DECONTAMINATION OF ANESTHESIA APPARATUS * †

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THE decontamination of rubber parts of the anesthesia machines, including the face-mask, tubing, and breathing bag, is often inadequate or occasionally entirely neglected in an effort to meet a busy surgical schedule. A soap-and-water rinse is most commonly used and soaking in alcohol is sometimes employed. To meet the demands of a busy surgical service a method of cleansing anesthesia apparatus must be available which is simple, rapid, effective, and non-injurious to the patient or apparatus. Lundy was among the first to study this problem (1).

It is the purpose of this paper to present the results of a bacteriologic survey of anesthesia equipment and a practical method of decontamination. The three phases of our study were: (1) the development of standard technique for culturing parts of the gas machines while doing a general bacterial survey of the current method of cleansing; (2) a general bacterial survey of gas equipment after slight modification of the existing cleansing method, and (3) a limited bacterial survey of such gas equipment after final modification of the existing cleansing method.

Standard Culturing Technique and General Bacterial Survey. Before this study was undertaken the current cleansing method consisted of rinsing of the face-mask, the inspiratory and expiratory tubing, and the breathing bag in soap and water and afterwards hanging them up to dry. Endotracheal tubes, suction catheters, and oral-pharyngeal airways were also washed in soap and water, the lumens being cleaned with appropriate brushes, and then placed in Zephiran® solution, 1:1,000, for 12 hours before being used again. All of the equipment was washed in the same container, the same soapy solution often being used for as many as from four to six different sets of equipment. Using Brewer's thioglycolate broth, cultures of the following equipment were taken immediately after completion of an operation and were incubated at 35 C. for three days:

1. Endotracheal tube.
2. Suction catheter.
3. Oral-pharyngeal airway.
4. Face-mask.
5. "Y" face-mask adapter.
6. Inspiratory tubing.
7. Expiratory tubing.
8. Breathing bags.
9. Soda lime.
10. Flutter valves (inspiratory and expiratory).
11. Zephiran cleansing solution 1:1,000).
12. Washing water (clean water without soap).

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The equipment was then washed as noted earlier and cultures were immediately taken again. Items 1 to 3, which were soaked in Zephiran, 1:1,000 solution, were cultured after their twelve-hour soaking. Cultures of items 1 to 3 were secured by forcing the thioglycolate broth through the various lumens, internally and externally, using a sterile 10 cc. pipette. Three such washings were taken of each item; these were placed in a single sterile wide-mouthed bottle and incubated as noted earlier. Cultures of items 4, 5, 9, and 10 were taken by

TABLE 1

Item No.	Before Washing	Item No.	After Washing
	Case 1 (Pentothal-Ether) November 7, 1950		
1	No growth	1	No growth
2	Staph. aureus, Hemolytic strep., N. catarrhalis	2	No growth
3	Hemolytic streptococcus	3	No growth
4	Staph. aureus, Hemolytic strep., Ps. aeruginosa	4	Staph. aureus, Hemolytic strep., Ps. aeruginosa
5	Staph. aureaus, Ps. aeruginosa	5	Staph. aureaus, Ps. aeruginosa, B. subtilis
6	Ps. aeruginosa	6	Ps. aeruginosa, Staph. albus
7	Ps. aeruginosa	7	Ps. aeruginosa
8	Ps. aeruginosa, Alc. faecalis, Alpha-hemolytic strep	8	Ps. aeruginosa, Alc. faecalis
9	No growth	9	No growth
	Case 2 (Pentothal-Ether) November 9, 1950		
1	No growth	1	No growth
2	No growth	2	No growth
3	Alpha-hemolytic strep.	3	No growth
4	Alpha-hemolytic strep.	4	Alc. faecalis, Micrococci, Alpha-hemolytic strep.
5	Alpha-hemolytic strep. Ps. aeruginosa	5	Alpha-hemolytic strep. Ps. aeruginosa
6	Ps. aeruginosa	6	Alpha-hemolytic strep., Ps. aeruginosa
7	Ps. aeruginosa, Caudida stellataidia	7	Ps. aeruginosa, Candida stellataidia
8	Ps. aeruginosa, B. subtilis	8	Ps. aeruginosa, Alc. faecalis, Alpha-hemolytic strep
9	No growth	9	Not done
	Case 3 (Pentothal-Ether) November 9, 1950		
1	Alpha-hemolytic strep., Alc. faecalis	1	No growth
2	Alpha-hemolytic strep., Ps. aeruginosa	2	No growth
3	No growth	3	No growth
4	Alpha-hemolytic strep., Ps. aeruginosa	4	Ps. aeruginosa, Alpha-hemolytic strep.
5	Ps. aeruginosa, B. subtilis	5	Ps. aeruginosa, Alc. faecalis
6	Ps. aeruginosa, Alc. faecalis	6	Ps. aeruginosa, Non-hemolytic strep., Alc. faecalis
7	Ps. aeruginosa, Alc. faecalis	7	Ps. aeruginosa, Alc. faecalis
8	Ps. aeruginosa, Alc. faecalis, B. subtilis	8	Ps. aeruginosa, Alc. faecalis. B. subtilis
9	No growth	9	Not done

