

Use of pressure cookers for sterilization of clinical instruments

R. J. Baez, DDS, MPH, HFADI*

Preamble

Various organizations and individuals have made efforts over the years to collaborate on provision of oral health services to population groups living in deprived communities; concerns have been expressed to best available practices to exercise adequate infection control especially in remote areas. Considering that several ADI fellows volunteer to provide oral health care and travel to remote areas where clinical facilities maybe less than optimal and essential sterilization equipment may not even be available, I thought appropriate to refer to a study conducted at the Dental School of the University of Texas Health Science Center at San Antonio in 1997 in which pressure cookers were assessed to verify whether sterilization conditions could be effectively achieved.

Background

An important element of the Academy's mission is to promote activities conducive to improvement of oral health of the population. The most cost-effective strategy to enjoy oral health lies on the principles of oral health promotion and disease prevention; the World Health Organization (WHO) oral health report 2003 (1) noted that dental caries can be controlled by the joint action of communities, professionals and individuals aimed at reducing the impact of sugar consumption and emphasizing the beneficial effect of fluorides. Population-wide automatic fluoridation measures are considered the most effective and equitable dental caries prevention methods and require no cooperative effort or direct action by the population. Such measures have a significant beneficial impact, particularly in deprived populations (2). In many developing countries, access to oral health services is limited; likewise, in developed countries, significant numbers of population groups are underserved (3). And, unfortunately, not all population groups have access to health services that are prevention oriented or existing resources are devoted to activities considered of having higher priority. In several countries dental disease prevalence and severity is a major problem and many individuals suffer from pain resulting from acute or chronic problems. It is known that various factors affect utilization of oral health services; one of such factors is availability of health services due to insufficient number of oral health professionals or their inadequate distribution throughout the country. Another factor relates to accessibility to health services, either because the patients cannot afford the cost or there is not insurance coverage available

**Adjunct Professor University of Texas Health Science Center at San Antonio School of Dentistry*

*** Presented at the International Association for Dental Research meeting, Nice, France, June 1998*

to them or they may have transportation difficulties that impede access to health care. A third factor is related to acceptability of health services, in this case health services may be available, patients can afford cost or have no transportation problems, yet they do not perceive the need of health care or may have cultural issues which influence health services demand. Whatever the influential factor is, there are populations groups underserved and with great oral health service's needs.

Organizations that can coordinate provision of oral health services in countries with greatest needs can play a significant role to alleviate most urgent oral health conditions and in reducing prevalence of dental disease. In countries or regions where oral health care providers are insufficient to address the population's oral health needs, volunteer health care providers can contribute to lessen suffering and prevent teeth loss with proper interventions. When an oral health professional volunteers to collaborate and provide dental care, it is difficult to precisely know the procedures that he/she will perform unless a previous assessment of needs has been conducted. Consequently, it is difficult to know the type of instruments that will be required; however, one indispensable element to have available in the field is a system for disinfecting or sterilizing clinical instruments. For years it has been confirmed that cross contamination with pathogen agents can occur during dental treatment and we have the responsibility of implementing universal precautions and measures to protect the patient, ourselves and those that participate in providing care.

Various barriers and recommendations have been developed by professional organizations or government agencies to prevent contamination. Disinfection of surfaces and sterilization of instruments that come into contact with tissues or fluids during treatment has long been recommended (4-9); it has been demonstrated that use of saturated steam under pressure is the most acceptable method for achieving sterilization. A temperature of 121°C is applied for 15 to 20 minutes, under 103 kPa (15 psi) pressure. Direct exposure to saturated steam at 121°C for 10 minutes normally destroys all forms of microbial life although additional time must be allowed for the temperature to reach all surfaces of instruments being subjected to the sterilizing cycle. Autoclaves are efficient but expensive and may not be available in the field, especially in developing countries or in remote areas. Pressure cookers are relatively inexpensive and likely available worldwide. Steam pressure and temperature reached inside these vessels are sufficient to produce sterilizing conditions similar to those obtained in an autoclave.

