The air-water syringe: contamination and disinfection

Eva D. Quinley, MS* / Nancy J. Williams, MS** / Lori L. Ames, MS** / Lynn R. Ingram, MS* / John S. Covington, DDS***

Introduction

Identifying all possible transmission routes of infectious agents is a key element of any infection control protocol. In dentistry, of particular concern as fomites (substances capable of absorbing and transmitting a disease contagium) are those devices that are placed within the oral cavity and that are not easily or routinely disinfected because of their design or some other consideration. One such device is the nonautoclavable air-water syringe (AWS), which, aside from topical disinfection of the barrel's external surface, is not usually included in a comprehensive infection control policy. Although autoclavable AWSs are available, most dental operatories are not equipped with that type. Most AWSs use one or more neoprene "O" rings to prevent leakage (Fig 1). The "O" rings quickly degrade in the heat of autoclaving or after exposure to liquid chemical disinfecting agents and lose their sealing ability. Routine replacement of these "O" rings, while not expensive, is a tedious process usually done only after the rings begin to leak.

A previously published study demonstrated that the incidence of bacterial contamination is high for these devices.[1] Water within the AWS lumen has contamination rates of more than 90%. Because routine autoclaving is not feasible, some degree of disinfection is often attempted by wipage of the outside of the barrel with a disinfecting agent and/or expression of water from the syringe to flush out contaminants between each patient's visit. Contaminants from the oral cavity enter the AWS by reflux and diffuse within the lumen until the AWS is used for the next patient. This reflux (also known as aspiration or retraction) occurs as the water button is released, closing the water valve. The valve action, in assuring a quick, positive cutoff of water flow, retracts the water column in the syringe lumen to some degree (Fig 2a), and causes the contents of the oral cavity aerosol to enter into the syringe. This reflux can be demonstrated in virtually every AWS model.[2] The aspiration of oral cavity aerosol into the AWS lumen provides a plausible mechanism for serial transmission of infectious agents.

The oral cavity contains a large number and variety of flora that are usually innocuous. However, some bacterial and viral agents encountered in dental prac-

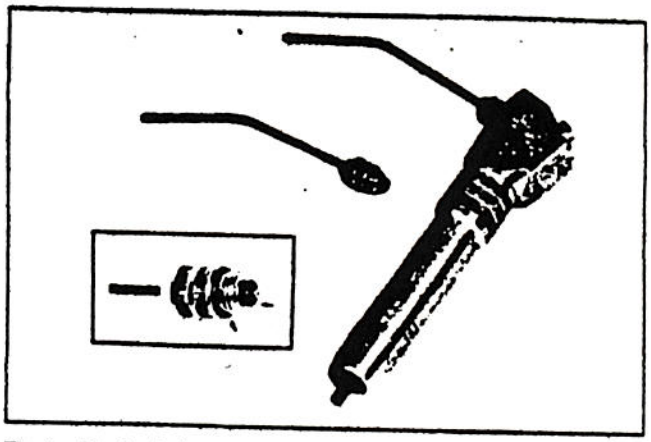

Fig 1 Typical air-water syringe; *(inset)* two neoprene "O" rings *(arrows)* quickly degrade with exposure to the heat of autoclaving or the caustic nature of chemical sterilizing solutions.

* Assistant Professor, Department of Clinical Laboratory Sciences, University of Tennessee, College of Allied Health Sciences, Memphis, Tennessee.

** Assistant Professor, Department of Dental Hygiene, University of Tennessee, College of Allied Health Sciences, Memphis, Tennessee.

*** Chairman, Department of Dental Hygiene, College of Allied Health Sciences; Associate Professor, Department of Biologic and Diagnostic Sciences, College of Dentistry, University of Tennessee, Memphis, Tennessee.

Address all correspondence to: Dr J. S. Covington, University of Tennessee, 847 Monroe Avenue, Memphis, Tennessee 38163.

Figs 2a and 2b Air-water syringe water column is retracted to some degree when water valve is released.

