

# Nebulizer Use and Maintenance by Cystic Fibrosis Patients: A Survey Study

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**INTRODUCTION:** Patients with cystic fibrosis (CF) suffer from chronic infection of the airways, and typical CF therapies include aerosolized medications. There is recent evidence that home nebulizers become contaminated by bacteria, causing concern that nebulizers may be a source of bacterial infection of the lower airways. A recent consensus document on infection-control issues for the CF population included recommendations on cleaning and disinfecting nebulizers. **METHODS:** We surveyed 39 patients and their parents, as well as 54 respiratory therapists, regarding their routine nebulizer use and maintenance practices. **RESULTS:** All the patients used at least one nebulized medication, and they used a variety of nebulizers, obtained from a wide variety of sources. Thirty percent of the patients used nebulizers well beyond the manufacturer's recommended replacement date. Ninety percent of the patients rinsed their nebulizers following use, but only 15% performed any routine disinfection. The respiratory therapists' nebulizer cleaning methods were widely disparate, with only 70% performing some method of rinsing. The respiratory therapists' self-report of cleaning methods and their instructions to patients regarding frequency of cleaning were so diverse that no standard is evident. **CONCLUSION:** This study demonstrates that CF patients and their respiratory therapists should immediately address and improve their nebulizer cleaning methods and replacement practices. There should be more focus on teaching patients to regularly clean and replace nebulizers. *Key words:* nebulizer, cystic fibrosis, disinfection, respiratory therapist. [Respir Care 2004;49(12):1504–1508. © 2004 Daedalus Enterprises]

## Introduction

Patients with cystic fibrosis (CF) suffer from chronic infection of the airways because they are locally immunocompromised and sensitive to *Pseudomonas aeruginosa* colonization in the lower airways.<sup>1</sup> They experience ex-

cessive airway secretions, leading to airway obstruction, which allows persistent infection and inflammation. Typical therapies for patients with CF include techniques to enhance clearance of airway secretions, appropriate use of antibiotics, and aerosolized medications. Epidemiological studies have reported the use of bronchodilators (eg, albuterol),<sup>2</sup> mucolytics (eg, dornase alfa),<sup>3</sup> and inhaled antibiotics (eg, tobramycin)<sup>3</sup> among 82%, 58%, and 61% of patients with CF, respectively. Based on a study that found bacterial contamination of home nebulizers,<sup>4</sup> there is growing concern that home nebulizers may be a source of bacterial infection of the lower airways.

Regular cleaning and replacement of nebulizers can reduce bacterial contamination.<sup>5</sup> Patients who follow directions for good nebulizer cleaning practices and who pay particular attention to drying the nebulizer have minimal nebulizer contamination.<sup>5</sup> These findings were addressed in a recent consensus document that addressed infection-control issues germane to the CF population.<sup>6</sup> The document included recommendations from the Centers for Dis-

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ease Control infection control guidelines,<sup>7</sup> which stress the importance of disinfecting the nebulizer after each use, and it offered 3 disinfection techniques:

1. Soak the nebulizer in a mixture of 1 part bleach to 50 parts water for 3 min
2. Soak the nebulizer in 70% isopropyl alcohol for 5 min
3. Soak the nebulizer in 3% hydrogen peroxide for 30 min

Those methods are not consistent with the most widely used method, soaking the nebulizer in a solution of vinegar and water, which is the method typically recommended by manufacturers in the nebulizer's package insert.

Prior to implementing those stringent nebulizer-cleaning guidelines, we sought to understand the cleaning methods that patients with CF use. We developed 2 surveys to examine (1) nebulizer cleaning practices of patients with CF who receive their care from our center and (2) nebulizer cleaning methods taught by respiratory therapists (RTs, who may or may not routinely care for patients with CF). The goal was to gain a better understanding of the actual use and maintenance of nebulizers among the CF population and to compare actual practices to the nebulizer-maintenance education that RTs typically provide.

