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Cleaning, Disinfecting, and Sterilizing Self-Contained Self-Rescuer Mouthpiece Assemblies Used in Hands-On Training

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UNITED STATES DEPARTMENT OF THE INTERIOR

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

°F	degree Fahrenheit	mL	milliliter
gal	gallon	min	minute
h	hour	ppm	part per million
Hz	hertz		

CLEANING, DISINFECTING, AND STERILIZING SELF-CONTAINED SELF-RESCUER MOUTHPIECE ASSEMBLIES USED IN HANDS-ON TRAINING

By Michael J. Brnich, Jr.[1] and Henry J. Kellner, Jr.[2]

ABSTRACT

This U.S. Bureau of Mines report addresses issues involved in using a limited number of training apparatus to give hands-on self-contained self-rescuer (SCSR) training to a succession of miners, and provides guidance regarding methods for minimizing the spread of infectious diseases. Procedures used for preventing the spread of infectious organisms in dentistry, cardiopulmonary resuscitation (CPR) training, and scuba training are examined. The sanitizing methods of three organizations that require individuals to insert the mouthpiece as part of the SCSR donning sequence are discussed. It was found that each of these organizations was able to render their mouthpiece assemblies microbe free simply and inexpensively.

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INTRODUCTION

In June 1987, the Mine Safety and Health Administration (MSHA) issued an Emergency Temporary Standard (ETS) requiring hands-on SCSR training for all persons entering underground mines (*1*).[3] The ETS specifies four elements that must be included in SCSR training. These are as follows: (1) Opening the device; (2) activating the oxygen; (3) inserting the mouthpiece or simulating this task while explaining the procedure; and (4) putting on the noseclips.

Studies of miners putting on the SCSR indicate that the failure to obtain a good seal on the mouthpiece is a fairly common error, which can be remedied and corrected through additional hands-on practice (*2*). Simulation of this task obviously provides no feedback, thus leaving in doubt the trainee's ability to complete this critical task during an actual mine emergency. Therefore, many mine trainers adopt a training strategy that includes insertion of the mouthpiece. This permits the practice of the entire sequence including breathing through the SCSR training apparatus.

The use of a single training apparatus to provide hands-on training for several miners presents a problem. There are widespread concerns over the spread of infectious organisms such as hepatitis B, herpes, and acquired immune deficiency syndrome (AIDS). Mine trainers seek methods for protecting miners as well as themselves from contracting these diseases during SCSR training. These concerns parallel similar expressions by individuals working in the medical and dental communities. This U.S. Bureau of Mines report explores the issues involved and provides guidance regarding the use of methods for minimizing the spread of infectious diseases during hands-on practice.

BACKGROUND

The terms sterilization, disinfection, and cleaning have different definitions, but quite often these terms are misused and interchanged. Sterilization is defined as the use of some form of chemical or physical method to destroy all microbial life, including highly resistant bacterial endospores (*3*). In effect, a sterilized object will remain sterile as long as it is kept in a sterile environment. Obviously, the process of sterilizing is more complex than disinfecting. Disinfection is defined as a process that inactivates nearly all pathogenic micro-organisms, but not all microbial forms (bacterial endospores) on inanimate objects (*3*). All other treatments come under the category known as *cleaning* which, in itself, can be useful. Table 1 provides a listing of chemical agents used in disinfection and/or sterilization; a chemical classification for these agents; and corresponding disinfectant and/or sterilant characteristics.

Many mine trainers have their trainees demonstrate the motor task of mouthpiece insertion. Consequently, a few mouthpiece assemblies may be used by many individuals in hands-on SCSR training. Therefore, it was decided that the researchers should review methods for preventing the spread of infectious organisms in other settings in which objects that contact mucus membranes of the body are used to serve the needs of many people. Techniques used for abating the spread of infectious organisms in dentistry, CPR training, and scuba diving were assessed to determine the feasibility of using these techniques in hands-on SCSR training.

Methods for preventing the transmission of infectious diseases in the dental profession have been reviewed in earlier studies (*4-5*). Information currently available for the dental profession discusses modes of transmission of infectious diseases. The information also reviews methods for prevention of transmission of such diseases including the use of sterilization, disinfection, and thorough cleaning of instruments, equipment, and work areas. Research focusing on disease transmission in CPR training was examined (*6-7*). The information reviewed discusses techniques that reduce the possibility of disease transmission. These methods include the use of protective equipment (face shields or masks) by trainees, simulation of rescue breathing in two-rescuer CPR training to reduce manikin contact, and procedures for decontaminating manikins once they are used.

