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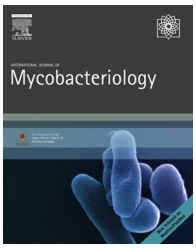

Full Length Article

Mycobacterial contamination of bronchoscopes: Challenges and possible solutions in low resource settings

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ABSTRACT

The use of bronchoscopes has increased in tuberculosis (TB) diagnostics to circumvent the diagnostic challenges that are associated with low sputum volume and smear-negative TB. In healthcare facilities situated in low income countries that have a high burden of TB, adequate decontamination of bronchoscopes is a challenge and often overlooked to save on time and costs. This amplifies the risk of outbreaks and pseudo-outbreaks due to *Mycobacterium tuberculosis* and nontuberculosis mycobacteria. In this minireview, we review published literature of contaminated bronchoscopes causing pseudo-outbreaks of *M. tuberculosis* and nontuberculosis mycobacteria in an effort to determine common sources, and possible mitigation strategies in low-resource settings.

Bronchoscopy is an important diagnostic and therapeutic tool [1,2] in both ambulatory and inpatient healthcare settings [1]. In the context of pulmonary tuberculosis, bronchoalveolar lavage or bronchial biopsy have been proven to be essential diagnostic tools, especially for patients who are unable to expectorate sufficient sputum samples [3]. However, this semicritical medical device [4] has also been reported to be a source of both pseudo-infections and infectious outbreaks [5]. An indication of an improperly disinfected bronchoscope acting as a potential reservoir for contamination of both cultures and patients can be gauged by the fact that the bioburden on bronchoscopes postwashing has been estimated to be around 6.4×10^4 colony forming units/mL [4]. According to a metadata analysis conducted from 1974 to 2004 by Seoane-Vazque et al. [6], the highest number of contaminating incidents was attributed to bronchoscopy and gastrointestinal endoscopy. In the United States, contaminated fiberoptic bronchoscopes are estimated to contribute to *Mycobacterium tuberculosis* (MTB) nosocomial infections in 460–2300 human immunodeficiency virus infected patients annually [7]. Additionally, pseudo-outbreaks due to environmental microorganisms contaminating bronchoscopes have also been reported [8]. However, data related to bronchoscope-associated infections and pseudo-outbreaks is underreported [5], with a dearth of data from low-income and developing countries.

MTB, nontuberculous mycobacteria (NTM), and *Pseudomonas aeruginosa* are the most common pathogens

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Table 1 – Reported pseudo-outbreaks of nontuberculous mycobacteria and *M. tuberculosis* associated with bronchoscopy.

Study design	Sample size (No. cases/No. of bronchoscopies performed)	Reason for suspecting outbreak	Organism	Identified source of contamination	Strain similarity	Refs.
Retrospective study	14/1270	Unique strain of *M. cholnea* isolated + inconsistent culture findings with clinical features of patients	*M. cholonae* subsp. *abscessus*	Rinse water	Not performed	[10]
Retrospective study	7/16 1/16 3/16	Inconsistent culture findings with clinical features of patients	*M. cholonae*, *M. avium* *M. gordonae*	Rinse water Water tank Contaminated glutaraldehyde disinfectant	Not performed	[11]
Retrospective study	17/21	Unusual No. of rapidly growing AFB	*M. xenopi*	Water	RFLP	[12]
Retrospective study	15/76	Not stated	*M. cholonae* & *M. fortuitum*	Mains water supply Disinfectant tank	Not performed	[13]
Retrospective case-controlled study	18/21	Unusual increase in isolation	*M. cholonae*	Suction channel	—	[14]
Surveillance of bronchoscopes	15/19 3/19	In response to previous pseudoinfection	*M. cholonae* *M. avium intercellularae*	Failure of AER disinfection procedure	—	[15]
Prospective-induced study	—	Efficacy of different disinfectants: iodophore, glutaraldehyde, peraceticacid	*M. gordonae*	Normal conditions for disinfection inadequate	—	[16]
Retrospective + prospective study	20	Unusual number of rapidly growing AFB	*M. cholonae*	Automated washer & glutaraldehyde disinfectant	DNA fingerprinting	[17]
Retrospective study	9/57	Isolation at increased frequency	*M. cholonae*	Incoming water, water filters, automated bronchoscope washing machine	REP-PCR	[18]
Retrospective	22/75	Culture isolates were inconsistent with clinical features of patients	*M. avium, M. intercellulare*	Water filter, hot & cold water lines	Nested PCR + RFLP	[19]
Prospective study	5/7	Isolation of *M. gordonae* in BAL	*M. gordonae*	Tap water, water supply channels	PFGE	[20]
Prospective study	4/5	Recurrent cases of mycobacterial cross-contamination	*M. tuberculosis*	Contaminated suction valve	Not performed	[21]
Retrospective cohort study	6/10	High incidence of *M. tuberculosis*	*M. tuberculosis*	Hole in bronchoscope sheath	RFLP	[22]
Retrospective cohort study	2/3	No cases reported in hospital the previous year, suspected nosocomial outbreak	*M. tuberculosis*	Inadequate cleaning & disinfection between patients use. AER was not approved	Spoligotyping + IS6110-based RFLP	[23]