### Methods

Two surveys, one for patients (or young patients' parents) (Appendix 1) and one for RTs (Appendix 2), were developed by our CF center's director, RT, and nurse coordinators. The intent was to collect data on home nebulizer maintenance practices, as part of a quality-improvement initiative. The patient survey was administered to our CF center's patients. The RT survey was administered to RTs from our hospital and other institutions. The surveys were designed to gain information regarding patient, family, and RTs' knowledge of and routine practices regarding nebulizer cleaning and replacement.

Adult patients with CF and parents of pediatric patients with CF met face-to-face with the CF RT and completed the patient survey while attending out-patient clinic appointments. We excluded patients who were not using nebulized medications. The study was performed over 6 months, and we used a convenience sample of our overall CF center population. Participants were asked to identify the brand of nebulizer and compressor they used, how often they replaced them, which medications they used in the nebulizer, their cleaning practices, and from whom they received instructions for cleaning.

The RT survey was distributed to RTs at a statewide continuing-education conference. Some of the RTs who attended that conference work at our institution. We did not ask the RTs to name their specific work environment. The survey did ask what cleaning methods they used in the hospital and what they were teaching their patients.

Table 1. Patient and Parent Survey Results

Survey Item	(n = 39)	%
Aerosolized medication*		
Albuterol	39	100
Pulmozyme	26	67
Antibiotic (inhaled tobramycin or colistin)	19	50
Nebulizer brand		
Pari LCD	7	18
Pari LC+	21	54
Hudson Updraft	4	10
Sidestream	2	5
Other	5	13
Where did you obtain nebulizer?		
Cystic fibrosis clinic	10	26
Hospital	8	21
Durable medical equipment company	10	26
Other (eg, pharmacy, doctor's office)	11	28
Where did you receive instructions regarding cleaning and maintenance?		
Respiratory therapist	1	3
Durable medical equipment company	13	33
Nobody	13	33
Already knew	8	21
Doctor's office	1	3
Pharmacy	1	3
Cannot recall	2	5
Method of cleaning nebulizer*		
Tap water rinse	21	54
Warm soapy water, followed by rinse	14	36
Vinegar soak and rinse	7	18
Dishwasher	3	8
Boiling water	3	8
Other	2	5

\*In these categories, some respondents checked more than one box.

### Results

Thirty-nine patients (13 adult and 26 pediatric) completed the patient survey (Table 1). All the patients nebulized bronchodilators and most were using dornase alfa and an inhaled antibiotic. A variety of nebulizers were used. Patients obtained their devices from various sources. Regarding how often they replaced their nebulizers, the responses ranged from "every 6 months" to as infrequently as "every 4 years." The patients stated that they received nebulizer cleaning and maintenance instructions from a number of sources. The reported nebulizer-cleaning methods differed both in the type of solution used and in the frequency of cleaning. Surprisingly few (15%) used a disinfectant cleaning method at least once a week.

Fifty-four RTs completed the RT survey (Table 2). The cleaning liquids the RTs most commonly recommended were tap water (33%) and soap-and-water (43%). Only

Table 2. Respiratory Therapist Survey Results

Survey Item*	(n = 54)	%
Brand of nebulizer used at your facility		
Pari LCD	19	35
Pari LC+	3	6
Hudson Updraft	37	68
Sidestream	0	0
Other	14	26
Nebulizer cleaning method used at your facility		
Air drying without rinse	17	30
Tap water rinse	26	48
Warm soapy water followed by rinse	6	11
Other (rinse with sterile solution)	6	11
Where do you dry the nebulizer?		
Back in the set-up bag	18	33
Drawer of bedside table	2	3
Dry paper towel at sink	28	52
Other	4	7
Nebulizer cleaning method routinely taught to patients		
Tap water rinse	18	33
Warm soapy water followed by rinse	34	63
Vinegar soak	32	59
Dishwasher	4	7
Boiling water	0	0
Other	0	0

\*Some respondents checked more than one box.