TABLE 2

Item No.	Before Washing	Item No.	After Washing
	Case 1 (Pentothal-Ether) November 16, 1950		
1	P. vulgaris, Ps. aeruginosa, A. aerogenes	1	No growth
2	E. coli, Ps. aeruginosa, A. aerogenes	2	No growth
3	Not done	3	Not done
4	Micrococci, Alpha-hemolytic strep., N. catarrhalis	4	Ps. aeruginosa, Alc. faecalis
5	Alpha-hemolytic strep., Ps. aeruginosa	5	Ps. aeruginosa, Alc. faecalis
6	Ps. aeruginosa, A. aerogenes	6	Ps. aeruginosa, A. aerogenes
7	Ps. aeruginosa, A. aerogenes, Yeasts	7	Ps. aeruginosa, Alc. faecalis, Yeasts
8	Ps. aeruginosa, A. aerogenes	8	Ps. aeruginosa, A. aerogenes
9	No growth	9	Not done
10	No growth	10	Not done
12	Washing water—No growth	12	Not done
	Case 2 (Pentothal-Ether) November 17, 1950		
1	Alpha-hemolytic strep., Beta-hemolytic strep.	1	No growth
2	No growth	2	No growth
3	Not done	3	Not done
4	Ps. aeruginosa, Alc. faecalis, Alpha-hemolytic strep.	4	Ps. aeruginosa, Alc. faecalis, Alpha-hemolytic strep
5	Ps. aeruginosa, Alc. faecalis	5	Ps. aeruginosa, Alc. faecalis, staph. aureus
6	Ps. aeruginosa, Alc. faecalis, A. aerogenes, Yeasts	6	Ps. aeruginosa, Alc. faecalis. A. aerogenes, Yeasts
7	Ps. aeruginosa, Alc. faecalis, Micrococci	7	Ps. aeruginosa, Alc. faecalis, Micrococci
8	Ps. aeruginosa, Alc. faecalis	8	Ps. aeruginosa, Alc. faecalis
9	No growth	9	Not done
10	Not done	10	Not done
12	Washing water—No growth	12	Not done
	Case 3 (Pentothal-Ether) November 22, 1950		
1	No growth	1	No growth
2	Alpha-hemolytic strep., Alc. faecalis	2	No growth
3	Not done	3	Not done
4	Staphylococcus aureus	4	Ps. aeruginosa
5	Ps. aeruginosa, B. subtilis, Yeasts	5	Ps. aeruginosa, B. subtilis, Yeasts
6	Ps. aeruginosa	6	Ps. aeruginosa
7	Ps. aeruginosa, A. aerogenes	6	Ps. aeruginosa, A. aerogenes
8	Ps. aeruginosa, Yeasts	8	Ps. aeruginosa, Yeasts
12	No growth	12	Not done

