Anesthesiology
54:369–372, 1981

Sterile Anesthesia Breathing Circuits Do Not Prevent Postoperative Pulmonary Infection

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In a prospective, randomized trial, the effectiveness of sterile anesthesia breathing circuits having bacterial filters in decreasing the incidence of postoperative pulmonary infection was evaluated. Two hundred ninety-three patients undergoing major surgical procedures were assigned randomly to receive anesthetics through a sterile, disposable circuit having a bacterial filter, or a resuable circuit that had been washed and dried after previous use. The two groups were well matched for age, sex, type of surgical procedure, type of anesthetic, and history of smoking or obstructive lung disease. A physician observer, who was unaware of these assignments, reviewed the patients' postoperative status for evidence of pulmonary infection. The overall rate of infection was 3.5 per cent; no significant difference in the rates of infection occurred between the two groups. Five (3.6 per cent) of the 138 patients anesthetized with sterile circuits had postoperative respiratory infection, compared with four (2.6 per cent) of the 155 patients anesthetized with unsterile circuits. In both groups, maximum postoperative temperature, white-blood-cell count, and the lowest values for arterial oxygen tension were similar. The authors therefore conclude that when simple hygienic measures are followed, the routine use of sterile anesthesia breathing circuits with bacterial filters does not decrease the risk of postoperative infection. (Key words: Complications: pneumonia. Equipment: filters. Lung: bronchus; pneumonia; trachea. Operating room: sterilization.)

POSTOPERATIVE HOSPITAL-ACQUIRED RESPIRATORY INFECTIONS are well-recognized complications of major surgery. Recently, the use of sterile anesthesia circuits having bacterial filters has been advocated to prevent such infections.[1–4] Although several reports indicate the anesthesia circuit as a source of infection, none of these reports are conclusive.[5] A study by du Moulin and Saubermann[6] failed to demonstrate that the anesthesia machine and circuit were significant sources of infection. We therefore investigated whether use of a sterile, disposable anesthesia circuit with a bacterial filter decreases the incidence of postoperative infection when compared with use of a clean but unsterile reusable circuit without such a filter.

Materials and Methods

Because of the greater risk of postoperative respiratory infection, we studied only patients having major operative procedures. Whenever possible, we selected procedures being done sequentially in the same operating room. Two hundred ninety-three patients were randomly assigned to one of two groups. The "sterile" group (n = 138) received their anesthetic through a sterile, disposable plastic circuit, reservoir bag, Y-piece airway, and endotracheal tube. A bacterial filter (Ohio Medical Products, Inc.) was placed in the proximal portion of the inspiratory limb. All disposable circuits were sterilized using gamma irradiation. Patients in the "nonsterile" group (n = 155) were anesthetized using reusable rubber circuits, reservoir bags, endotracheal tubes, Y-connectors, and airways that had been washed with soap and water and dried after previous use. No bacterial filters were used. For all patients, the laryngoscope was washed with soap and water between procedures. The care of the rest of the circle, anesthesia machine, and ventilator was the same for both groups.

After surgery, we reviewed the patients' charts for evidence of postoperative pulmonary infection and recorded name, age, sex, operation, type of anesthetic, and preoperative history of smoking or lung disease. We recorded the patient's maximum temperature, white-blood-cell count, results of chest examination, use of immunosuppressive agents, and treatment for any infection on a daily basis. Results of blood-gas analyses, chest x-rays, and sputum cultures were examined whenever obtained.

All charts were reviewed by a physician who was unaware of the group to which the patient was assigned. Pneumonia was diagnosed as occurring when the patient developed fever, leukocytosis, rales or

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Received from the Departments of Anesthesia of the University of California, San Francisco, California 94143, and Stanford University School of Medicine, Stanford, California 94305. Accepted for publication November 13, 1980. Supported in part by NIH Anesthesia Research Center Grant GM 15571 and a grant from Ohio Medical Products, Inc. Presented in part at the annual meeting of the American Society of Anesthesiologists, St. Louis, October 1980.