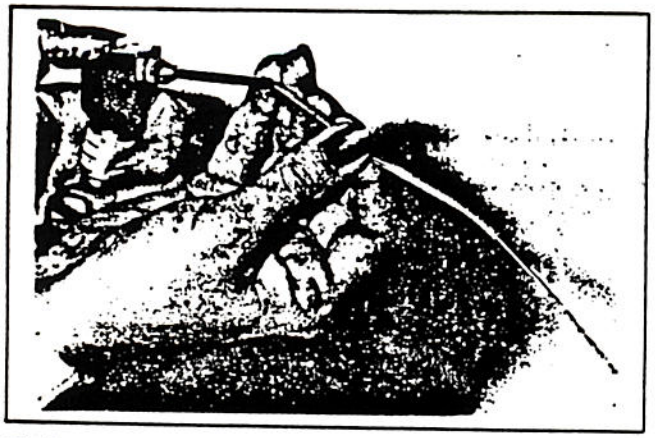

Fig 2a Air-water syringe expelling water through plastic tubing.

Fig 2b When water valve is released, the valve mechanism retracts the water column to some degree *(arrow)*, with ability to aspirate the oral cavity aerosol.

Table 1 Potential pathogens of concern in dental practice

Viral	Bacterial and fungal species
Cytomegalovirus	*Bordetella*
Epstein-Barr virus	*Clostridia*
Hapatitis B virus	*Mycobacteria*
Hepatitis A virus	*Neisseria*
Delta antigen	*Staphylococcus*
Non-A, Non-B hepatitis	*Streptococcus*
Human immunodeficiency virus	*Treponemes*
	Candida
Herpes 1,2	
Rubella	
Mumps	
Respiratory viruses	
Neurotropic viruses	

tice present the possibility of disease transmission (Table 1). The extent of AWS contamination could indicate the nonautoclavable AWS as a possible route of disease transmission. Therefore, the purpose of this study was to determine if the aspiration mechanism could be used to induce a disinfecting solution within the AWS lumen, providing a contamination reduction mechanism without necessitating retrofitting autoclavable syringe barrels to existing equipment.

Method and materials

Air-water syringes of various types and models were examined in the following practice settings: *(1)* dental clinics based in a large university, *(2)* a hospital, *(3)* a public health clinic, and *(4)* a private practice dental office. Practitioners in all four practice settings used some form of external disinfection and expressed water from the AWS in an attempt to flush out contaminants. Testing was done at random times when dental units were not in use, and no attempt was made to correlate this experiment with infection control practices. More than 300 AWS units were examined.

Aspiration occurred to some extent in every AWS examined (Fig 2b). This type of aspiration has been addressed with respect to dental handpieces. The American National Standard Institute Specification No. 47 uses a 6-in length of 0.0625-in inside diameter transparent tubing to test for the presence of aspiration.[3] Conducting the same test on AWS barrels required a variety of tubing sizes; but the 0.045-in inside diameter was suitable for many AWS models.[4] The average length of aspiration was 0.45 in, which corresponded to a volume calculation of 1.17×10^{-2} mL.

Based on bacterial culturing methodology, the AWS units examined were contaminated. For units testing

positive, a morphologic analysis was conducted via a secondary culture. Three cultures were collected from each AWS using accepted bacteriologic techniques: *(1)* collecting cultures from the AWS outer surface using a sterile cotton swab; *(2)* collecting cultures from the AWS lumen using a sterile wire; and *(3)* expressing the water within the lumen directly onto a sterile cotton swab.

With undiluted Biocide disinfecting solution (Biotrol International) as the aspirant, bacterial cultures were then made to assess the effectiveness of aspirating the disinfecting solution. Biocide is an iodophor-based disinfectant with 1% available iodine, and is effective on a broad range of pathogens. This experiment was performed with 27 air-water syringes (15 Biocide-treated units and 12 controls). All units were cultured before treatment. Three cultures were obtained as follows:

1. Culture A: A sterile swab was rubbed on the outside of the AWS barrel.
2. Culture B: A sterile loop was placed approximately 20 mm into the central lumen of the AWS.
3. Culture C: A small amount (< 1 mL) was displaced from the AWS onto a sterile swab.

All cultures were then placed in thioglycolate broth (to screen both aerobic and anaerobic organisms) and incubated at 37 °C.

The treatment units and the control units were then treated as follows:

Treated units. The exterior of the AWS was wiped with a sterile gauze pad saturated with Biocide. Approximately 5 mL of undiluted Biocide was placed into a narrow-bottomed beaker. The AWS tip was placed into the solution and the water valve opened briefly to allow the Biocide to be aspirated into the AWS lumen. The Biocide was allowed to remain in contact with the AWS for ten minutes, the exterior was wiped with a sterile gauze, and the AWS lumen was flushed with a large amount of water to clear the Biocide.

Control units. The units were treated in a similar manner, except that sterile water was used in place of the Biocide solution.