means of a sterile cotton swab. Again, the various lumens were swabbed internally and externally. Cultures of both the superior and inferior surfaces of the flutter valves were taken. The cultures of the soda lime were taken by swabbing the most superficial granules as well as those granules deep inside the soda lime canister. The swabs were placed in separate sterile test tubes of thioglycolate

broth. The inspiratory and expiratory tubes were cultured by pouring approximately 50 cc. of the broth into each tube, which was then carefully rotated in a clockwise direction for three complete revolutions, at the same time elevating and depressing one end so that the broth traveled the full length of the tube as well as covering the creases of the corrugated tubing. After this maneuver, the broth was carefully poured into a sterile wide-mouthed bottle. The breathing bag culture was taken by pouring 50 cc. of the broth into the bag, the bag being rotated in all directions and its contents then discharged into a sterile wide-mouthed bottle. Standard, sterile, bacteriologic techniques were observed throughout.

Three sets of equipment were cultured in this manner and the results were as noted in table 1.

General Bacterial Survey with Slight Modification of Cleansing Technique. After the results of the first bacterial survey were established, a simple change in cleansing technique was tried and cultures were again taken. Instead of using the same soapy solution for from four to six different sets of equipment, each set was washed in a freshly prepared soapy solution. The rinsing container was washed carefully between rinsings. Cultures were taken as previously outlined with the exception that cultures of the washing water (prior to the addition of soap) were also taken. The bacterial results after the above modification are as noted in table 2.

Limited Bacterial Survey with Final Modification of Cleansing Technique. It was noted early in our study that the apparatus which had been soaked in zephiran solution never grew any organisms. It occurred to me, then, that perhaps a method of limited soaking might be tried which would eliminate most of the organisms demonstrated. Accordingly, the 5-minute zephiran (1:1,000) soak was tried. It is apparent from tables 1 and 2 that the best spectrums of bacterial growth resulted from culturing the inspiratory and expiratory tubing and the breathing bag. These three items were therefore chosen for further study in order to evaluate the effectiveness of the five-minute zephiran soak.

Cultures of this apparatus were taken immediately after operation as noted above. The tubing and bag were then placed in zephiran 1:1,000 solution for a five-minute soaking period. Before allowing the soaking to take place, the interior surface of the tubing and bag were thoroughly wetted with the zephiran solution by rapid, repeated rinsing. Immediately after the five-minute soaking period had elapsed, cultures were again taken, attempts being made to drain off as much of the zephiran solution as possible before culturing took place. In addition to incubating these cultures at 35 C. for three days, these cultures were incubated at room temperature (24 to 25 C.) for three days more after their original incubation period, making a total incubation period of six days. The results are shown in table 3.