Finally, research addressing the topic of disinfection procedures for scuba equipment was reviewed (*8*). Although there are a number of diving training and certification agencies in addition to equipment manufacturers, the literature indicates there are no standardized recommendations for decontamination of shared scuba equipment. However, the literature does discuss methods that can be used for adequate cleaning and disinfection of shared scuba equipment used in training and rental settings.

[3]Italic numbers in parentheses refer to items in the list of references at the end of this report.

Table 1.–Guide to chemical agents for disinfection and/or sterilization

Accepted products	Chemical classification	Disinfectant	Sterilant
ProMed brand Wescodyne-D Biocide.	Iodophors, 1% available iodine.	Diluted according to manufacturer's instructions, 30 min.	NAp
Household bleach.	Sodium hypochlorite.	Diluted 1:5 to 1:100,[1] 10 to 30 min.	NAp
Dentaseptic Multicide Omni II.	o-phenylphenol, 9% and o-benzyl-p-chlorophenol, 1%.	Diluted 1:32, 10 min at room temperature.	NAp
Sporicidin	Glutaraldehyde 2% alkaline with phenolic buffer.	Diluted 1:16, 10 min at room temperature.	Full strength, 6-3/4 h at room temperature.
Glutarex	Glutaraldehyde 2% neutral.	Full strength, 10 min at room temperature.	Full strength, 10 h at room temperature.
Banicide ..... Sterall Wavicide 01.	Glutaraldehyde 2% acidic potentiated with nonionic ethoxylates of linear alchohols	Diluted 1:2, 10 min at room temperature.	Full strength, 1 h at 140° F 4 h at 104° to 122° F, 10 h at room temperature.
Exspor	Chlorine dioxide	2 min at room temperature.	6 h at room temperature.
Centra[2] Cidex 7	Glutaraldehyde 2% alkaline.	Full strength, 10 min at room temperature.	Full strength, 10 h at room temperature.

NAp Not applicable.
[1]Ratio used bleach to water.
[2]Available in regular (14-day activity) or long life (28-day activity).

STERILIZATION

Several types of sterilization procedures are employed in the dental profession to sterilize instruments and equipment used. These techniques include hot sterilization using steam or dry heat, gas sterilization, and chemical cold sterilization. Sterilization is not used in CPR training, nor is it advocated for use with scuba diving equipment.

Hot sterilization involves the use of pressurized steam in a steam autoclave or the application of dry heat. For proper sterilization to occur, the temperature inside the steam autoclave must be from 250° to 270° F. When dry heat sterilization is used, temperatures must range from 340° F for 1 h to 250° F for 16 h. For gas sterilization, instruments are placed in ethylene oxide gas sterilizers. For gas systems, special piping and other provisions including venting to the outside are required because the gas is toxic. Cold sterilization uses liquid chemicals and is employed for heat-sensitive instruments or objects.

DISINFECTION AND CLEANING

Several methods are employed for conducting disinfection cleaning in the dental profession, CPR training, scuba training, and in annual refresher SCSR training for miners. Methods for disinfection include high-level disinfection using disinfectant-sterilant chemicals registered by the U.S. Environmental Protection Agency (EPA) or boiling water and disinfection using chemical germicide solutions. Several methods are available for cleaning dental instruments and other objects. These methods include thorough washing and ultrasonic cleaning. Ultrasonic cleaning is a technique in which objects are immersed in a liquid cleaning medium that is aided by ultrasonic waves (waves greater than 16,000 Hz) generated by the cleaning vessel.

DENTAL PROFESSION

High-level disinfection can be accomplished by immersion in either boiling water for at least 10 min or an EPA-registered disinfectant-sterilant chemical for the exposure time recommended by the chemical's manufacturer. Disinfection can also be done with suitable chemical germicides. For disinfection of work areas in dentistry, a solution of sodium hypochlorite (household bleach) prepared fresh daily is recommended as an inexpensive and effective germicide. Bleach-water concentrations that range from 5,000 to 500 ppm (1:10 to 1:100 dilution of bleach) are effective, depending on the amount of organic material on the surface to be cleaned and disinfected.