The same three cultures were then repeated and incubated. The thioglycolate tubes were examined for turbidity (which indicates growth) at 48 hours. Tubes with growth were subcultured onto sheep's blood agar plates for definitive study of colony growth and morphology. No anaerobic organisms were identified in the thioglycolate tubes, thus all blood agar plates were incubated aerobically. Viral cultures were not attempted, and appropriate controls were performed.

In addition to the AWS cultures, water from 14 nearby sinks (11 in the university dental clinic, two in the public health clinic, and one in the private practice office) was similarly cultured as a control to rule out contamination of the water supply line.

Results

The control units, treated only with water, had approximately the same level of contamination before and after treatment with sterile water, and the Biocide units had a decreased contamination level (Fig 3). A variety of organisms were cultured, and are identified in Table 2. While no anaerobic organisms were cultured, a variety of aerobes were found. Figure 4 summarizes the findings in each practice setting. All practice settings using nonautoclavable AWSs had similar rates of contamination. The outside barrels were the least contaminated, and the water in the lumen was the most contaminated, with a rate exceeding 90% in all practice settings. Water from the sink cultures was generally free from organisms, with only three cultures exhibiting any growth (two in the university dental clinic and one in the private dental practice). This growth was less than 10^3 colony-forming units per milliliter, which is within the range of potable water. The growth from the private dental office culture was fungal and believed to be the result of an airborne contaminant.

Discussion

This study indicated that the nonautoclavable AWS could easily play a part in disease transmission, and that no particular practice setting is immune from the problem, because it appears to be associated, at least in part, with the design of the AWS. The similarity of the positive growth rate of all three types of cultures across the practice setting spectrum supports this contention. The high incidence (> 92%) of water contamination within the lumen would lend credibility to the argument that routine disinfection might not be possible within the scope of the equipment. Many viral and some bacterial organisms *(diptheroids, staphylococcus,* and spore formers in general) are able to colonize and affix themselves to inert surfaces and remain viable for extended periods of time. This attachment could take place within the AWS lumen in such a manner that even lengthy flushing (recommended by some

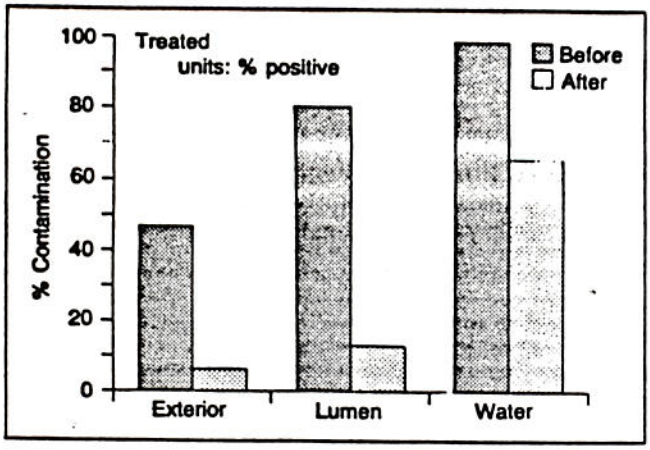

Fig 3a Control units showed no difference in levels of contamination before and after treatment with sterile water.

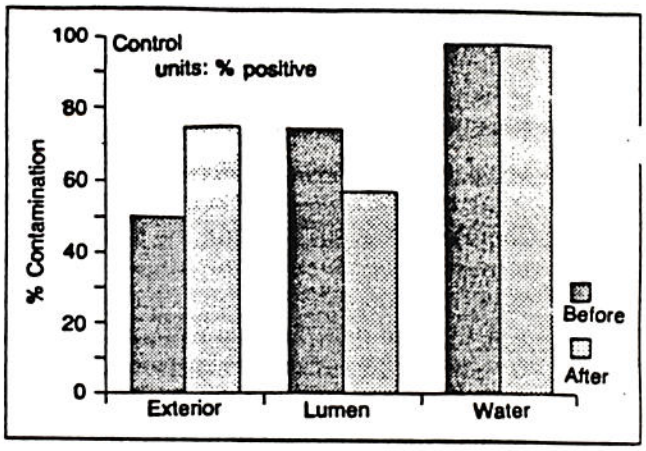

Fig 3b The Biocide-treated units had significantly less contamination after treatment, although lumen water contamination levels were reduced only by one third.