Methods

Sterilization effectiveness

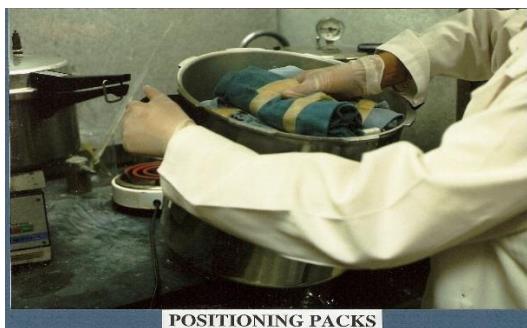
Questions are raised regarding whether indeed pressure cookers could be used as vessels for sterilization of instruments used in the clinic, whether “all” sizes of pressure cookers are suitable and whether the source of heat play a role in the process. In a study conducted at the Dental School of the University of Texas Health Science Center at San Antonio in 1997 (10 four pressure pots marketed by three different manufacturers were evaluated (Figures 1). The study evaluated a “Presto” cooker vessel of 22 quarts



(approx. 21 liters) capacity [Vessel 2], “Mirromatic” 6 quarts (5.7 liters) [Vessel 3], “Presto” 6 quarts (5.7 liters) [Vessel 4] and “Mirro” 4 quarts (3.8 liters) [Vessel 5] to determine if sterilization conditions could be achieved around dental instruments packed in conventional wrappings upon exposure to saturated steam at 103 kPa (15 psi) and a

temperature of 121°C (11) during three separate cycles; additional trials were conducted exposing instruments to 138 kPa (20 psi) at 127°C for 5, 10, 15 and 20 minutes. Pressure cookers of a 5.7 liters (6 quarts) capacity require approximately 1.5 liters (6 cups) of water and a large vessel such as the 21 liters (22 quarts) require 3.750 liters (15 cups) of water for the sterilization process. A supporting platform was constructed using the plate provided with the cookers to keep food from contacting the bottom of the cooker; three metal legs of about 57 by 16-18 mm (21/4 by 5/8-3/4 inches) were attached to the plate so that instruments would be above water during sterilization process. Packs were distributed strategically in each of the vessels used and the respective location within the vessel recorded (Figures 5 and 6).

Figure 1



POSITIONING PACKS



Figure 5

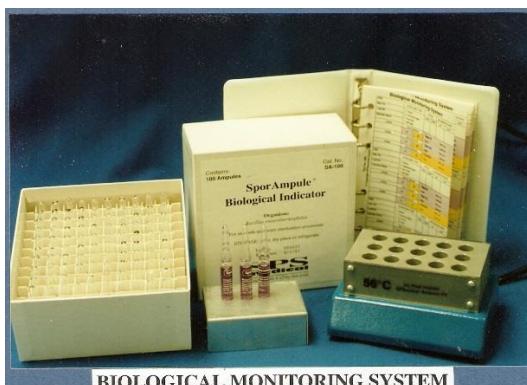
Electrical appliances were used as source of heat (Figure 4). *Bacillus Stearothermophilus* contained in a "Spor-Ampule" (SPS Medical, Rochester, NY) was used as biological indicator (Figures 3 and 4).



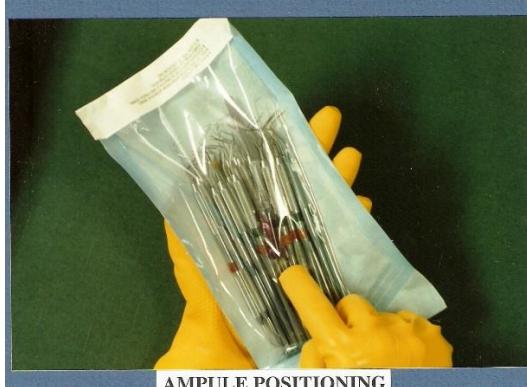
POSITIONING BAGS



Figure 6



BIOLOGICAL MONITORING SYSTEM



AMPULE POSITIONING

Figure 3



VESSELS USED IN STUDY



INCUBATED AMPULES
(SPS, MEDICAL, ROCHESTER, NY)