Before disinfection or sterilization of instruments can take place, they must be thoroughly cleaned to remove blood, saliva, and other substances that are present. Cleaning can be accomplished in several ways. First, one can clean by thoroughly scrubbing instruments with soap and water or a detergent. All adherent debris must be removed, the instruments thoroughly rinsed, and then dried. Cleaning can also be accomplished by using mechanical devices such as ultrasonic cleaners.

CARDIOPULMONARY RESUSCITATION TRAINING

In 1983, an ad hoc committee for evaluating sanitary practices in CPR training was formed and developed recommendations for decontaminating manikins used in CPR training. The committee was comprised of representatives from the American Heart Association, the American Red Cross, and the Centers for Disease Control. The committee recommended that CPR manikins be disassembled, thoroughly washed, and rinsed. Following washing, all surfaces capable of disease transmission are to be wet for 10 min with a sodium hypochlorite solution containing at least 500 ppm free available chlorine (1/4 cup household bleach per gallon of tap water). Following use of the bleach and water solution, the parts are to be rinsed thoroughly with tap water and dried. This bleach solution must be made fresh for each CPR class and discarded after use.

Cleaning standards for CPR manikins closely follow those advocated for the dental profession. CPR instructors are advised to disassemble the manikins according to the manufacturer's directions. The components are to then be thoroughly washed with warm soapy water. The manikin parts are to be scrubbed with a brush to remove all saliva and other substances. Once washed, the parts can be rinsed with tap water and allowed to air-dry.

In 1985, inquiries began to increase regarding the adequacy of the standards recommended for manikin decontamination in killing the AIDS viral agent. Subsequent studies revealed that the viral agent causing AIDS, human T-cell lymphotropic virus type III-lymphadenopathy-associated virus (HTLV-III-LAV), is delicate and is inactivated at room temperature in less than 10 min by a number of disinfectant chemical solutions including sodium hypochlorite.

The bleach dilution, used in conjunction with thorough scrubbing and rinsing, will ensure that the HTLV-III-LAV virus and a variety of other infectious agents will be killed. The literature indicates that if the recommended decontamination procedures are followed consistently in CPR training, students will use manikins that have a sanitary quality equal to or better than that of eating utensils found in restaurants.

SCUBA TRAINING

In scuba training and scuba equipment rental, the use of shared equipment is common. As mentioned earlier, literature indicates that there are no formal standards for decontaminating shared scuba equipment. It is known that in certified, nationally recognized diving courses, training is required to be conducted with special diving equipment having a second regulator-mouthpiece and hose assembly attached to the primary air tank regulator. With this type of equipment, each diver will have his or her own mouthpiece during training. As a result, the risks of disease transmission are reduced.

The Centers for Disease Control have made some recommendations for decontaminating scuba mouthpieces. These recommendations include thorough cleaning of the devices followed by disinfection. Disinfection can be accomplished by immersing the mouthpiece in some broad-spectrum germicidal solution. Exposure to a fresh solution of household bleach (1/4 cup bleach in 1 gal of tap water) for 10 min is considered sufficient for disinfection. Following disinfection, the mouthpieces can be rinsed with fresh tap water and permitted to air-dry.

Manufacturers of scuba equipment have recommended that devices be rinsed thoroughly with fresh tap water. For shared equipment, it is recommended that the mouthpieces be removed from the unit and thoroughly scrubbed with soap and warm water. Brushes should be used to scrub away substances found on the surfaces of the mouthpiece and to adequately scrub the breathing hoses. Following scrubbing, the mouthpieces can be rinsed with fresh tap water and permitted to air-dry.

METHODS USED IN MINING

The cleaning procedures used by three mining organizations in preventing the spread of infectious diseases during SCSR training are described below. These three organizations are providing a method of hands-on training that requires individuals to insert the mouthpiece as part of the training sequence.

Organization A: Since July 1986, Organization A has been involved in hands-on SCSR training for its personnel using three Draeger[4] OXY-SR 60B training apparatus modified to permit quick changeout of mouthpiece assemblies. Twenty additional mouthpieces were purchased, permitting a clean assembly to be installed before each use. Following use, the mouthpiece assemblies were removed, scrubbed in soap and water, and rinsed. Following rinsing, the assemblies were then soaked overnight in a chemical sterilant solution known as Cidex 7. The assemblies were then removed from the sterilant solution, thoroughly rinsed with water, and permitted to air-dry.