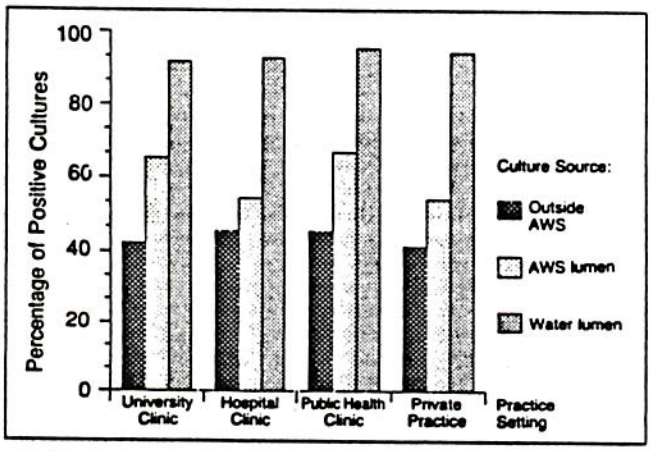

Fig 4 Positive cultures from air-water syringes in each dental operatory. All practice settings that used nonautoclavable AWSs had similar contamination rates.

Table 2 Organisms cultured from AWSs

Diptheroid species
Staphylococcus aureus
Staphylococcus epidermidis
Pseudomonas species
Alpha-hemolytic *streptococcus*
Beta-hemolytic *streptococcus*

manufacturers) may not remove the colonies. The level of disinfection provided by lengthy flushing is currently under investigation by the authors.

Most of the collected bacteria species were in the category of normal oral flora. Many pathogens ar fastidious (having complex nutritional requirements) and thus would only remain viable for a short time in an improper environment. Some pathogens (eg, the hepatitis virus) can exist for extended periods of time in a multitude of environments. In an extreme case, serial transmission could occur via this route.

With the exception of beta hemolytic *streptococcus*, the organisms identified generally are not considered strict pathogens. The mode of organism transmission, whether pathogenic or not, however, is easily shown. Many agents need only a fraction of the proven AWS aspirant volume to be able to transmit disease.[5,6] The contamination level reduction was analyzed using both a chi-square analysis and the Mann-Whitney *U* test. The Mann-Whitney *U* test is a type of nonparametric *t* test appropriate for these data* (Tables 3

* The Mann-Whitney U test is a nonparametric *t* test that is used to compare two groups when the data are continuous, but it cannot be assumed that the data are normal and/or the variances of the two groups are equal. The data values are replaced by their respective ranks from 1 to n and m (the two samples sizes). The test is then performed on the ranks.

Figs 5a and 5b Retrofitting standard air-water syringes with autoclavable tips is a straightforward operation. Kits are provided by many manufacturers.

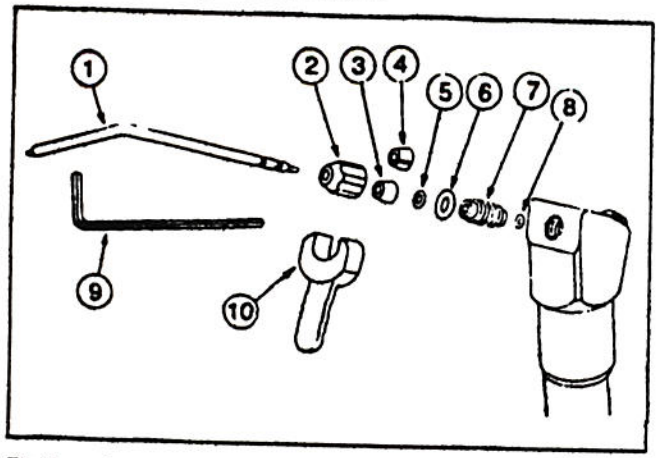

Fig 5a An exploded view of the kit provided by American Dental Equipment Co. Installation requires no special tools other than those provided in the kit.

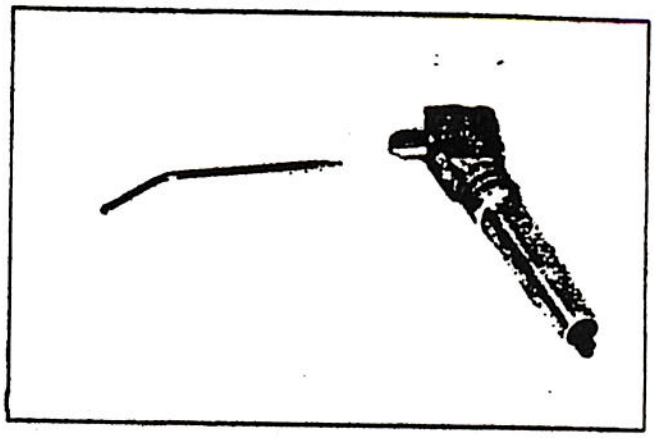

Fig 5b Tips are easily removed for disinfection, after which they are inserted into the special friction fit adapter. (Courtesy of American Dental Equipment Company).

