Sterilization and disinfection

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Good surgical results are dependent upon sterile instruments in good working order used by skilled people who care.

This article gives an overview of the principles and guidelines for the methods of sterilization and disinfection which can be used for ophthalmic instruments. It has been stimulated by the many enquiries received by the International Resource Centre at the International Centre for Eye Health regarding the need for information on this topic. The authors, who have also produced an expanded text on ophthalmic operating theatre practice[1], hope this overview will help enquirers, and others, to set the necessary standards ensuring good practice in even the remotest of eye clinics. John Sandford-Smith, in his book *Eye Surgery in Hot Climates*, insists that there 'be no compromise in considerations regarding sterilization and instrument care.'[2]

The responsibility for sterilization, disinfection and prevention of cross infection in a clinical situation is very great and lies with everyone involved on the health care team. Traditionally, it has been accepted as a nurse's role. Whoever has ultimate responsibility, however, will be well advised to ensure that policy and ground rules are followed by every team member. Each member must be aware of the importance of infection control and the team leader will need to reaffirm policy periodically. Perhaps the most important factor in policy making is to recognise that the methods of sterilization and disinfection chosen must be appropriate to the individual situation, in terms of cost and availability, as well as in terms of the clinical needs. Re-evaluation is necessary from time to time because, despite the most stringent following of rules and the safest of practice, complications still occur, sometimes to the detriment of patient care and staff safety.

Fig 1. Metal sterilizing drums

Photo: Ingrid Cox

Glossary

Antiseptic: Chemicals which can kill micro-organisms or prevent them multiplying, without being harmful to human tissue.
Asepsis: Ensuring the absence of micro-organisms.
Aseptic technique: Procedure used to prevent micro-organisms reaching the operation site.
Autoclave (steam sterilizer): Container used for sterilization which is designed to withstand steam at high pressure.
Bowie Dick test: A test to ensure that air has been removed and full steam penetration has occurred during autoclaving A cross is made with autoclave tape on a sheet of steam-permeable paper or drape which is placed in the middle of a stack of cotton towels and all then put through the sterilization cycle. The complete and uniform change of tape colour indicates satisfactory steam penetration. It does not, however, guarantee that sterilization has been achieved.
Corrosion: Gradual eating away by degrees of any metal surface by rust or othe chemical reactions.
Contamination: The introduction of micro-organisms and foreign mater into sterile materials or living tissue. (Note: Therefore, a 'contaminated instrument' is 'not sterile'!).
Decontamination: The process of rendering an item free from infection, e.g., a surgical instrument.
Detergent: a substance, usually dissolved in water, used as an aid for cleaning purposes.
Disinfectant: A chemical used to kill some pathogenic micro-organisms. (Note: some disinfectants are harmful to human tissue.)
High level disinfection: Achieves disinfection but does not kill spores.
Dry heat: Air heated to a high temperature by electricity and used, at high temperatures, for sterilizing purposes.
Infection: The invasion, establishment and growth of micro-organisms in living tissue.
Micro-organisms: Bacteria, viruses, fungi and spores.
Moist heat: Heat produced by steam at high temperature and under pressure
Pathogenic micro-organisms: Micro-organisms capable of causing infection
Spores: The seeds of micro-organisms which are resistant to dryng, heat and disinfectants.
Sterilization: The complete destruction of all types of infective micro-organisms.

Note: It is essential that all instruments are cleaned thoroughly with a suitable detergent and water, at a reasonable temperature, and gentle brush, e.g., toothbrush, and rinsed in clean water before using any of the methods discussed. Cannulae must be flushed through with the detergent and water, followed by clean water, before sterilizing.

PHYSICAL METHODS

- Steam under pressure
- Dry heat
- Ionising irradiation
- Boiling

Autoclaves

These sterilize by *steam under pressure*. The temperature setting and sterilizing time is dependent on the type of autoclave and articles being treated. It is important to follow the specific manufacturer's instructions very carefully. The recommended time and temperature relationships for steam sterilizers are 134º C for 3.5 minutes or 121ºC 15 minutes. However, the total cycle time will be longer than the sterilizing times quoted to enable the various stages of the cycle to be achieved. The complete cycle can take up to 45 minutes which includes drying time.[3] Articles can be placed in metal sterilizing drums with holes to allow for steam penetration (Fig. 1). These articles should, ideally, be used within 24 hours of being sterilized but this is not always practical in rural hospitals where autoclaving cannot be done daily.

