Manual Ventilation Bags as a Source for Bacterial Colonization of Intubated Patients[1,2]

DAVID J. WEBER, M. BREJETTA WILSON, WILLIAM A. RUTALA, and CHARLOTTE A. THOMANN

SUMMARY **A group of 14 intensive care unit (ICU) patients were studied to determine if manual ventilation bags (MVB) could serve as a source of bacterial or fungal pathogens that could colonize the respiratory tract of intubated patients. A total of 51 cultures were simultaneously obtained of patient's sputum, the exterior MVB surface, MVB port, and MVB interior (postexhalation valve). Pathogens colonizing or infecting the respiratory tract of intubated ICU patients were frequently simultaneously present on the exterior surface of the MVB and inside the MVB port used to connect the MVB with the endotracheal tube. In addition, coagulase-negative staphylococci and yeast were frequently present on the exterior surface of the MVB. The interior of the MVB was usually sterile. In three instances pathogens were isolated from the MVB before isolation from the patient's sputum.**

MVB may serve as a source for colonizing the respiratory tract of intubated ICU patients and/or the hands of medical personnel. The exterior surface and port of MVB should be cleaned of visible debris and disinfected at least once a day. **AM REV RESPIR DIS 1990; 142:892-894**

Nosocomial lower respiratory tract infections remain an important source of morbidity and mortality (1-3). The incidence of nosocomial pneumonia in the United States is 6.0 per 1,000 hospital discharges based on data collected in the National Nosocomial Infections Surveillance System (4). The incidence of nosocomial pneumonia in intensive care unit patients (ICU) intubated for longer than 24 to 48 h has been reported to be far higher, ranging from 21 to 49% (5-8). Nosocomial pneumonia has been associated with fatality rates up to 35 to 60% (5, 6, 9, 10). In addition, nosocomial pneumonia prolongs the average ICU stay in survivors almost threefold (11).

Nosocomial pneumonia may occur as a result of hematogenous spread of pathogens, inhalation of contaminated aerosols, or aspiration of oropharyngeal secretions (1, 2). The majority of nosocomial pneumonia cases appear to result from colonization of the patient's oropharynx followed by aspiration and infection in the setting of impaired host defenses (1, 2, 12). The source of the colonizing organisms has not been entirely elucidated but includes both endogenous and exogenous flora. The gastrointestinal tract is the most common endogenous source of gram-negative bacilli that may colonize the oropharynx (2, 13, 14). Exogenous sources of pulmonary pathogens include contaminated respiratory equipment (8, 15, 16) and carriage on hands of medical personnel (17).

Recent studies have noted that the exhalation port of manual ventilation bags (MVB) may become contaminated with bacteria during use (18) and have linked contaminated MVB to epidemics of *Acinetobacter calcoaceticus* pulmonary infections (19, 20). This study was undertaken to answer the following questions: (*1*) do MVB used in the ICU setting harbor potentially pathogenic organisms; (*2*) are only the exterior surfaces of the MVB contaminated, or are potential pathogens present post-MVB exhalation valve; and (*3*) can contaminated MVB serve as the source for colonization or infection of intubated patients, and if so, can they be disinfected or must they be exchanged on a routine basis?

This study was conducted at the University of North Carolina Hospitals, a 600-bed acute care facility that serves as the main teaching hospital for the University of North Carolina School of Medicine. All patients selected for the study were intubated and receiving care in an ICU. Underlying diseases were as follows: aspirin toxicity, 1; chronic obstructive pulmonary disease, 3; neurologic dysfunction with respiratory failure, 3; leukemia, 1; lung tumor with respiratory failure, 1; hepatitis, 1; pulmonary emboli, 1; cystic fibrosis, 1; and respiratory failure of unclear etiology, 1. At the initiation of the study, 8 patients met our criteria for lower respiratory infection (21); respiratory material obtained via deep-suctioning yielded bacterial growth in all other patients (colonization).

An initial sputum culture was obtained by deep-suctioning in all patients within 24 h of admission. Each intubated patient was provided with a sterile MVB for bedside use, which was not routinely changed during the patient's ICU stay. The MVB was used daily to ventilate the patient during tracheal suctioning, transport for diagnostic studies, or urgent ventilation. Hospital infection control policies did not specify a decontamination frequency while the MVB was in use.

Once patients meeting study criteria were identified, the following cultures were performed simultaneously twice weekly (Monday and Thursday): deep-suctioned sputum, MVB exterior surface, MVB port, and MVB interior postexhalation valve (figure 1).

