

# INFECTION RISKS ASSOCIATED WITH SPIROMETRY

Donna Renfrow Rutala, BSN, JD; William A. Rutala, PhD, MPH;  
David J. Weber, MD, MPH; Charlotte A. Thomann, MT(ASCP)

## ABSTRACT

**OBJECTIVES:** Spirometry is a widely used pulmonary function test that allows measurement of forced vital capacity and time-related measures of dynamic pulmonary function. This study was designed to identify the risk of cross-transmission associated with two commonly used dry-rolling seal spirometers.

**DESIGN:** Using a prospective study design, we examined whether microbial contamination of spirometers occurred following use by patients with a heavily colonized or infected respiratory tract. Prior to spirometry evaluation, a patient's sputum culture and equipment samples (i.e., mouthpiece, proximal tubing, piston surface) were obtained. After patient evaluation, a sterile 2 L ventilation bag and sterile tubing were used to simulate the risk of infection of subsequent patients. Simulation 1 was performed immediately after patient testing and Simulation 2, representing a second patient was conducted approximately 18 hours later.

**SETTING:** This study was conducted at the

University of North Carolina Hospitals, a large university teaching facility.

**PATIENTS:** Fourteen patients with underlying pulmonary disease were studied.

**RESULTS:** Our study revealed that the mouthpieces became contaminated with the patients' oral flora and with the associated respiratory pathogen. Fourteen percent of the associated tubing after patient testing contained the respiratory pathogen. All other equipment samples (e.g., interior surfaces of the machine, Simulation 1, Simulation 2 samples) were negative for the respiratory pathogen.

**CONCLUSIONS:** These data suggest that mouthpieces and spirometry tubing may become contaminated with microorganisms and should not be shared between patients. Since there is little or no bacterial contamination of the surfaces inside the spirometers and cross transmission is unlikely, it is unnecessary to routinely clean the interior surfaces of the spirometers. (*Infect Control Hosp Epidemiol.* 1991;12:89-92.)

## INTRODUCTION

Spirometry is a basic pulmonary function test that allows the measurement of forced vital capacity (FVC) and time-related measures of dynamic pulmo-

nary function.<sup>1,2</sup> Data obtained from the forced expiratory maneuver can be used to generate both flow-volume and volume-time curves. Such measures are widely used in the diagnosis of pulmonary disorders,

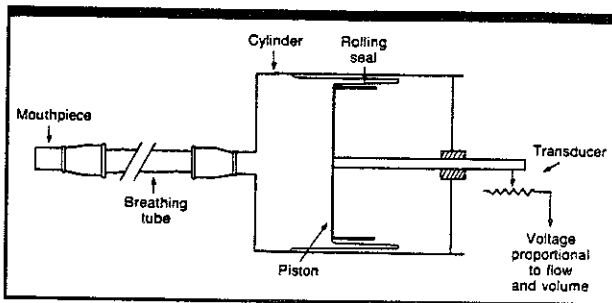
*From the Department of Hospital Epidemiology, University of North Carolina Hospitals (Drs. D. Rutala, W. Rutala, Weber, and Ms Thomann), and the Division of Infectious Diseases, Department of Medicine, University of North Carolina School of Medicine (Drs. W. Rutala and Weber), Chapel Hill, North Carolina. Present address (Dr. D. Rutala): Patterson, Dilthey, Clay, Cranfill, Sumner and Hartzog, Hillsborough Place, Raleigh, North Carolina.*

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*Address reprint request to William A. Rutala, PhD, MPH, 547 Burnett-Womack Building, CB #7030, University of North Carolina School of Medicine, UNC at Chapel Hill, Chapel Hill, NC 27599-7030.*

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**FIGURE.** Diagram of a dry-rolling seal spirometer. Movement of air through the breathing tube results in movement of the piston.

evaluating the risks associated with intra-abdominal surgery, and assessing the response to bronchodilators. In recent years, there has been great attention to standardizing the equipment and methods for performing spirometry.<sup>3-5</sup>

Contaminated respiratory therapy equipment has been linked to several outbreaks of nosocomial pneumonia.<sup>6-8</sup> Devices involved in these outbreaks have included nebulizers, humidifiers, ventilators, inhaled medications, and resuscitation bags. In mechanically ventilated patients, contaminated spirometers have been linked to cross-transmission of *Pseudomonas maltophilia*<sup>9</sup> and *Acinetobacter calcoaceticus* subspecies *anitratus*.<sup>10</sup>