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0003-3022/81/0500/0369 $00.70

TABLE 1. Incidence and Signs of Respiratory Infection for Patients Receiving Anesthesia Through a Sterile, Disposable Circuit or a Washed, Reusable Circuit*

	Sterile, Disposable Circuit (n = 138)	Washed, Reusable Circuit (n = 155)	Total (n = 293)
Respiratory infection	5 (3.6 per cent)	4 (2.6 per cent)	9 (3.1 per cent)
Lobar consolidation	3 (2.2 per cent)	4 (2.5 per cent)	7 (2.4 per cent)
Maximum temperature (°C)†	37.9 ± 0.6	37.9 ± 0.7	37.9 ± 0.7
Maximum white-blood-cell count × 1000 (per mm^3)†	11.7 ± 3.8	11.7 ± 4.8	11.8 ± 4.5
Lowest Pa_{O_2} (FI_{O_2} 0.21)† (torr)	73 ± 17	69 ± 17	71 ± 17

* There were no significant differences between the "sterile" and "nonsterile" groups.

† Values are means ± SD.

rhonchi, increased sputum production, or consolidation on chest x-ray.[6,7] Tracheobronchitis was diagnosed as occurring when the patient developed fever, leukocytosis, rhonchi, and increased sputum production without radiographic changes. The rate of pulmonary infection was determined by combining cases of pneumonia with cases of tracheobronchitis.

Using chi-square analyses, we compared the "sterile" group with the "nonsterile" group for rate of infection, number of smokers, incidence of lung disease, sex, type of operation, type of anesthetic received, and use of immunosuppressive agents. Using Student's *t* test for unpaired data, we also compared the maximum postoperative temperature, white-blood-cell count, and the lowest arterial oxygen tension that occurred during breathing of room air. Infected patients were then compared with noninfected patients with respect to age, sex, type of operation, type of anesthetic, maximum temperature, white-blood-cell count, lowest value for oxygen tension, and the incidence of lung consolidation, again using chi-square analysis and Student's *t* test for unpaired data.[8] A probability level of 0.05 was chosen for significance.

This study was approved by the Committee on Human Research of the University of California, San Francisco.

Results

Nine patients (3.1 per cent) had postoperative respiratory infections. There was no significant difference in the rate of infection between the "sterile" group (3.6 per cent) and the "nonsterile" groups (2.6 per cent) ($P > 0.10$). There were also no significant differences in the maximum postoperative temperature, maximum white-blood-cell count, lowest arterial oxygen tension, or the frequency of lung consolidation on chest x-ray (table 1). Three cases of pneumonia and two cases of tracheobronchitis occurred in the sterile group, and four cases of pneumonia and no cases of tracheobronchitis appeared in the nonsterile group. The organisms causing pneumonia in the sterile group were *Escherichia coli*, one case; *Pseudomonas aeruginosa*, one case; and one case was unidentified. The nonsterile group had one case each caused by *Streptococcus pneumoniae, Staphylococcus aureus*, and *Hemophilus influenzae*; and one case was unidentified.

The two groups were similar in age, sex, history of smoking, lung disease (table 2), and type of operation (table 3). There were more cardiac operations in the "nonsterile" group (20 per cent *vs.* 10 per cent in the "sterile" group") ($P < 0.01$). Also, more patients in the sterile group received enflurane than in the nonsterile group ($P < 0.05$) (table 3).