All cultures of the MVB were performed using sterile cotton-tipped applicators premoistened with trypticase soy broth (BBL Microbiology Systems, Cockeysville, MD) (22). Cultures of the MVB were obtained by swabbing the exterior surface of the bag. Cultures of the port were obtained by swabbing the endotracheal tube connector junction of the MVB and the anterior portion of the flutter valve in the exhalation valve assembly. Cultures of the interior of the MVB were obtained by disassembling the exhalation valve and swabbing the posterior side of the assembly. Following sampling, the cotton applicators were placed in trypticase soy broth with 5% fetal bovine serum (GIBCO Laboratories, Grand Island, NY) and incubated at 35° C for 18 to 24 h. After incubation, the broth was subcultured onto sheep blood agar and MacConkey agar. Potential pathogens were identified by standard techniques (23).

After demonstrating the heavy contaminations of MVB following patient use, we evaluated the ability of 70% isopropyl alcohol to disinfect a contaminated MVB. Cultures of the MVB exterior and port were conducted as earlier except quantitative cultures were performed. Cultures were obtained immediately before and 30 s after alcohol disinfection. Disinfection was accomplished by wiping the outside of the MVB with alcohol-soaked 4 × 4 inch gauze pads, the mouthpiece with an alcohol towelette, and the inside of the port and around the flutter valve with an alcohol-saturated cotton-tipped swab. Approximately 1 min was required to disinfect the MVB.

Overall, 51 simultaneous cultures of the MVB and material obtained from the patients by tracheal aspiration were performed. The number of cultures yielding potential pathogens were as follows: sputum, 48 (94.1%); MVB exterior surface, 51 (100%); MVB exhalation port, 49 (96.1%); and MVB interior, 6 (11.8%).

Gram-negative bacilli were commonly isolated from all sites except the MVB interior (table 1). Coagulase-negative staphylococci were commonly isolated from the surface of the MVB but only occasionally from sputum. The frequency of isolation of coagulase-negative staphylococci from the MVB port

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[1] From the Division of Infectious Diseases, University of North Carolina School of Medicine, and the Department of Hospital Epidemiology, University of North Carolina Hospitals, Chapel Hill, North Carolina.

[2] Correspondence and requests for reprints should be addressed to David J. Weber, M.D., M.P.H., CB#7030 Burnett-Womack 547, Division of Infectious Diseases, UNC at Chapel Hill, Chapel Hill, NC 27599-7030.

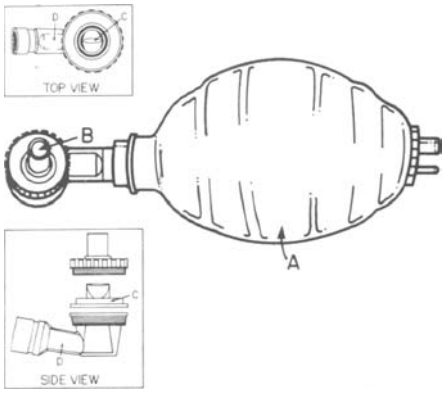

Fig. 1. Manual ventilation bag: (*A*) exterior surface; (*B*) connector junction (i.e., port) to endotracheal tube; (*C*) one-way exhalation valve; (*D*) postexhalation valve assembly.

was intermediate between that found in sputum and that found on the exterior surface of the MVB. Except for coagulase-negative staphylococci, organisms isolated from the MVB port were found to be simultaneously colonizing or infecting the patient in 50 of 51 instances (98.0%).

Post-MVB valve cultures were rarely positive. Of the six positive cultures, two were associated with the one-way valve being placed in the MVB backward. The other four instances occurred in patients with thick, tenacious sputum.

In three instances (5.9%), potential pathogens were isolated from a MVB culture before appearing in the patient's sputum. Pathogens included *Enterobacter* twice and *Pseudomonas maltophilia* once. Sites of positive cultures included the MVB port twice and the exterior surface once.

A total of 12 disinfection trials were performed on a single patient with copious sputum. In all trials the MVB exterior, and in all but one trial the MVB port, yielded *Pseudomonas aeruginosa*, *Serratia*, *Enterobacter cloacae*, or a mixture of these organisms. Disinfection reduced the level of exterior contamination from a mean of 1,147 cfu (range 200 to 2,000) to 4 cfu (range zero to 33) and MVB port contamination from a mean of 130 cfu (range 1 to 700) to zero cfu. Of the 24 postdisinfection cultures only 2, both of the exterior MVB surface, yielded low numbers of gram-negative pathogens.

An additional four disinfection trials were conducted on a patient with thick, tenacious sputum. All trials yielded *Staphylococcus aureus* or *E. cloacae* contaminating the MVB exterior and port. Disinfection reduced the level of exterior contamination from a mean of > 3,000 cfu (range 3,000 to 3,000*) to 2 cfu (range zero to 6), and MVB port contamination from a mean of 1,296 cfu (range 45 to 5,000) to 101 cfu (range zero to 400). In this patient with tenacious sputum, although the level of contamination was reduced, three of eight postdisinfection cultures yielded growth of a pathogen.