Alternatively, items may be double wrapped, for porous loads only, and marked with autoclave indicator tape – a change from beige to brown coloured lines indicates the desired temperature and pressure has been achieved. (The indicator tape is sensitive to sunlight and should, therefore, be stored appropriately.) These items have a shelf life of eight weeks, if wrapped in polythene after cooling, and should be marked within the date of autoclaving and packer's name.[4 5]

If dampness of drapes and gowns, etc., is noted when they are removed from the autoclaves they must not be used as this indicates a faulty cycle and sterility has not been achieved.

Many varieties of autoclaves are available. Choice is dependent on suitability for local needs.

'Little Sister' Autoclaves

This equipment is also effective for sterilization using ***steam under pressure***. These autoclaves are small enough to place on a work surface, bench top, shelf or trolley and are particularly useful for re-sterilizing instruments during operating sessions, e.g., if contamination has occurred or for subsequent cases. It is extremely important to wash all cannulae and other lumens thoroughly with detergent and water, before placing in a 'Little Sister', otherwise nay debris will prevent steam penetration.

Portable Autoclaves and Domestic Pressure Cookers

These also sterilize by ***steam under pressure*** and are useful in theatres for sterilizing sets of instruments. They are very quick, efficient and popular in rural areas.

Safe practice points to ensure quality control in autoclaving:

- Operating instructions for the particular autoclave must be read carefully and followed exactly. Times and temperatures are variable.
- Because of varying sterilization times for different items it is recommended that similar items are placed together.
- Instruments must not be left in an autoclave for longer than necessary as this will cause corrosion.
- The steam must penetrate the contents and, therefore, the autoclave must not be packed tightly.
- Distilled or rain water should be used for filling the autoclave. It is very important to check that the distilled water is at the correct level in the reservoir before using.
- Rubber items should be powdered to prevent disintegration.
- Instrument tips should be protected, e.g., with silicone tubing.
- Porous-load items must be double wrapped, marked with indicator tape and date of autoclaving, and also the packer's name.
- A 'Bowie Dick Test' should be done on porous-loads to ensure that full steam penetration is being achieved. Ideally, this is advised daily but is not usually practical. Weekly tests, at least, are acceptable.
- Training sessions for staff responsible for autoclave maintenance should be provided at regular intervals.
- Spare parts should always be available.
- Sterilizing drums must be 'open' during the cycle and 'closed' on completion.

Hot Air Ovens

These fan-assisted ovens sterilize by ***dry heat*** and are often used in larger, central medical centres. They are not suitable for rural use. The sterilizing time is 2 hours but the complete cycle is 4 hours and, therefore, only of use where there is no shortage of surgical instruments. These, if wrapped in polythene, have a shelf life of 8 weeks. Hot air ovens are useful for drying washed instruments.

Ionising Irradiation

This method of sterilization is used commercially by large manufacturing companies especially for syringes, needles and suture material. It is very expensive and usually available only to tertiary centres.

All the methods discussed above achieve ***sterilization*** and therefore all micro-organisms, including the AIDS virus, are destroyed using these methods. Many others are often referred to as 'sterilizing methods' but, as the text below will show, many only achieve ***disinfection***. The words cannot be used interchangeably.

Boiling

High-level disinfection is achieved by ***boiling***. Instruments must be completely immersed in already boiling water in a container, preferably with a lid.[6] It is better to use distilled or rain water. Boil at 100ºC for a minimum of 10 minutes. Although probably the most readily available method, it has the distinct disadvantage of blunting instruments. Instruments must not be placed on top of each other. A silicone mat on the bottom of the container will help to protect the instruments. Silicone or intravenous tubing will also protect the tips of fine instruments.

Boiling kills bacteria, fungi and viruses, including the AIDS virus, but not spores.

It is bad practice to place boilers, or autoclaves, on the floor or at a level where they may be a safety hazard. Boiling pans at floor level defeats the purpose of the practice as debris can easily be kicked into containers which do not have well fitting lids. Considerable planning is necessary when organising

a sterilizing area: there must be no margin for error and consequent risk for patients and staff.