Table 3 Chi-square analysis

	Before		After	
Culture	% Pos	*P* value	% Pos	*P* value
Culture A				
Control	50	.86	75	<.01
Treated	46		6	
Culture B				
Control	68	.43	58	.01
Treated	70		5	
Culture C				
Control	100	1.00	100	.03
Treated	100		67	

Table 4 Mann-Whitney *U* test analysis

	Before		After		Change	
	% Pos	*P* value	% Pos	*P* value	% Pos	*P* value
Overall control	13	.65	20	<.01	19	<.01
Overall treated	15		9		10	

and 4). The *P* values indicated that the degree of reduction of the Biocide-treated units was significant at all levels, yet the lumen water *P* value (0.03) showed that this method of disinfection could effectively disinfect the AWS. Many types of organisms can adhere to the walls of inert surfaces, often aided by oral aerosol products (blood and salivary proteins). Expelling copious amounts of water from the AWS to flush out contaminants is currently being studied by this group, and it is possible that a combination of the two methods could be used to attain disinfection.

One disadvantage of this type of disinfectant solution aspiration would be failure to recognize that disinfectant solution remained in the AWS lumen, thereby expelling solution directly into the patient's mouth. The effective concentration of the solution, when fully diluted with the lumen water, is approximately 20% of full strength, which is easily strong enough to cause tissue damage.

This study did not culture any overt pathogens, but the mechanism of transmission is plausible. As the epidemic of human immunodeficiency virus transmission unfolds, it is worth repeating that the practice of dentistry does not place a person at undue risk of this disease. Hepatitis is still unquestionably the most critical occupational health hazard within dentistry. The virulence of the virus is so high that as little as 10^{-8} ml. of blood is capable of causing the disease. Ad-

ditionally, the hepatitis virus has been known to survive for more than seven days on inert surfaces at room temperature.[5] Hepatitis and other viruses, ie, herpes simplex 1 virus, cytomegalovirus, and Epstein-Barr virus, are excreted into the saliva, causing occupational as well as serial transmission hazards.

Conclusion

While the possible problem of contamination of non-autoclavable dental instruments has been addressed previously,[3,7,8] handpieces have been of principal concern. This study indicates that a piece of equipment found in virtually all dental operatories has a high rate of contamination, not related to the type of practice setting, but as a result of equipment design and/or incomplete infection control practices. Retrofitting autoclavable air-water syringes is a solution to both shortcomings, and several manufacturers provide such equipment. Often the retrofit is a modified, autoclavable barrel; the original handle and valving are retained (Fig 5). The cost associated with the retrofit is not expensive. The university-based dental clinic, equipped with ADEC units (American Dental Equipment Co), retrofitted autoclavable AWS tips to all of its dental units (approximately 300) at a cost of approximately US$18.00 each, excluding associated labor. Therefore, the authors recommend autoclavable air-water syringes as an integral part of infection control.

References

1. Quinley ED, Williams NJ, Ames LL, et al: Contamination of the dental unit airwater syringe. *J Dent Res* 1988;67 (special issue):152 (abstr No. 312).
2. Ingram LR, Covington JS, Williams NJ, et al: Disinfection of the dental unit non-autoclavable air-water syringe. *J Dent Res* 1988;67:313.
3. Council on Dental Materials, Instruments, and Equipment: Dental units and water retraction. *J Am Dent Assoc* 1988;116:417–420.
4. Technicon Instruments Corporation: *Technicon Autoanalyzer General Operating Instruction Manual*. Terrytown, NY, Technicon Instruments Corporation, 1973, p 239.
5. Allukian M: The control of transmissible diseases in dental practice: a position paper of the American Association of Public Health Dentistry. *J Public Health Dent* 1986;46:13–21.
6. Jakush J: AIDS: the disease and its implications for dentistry. *J Am Dent Assoc* 1987;115:395–403.
7. Sampson E, Dhuru VB: Infection control in North American dental schools. *J Dent Educ* 1983;47:329.
8. Shovelton DS: The prevention of cross-infection in dentistry. *Br Dent J* 1982;153:260.

□