CONCISE COMMUNICATION

Frequency of Contamination of Single-Patient-Use Nebulizers Over Time

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Adult hospitalized patients with cystic fibrosis commonly receive nebulized medications. For single-patient-use nebulizers that are cleaned after each use, there is infrequent nebulizer contamination (0%–11%) with only low numbers of epidemiologically important pathogens (less than 100 colony-forming units), and this contamination is similar after 24, 48, and 72 hours of use.

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Cystic fibrosis (CF) is a common lethal genetic disease with an estimated 30,000 affected persons in the United States.[1,2] Inhaled medications delivered by a nebulizer are frequently used to control the symptoms and progression of lung disease.[3-5] However, nebulizers have been reported as a source of pathogens for patients.[4,5] Recommendations for the cleaning and disinfection of small-volume medication nebulizers have been provided by the Centers for Disease Control and Prevention (CDC) as follows: between treatments for the same patient, the nebulizer should be cleaned, disinfected, and rinsed with sterile water.[4] The 2013 CF Infection Control Guideline recommends that, after each use, the nebulizer be rinsed with sterile water and the mask and mouthpiece be wiped with an alcohol pad and that the nebulizer be discarded every 24 hours.[5] This recommendation is based on a study that cultured nebulizers 24 hours after in-hospital use by patients with CF and identified only infrequent growth of organisms that are generally considered skin flora, even though the nebulizer was not cleaned or disinfected between multiple uses.[6] We conducted this study to assess the contamination frequency of nebulizers used by the same patient for up to 72 hours.

METHODS

This study was conducted at the University of North Carolina (UNC) Hospitals, an 806-bed academic center, between October and November 2013. Hospitalized adult and pediatric patients with CF who were receiving at least 1 nebulized medication were identified by the respiratory care department. Standard procedure at UNC Hospitals is for single-patient-use nebulizers to be thoroughly rinsed with sterile water and then air dried after each patient use; they are replaced on Mondays, Wednesdays, and Fridays (ie, after up to 72 hours of use).

We cultured nebulizers after 24, 48, and 72 hours of use. Two samples were obtained, 1 from the nebulizer and 1 from the T-tube connector. The nebulizer samples were collected using sterile syringes that were filled aseptically under a biologic safety cabinet with 10 mL of sterile saline. For each nebulizer, the saline was gently dispensed into the nebulizer chamber, the nebulizer lid was secured, and the nebulizer was swirled as vigorously as possible for approximately 1 minute, after which the saline was drawn back in the syringe and delivered to the laboratory. Once in the laboratory, the 10-mL syringe of saline was filtered, and the filter was aseptically removed and divided in half. Half of the filter was cultured on sheep blood agar, and the other half was cultured on chocolate agar. The T-tube was cultured by gently rotating a culturette to swab as much of the inner lumen of the T-tube as possible, after which the culturette was replaced in its original tube and delivered to the laboratory, where the culturette was cultured directly on sheep blood, chocolate, and McConkey agar. All cultures were incubated at 37°C and read daily for 7 days. All growth was quantitated and pathogens identified using standard microbiologic methods.

Information on the pathogens colonizing or infecting the patient was obtained by retrospective chart review of sputum or respiratory tract cultures obtained during the same hospitalization as cultures of the nebulizer. Data on the cost of the nebulizer were obtained from purchasing records. This study was approved by the institutional review board of UNC.

We obtained the number of nebulizers ordered for inpatient use from purchasing records for 2013. Costs were $1.70 each for Pari nebulizers and $0.60 each for Misty nebulizers. We calculated the estimated cost of changing from our Monday, Wednesday, and Friday nebulizer replacement to daily nebulizer replacement by dividing the total purchase cost of nebulizers for inpatients by 3 and multiplying by 7.

TABLE 1. Epidemiologically Important Pathogens Cultured from Sputum of Patients with Cystic Fibrosis

Pathogen	No. (%) of isolates (n = 32)
Pseudomonas aeruginosa	19 (59.4)
Methicillin-resistant *Staphylococcus aureus*	11 (34.4)
Burkholderia species	8 (25.0)
Methicillin-susceptible *S. aureus*	7 (21.9)
Mold	7 (21.9)
Achromobacter species	6 (18.8)
Stenotrophomonas maltophilia	1 (3.12)
Ralstonia pickettii	1 (3.12)
Enteric gram-negative bacillus	0 (0)

TABLE 2. Results of Nebulizer and T-Tube Cultures by Time since Nebulizer First Used