Figure 4

A commercial autoclave (“Ritter Speed-clave”, Ritter Dental, San Antonio, TX) was used as control vessel [Vessel 1] (Figure 6). Three processing cycles were conducted at each time period. After each run, processed ampules were retrieved and incubated at 56°C for 24 hours and 7 days. An unprocessed ampule was incubated as control. A purple to yellow color change after incubation indicated spore growth (Figure 10). Results of this study indicated that adequate sterilization conditions were achieved in Vessel 1 at all time periods and in vessels 2 and 5 at 103 kPa (15 psi) at 121°C for 10 minutes, and in all vessels at 103 kPa(15 psi) at 121°C for 15 and 20 minutes (Figures 11 and 12). Pressure cookers included in the study were equipped with a pressure regulating weight of 90 ± 1 grams which was sufficient for achieving the target pressure as part of the sterilization conditions described. Sterilization conditions were also achieved at 138 kPa (20 psi) at 127°C in vessels 2, 3 and 4 but in order to achieve this pressure, a modification to the pressure regulating weight was necessary; its weight had to be increased 30 grams for a total of 120 ± 1 grams (Figures 2, 7 and 8).



Figure 2



Figure 7



Figure 8

Discussion

Steam pressure of 103 kPa (15 psi) at 121°C can be achieved in all vessels included in the study without any modification to their components. However, the time necessary to achieve sterilization conditions was not consistent in all pressure cookers. Failure to achieve these conditions was judged by positive growth of *bacillus stearothermophilus* in the “Spor Ampules” after 24 hours and seven days culture at 56°C. Differences can be attributed to number of packs loaded in each vessel, location of ampules within the pack, and sealing ability of the pressure cooker gasket. Although pressure gauges indicated the required pressure, small leaks around the gasket could have caused undetectable drop in pressure and temperature which might have not be sufficient to destroy spores at the five minute period in all trials. After culture for the recommended seven days, “Spor-Ampules” exposed to saturated steam in cloth wrappings for 15 minutes were further cultured for one month. No evidence of color change was observed in the ampules that would indicate growth of *bacillus stearothermophilus*.

Steam pressure of 0.138 kPa (20 psi) at 127°C can also be obtained in pressure cookers, but a modification of the pressure regulating device is necessary by increasing its total weight to 120 ± 1 grams. No positive cultures were evident in any ampules processed at the increased saturated steam pressure for 5, 10, 15 and 20 minutes in all vessels.

Use of a thermometer with a capacity up to 150°C (302°F) graduated in one degree fractions with an accuracy of $\pm 1\%$ of Scale Range, for example Code DR 50/300°F and 10/150°C Straight form Type 3S manufactured by Weksler Instruments (Division of Ashcroft Inc Stratford, CT – USA can be installed on the pressure cooker lid for chamber temperature verification (Figure 13). It should be noted that for accurate readings stem must be immersed at least 2 inches in liquids and 4 inches in gases; other types of thermometers are available in the market.



Figure 13 Typical thermometer that can be installed on the pressure cooker lid for monitoring chamber temperature

Oral health care providers must exercise universal precautions for preventing contamination with infective agents when performing dental treatment procedures. It is the responsibility of the oral health care provider to protect the patients, him/her and auxiliary personnel from possible cross infection during provision of dental services. The difficulties encountered by oral health care providers, including volunteers, that travel to remote areas where in most cases

there are limited facilities for the proper provision of oral health services are acknowledged; however, there is no excuse for not exercising universal precautions even in remote areas. The availability of utensils such as pressure pots, cookers or caners is a viable alternative that can be used for sterilizing clinical instruments in absence of an autoclave. According to the results of the study cited, instruments placed in bags or packs can be successfully sterilized achieving 103 kPa (15 psi) at 121°C, provided that instruments are placed above the water surface so that saturated steam reaches all instrument surfaces; this is an important requirement since if instruments are submerged in water, boiling temperature is not enough to destroy all forms of microbial life including spores. A modification of the pressure regulating weight by adding a 30 grams weight so that the total weight is increased to 120 ± 1 grams permits increasing pressure to 138 kPa (20 psi) and 127°C reducing the time required and ensuring sterilization.