* * *

Nosocomial pneumonia is the leading cause of death attributed to nosocomial infection. Risk factors for infection include most importantly factors that promote oropharyngeal colonization with gram-negative bacilli, such as increased severity of illness, longer duration of hospitalization, previous or concomitant use of antibiotics, advanced age and disability, intubation, and major surgery (1, 2).

Sources for colonization include both endogenous and exogenous source. The gastrointestinal tract is the most common endogenous source of colonizing pathogens. An elevated stomach pH due to administration of H_2 blockers or antacids has been shown to lead to increased gastric colonization and more frequent nosocomial pneumonia (14, 24). Elucidation of these risk factors led to studies showing that sucralfate used in place of antacids or H_2 blockers to prevent stress ulcers can reduce the incidence of nosocomial pneumonia (25) and to studies of prophylactic intratracheal antibiotics to reduce colonization rates (26).

Contaminated respiratory equipment has been linked to multiple outbreaks of nosocomial respiratory infections (16). The widespread adoption of techniques to sterilize or adequately disinfect respiratory therapy equipment has led to a decrease in infection due to these devices (8, 15). Our data suggest that MVB frequently become contaminated with potential bacterial and fungal pathogens during use. The patient's sputum serves as the source for contaminating the MVB port and exterior surface with gram-negative bacilli. The finding that the exterior surface of the MVB also frequently becomes contaminated with coagulase-negative staphylococci and/or *Candida* suggests that this surface may also become contaminated by flora found on the hands of medical personnel. Contaminated MVB may serve as important sources of nosocomial infection in two ways. First, they may serve as a source for colonizing the hands of medical personnel who then may cross-transmit such pathogens directly to other patients or colonize respiratory or other medical equipment. Second, they may serve as a source for introducing pathogens into a patient. The finding that the MVB may occasionally become colonized before colonization of the patient suggests that contamination of MVB, presumably by health care personnel, may be a means by which pathogens are cross-transmitted between ICU patients. Based on our data, it is not surprising that contaminated MVB have been linked to the transmission of nosocomial respiratory infections (19, 20). Both outbreaks involved isolating an epidemic strain of *A. calcoaceticus* from inadequately disinfected MVB. Effective decontamination (i.e., disinfection or sterilization) of the MVB was associated with control of both epidemics.

Based on our data, we suggest the following guidelines. First, all medical personnel should follow universal blood and bloody body fluid precautions and existing guidelines to wash their hands before and immediately after any contact with patients or potentially contaminated equipment, such as MVB (27). Second, MVB should be sterilized or high-level disinfected between patients. Third, MVB should be cleaned of visible secretions daily and then disinfected with alcohol. Both the exterior surface and the MVB exhalation port should be disinfected. The interior surface of the MVB does not need to be disinfected during routine patient use. If the exhalation port cannot be cleaned of tenacious

TABLE 1

MICROBIAL CONTAMINATION OF MANUAL VENTILATION BAGS BY CULTURE SITE AND PATHOGEN*

Pathogen	Patients with Pathogen in Sputum	Number of Isolations from Sputum	Number of Isolations from MVB Exterior	Number of Isolations from MVB Port	Number of Isolations from MVB Interior Postexhalation Valve
P. aeruginosa	5	25	19 (19)†	21 (21)	2 (2)‡
Serratia	3	15	12 (11)	9 (9)	0 (0)
Candida	5	7	11 (1)	3 (3)	0 (0)
Coagulase-negative staphylococci	4	6	32 (5)	17 (5)	1 (0)
Enterobacter	3	6§	6 (2)	1 (1)	1 (1)
P. cepacia	1	6	2 (2)	5 (5)	0 (0)
S. aureus	1	4	3 (1)	3 (3)	2 (2)
Bacillus	1	1	7 (1)	1 (1)	0 (0)
E. coli	1	1	1 (1)	1 (1)	0 (0)
P. maltophilia	1	2‖	1 (1)	2 (1)	0 (0)
Total		73	94 (44)	63 (50)	6 (5)

* Represents 51 simultaneous cultures of patient-expectorated sputum and three MVB sites.

† Number of isolates from designated locations that were simultaneously cultured from sputum.

‡ Associated with MVB valve placed in MVB backward.

§ Two patients had *Enterobacter* isolated from an MVB culture (MVB port, 1; MVB exterior, 1) immediately before being isolated from the sputum.

‖ One patient had *P. maltophilia* isolated from an MVB port culture 14 days before being isolated from the sputum.

sputum, then it should be disassembled daily and sterilized or high-level disinfected.