Cheatle's forceps are used to remove articles from boilers and formalin cabinets (see below). The forceps are placed in a container of methylated spirit when not in use. Both forceps and container must be boiled before each theatre session.

CHEMICAL METHODS

- **Gas**
- **Vapour**
- **Soaking in liquid chemicals**

Ethylene Oxide (C2H40)

This ***gas*** is effective for almost all instruments and materials and especially for those which do not tolerate heat sterilization or soaking in chemicals. It is used for eye shields, ophthalmic probes, tubing and vitrectomy equipment. It is, potentially, extremely hazardous! The sterilizing cycle is lengthy (12 hours) and it is enormously expensive to set up and to run.[7] Special training for staff needs to be provided. Its use is, therefore, limited to large tertiary centres servicing a wide area and is not appropriate for routine use in most developing countries.

All micro-organisms are destroyed, including the AIDS virus.

Formalin

A cabinet containing formalin tablets can be used to sterilize instruments and also to store them. A cabinet may be made from an old refrigerator which can be adapted for this purpose or it can be made from a simple tin, depending on the size required, provided the receptacle is airtight. The area should be well ventilated (Fig. 2).

A heat source is required for the larger cabinet, and perforated metal shelves, to allow the ***vapour*** to circulate. Heat can be provided by an electric 25 watt light bulb above which a shelf holds the formalin tablets. The container needs to be kept at a room temperature of 20°C. Sterilizing time is 12 hours. The cabinet must not be opened during this time.

Although this method is known to be practised widely in rural areas, its effectiveness is said to be uncertain. Formalin is an irritant to eyes and skin and precautions must be taken in handling. It is a known carcinogenic! Eye protection, if available, should be worn and cheatles must be used to remove instruments from the tin or cabinet. The use of formalin is not encouraged if alternative methods are available.

Safe practice points to ensure quality control when using formalin:

- Instruments must be dismantled, where possible.
- Sterilization must be done in a sealed airtight container.
- Requires 7 grams of formalin per cubic metre.
- Tin or cabinet must be left unopened for 12 hours and marked with the time and date it was sealed.
- Room temperature must be kept at 20°C.
- Instruments must be rinsed in sterile water before use.

Good practice achieves destruction of all micro-organisms, including the AIDS virus.

Soaking in Liquid Chemicals

This method is used when alternative methods are unavailable or known to damage instruments and other materials. Long-term, it can cause problems, e.g., staining, corrosion and blunting of instruments. It is recommended that an anti-rush agent, e.g., sodium nitrite 0.1%, be added to the solution where applicable, and if available. Soaked instruments should be rinsed unde a 'stream' of sterile water before being used. It is not advisable to use chemical soaking for syringes, needles and other skin-cutting instruments.[8] Space will allow for only some of the most commonly used liquids to be discussed here. Manufacturers' instructions should always be followed carefully.

Glutaraldehyde 2%

Glutaraldehyde 2% has been used in many tertiary centres when heat sterilization is impractical and other methods are unavailable. It has been readily available in most parts of Africa. It was withdrawn from sale as from May 2002 on the advice of the Health and Safety Executive, UK. If overseas programmes continue to use this chemical, the following guidelines must be followed. Items must be totally immersed with no air bubbles present in a covered container for a minimum of 10 minutes, which achieves disinfection. Sterilization takes 10 hours. It is vital that manufacturers' instructions are followed as various proprietary names are now available. Thorough rinsing under a 'stream' of sterile water is extremely important! This is a corrosive chemical and a severe irritant if its vapour is inhaled or it comes into contact with the skin. The area should be well ventilated. Cheatles' forceps must be used to remove instruments. Corneal oedema has been reported in patients following the use of glutaraldehyde to sterilize cannulae used during cataract surgery. These cannulae and all lumens must be thoroughly irrigated with detergent and rinsed with sterile water.[9] [10]

Shelf life (once activated): 14-28 days. (The various manufacturers' instructions must be followed).

The quantity used for soaking instruments must be changed according to the specific manufacturers' instructions.

It kills bacteria, spores, fungi and viruses, including the AIDS virus.

When all supplies have been used the recommended alternative, Perasafe, should be ordered (see table), although this is not yet available in all developing countries.