Comparison of infected with noninfected patients revealed that the former were predominantly men. Maximum postoperative temperature, white-blood-cell count, and frequency of lobar consolidation were significantly higher in infected patients than noninfected patients (table 4). Nearly half of the infected patients had undergone gastrointestinal surgery (table 5). The frequency of postoperative pulmonary infection among these patients was 9.3 per cent. Pulmonary infections occurred in 4.8 per cent of patients having vascular surgery, in 4.4 per cent of patients having cardiac surgery, and in only 1.7 per cent of patients undergoing renal transplantation or trans-

TABLE 2. Comparison of Age, Sex, Lung Disease, and Immunosuppression in Patients Receiving Anesthesia Through a Sterile, Disposable Circuit or a Washed, Reusable Circuit*

	Sterile, Disposable Circuit (n = 138)	Washed, Reusable Circuit (n = 155)	Total (n = 293)
Age (yr)	47 ± 17†	51 ± 18†	49 ± 17†
Men	71 (51)‡	75 (48)	146 (50)
Women	67 (49)	80 (52)	147 (50)
Smokers	36 (26)	32 (21)	68 (23)
Chronic obstructive lung disease	4 (3)	8 (5)	12 (4)
Immunosuppression	33 (24)	26 (17)	59 (20)

* There were no significant differences between the "sterile" and "nonsterile" groups.

† Mean ± SD.

‡ Numbers in parentheses are percentages of the total number of patients for each group.

TABLE 3. Type of Operation and Anesthetic for Patients Receiving Anesthesia Through a Sterile, Disposable Circuit or a Washed, Reusable Circuit

	Sterile, Disposable Circuit (n = 138)	Washed, Reusable Circuit (n = 155)	Total (n = 293)
Operation			
Renal*	31 (22)†	26 (17)	57 (19)
Craniotomy	26 (19)	24 (15)	50 (17)
Cardiac	14 (10)	31 (20)‡	45 (15)
Gastrointestinal	20 (14)	23 (15)	43 (14)
Vascular	19 (14)	23 (15)	42 (14)
Neck	8 (6)	12 (8)	20 (7)
Thoracic	6 (5)	5 (3)	11 (5)
Orthopedic	3 (2)	3 (2)	6 (2)
Other§	11 (8)	8 (5)	19 (7)
Anesthetic			
Halothane	78 (57)	88 (57)	166 (57)
Nitrous oxide-narcotic	31 (22)	49 (32)	80 (27)
Enflurane	29 (21)	18 (12)‡	47 (16)

* Renal transplantation or transplant nephrectomy.
† Numbers in parentheses are percentages of the total number of patients in each group.
‡ Significantly different from sterile, disposable circuit group.
§ Includes patients undergoing gynecologic and spinal operations.

plant nephrectomy. The mean time of onset of infection was 3.2 ± 2.3 days.

Discussion

Postoperative pneumonia occurs in 3 to 25 per cent of surgical patients.[9,10] Nosocomial pulmonary infection is usually preceded by colonization of microorganisms in the airway[11,12] from various sources. Both humidifiers and nebulizers have been implicated in nosocomial pneumonia.[13,14] Mechanical ventilators have been implicated as a source of nosocomial pneumonia; it is the nebulizer within the ventilator that accuonts for most such infections.[15,16] Effective decontamination of this equipment decreases the risk of developing pneumonia.[14]

The role anesthesia equipment plays in the development of postoperative pulmonary infection is controversial. In 1968, a survey of 157 academic anesthesia departments reported that only 39 per cent provided a sterile endotracheal tube and breathing circuit for every patient.[17] Also, 68 per cent of the institutions that cultured their equipment found evidence of bacterial contamination. Numerous studies have documented the presence of bacteria on and in anesthesia equipment.[18–21] One investigator reported that the carbon-dioxide absorber and valves can also be reservoirs of organisms.[22,23] Despite the abundance of evidence that organisms can reside in anesthesia equipment, the evidence for their being a source of clinical infection is inconclusive. Although a report by Joseph[24] in 1952 attempted to implicate contaminated anesthesia equipment in an outbreak of follicular

TABLE 4. Comparison of Infected with Noninfected Patients

	Infected (n = 9)	Noninfected (n = 284)	P
Men	7 (78)*	139 (49)	<0.05
Women	2 (12)	145 (51)	<0.05
Smokers	2 (22)	66 (23)	NS
Chronic obstructive lung disease	1 (12)	11 (4)	NS
Immune suppression	1 (12)	58 (20)	NS
Age (yr)†	55 ± 21	49 ± 17	NS
Maximum temperature (°C)†	38.8 ± 0.5	37.9 ± 0.7	<0.01
Maximum white-blood-cell count × 1000 (per mm^3)†	16.9 ± 7.3	11.5 ± 4.2	<0.05
Lowest Pa_{O_2} (FI_{O_2} 0.21) (torr)†	60 ± 11	73 ± 17	NS