However, the role of pulmonary function testing equipment in the cross-transmission of infection between ambulatory patients has been incompletely defined.<sup>11</sup> Although microorganisms have been recovered from parts of in-use pulmonary function testing equipment, a relationship between equipment contamination and transmission of infection has not been documented.<sup>11</sup> Hazaleus et al have reported transmission of *Mycobacterium tuberculosis* infection to one of 22 patients who underwent pulmonary function testing using a dry seal spirometer within 12 days of its use by a patient with active pulmonary tuberculosis.<sup>12</sup>

To evaluate the risk of infection associated with the use of two commonly used dry-rolling seal spirometers, we determined the degree of microbial contamination of the spirometry equipment before and after use by heavily colonized and infected patients. We were particularly interested in determining whether the gas collection reservoir of the spirometer became contaminated during patient testing and if there was a subsequent risk of inhalation of airborne organisms.

## MATERIALS AND METHODS

### Spirometers

Two commonly marketed dry-rolling seal spirometers, the CPI 221 (Cardio Pulmonary Instruments; Sensor Medics, Yorba Linda, California) and the Ohio 822 (Ohio Medical Products, Madison, Wisconsin) were evaluated. A dry-rolling seal spirometer is a

piston placed in a cylindrical chamber and sealed at its periphery by a silastic dry seal (Figure). This silastical seal, used to close the system, is positioned to roll back on itself when a patient expires into the machine. Displacement of the piston is recorded by an electronic potentiometer. The voltage signal is electronically processed to calculate the rate of volume change or flow over time.

### Patient Characteristics

To determine if equipment contamination occurs in clinical practice, we evaluated 14 patients with respiratory tract infections from July 1984 through April 1985. The patients ranged in age from 16 to 84 years (mean 52.3 years) and had a variety of underlying diagnoses, including cystic fibrosis (4), chronic obstructive pulmonary disease (3), possible carcinoma (2), pulmonary abscess (1), esophagitis (1), chronic bronchitis (1), congestive heart failure (1), and carcinoma with pneumonia (1). Radiographic findings included ten patients with pulmonary infiltrates, three with atelectasis and/or effusions, and one with a questionable cavitory lesion. Thirteen patients had community-acquired respiratory tract infections, and one patient had a nosocomial respiratory tract infection. Thirteen patients were started on antibiotics just prior to or after the spirometry testing. The CPI 221 was used to evaluate the first six patients and the Ohio 822 was used to test the remaining eight.

### Evaluation Of Potential Spirometer Contamination

Prior to each spirometry evaluation, a sputum culture was obtained from the patient and a microbiological evaluation of the equipment was performed. This included sampling the mouthpiece, the proximal end of the tubing (i.e., near the patient), and the piston surface. Trypticase soy broth (TSB) premoistened swabs were used for sampling the mouthpiece and tubing. The spirometer was disassembled and piston surfaces were sampled at the 3 o'clock and 6 o'clock position using Rodac plates containing D/E neutralizing agar (Difco Laboratories, Detroit, Michigan). During this study, the piston surface was cleaned before each patient with a 2% glutaraldehyde.

The patient then completed the spirometry testing by sitting in a chair facing the spirometer. With nose clips in place, the patient was instructed to breathe normally into the apparatus. After several breaths to establish a resting and expiratory level, the patient was instructed to inhale maximally and exhale as completely and rapidly as possible. Three attempts were usually necessary to obtain a flow-volume tracing.

After the patient completed the spirometry test-

**TABLE 1**  
MICROBIOLOGIC EVALUATION OF SPIROMETRY  
EQUIPMENT (n = 14)

	% Culture- Positive	% Patient- Associated Pathogen
Prepatient	0	0
Postpatient		
Mouthpiece	92	50
Proximal tubing	50	7
Distal tubing	0	0
Piston surface	0	0
Tubing rinse	43	14
Simulation 1	43	0
Simulation 2	36	0

ing, the equipment was again sampled. The interior surfaces of the mouthpiece and the proximal and distal tubing were swabbed with a TSB premoistened sterile cotton swab. The tubing was rinsed for approximately ten seconds with 50 ml of TSB.

#### Evaluation Of Potential Cross-Transmission Via Aerosol Production

In an attempt to simulate infection risks to subsequent patients, a sterile 2 L ventilation bag with new sterile tubing was attached to the spirometer. The simulation was performed by mechanically moving the posterior piston rod to deliver airflow volumes of a typical patient, which is about 500 ml to the ventilation bag. A simulation (Simulation 1) was performed immediately after the initial patient evaluation and again 18 hours later (Simulation 2).