Note: In the study cited, units used were psi (pounds per square inch), a unit of pressure in the imperial system; the current standard recommendations are to differentiate more specific designations such as pounds per square inch absolute (psia, referenced to an absolute vacuum), pounds per square inch gauge (psig, referenced to atmospheric pressure), and kilo Pascals (kPa, referenced to absolute vacuum). Gauges used in pressure cookers still use the imperial system and may display dual units in imperial and metric systems or units in the imperial system with the corresponding temperature in degrees Celsius or Fahrenheit.

When planning a service activity in remote areas a pressure cooker should be acquired ahead of time and modifications required made in advance before traveling to the remote site, especially when there is uncertainty of their availability in the target region; such modifications may be constructing or adapting a platform and fabricating an additional pressure regulating weight. If a weight is added so that 138 kPa (20 psi) conditions are attained, it is critical that the weight added does not exceed 30.0 grams otherwise the chamber pressure will continue increasing and the safety valve (installed by the manufacturer) may be activated with the consequent release of hot steam that can cause severe burns.

Some pressure cookers especially those marketed for canning food come equipped with a pressure indicator gauge; this is considered a great advantage since pressure rise can be monitored. If the pressure cooker is not equipped with a pressure gauge, this can be installed before departure to the camp or service site; there are several products available in the market, for example a gauge graduated from 0 to 30 PSIG (approx. 0 to 200 kPa) [Figure 14] (Weksler Instruments a Division of Ashcroft Inc Stratford, CT – USA).

Figure 14



Size of pressure cookers does not seem to have a negative effect; it may be advantageous to use a large vessel for clinical settings that require larger number of instruments to be sterilized at one time, however, time to reach the required temperature is a factor to be taken into consideration and the bulk of the vessel

should also be considered. For small operations a smaller vessel may be satisfactory. It is practical to start the heating process with a high heat setting on the heating device used until the desired chamber pressure

is attained and then lower or reduce the heat to a point just enough to maintain target pressure stable; obviously, if no electricity or gas source is available heating rate will depend of the energy used, charcoal, wood, etc. Tables I and II depict approximate time required for water in two sizes of pressure cookers, such as those used in the study cited, to reach boiling temperature and sterilization conditions.

Use of barriers, such as gloves, masks, caps and gowns, protective glasses etc. and other recommendations (4-9) is a fundamental complement for exercising universal precautions. The nature of heat source was not addressed in the study cited and it is not considered a definitive factor; however, a recommendation in the original study was to conduct further studies using, coal, charcoal, gas or wood to assess possible influence. As noted above not having heat regulating capability in the heating device may be inconvenient but would not preclude their use for achieving sterilizing conditions using pressure cookers when no autoclaves or other forms of sterilization are available.

Table I

Time in minutes to reach boiling temperature		
Liters of water		
1.5	3.75	
In vessels		
5.7 L capacity (6 quarts)		21 L capacity (22 quarts)
Starting with Water at 25°C (77°F)	6 minutes	9.5 minutes

Table II

Time to reach sterilization conditions			
103 kPa (15 psi) 121°C (250°F)		138 kPa (20 psi) 127°C (260.6°F)	
Vessel		Vessel	
5.7 L capacity	21 L capacity	5.7 L capacity	21 L capacity

	(6 quarts)	(22 quarts)	(6 quarts)	(22 quarts)
	Minutes		Additional minutes	
Starting with Water at Boiling Temperature	1 and $\frac{3}{4}$	3 and $\frac{3}{4}$	2	1

