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**TB Transmission...Percent Infected**

**Smear-Positive vs. -Negative Source**

**Case Proximity to Source Case**

*AFB smear negative cases account for 17% TB transmission*

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Behr MA et al: Lancet 1999
Traditional CDC Isolation Recommendations

Patients are not considered infectious if they meet the following criteria:

- Adequate therapy for 2 or 3 weeks
- Favorable clinical response
- Sputum smear *negative* x 3

Disconnect: Regulation vs. Reality

Scientific/Common Sense Criteria for TB Non-Contagion

- TB chemotherapy rapidly reduces contagion
  - Viable TB bacilli in sputum reduced >90% in the first 2 days
- Low likelihood of MDR TB
- Complete adherence to DOT multi-drug Rx x2-3 weeks
  - 5-7 days if AFB smear negative at onset
- Clinical improvement evident (e.g., reduced cough frequency, ↓ AFB smear grade)
- Close contacts identified, evaluated, started on Rx (LTBI or even active TB)
- Most stringent criteria for congregate settings & suspect or proven MDR TB: 3 consecutive negative AFB smear results (8-24 hours apart)
Amended CDC Isolation Recommendations

Patients are not considered infectious:

• Adequate therapy for 2 or 3 weeks (susceptibility data helpful)
• Favorable clinical response (cough resolved, energy improved)
• Mycobacteriologic response (↓ Smear Grade, pan-susceptible organism)….

Outpatient or Inpatient Therapy?

• Guiding principle: Minimize transmission risk
• Inpatient therapy guidelines:
  – Is it worth putting more people at risk?
  – Clinical indications (e.g., massive hemoptysis, concurrent disease complications)
  – High risk for poor adherence to therapy
What are the Fundamentals of TB Infection Control?

- Early identification and isolation
- Effective Airborne Infection Isolation (AII)
- Rapid institution of effective treatment

2005 CDC Guidelines
Three Tier Control Hierarchy Continue

- Administrative controls
- Engineering controls
- Personal Respiratory protection

Guidelines for Preventing the Transmission of TB in Health-Care Settings, 2005

*MMWR Recommendations & Reports 12/30/05*
Fundamentals of Infection Control
Hierarchy of Infection Control

- **Administrative controls**: reduce risk of exposure via effective IC program
- **Environmental controls**: prevent spread and reduce concentration of droplet nuclei
- **Respiratory protection controls**: further reduce risk of exposure in special areas and circumstances
Administrative Controls
Most Important

• Assign responsibility for TB infection control (IC)
• Assess TB Risk
• Work with health department to conduct TB risk assessment and develop written TB IC plan, including All precautions
• Ensure timely lab processing and reporting
• Implement effective work practices for managing TB patients

Administrative Controls

• Test and evaluate HCWs at risk for TB or for exposure to *M. tuberculosis*
• Train HCWs about TB infection control
• Screen & Evaluate HCWs
• Ensure proper cleaning of equipment
• Use appropriate signage advising cough etiquette and respiratory hygiene
Environmental Controls

- Control source of infection
- Dilute and remove contaminated air
- Control airflow (clean air to less-clean air)

Environmental Controls
Second Level
Control source of infection:
- Removing contaminated air by ventilation
- Preventing contamination in areas adjacent to source case (Air rooms)
- Cleaning air by use of HEPA filtration (min efficiency: 99.97% ≥ 0.3 \( \mu \)m particle)
- UV germicidal irradiation only w/ simultaneous use of HEPA filters & high rate of purge airflow
General Ventilation Issues

- Single pass (preferred)
- Recirculation (use of HEPA/UVGI)
- All: negative pressure
  (New facilities: 12 ACH; Existing facilities: 6ACH)

Air Flow Patterns for Mixing & Preventing Short Circuit Circulation

Ante room preferred for AII rooms
- Helps maintain negative pressure
- Limits impact of opening door/traffic in/out

Monitoring room airflow recommended
Respiratory Protection (RP) Controls

- Implement RP program
- Train HCWs in RP
- Train patients in respiratory hygiene