Isopropyl Alcohol 70%

Isopropyl alcohol 70% is available at low cost and ready to use, for disinfecting indirect ophthalmoscope lenses and metal instruments, including 'sharps'. It can also be used to disinfect the plunger and plate of a Schiotz tonometer and the tip of applanation prisms. It is not advisable to leave prisms soaking as it can cause damage to the plastic. Suitable receptacles are recommended.[11] [12] Other items must be completely immersed.

When soaking, it is a rapid method taking only 2 minutes in a covered container.

If this agent is used for wiping tips of applanation prisms, it is recommended they are wiped dry after rinsing as corneal epithelium reaction has been reported.[13]

Extreme caution must be taken as this agent is highly inflammable.

The quantity used for soaking must be changed daily.

It kills bacteria, spores, some viruses including the AIDS virus, but not entero- or adenoviruses, or fungi.

Using Cheatle's forceps in a boiling pan.
Photo: Murray McGavin

Sodium Hypochlorite

Sodium hypochlorite is becoming more readily available.

To prepare: Add 500mls of sodium hypochlorite 1% to 1 litre of boiled water (rain water is preferred). This makes a total quantity of 1.5 litres.

Shelf life: 7-14 days.

The quantity used for soaking instruments must be changed daily.

Use a plastic or glass container only. Metal containers for shelf or soaking storage are not suitable as sodium hypochlorite is a bleach, highly volatile and corrosive. It must not be used to disinfect a Schiotz tonometer!

Items must be completely immersed in a covered container for a minimum of 10 minutes and rinsed under a 'stream' of sterile water before use.

Sodium hypochlorite kills bacteria, spores and viruses including the AIDS virus,[14] but not fungi.

Chlorhexidine

Chlorhexidine is readily available at low cost.

To prepare: Add 100ml of chlorhexidine gluconate 0.5% to 900ml of boiled water (rain water is preferred) and 1 gm of sodium nitrite (anti-rust agent). This makes a total quantity of 1 litre.

Shelf life: 7 days.

The quantity used for soaking must be changed daily.

It is suitable for disinfecting plastic, rubber and metal instruments but can cause blunting of scissors and knives. Items must be completely immersed in a covered container for a minimum of 10 minutes. They must be rinsed under a 'stream' of sterile water before use.

This method is effective against bacteria, spores and fungi but does not kill viruses.

Povidone Iodine

Povidone iodine aqueous solution 10% is probably the most popular and widely available disinfecting agent available to developing countries.

The powder has the great advantage of being very inexpensive, and very versatile. Caution is strongly emphasised in its preparation as varying strengths are recommended for individual practices. The disadvantages are that it stains fabric, surfaces and instruments and, because it is dark in colour, it is often difficult to see instruments in the liquid. Skin irritation has also been reported.[15]

To prepare: Add povidone iodine, 50gms; sodium phosphate, 16.6gms; citric acid (water free) 3.4gms; to 500ml of distilled or cooled boiled rain water.

Mix the citric acid and sodium phosphate first and then add 300ml of distilled water. Next, slowly add the povidone iodine in small portions until dissolved and lastly add the remaining 200ml of distilled water.

Shelf life: One month.

The quantity used for soaking must be changed daily.

Povidone iodine is effective against bacteria, spores, fungi, some viruses including the AIDS virus,[16] but not entero-or adenovirus.

It is also available commercially as the following:

BETADINE ANTISEPTIC SOLUTION 10% – for 'prepping' operation (skin) sites, other than ophthalmic.

BETADINE SURGICAL SCRUB 7.5% – a soap used for hand scrubbing.

Fig 2. Formalin cabinet in well ventilated room.
Photo: Ingrid Cox

BETADINE OPHTHALMIC PREPARATION 5% – for 'prepping' the peri-ocular region ad irrigating the ocular surface.

BETADINE EYE DROPS 5% are standard use in developing countries. Do not confuse the eye drops with other Betadine preparations!

Author's Comments

Specific equipment/manufacturers cannot be recommended. The choice and suitability of autoclaves, for example, will be dependent on:

Local conditions, e.g., base hospital or mobile unit needs.

Demands, e.g., surgical throughput.

Maintenance, e.g., spare parts, trained personnel, manufacturers' planned programme.[17]

Whilst it is always good to aim for the highest of standards, readers will recognise and appreciate the need to adapt practice to suit local facilities and situations.

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