Conclusions

1. Adequate sterilizing conditions can be achieved using pressure cookers
2. Packs or bags containing instruments must be placed on a 'platform' above water level in the vessel; otherwise instruments may be at boiling temperature which is not sufficient to destroy all forms of microbial life including spores
3. Instruments must be exposed to saturated steam at a pressure of 103 kPa (15 psi) and 121°C for 15 minutes or longer to ensure proper sterilization conditions
4. Constant monitoring with biological indicator is essential
5. Increasing pressure to 138 kPa (20 psi) and 127°C ensures that sterilization conditions are achieved in less time; a modification to the regulating pressure weight is necessary
6. Effectiveness of pressure cookers to achieve sterilization conditions could be affected by gasket sealing ability and quality of fabrication of the vessel; Cookers claimed to have metal-on-metal sealing system were not evaluated.
7. Over the years universal precaution guidelines have been updated to advice oral health care providers on best recommended practices; however, the principle of sterilization utilizing saturated steam under pressure remains valid. The reader is encouraged to consult current guidelines issued by government agencies or professional organizations on appropriate infection control practice in the clinical setting.

References

1. Petersen P.E. WHO/NMH/NPH/ORH/03.2 The World Oral Health Report 2003
2. P.E. Petersen, R.J. Baez and M.A. Lennon. Community-oriented Administration of Fluoride for the Prevention of Dental Caries: A Summary of the Current Situation in Asia. *ADR* 2012 24: DOI: 9

10.1177/0022034511429349. Published by: *Sage Publications on behalf of: International and American Associations for Dental Research*

3. Petersen PE, Lennon MA. Effective use of fluorides for the prevention of dental caries in the 21st century: the WHO approach. *Community Dent Oral Epidemiol* 2004; 32: 319–21. Blackwell Munksgaard, (2004)
4. Cottone , James, A. et al. Practical infection control in Dentistry. 1st Ed, pp.4-14. Lea & Febiger. Malvern Penn. 1991
5. WHO Hygiene and Infection Control in Oral Care Clinics. Oral Health Programme WHO/Oral Hygiene, 1993
6. CDC Recommended Infection Control-Practices. MMWR 1986;237-42.
7. US Department of Health Sciences. Infection Control file: practical infection control in the dental office.
8. Proposal American National Standards/American Dental Association Specification No. 59 for portable steam sterilizers for use in dentistry. Chicago: ADA, April 1991
9. Council on Dental Materials Instruments and Equipment; Dental Practice: and Dental Therapeutics. American dental Association. Infection Control recommendations for the dental office and the dental laboratory. J AM Dent Assoc 1988; 1126:2412-8.
10. Baez RJ, Baez XL. Use of pressure cookers for sterilization of clinical instruments. *Journal of Dental research*, 1998, 77: Abstract 1774.
11. American Association for the Advancement of Instrumentation/America National Standards Institute, ANSI/AAMI ST55 Tabletop steam sterilizers. First edition, 1995.

NOTE: With exception of references 1, 2, and 3, all references cited were current at the time the original study mentioned in the article was conducted. It is also important to note that the reference cited under

No. 8. Proposal American National Standards/American Dental Association Specification No. 59 for portable steam sterilizers for use in dentistry was superseded by ANSI/AAMI ST55. "The AAMI Sterilization Standards Committee determined that this standard, because of its narrow scope, was of limited value in providing guidance to sterilizer manufacturers concerning the performance qualification of table-top sterilizers for general care use. Consequently, the Hospital Steam Sterilizer Working Group was charged with the responsibility of developing a performance standard for tabletop steam sterilizers intended for use in health care facilities. The second edition was published in 2004. The current edition covers cassette sterilizers (which were excluded from the scope of previous editions), incorporates revisions of the methodology for testing the biological performance of table-top steam sterilizers with dental handpieces, and includes a requirement that certain sterilizers be tested for non-condensable gases." Interested reader is encouraged to consult the Proposed American National Standard/American Dental Association/Association for the Advancement of Medical Instrumentation ST55:2010 for Table-top Steam Sterilizers.