Simulation microbiological samples included the mouthpiece, the proximal and distal end of the tubing, 50 ml TSB rinses of the tubing, and ventilation bag. The spirometer was disassembled and Rodac cultures of the piston surface were obtained at the 3 o'clock and 6 o'clock position. A total of 20 equipment and simulated patient samples were collected per patient.

#### Microbiologic Analysis

All swabs were incubated at 35°C for 24 hours to 48 hours in 5 ml of TSB; positive tubes were plated onto sheep blood agar and MacConkey agar plates and incubated for 24 hours to 48 hours. TSB washings were analyzed by plating 0.25 ml onto sheep blood agar and MacConkey agar plates and incubated for 24 hours to 48 hours. Gram-negative rods were identified by API20E (Analytab Products, Plainview, New York), while other microorganisms were identified using standard methods.<sup>13</sup>

**TABLE 2**  
ISOLATION OF RESPIRATORY FLORA FOLLOWING  
SIMULATIONS\*

Site Sampled	Simulation 1 (%)	Simulation 2 (%)
Mouthpiece	7	0
Proximal tubing	22	14
Distal tubing	7	7
Tubing rinse	29	14
Ventilation bag rinse	36	29
Piston surface	0	0

\* No patient-associated pathogens isolated.

#### RESULTS

A variety of bacteria and yeast were isolated from our subjects' sputum on the day of testing and included *Staphylococcus aureus* (1), coagulase-negative *Staphylococcus* (1), *Enterococcus* (1), *Escherichia coli* (4), *Klebsiella ozonae* (1), *Klebsiella pneumoniae* (2), *Acinetobacter calcoaceticus* subspecies *anitratus* (2), *Citrobacter freundii* (1), *Enterobacter cloacae* (4), *Proteus mirabilis* (2), *Proteus vulgaris* (1), *Pseudomonas aeruginosa* (7), *Pseudomonas cepacia* (1), unidentified gram-negative rods (2), yeasts (5), and normal respiratory flora (1).

All prepatient equipment samples were negative for microorganisms (Table 1). Cultures taken immediately after patient testing yielded growth in 92% of the mouthpieces and 50% of the proximal tubing. Potential pathogens similar to those isolated from the test subjects were isolated from 50% of the mouthpieces and 7% of the proximal tubing. The distal tubing and piston surfaces remained sterile in all 14 spirometer evaluations.

The Simulation 1 and Simulation 2 cultures were positive in 43% and 36%, respectively, of the 14 runs tested (Table 2). In no case was the associated respiratory pathogen isolated similar to that colonizing or infecting a patient. The positive cultures yielded organisms generally considered to be normal respiratory flora or skin flora (e.g., coagulase-negative *Staphylococcus*, diphtheroids, *Bacillus*).

To determine if these organisms were from the original patient's sputum or from contamination occurring during the sampling process, we conducted control runs in which we manipulated the equipment using the same technique as we did in the postpatient simulations. Microbial flora commonly recovered from the respiratory tract or skin, such as  $\alpha$ -hemolytic streptococci, coagulase-negative *Staphylococcus*, diphtheroids, or *Bacillus*, were recovered in 83% of the

control runs. Thus, it is likely that the organisms recovered by the simulation runs occurred as a result of contamination during the sampling process.

## DISCUSSION

Contaminated respiratory therapy equipment has been linked to outbreaks<sup>6-8</sup> and endemic transmission<sup>14</sup> of nosocomial lower respiratory infections. Following recognition of this hazard, guidelines have been developed in an attempt to eliminate respiratory equipment associated with anesthesia or mechanical ventilation as a nosocomial hazard.<sup>8,15,16</sup>

The cannula connectors of mechanical ventilators<sup>17</sup> and mouthpieces of inhalation therapy equipment<sup>18</sup> have been shown to become contaminated with flora derived from patients' respiratory tract. Since pulmonary function devices are used on multiple patients and respiratory devices may become contaminated with the patients' respiratory microflora, concerns about potential transmission of infectious agents have led to the publication of preliminary infection control guidelines for pulmonary function laboratories.<sup>2,3,11,19,20</sup>

Our data demonstrate that the mouthpieces and proximal tubing used on spirometers can become contaminated with potential respiratory pathogens. For this reason, this equipment should not be shared between patients. Either disposable mouthpieces and proximal tubing should be used or this equipment should be at least high-level disinfected between patients.

Our data revealed that there was no bacterial contamination of the surfaces inside the spirometers. Further, our simulations failed to provide any evidence to support the possibility of cross-transmission with patient-derived potential respiratory pathogens to subsequent simulated patients. Therefore, we believe it is unnecessary to routinely disinfect interior surfaces of spirometers after use by infected patients.

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