41% of the RTs taught patients to use a disinfectant. For those who taught use of tap water, the most-recommended frequency was "after each treatment" ( $n = 12$ ), though one taught daily cleaning, and one taught weekly cleaning. For those who taught use of soap-and-water, only one taught cleaning after each treatment; the other cleaning frequencies were daily ( $n = 11$ ), weekly ( $n = 6$ ), monthly ( $n = 1$ ), and other (eg, every other day and every third day) ( $n = 4$ ). Of those who taught disinfectant use, the recommended frequencies included daily ( $n = 6$ ), weekly ( $n = 9$ ), monthly ( $n = 1$ ), and other (every other day and every third day) ( $n = 6$ ). With regard to their current in-hospital cleaning practices after each nebulizer treatment, 30% of the RTs allowed the device to air dry without any type of rinsing.

## Discussion

Our results demonstrate a wide variety of nebulizer cleaning practices by patients with CF. This is not surprising, given the other findings of this survey. First, patients reported getting their devices and their nebulizer education from a number of different sources. Second, it appears that the patients may witness a wide variety of cleaning methods in the hospital. Third, if the RTs in this study reflect other sources of nebulizer education, then there is no standard method of

cleaning being taught to patients; RTs teach a wide variety of nebulizer cleaning methods and cleaning frequency. Furthermore, the study found 2 very worrisome facts:

1. A substantial proportion of patients were not disinfecting, and in some cases not even cleaning, their nebulizers as often as recommended in the infection control guidelines of the Centers for Disease Control's Healthcare Infection Control Practices Advisory Committee (formerly known as the Hospital Infection Control Practices Advisory Committee).<sup>7</sup>

2. Many patients were overusing disposable devices. It is important to note that 32% of the identified nebulizers used by these patients are disposable or single-use nebulizers.

Inhaled medication is essential in CF therapy because it allows for application of high concentrations of drug to the respiratory tract while causing minimal systemic absorption. The development of current aerosolized therapies is thought to be a major advance in the care of patients with CF, and new aerosolized therapies are being developed. Most of our patient respondents had prescriptions for 2 medications, and many were using three. Thus, nebulizers are likely to remain a standard treatment for most if not all patients with CF. Unsatisfactory nebulizer cleanliness may influence nebulizer performance and could expose patients to bacteria from lack of proper nebulizer disinfection.

Patients with CF are vulnerable to chronic airways infection because of the basic CF genetic defect. The entry of bacteria into the lower airways is generally thought to be due to microaspiration of oropharyngeal organisms. The nebulizer, if contaminated with bacteria from the environment or the patient, could aid in the delivery of organisms to the lower airways.<sup>5</sup> Though this has not been shown definitively, a number of studies have demonstrated growth of organisms in nebulizer devices.<sup>1,5,8</sup> Rosenfeld et al<sup>8</sup> reported that cultures taken from nebulizers used at home by patients with CF were frequently positive for *Staphylococcus aureus* (55%), *Pseudomonas aeruginosa* (35%), and *Klebsiella* species (19%). Although that would suggest that the patients themselves were the source of the bacteria, there was no genotyping to prove that the organisms were identical to those in the patients' sputum. Vassal et al found that the nebulizers of patients who had cultured heavy growth of Gram-negative bacteria from their sputum were twice as likely to have contaminated nebulizers as were patients with lighter growth of *Pseudomonas* in their sputum.<sup>1</sup>

## Conclusions

There are now published guidelines that establish implementable nebulizer cleaning methods.<sup>6</sup> The consensus guidelines point out that all patients with CF have transmittable pathogens and that home nebulizers and tap water harbor pathogens.<sup>6</sup> Our study indicates an immediate need to address nebulizer cleaning methods, among both pa-

tients and RTs. Assuming that the bacteria cultured from nebulizer devices are potentially pathogenic, then a standard method of cleaning is imperative. A reliable, proven cleaning method should be used both in the hospital and at home. There should be more focus on educating patients about cleaning and replacing nebulizers, and there should be a readily available and consistently distributed, written, standard cleaning and replacement guideline for patients to follow at home. Nebulizer cleaning/disinfection/replacement should be an important topic in the curriculum of respiratory therapy schools, and nebulizer cleaning/disinfection/replacement education should be required for anyone who dispenses medication for nebulization.