TABLE 3

Before 5-minute Zephiran Soak		After 5-minute Zephiran Soak	
Incub. 35C.	Incub. 24C.	Incub. 35C.	Incub. 24C.
Case 1 (Pentothal-Ether) April 23, 1951			
1. B. subtilis, Ps. aeruginosa, Alpha-hemolytic strep.	1. B. subtilis, Ps. aeruginosa, Alpha-hemolytic strep.	1. No growth	1. No growth
2. Ps. aeruginosa	2. Ps. aeruginosa	2. No growth	2. No growth
3. Ps. aeruginosa	3. Ps. aeruginosa	3. No growth	3. No growth
Case 2 (Pentothal-Ether) April 25, 1951			
1. Ps. aeruginosa, Alpha-hemolytic strep., Micrococci	1. Ps. aeruginosa, Alpha-hemolytic strep., Micrococci, B. subtilis	1. No growth	1. No growth
2. Ps. aeruginosa, A. aerogenes, B. subtilis	2. Ps. aeruginosa, A. aerogenes, B. subtilis	2. No growth	2. No growth
3. Same as Item 2	3. Same as Item 2	3. No growth	3. No growth
Case 3 (Pentothal-Ether) April 25, 1951			
1. K. pneumo., Ps. aeruginosa, Alpha-hemolytic strep., A. aerogenes, Micrococci	1. K. pneumo., Ps. aeruginosa, Alpha-hemolytic strep., A. aerogenes, Micrococci	1. No growth	1. Alpha-hemolytic strep.
2. Ps. aeruginosa, A. aerogenes, Alpha-hemolytic strep., B. subtilis	2. Ps. aeruginosa, A. aerogenes, Alpha-hemolytic strep., B. subtilis	2. No growth	2. B. subtilis
3. Ps. aeruginosa, Alpha-hemolytic strep.	3. Ps. aeruginosa, Alpha-hemolytic strep.	3. No growth	3. No growth
Case 4 (Pentothal-Ether) April 26, 1951			
1. Micrococci, Alpha-hemolytic strep.	1. Micrococci, Alpha-hemolytic strep.	1. No growth	1. No growth
2. Ps. aeruginosa	2. Alpha-hemolytic strep., Mold	2. No growth	2. No growth
3. Ps. aeruginosa, Micrococci, Alpha-hemolytic strep., Yeasts	3. Alpha-hemolytic, strep., Yeasts	3. No growth	3. No growth
Case 5 (Pentothal-Ether) April 27, 1951			
1. Ps. aeruginosa	1. Ps. aeruginosa	1. Alc. faecalis	1. Alc. faecalis
2. Ps. aeruginosa	2. Ps. aeruginosa	3. Alc. faecalis	2. Alc. faecalis
3. K. pneumo., Alpha-hemolytic strep.	3. K. pneumo., Alc. faecalis	3. No growth	3. No growth
Case 6 (Pentothal-Ether) April 27, 1951			
1. Ps. aeruginosa	1. Ps. aeruginosa	1. No growth	1. No growth
2. Ps. aeruginosa	2. Ps. aeruginosa, Alc. faecalis, B. subtilis	2. Alc. faecalis	2. Alc. faecalis
3. Ps. aeruginosa, Alpha-hemolytic strep., B. subtilis	3. Ps. aeruginosa, Alc. faecalis, B. subtilis	3. No growth	3. No growth
Case 7 (Pentothal-Ether) April 30, 1951			
1. K. pneumo., Alpha-hemolytic strep., B. subtilis, Paracolabactrum acrogenaides	1. K. pneumo., Ps. Aeruginosa	1. Alc. faecalis	1. Alc. faecalis
2. K. pneumo., Alpha-hemolytic strep., Ps. aeruginosa, Alc. faecalis	2. K. pneumo., Alpha-hemolytic strep., Ps. aeruginosa, Alc. faecalis	2. Alc. faecalis	2. Alc. faecalis
3. Same as Item 2	3. B. subtilis, Ps. aeruginosa	3. Alc. facalis	3. Alc. faecalis
Case 8 (Pentothal-Ether) April 30, 1951			
1. Ps. aeruginosa, Alpha-hemolytic strep., B. subtilis, Alc. faecalis	1. B. subtilis, Alc. faecalis, Ps. aeruginosa	1. No growth	1. No growth
3. Ps. aeruginosa, Alpha-hemolytic strep., B. subtilis, Alc. faecalis	2. Alc. faecalis	2. No growth	2. No growth
3. Same as Item 2	3. Alc. faecalis	3. Alc. faecalis, Ps. aeruginosa	3. Alc. faecalis

TABLE 3—(Continued)