Personal Respiratory Protection Level Three

- Use in high risk situations
- Most of the benefit: Administrative & Environmental controls
- Epidemiologic data lacks power to support respiratory protection /fit-testing of minimal import
- Respiratory protection & particularly fit-testing remains contentious issue
Evidence for Effectiveness of Respiratory Protection

- Published surveys of hospitals (Columbia, St. Clares, UVa, SHEA) show that TST conversion rates fall or remain low more as a result of administrative & engineering controls vs. respiratory protection (Bangsberg et al: ICHE 1997; Fella et al: AJIC 1995, Jernigan et al: AJIC 1994; Fridkin et al: ICHE 1995)

- No data regarding effect of fit-testing
- No study that isolates and evaluates impact of respiratory protection program in the hierarchy of controls

Respiratory Protection Measures Part 1

- Respiratory Protection Program
  - Select respirators
  - Write SOP
  - Medically screen users
  - Provide training: user seal-check
  - Fit testing
  - Evaluate program
Respiratory Protection Measures
Part 2

• Training HCWs about respiratory protection & TB
• Use Respiratory Protection:
  – Entering All room
  – During cough/aerosol inducing procedures
  – Where Administrative &/or Environmental controls insufficient to protect you from inhaling droplet nuclei
• Training patients on respiratory hygiene & cough etiquette
  What mask should patient wear in room with visitors?

Coughing propels & disperses a plume of TB droplet nuclei ~1-2 m outward
Wearing any mask blocks forward momentum of cough plume
Respiratory Protection Devices

- NIOSH certifies respirator design

Types of devices:
- N95: inexpensive, simple, disposable (eg, duck bill)
- APR/PAPR: greater protection; ([Powered] Air Purifying Resp)
- Others: Air hood/helmet; Cartridge respirator; body suit
- Surgical, DM; DMF vs. HEPA respirators... no longer in use

Fit-Testing

- Quantitative: concentration of a marker material measured inside & outside; requires trained personnel & complex equipment
- Qualitative: pass/fail (saccharin, bitrex, irritant smoke)
- Seal-check: performed by user each time respirator put on (positive/negative).
Special Situation: TB Infection Control in Resource Poor Setting (esp. ↑ HIV Incidence)

Administrative Controls
• Proactive Planning
• Select individual responsible & encourage creative implementation (eg, change attitudes/stigma, eliminate cohorting in TB wards, ↓ LOS)

Environmental Controls
• Open-Window Ventilation & Fans
• Inexpensive ceiling UV light/shield/fan set-up
• Continuous teaching patients proper cough hygiene

Personal Respiratory Protection
• N95 respirator availability
• Model/teach proper use

Special Situation: Operating Room
• Normal OR Airflow: OR ⇒ Hallway
  – ↓ Bacterial contamination of surgical field
  – But…↑ Dissemination of TB from surgical field

• Measures to prevent TB dissemination in OR
  – Administrative: Schedule TB case during low-use period (few other patients/staff, extended time after case for air purification)
  – Environmental: OR w/ ante room; Ante room air flow pressure either positive or negative cp OR & hallway; >95% efficiency filter on expiratory port vent/anesthesia machine
  – Respiratory Protection: Staff wear N95 mask (no PAPRs)
TB Control in Health-Care Setting

- Review of TB contagion
- TB incidence in community & hospitals is decreasing
- Risk to health care workers is decreasing (…Risk for increased complacency!)
- CDC Guidelines 2005 update reviewed
  - Applies to traditional & non-traditional settings
  - Implementation of 3 tiers of control: Administrative, Environmental & Respiratory
- Re-evaluation of TST screening
- New technology (eg, IGRA)

Overview of Differences
2005 Compared to 1994 Guidelines

- Applies to entire health care setting rather than selected areas
- Scope of settings broader: laboratories, more outpatient & non-traditional settings
- Terminology & abbreviations
  - Tuberculin skin test (TST) replaces purified protein derivative (PPD)
  - Airborne infection isolation (AII)
  - New technology breeds new abbreviations:
    - Blood analysis for *Mycobacterium tuberculosis* (BAMT)
    - QuantiFERON-TB Gold (QFT-G) [IGRA] substitutes for TST in HCW screen
- TB screening for HCW
  - Criteria change
  - Decreased frequency
  - Clearer definitions for which HCW need serial testing
- Expanded information:
  - UV germicidal irradiation (UVGI) & room air circulation
  - Dealing w/ MDRTB & HIV
  - Respirator training
What Agencies Oversee Infection Control?