	Culture time, hours					
	24		48		72	
Variable	Nebulizer (n = 104)	T-tube (n = 100)	Nebulizer (n = 111)	T-tube (n = 106)	Nebulizer (n = 66)	T-tube (n = 64)
No. of sites with positive culture (mean % [95% CI])	49 (47 [37–57])	18 (18 [11–27])	58 (52 [42–62])	11 (10 [5–18])	36 (55 [42–67])	12 (19 [10–30])
Total colony counts	1,256	649	1,352	314	832	327
No. of cultures with epidemiologically important pathogens (mean % [95% CI])	11 (11 [5–18])	4 (4.0 [1–10])	1 (0.9 [0.02–5])	0 (0 [0–3])	4 (6.1 [2–15])	2 (3.1 [0.4–11])
Epidemiologically important pathogens from different cultures[a] (same pathogen recovered from sputum)	1. MRSA, 1 (Y); 2. MRSA, 1 (Y); 3. MRSA, 25 (Y); 4. MRSA, 20 (Y); 5. *Moraxella*, 2 (N); 6. MRSA, 163 (Y); 7. MRSA, 116 (Y); 8. MRSA, 12 (Y); 9. MSSA, 3 (Y); 10. MRSA, 12 (N); 11. *Acinetobacter lwoffii*, 6 (N)	1. MRSA, 7 (Y); 2. MRSA, 1 (Y); 3. *Sphinomonas paucimobilis*, 1 (N); 4. MRSA, TNTC (Y)	1. *Stenotrophomonas maltophilia*, 2 (N)		1. *Burkholderia multivorans*, 1 (Y); 2. MSSA, 2 (Y); 3. MRSA, 18 (Y); 4. *Pantoea* spp., 11 (N)	1. *Pantoea agglomerans*, 1 (N); 2. MRSA, 31 (Y)

NOTE. Confidence intervals (CIs) were calculated using the Fisher exact method. MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-susceptible *Staphylococcus aureus*; N, no; TNTC, too numerous to count; Y, yes.

[a] Data include only patients for whom a pathogen was isolated from sputum. Organisms not considered epidemiologically important included coagulase-negative staphylococcus, *Micrococcus* species, yeast, diphtheroids, *Bacillis* species, *Propionibacterium acnes*, and *Streptococcus* species.

RESULTS

The nebulizers of 33 adult and pediatric patients with CF were evaluated. Of these patients, 32 (97.0%) had at least 1 sputum culture obtained during the hospitalization in which their nebulizer was evaluated. Of these 32 patients, 31 (96.9%) had a least 1 pathogen isolated; the mean number of pathogens per patient was 2.94, with a range of 2–4 (Table 1). Overall, 281 nebulizer cultures were obtained (Table 2). Approximately 50% of nebulizer cultures demonstrated bacteria. The likelihood of a positive culture was not statistically different at 24, 48, and 72 hours. The likelihood of a clinically important pathogen being isolated was 11% at 24 hours, 0.9% at 48 hours, and 6.1% at 72 hours, but no time point had a statistically higher rate of culture positivity. Overall, 16 nebulizer cultures yielded a potential pathogen, with 14 cultures demonstrating fewer than 100 colonies. In 11 cases (68.8%), the same pathogen found in the nebulizer was also cultured from the patient's sputum.

Overall, 270 T-tube cultures were obtained (Table 2). Approximately 15% (range, 10%–19%) of T-tubes cultures demonstrated bacteria. The likelihood of a positive culture was not statistically different at 24, 48, and 72 hours. The likelihood of a clinically important pathogen being isolated ranged from 4% at 24 hours to 0% at 48 hours and was not statistically different. Overall, 6 cultures yielded a potential pathogen, with 5 cultures demonstrating fewer than 100 colonies. In 4 cases (67%), the same pathogen (methicillin-resistant *Staphylococcus aureus*) found in the T-tube was also cultured from the patient's sputum.

We estimate that replacing all nebulizers daily instead of 3 times per week would lead to use of an additional 29,048 nebulizers at an additional cost of $22,064.93 per year (approximately $108.86 per 1,000 patient-days).

DISCUSSION

CF is characterized in adulthood by chronic colonization or infection of the respiratory tract. Because most patients with CF receive inhaled medications via nebulizers, and nebulizers represent a potential source of pathogens for a patient with CF, the CF Foundation has published recommendations for cleaning and disinfection between uses. However, whether disinfection of nebulizers between each use in the hospital is beneficial has not been scientifically demonstrated. Disinfecting the nebulizer in the hospital using an Environmental Protection Agency–registered disinfectant is logistically challenging given the frequency of use (4 or more times per day).

Our data demonstrated that nebulizers were relatively infrequently contaminated with pathogens, and in most cases in which a pathogen was isolated, it was in low numbers and was the same species as found in the patient's sputum. Contamination was not statistically more likely at 48 or 72 hours than at 24 hours. However, we did occasionally isolate a pathogen, generally in low numbers, that had not been isolated from the patient. The source of these pathogens could have been the environment, contamination from the hands of healthcare personnel or visitors/family members, or they could have been present in the patient's respiratory tract but in such low numbers as not to be detected in the sputum culture. Limitations of our study include the following: there was a lack of molecular characterization of bacterial strains to determine their source, cultures for nontuberculous mycobacteria were not performed, our study included mostly adult patients and therefore may not be generalizable to children, and our data can only be used to assess the safety of nebulizer use up to 72 hours.

Adhering to the new CF infection control guideline by disposing of nebulizers daily instead of 3 times per week would cost UNC Hospitals an estimated $22,064.93 per year based on our nebulizer acquisition costs. Adhering to the 2003 CDC pneumonia guideline would likely increase costs by another fivefold given the daily frequency of administration of our inhaled medications. On the basis of this study, we believe that nebulizers can be safely used for up to 72 hours before being discarded.

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