References

1. Pugliese G, Lichtenberg DA. Nosocomial bacterial pneumonia: an overview. Am J Infect Control 1987; 15:249–65.
2. Craven DE, Driks MR. Nosocomial pneumonia in the intubated patient. Respir Infect 1987; 2:20–33.
3. Gross PA. Epidemiology of hospital-acquired pneumonia. Respir Infect 1987; 2:2–7.
4. Horan TC, White JW, Jarvis WR, *et al.* Nosocomial infection surveillance. 1984; 35:17SS–26SS.
5. Craven DE, Kunches LM, Kilinsky V, Lichtenberg DA, Make BJ, McCabe WR. Risk factors for pneumonia and fatality in patients receiving continuous mechanical ventilation. Am Rev Respir Dis 1986; 133:792–6.
6. Stevens RM, Teres D, Skillman JJ, Feingold DS. Pneumonia in an intensive care unit. Arch Intern Med 1974; 134:106–11.
7. Ruiz-Santana S, Jimenez AG, Esteban A, *et al.* ICU pneumonias: a multi-institutional study. Crit Care Med 1987; 15:930–2.
8. Cross AS, Roup B. Role of respiratory assistance devices in endemic nosocomial pneumonia. Am J. Med 1981; 70:681–5.
9. Gross PA, Neu HC, Aswapokee P, Antwerpen CV, Aswapokee N. Deaths from nosocomial infections: experience in a university hospital and a community hospital. Am J Med 1980; 68:219–23.
10. Celis R, Torres A, Gatell JM, Almela M, Rodriguez-Roisin R, Agusti-Vidal A. Nosocomial pneumonia – a multivariate analysis of risk and prognosis. Chest 1988; 93:318–24.
11. Craig CP, Connelly S. Effect of intensive care unit nosocomial pneumonia on duration of stay and mortality. Am J Infect Control 1984; 12:233–8.
12. Johanson WG, Pierce AK, Sanford JP, Thomas GD. Nosocomial respiratory infections with gram-negative bacilli. Ann Intern Med 1972; 77: 701–6.
13. LeFrock JL, Ellis CA, Weinstein L. The relation between aerobic fecal and oropharyngeal microflora in hospitalized patients. Am J Med Sci 1979; 277:275–80.
14. Daschner F, Kappstein I, Engels K, *et al.* Stress ulcer prophylaxis and ventilation pneumonia: prevention by antibacterial cytoprotective agents? Infect Control Hosp Epidemiol 1988; 9:59–65.
15. Pierce AK, Sanford JP, Thomas GD, Leonard JS. Long-term evaluation of decontamination of inhalation-therapy equipment and the occurrence of necrotizing pneumonia. N Engl J Med 1979; 282:528–31.
16. Rutala WA, Weber DJ. Environmental issues and nosocomial infections. In: Farber BF, ed. Infection control in intensive care. New York: Churchill Livingston, 1987; 131–71.
17. Buxton AE, Anderson RL, Werdegar D, Atlas E. Nosocomial respiratory tract infection and colonization with *Acinetobacter calcoaceticus.* Am J Med 1978; 65:507–13.
18. Thompson AC, Wilder BJ, Powner DJ. Bedside resuscitation bags: a source of bacterial contamination. Infect Control 1985; 6:231–2.
19. Stone JW, Das BC. Investigation of an outbreak of infection with *Acinetobacter calcoaceticus* in a special care baby unit. J Hosp Infect 1985; 6:42–8.
20. Hartstein AI, Rashad AL, Liebler JM, *et al.* Multiple intensive care unit outbreak of *Acinetobacter calcoaceticus* subspecies *anitratus* respiratory infection and colonization associated with contaminated, reusable ventilator circuits and resuscitation bags. Am J Med 1988; 85:624–31.
21. Brawley RL, Weber DJ, Samsa GP, Rutala WA. Multiple nosocomial infections: an incidence study. Am J Epidemiol 1989; 130:769–80.
22. Yamayoshi T, Doi H, Tatsumi N. Surface sampling using a single swab method. J Hosp Infect 1984; 5:386–90.
23. Lennette EH, Balows A, Hausler WJ Jr, Shadomy HJ. Manual of clinical microbiology. 4th ed. Washington, D.C.: American Society of Microbiology, 1985.
24. Tryba M. Risk of acute stress bleeding and nosocomial pneumonia in ventilated intensive care unit patients: sucralfate versus antacids. Am J Med 1987; 83:117–24.
25. Driks MR, Craven DE, Celli BR, *et al.* Nosocomial pneumonia in intubated patients given sucralfate as compared with antacids or histamine type 2 blockers. N Engl J Med 1987; 317:1376–82.
26. Altman FM. Prophylactic strategies for hospitalized patients at risk for pneumonia. Respir Infect 1987; 2:74–81.
27. Larson E. A casual link between handwashing and risk of infection? Examination of the evidence. Infect Control Hosp Epidemiol 1988; 9: 28–36.