* Numbers in parentheses are percentages of the total number of patients in each group.
† Values are means ± SD.

tonsillitis, no data were presented. Olds *et al.*[25] reported an outbreak in cardiac surgical patients of *Pseudomonas aeruginosa* pneumonia, which was retrospectively linked to a contaminated anesthesia machine. Tinne *et al.*[26] reported a series of postoperative pneumonias caused by *P. aeruginosa*. They also retrospectively cultured *P. aeruginosa* with the identical pyocine type from the corrugated tubing of the anesthesia ventilator and from the Ambu bag. In neither of those two reports was a cause-and-effect relationship demonstrated bacteriologically. In 1974, Albrecht and Dryden[2] reported that the incidence of postoperative pneumonia at their institution was reduced to 6 per cent from an incidence of 26 per cent with the advent of using a sterile breathing circuit and carbon-dioxide absorber. The control and "experimental" groups were treated at two different times; sometimes separated by several years. The study also provides neither bacteriologic evidence that contaminated anesthesia

TABLE 5. Type of Operation and Anesthetic in Infected and Noninfected Patients

	Infected (n = 9)	Noninfected (n = 284)
Operation		
Gastrointestinal	4 (44)*	39 (14)
Vascular	2 (22)	40 (14)
Cardiac	2 (22)	34 (15)
Renal	1 (12)	56 (20)
Carniotomy	0	50 (18)
Neck	0	20 (7)
Thoracic	0	11 (4)
Orthopedic	0	6 (2)
Other	0	19 (6)
Anesthetic		
Halothane	3 (33)	167 (57)
Nitrous oxide-narcotic	3 (33)	77 (28)
Enflurane	3 (33)	44 (15)

* Values in parentheses are percentages of the total number of patients in each group.

equipment accounted for the initially high postoperative infection rate or sufficient information concerning how infection was diagnosed.

Some authors claim that unsterilized anesthesia equipment does not lead to postoperative infection. Stark *et al.*[27] reported that the number of organisms found in anesthesia circuits was too small to be picked up by the gas flow and carried to the patient. He suggested that only equipment having direct contact with the patient should be sterilized. Du Moulin and Saubermann[6] found that patients with heavy colonization of the airway and infection did not deposit bacteria in any part of the anesthesia circuit or absorber, even after prolonged administration of anesthetics. Also, heavy deposits of organisms placed within the circuit were not disseminated and were, in fact, destroyed within the circle. They conclude that the environment within the circle is probably not conducive to survival of bacteria because of the cold, dry gas flow, the bacteriostatic properties of rubber and metal, and the alkaline condensate in the carbon-dioxide absorber. They also concluded that simple hygienic measures were sufficient to prevent cross-infection.

The present study demonstrates that the use of a sterile anesthesia breathing circuit with a bacterial filter offers no more protection against the development of postoperative pulmonary infection than does the use of washed, reusable circuits. Our study confirms the work of Stark and co-workers[27] and du Moulin and Saubermann[6], who also believed the anesthesia circle to be an unlikely source of infection. Gastrointestinal surgery was associated with the highest incidence of postoperative infection. Abdominal surgery results in the greatest reduction in vital capacity of all surgical procedures and may in part explain the high frequency of infection in that group of patients. The incidence of pulmonary infection in patients receiving immunosuppressive therapy was not increased. Although these patients have alterations in their defense mechanism, these alterations did not appear to increase the risk of postoperative pulmonary infection. We conclude that the routine use of sterile disposable circuits is not justified, and that simple hygienic measures are satisfactory for preventing cross-infection from the anesthesia breathing circuit.

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