- Advisory Recommendations (Toothless)
  - Center for Disease Control (CDC)
  - National Institute for Occupational Safety & Health (NIOSH): Certifies respirator design
- Regulatory (Teeth): Occupational Safety & Health Administration (OSHA)
  - Private employers
  - Federal agencies (certain restrictions)
  - States choose to participate (Local/state agencies)
    - ~50% states so choose
    - Iowa does not, but Iowa OSHA follows federal agency regulations closely

TB Risk Assessment Worksheet...Appendix B

- Community rate of active TB
- Number of TB patients treated at your facility
- Screening for LTBI among workers
- TB infection control program in place
- Types of Environmental Controls in use
- Respiratory Protection Plan
- Level of laboratory support
- Annual risk re-assessment plan
Screening for TB among HCWs
Guidelines…Appendix C

- Baseline testing TST (two step)
- Screen for active TB
- Training & education about TB
- Serial testing

Serial Testing of HCWs for LTBI
Part 1

- Serial testing: administer, read & interpret TST according to guidelines…
- No serial testing for Low Risk classification (Appendix C).
- Exempt those HCWs w/ LTBI & Rx completed
  – Consider annual TB assessment in lieu of TST
- IGRA substitute for TST in serial testing…
Serial Testing of HCWs for LTBI
Part 2

• Rationale for decreased emphasis on serial testing:
  – Most hospitals: transmission of TB infection approaches a level (< 2%) which predicts that TST less likely to detect disease & more likely to be false positive
  – UIHC: TST screening data review suggests TST conversion rate (0.05%) most likely false positive rather than indicating TB transmission

LTBI Testing Upgrade...Generalizations
Interferon-γ Release Assay (IGRA)

• Accurate blood testing is a reality; Substitute for TST
• QuantIFERON-TB Gold®, aka QFT-G (99, upgrade ‘05, ‘07*)
  – Commercially available, costly
  – Measures Interferon-γ production by sensitized lymphocytes (T-cells)
  – Does not cross-react with BCG or MAC (antigens: ESAT-6, CFP-10)
• Advantages/Indications
  – Patients in whom false positive TST likely (eg BCG, NTM)
  – F/u not necessary in 48-72 hours; Ideal for patients unlikely to return
  – Equal Sensitivity, Increased Specificity compared to TST
• Limitations: Blood must be processed w/in 12h*; Multi-popn. data limited (HIV, Elderly, Children); Serial testing performance uncertain; Cost
• Does not distinguish latent from active disease
• New: *QFT-GIT (in tube... time factor) & T-Spot. TB®

Key Recent References


Pediatric Infection Control

- Children with confirmed or suspected TB
  - Less likely than adults to be infectious
    - Low number of organisms
    - Reduced tussive force
  - Usually do not require infection control measures, but ...
  - Evaluate for infectiousness as in adults
    - Extensive pulmonary/laryngeal involvement
      - Prolonged cough, miliary TB, cavitation on CXR, + AFB sputum smears
    - Not on adequate anti-TB therapy or just started anti-TB therapy
Case Example
- 27 YO Mexican-American male diagnosed with schizophrenia
- Initial treatment in a psychiatric facility.
- Complained of cough, weight loss and fever.
- TST +, CXR Inconclusive, AFB Smears negative, Cultures pending

Case Example Continued
- Placed on preventive chemotherapy (Isoniazid LTBI treatment).
- Clinical condition begins to deteriorate (worsen)
- CXR repeated: findings consistent with cavitary TB disease.
- Cultures come back positive
Results

• Patient develops Isoniazid resistance
• Places other patients at risk

Mistakes?

• Starting LTBI treatment before ruling out active disease
Teaching Points

• LTBI is asymptomatic
• Never start LTBI treatment without unequivocally ruling out active disease

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• Guidelines for Preventing the Transmission of *M. tuberculosis* in Health-Care Settings, CDC 2005
• Control of Communicable Diseases Manual, David L. Heymann, APHA, 2004
QUESTIONS?