Based on our findings, we are exploring ways to implement appropriate measures for care and cleaning of nebulizers, through staff and patient awareness programs, training, and education. We are developing standard written instructions for patients and their families. Finally, we are planning follow-up data collection that will include culture studies from patient nebulizers.

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Appendix 1

Home Nebulizer Use Patient Survey																																																										
<p>1. What medications do you nebulize and how long does each take?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Albuterol</td> <td style="width: 100px;">_____ minutes</td> </tr> <tr> <td><input type="checkbox"/> Pulmozym</td> <td>_____ minutes</td> </tr> <tr> <td><input type="checkbox"/> Tobit</td> <td>_____ minutes</td> </tr> <tr> <td><input type="checkbox"/> Other</td> <td>_____ minutes</td> </tr> </table> <p>2. How many nebulizers are you currently using? _____</p> <p>3. What brand of nebulizers do you use and how often do you replace them?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Pari LCD</td> <td style="width: 100px;">_____</td> </tr> <tr> <td><input type="checkbox"/> Pari LC+</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Hudson Updraft</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Sidestream</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Other</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Do not know?</td> <td>_____</td> </tr> </table> <p style="text-align: right; margin-right: 50px;"><u>Replacement Interval</u></p> <p>4. Where did you get your nebulizer? _____</p> <p>5. Which brand of compressor do you use?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Devillbis Pulmo-Aide</td> <td style="width: 100px;">_____</td> </tr> <tr> <td><input type="checkbox"/> Respironics Inspiration</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Pari Pronieb</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Omron Comp Air Elite</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Other</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Do not know?</td> <td>_____</td> </tr> </table> <p style="text-align: right; margin-right: 50px;">How long have you had it?</p> <p>6. How often do you replace the compressor filter? _____</p>	<input type="checkbox"/> Albuterol	_____ minutes	<input type="checkbox"/> Pulmozym	_____ minutes	<input type="checkbox"/> Tobit	_____ minutes	<input type="checkbox"/> Other	_____ minutes	<input type="checkbox"/> Pari LCD	_____	<input type="checkbox"/> Pari LC+	_____	<input type="checkbox"/> Hudson Updraft	_____	<input type="checkbox"/> Sidestream	_____	<input type="checkbox"/> Other	_____	<input type="checkbox"/> Do not know?	_____	<input type="checkbox"/> Devillbis Pulmo-Aide	_____	<input type="checkbox"/> Respironics Inspiration	_____	<input type="checkbox"/> Pari Pronieb	_____	<input type="checkbox"/> Omron Comp Air Elite	_____	<input type="checkbox"/> Other	_____	<input type="checkbox"/> Do not know?	_____	<p>7. Where did you get your compressor?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> While in the hospital</td> </tr> <tr> <td><input type="checkbox"/> Drugstore</td> </tr> <tr> <td><input type="checkbox"/> Home medical equipment company</td> </tr> <tr> <td><input type="checkbox"/> Other</td> </tr> </table> <p>8. How many nebulizer sets did you receive when your equipment was first set up? _____</p> <p>9. Who instructed you in the function and maintenance of your equipment?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Hospital respiratory therapist</td> </tr> <tr> <td><input type="checkbox"/> Drug store personnel</td> </tr> <tr> <td><input type="checkbox"/> Medical equipment company employee</td> </tr> <tr> <td><input type="checkbox"/> Other _____</td> </tr> </table> <p>10. Which of the following nebulizer cleaning methods do you use? Please check all that apply. For each item checked please indicate how often you use that method.</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Tap water rinse</td> <td style="width: 100px;">_____</td> </tr> <tr> <td><input type="checkbox"/> Warm soapy water followed by rinse</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Vinegar soak and rinse</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Dishwasher</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Boiling water</td> <td>_____</td> </tr> <tr> <td><input type="checkbox"/> Other: _____</td> <td>_____</td> </tr> </table> <p>11. How do you cover the cost of the nebulizer / compressor?</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 150px;"><input type="checkbox"/> Medicare</td> </tr> <tr> <td><input type="checkbox"/> Medicaid</td> </tr> <tr> <td><input type="checkbox"/> Cash</td> </tr> <tr> <td><input type="checkbox"/> Private Insurance</td> </tr> <tr> <td><input type="checkbox"/> Other</td> </tr> </table>	<input type="checkbox"/> While in the hospital	<input type="checkbox"/> Drugstore	<input type="checkbox"/> Home medical equipment company	<input type="checkbox"/> Other	<input type="checkbox"/> Hospital respiratory therapist	<input type="checkbox"/> Drug store personnel	<input type="checkbox"/> Medical equipment company employee	<input type="checkbox"/> Other _____	<input type="checkbox"/> Tap water rinse	_____	<input type="checkbox"/> Warm soapy water followed by rinse	_____	<input type="checkbox"/> Vinegar soak and rinse	_____	<input type="checkbox"/> Dishwasher	_____	<input type="checkbox"/> Boiling water	_____	<input type="checkbox"/> Other: _____	_____	<input type="checkbox"/> Medicare	<input type="checkbox"/> Medicaid	<input type="checkbox"/> Cash	<input type="checkbox"/> Private Insurance	<input type="checkbox"/> Other
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## Appendix 2