Before 5-minute Zephiran Soak		After 5-minute Zephrian Soak	
Incub. 35C.	Incub. 24C.	Incub. 35C.	Incub. 24C.
Case 9 (Pentothal-Ether) May 1, 1951			
1. Paracolabactrum aerogenaides	1. Paracolon aerogenes, Ps. Aeruginosa	1. Alc. faecalis	1. Alc. faecalis
3. Ps. aeruginosa, Alpha-hemolytic strep.	2. Ps. aeruginosa	2. No growth	2. No growth
3. B. subtilis, Alc. faecalis	3. B. subtilis, Alc. faecalis	3. No growth	3. No growth
Case 10 (Pentothal-Ether) May 1, 1951			
1. Ps. aeruginosa, Alpha-hemolytic strep., Alc. faecalis. B. subtilis	1. Ps. aeruginosa, Alc. faecalis	1. No growth	1. No growth
2. Ps. aeruginosa, B. subtilis, Alpha-hemolytic strep.	2. Ps. aeruginosa	2. No growth	2. No growth
3. Ps. aeruginosa, B. subtilis, Alpha-hemolytic strep.	3. Ps. aeruginosa	3. No growth	3. No growth
Case 11 (Pentothal-Ether) May 1, 1951			
1. Ps. aeruginosa, Alc. faecalis, B. subtilis, Alpha-hemolytic strep.	1. Ps. aeruginosa, Alc. faecalis, B. subtilis	1. No growth	1. No growth
2. Ps. aeruginosa	2. Ps. aeruginosa, Alc. faecalis	2. B. subtilis, Alc. faecalis	2. Alc. faecalis
3. Alc. faecalis, B. subtilis, Ps. aeruginosa, Alpha-hemolytic strep.	3. Ps. aeruginosa, Alc. faecalis, B. subtilis	3. Alc. faecalis	3. Alc. faecalis
Case 12 (Pentothal-Ether) May 8, 1951			
1. Ps. aeruginosa, Alpha-hemolytic strep.	1. Ps. aeruginosa, Alpha-hemolytic strep.	1. No growth	1. No growth
2. Ps. aeruginosa	2. Ps. aeruginosa	2. No growth	2. No growth
3. Alc. faecalis, B. subtilis	3. Alc. faecalis, B. subtilis	3. No growth	3. No growth

DISCUSSION

Comparing tables 1 and 2 with table 3, one sees the almost complete disappearance of organisms after the five-minute Zephiran soak. This occurred in spite of the fact that on several occasions the same zephiran solution was used for as many as four sets of tubing and breathing bags. The cultures were allowed to incubate for three days at room temperature after the original incubation period at 35 C., since it has been demonstrated that organisms not growing at 35 C. frequently will do so at room temperature. *Alcaligenes faecalis* was the most prominent of the few organisms which grew under this method. It is felt that this organism may well be a resistant contaminant present in the reservoir of diluted zephiran prepared here for the study. This contaminant has been found to grow in 1:1,000 Zephiran solution at room temperature. This same organism has also been demonstrated in various other Zephiran reservoirs in the hospital.

Aside from the alpha-hemolytic streptococci and micrococci groups, the organisms which we found in our study which are not inhabitants of the normal pharynx were *Alc. faecalis, Ps. aeruginosa,*

and *B. subtilis.* All three of these organisms are commonly found in feces and have been known to produce resistant genito-urinary tract infections. *Ps. aeruginosa* is commonly found mixed with streptococci and staphylococci and has been found in pure culture in abscesses in different parts of the body, especially in the middle ear (4). Cases of endocarditis and pneumonia have been reported where *Ps. aeruginosa* seemed to be the sole responsible micro-organism. Spontaneous infection with *B. subtilis* in man may produce a panopthalmitis (5). Since the above common contaminants are ubiquitous in dust and water and may at any time become pathogenic, the use of Zephiran 1:1,000 is suggested for their elimination. The method is rapid, cheap, effective and permits early and continuous re-use of limited quantities of expendable rubber equipment.

SUMMARY

A method of bacteriologic survey of anesthesia equipment and a safe, simple, rapid and efficient cleansing routine is presented. Culture studies have shown that a five-minute Zephiran soak serves to eliminate almost all bacteria commonly found in the tubing and breathing bags. No injury to either patient or anesthesia equipment was demonstrated with this cleansing method.

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