Organization B: Trainers purchased 27 extra mouthpiece assemblies for use with 6 to 12 CSE AU-9A1 training models. Used assemblies are removed, cleaned, and then disinfected by soaking in a household bleach-water solution for 30 to 45 min. Trainers mix the bleach-water solution at a ratio of approximately 1 part bleach to 10 parts warm water (5,000 ppm bleach solution). After soaking, the mouthpiece assemblies are rinsed with warm water and are allowed to air-dry.

Organization C: This organization chose to purchase mouthpiece assemblies for each of the employees receiving hands-on training at their operation. Nearly 100 Draeger OXY-SR 60B assemblies were bought and each was engraved with a serial number to identify the worker who used it. After use, the assemblies were cleaned in a soap-water solution and then packaged each in a separate plastic storage bag. The mouthpieces were not disinfected or sterilized in any form. Trainers maintain the mouthpiece assemblies for reuse during followup evaluations. The organization felt that with this program, it could ensure each miner that an individual would use only his or her own mouthpiece.

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[4]Reference to specific products does not imply endorsement by the U.S. Bureau of Mines.

SELF-CONTAINED SELF-RESCUER MOUTHPIECE TESTING

In early 1988, the Bureau obtained a random sample of four mouthpiece assemblies from organization A, four from organization B, and five from organization C. As mentioned earlier, organization A used a chemical cold sterilant for mouthpiece assemblies and organization B used a bleach-water solution to disinfect. Organization C cleaned their assemblies with a soap and water solution.

An independent biological testing laboratory conducted tests for micro-organisms on each mouthpiece assembly. Two major tests were conducted. The first was a standard plate count, which is a broad-spectrum bacteria test. The second was an anaerobic plate count for determining the presence of organisms that grow in oxygen-free environments. Test results indicated that, for each mouthpiece tested, a count of fewer than 100 organisms per milliliter of sterile water was observed for both types of plate counts. For drinking water, the legal safe limit for micro-organisms is 500 per milliliter of sterile water. These results indicate that each mouthpiece tested was free of micro-organisms, regardless of which cleaning-disinfecting-sterilizing method was used.

DISCUSSION

The methods for cleaning and disinfecting SCSR mouthpiece-hose assemblies reviewed in this report are procedures currently used by trainers. Other methods may be practiced. For example, organization A originally rinsed used mouthpieces with water, immersed the assemblies in rubbing alcohol (70% alcohol) for several minutes, and then permitted them to air-dry. Many trainees complained of the foul taste of alcohol left on the mouthpiece after cleaning, however. Later, this organization switched to rinsing the mouthpieces and soaking them in a soap solution. Following immersion in the soap and water solution, the mouthpieces were rinsed thoroughly with water and permitted to air-dry. Finally, the trainers began using the Cidex 7 solution discussed above.

In August 1987, Bureau personnel investigated the possibility of using hot (steam) sterilization for sanitizing SCSR mouthpieces. Several Draeger mouthpiece assemblies were placed into a steam autoclave in an attempt to sterilize them. When the mouthpieces were removed from the autoclave, major deformation of the plastic parts of the assemblies was noted. Hot sterilization is therefore impractical because of heat damage to the mouthpiece assemblies. Gas sterilization may not be feasible since special piping, venting, and other provisions are required.

CONCLUSIONS

Based on this review of available information, the approach at the Bureau in the future will be to use a thorough cleaning process followed by immersion in a bleach-water solution for disinfecting SCSR mouthpieces. This form of cleaning and disinfection is not expensive. This recommendation is based upon the results of microbial testing and similar procedures advocated for disinfecting CPR and scuba training equipment. These procedures are thought to be effective in abating the spread of infectious disease.

Chemical cold sterilants, which are not prohibitively expensive, could also be used. With respect to SCSR mouthpiece assemblies, microbial test results indicate that there is no advantage for sterilization over disinfection. At the same time, chemical sterilants are not readily available and must be purchased from medical supply houses. Ultimately, the trainer must decide if individual mouthpieces will be used or if mouthpieces will be shared by trainees. This decision will dictate the type of cleaning and/or disinfection routine that will be used.

It is hoped that this report will provide mine trainers and others with useful information for adequately cleaning and disinfecting SCSR mouthpieces to aid in preventing the spread of infectious disease during hands-on SCSR training.

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