Home Nebulizer Use Hospital Respiratory Therapist Survey															
<p>1. Which of the following brands of nebulizers are you currently using at your facility? (For all items checked, please indicate how often you recommend replacement.)</p> <table style="width: 100%; border: none;"> <thead> <tr> <th style="width: 70%;"></th> <th style="text-align: center; border-bottom: 1px solid black;">Replacement Time</th> </tr> </thead> <tbody> <tr> <td><input type="checkbox"/> Pari LCD</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Pari LCC+</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Hudson</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Other: _____</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table>			Replacement Time	<input type="checkbox"/> Pari LCD	_____	<input type="checkbox"/> Pari LCC+	_____	<input type="checkbox"/> Hudson	_____	<input type="checkbox"/> Other: _____	_____				
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<p>2. How are you cleaning the nebulizer set-up between treatments?</p> <p><input type="checkbox"/> Air drying without rinsing.</p> <p><input type="checkbox"/> Tap water rinse.</p> <p><input type="checkbox"/> Warm soapy water followed by rinse.</p> <p><input type="checkbox"/> Other: _____</p>															
<p>3. Once you have cleaned the set-up, where are you placing it to dry?</p> <p><input type="checkbox"/> Back into the set-up bag.</p> <p><input type="checkbox"/> In a drawer of the bedside table.</p> <p><input type="checkbox"/> On dry paper towels at sink.</p> <p><input type="checkbox"/> Other: _____</p>															
<p>4. Which of the following nebulizer cleaning methods do you routinely review with patients? (Check all that apply and list the cleaning schedule you recommend to the patient.)</p> <table style="width: 100%; border: none;"> <thead> <tr> <th style="width: 70%;"></th> <th style="text-align: center; border-bottom: 1px solid black;">Recommended cleaning schedule</th> </tr> </thead> <tbody> <tr> <td><input type="checkbox"/> Tap water rinse.</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Warm soapy water followed by rinse.</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Vinegar soak.</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Dishwasher.</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Boiling water.</td> <td style="text-align: center;">_____</td> </tr> <tr> <td><input type="checkbox"/> Other: _____</td> <td style="text-align: center;">_____</td> </tr> </tbody> </table>			Recommended cleaning schedule	<input type="checkbox"/> Tap water rinse.	_____	<input type="checkbox"/> Warm soapy water followed by rinse.	_____	<input type="checkbox"/> Vinegar soak.	_____	<input type="checkbox"/> Dishwasher.	_____	<input type="checkbox"/> Boiling water.	_____	<input type="checkbox"/> Other: _____	_____
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<p>5. Prior to hospital discharge do you discuss the care and maintenance of the home nebulizer and compressor with the patient?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>															