Note. AFB = acid-fast bacilli; BAL = bronchoalveolar lavage; M. = *Mycobacterium*; PCR = polymerase chain reaction; RFLP = restriction fragment length polymorphism.

associated with transmission during bronchoscopy and pseudo-outbreaks [5]. Bronchoscope contamination with MTB is associated with extensive healthcare costs on the system or on patients (where out-of-pocket expenses are involved); false-positive cases are often investigated with repeat cultures and advanced radiological investigations, receive unnecessary antimycobacterial treatment, and risk adverse effects of medication. An interesting study by Shim et al. [9] highlights the limitations of direct amplification tests created by the presence of false-positive results even by the presence of a few dead MTB contaminating the bronchoscopes. It is therefore imperative that special attention be placed on addressing and circumventing not only false-positive cultures but also false-positive molecular detection tests such as Xpert MTB/RIF (Cepheid), and molecular probe assays, due to bronchoscope contamination with mycobacteria.

Reports of bronchoscope contamination with NTM and MTB in literature from 1990 to 2016 are briefly outlined in Table 1. While many NTM-associated outbreaks have been reported, MTB-associated pseudo-outbreaks have not been reported with equal frequency.

Possible factors indicated in the failure of the bronchoscope decontamination process and leading to NTM infections include the design of bronchoscopes/endoscopes, an over-reliance on automated endoscope reprocessors, malfunctioning parts and damage during use, noncompliance of decontaminating and handling guidelines, and use of contaminated/nonsterile water during washing [24–26]. Reported causes of bronchoscopy-associated pseudo-outbreaks further include damage to the internal channel of the bronchoscope, the ability of bacteria to form biofilms that are difficult to remove, along with inadequate cleaning with low- or intermediate-level disinfectants. To prevent bronchoscope-associated pseudo-outbreaks it is thus imperative to implement standardized decontamination guidelines, such as those issued by the Centers for Disease Control and Prevention [4], Association for Professionals in Infection Control and Epidemiology [27], Food and Drug Administration [28], and European Society of Gastrointestinal Endoscopy-European Society of Gastroenterology and Endoscopy Nurses and Associates [29]. There are, however, differences amongst these guidelines; for example, for recommendations on microbiological culture surveillance of bronchoscopes and on the frequency of culture as well as on interpretation of data. In light of such differences, a recommendation for an initial validation study of the protocol to be used demonstrating its effectiveness in particular healthcare settings would be useful [24]. While automated endoscope reprocessors are recommended by British Society of Gastroenterology and World Gastroenterology Organisation in advanced settings, manual cleaning, and disinfection are widely carried out in resource-limited settings [30]. Ensuring quality control particularly in resource-limited healthcare settings using manual cleaning and disinfection in particular, is a considerable challenge. Since water is identified as a major environmental source of bronchoscope contamination, this challenge is made all the more difficult by limited access to clean water in many resource-limited settings. The Health Protection Surveillance Center-Ireland recommends that there should be no viable environmental mycobacteria/100 mL of postflush water from bronchoscopes [31].

False-positive results of MTB smears, cultures, or molecular tests in bronchoscopically obtained samples are mainly due to cross-contamination owing to insufficient decontamination of bronchoscopes between use [5,32] or cross-contamination in the laboratory [33,34]. Given that Xpert MTB/RIF (Cepheid) is a closed system, and risk of cross-contamination in the laboratory is lower, false-positive or unexpected positive Xpert results on bronchoscope samples are likely to be a consequence of inadequate decontamination of the bronchoscope itself. Guidelines, however, do not focus on decontamination to ensure complete removal of DNA or antibiotic resistance genes from bronchoscopes.

Awareness and advocacy for stringent monitoring and surveillance within the bronchoscope suite and disinfection unit including monitoring of disinfectants used [31] thus becomes essential. Implementing regular training and competency assessment of personnel concerned with bronchoscope disinfection would ensure compliance with recommended guidelines.

While implementation and compliance of decontamination guidelines cannot be stressed enough, it is also necessary that proper communication be established between the clinicians, bronchoscopists, and laboratories so that not only are pseudo-outbreaks promptly detected but a coordinated approach is implemented to handle postcontamination responses.

As access to bronchoscopy, as well as its use in the diagnosis of TB and in particular smear-negative TB increases [35–37], implementation of policies ensuring proper decontamination of instruments being used as well as safety during the procedure achieve paramount importance. We therefore recommend that in addition to development of regional and/or national guidelines for manual bronchoscope decontamination to remove mycobacteria, innovative and low-cost regional quality assurance programs be introduced to ensure that specimens obtained through bronchoscopic techniques are free of cross-contaminating mycobacterial DNA.

Conflicts of interest

The authors have nothing to disclose.

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