Sterilization of hydrophilic* contact lenses

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Although contact lenses are potential carriers of infection, this has not been a problem with lenses made of hard material, glass or plastic. It was found that cleaning the surface of these lenses with soap or with detergents and water, and subsequent drying, was satisfactory for bacteriological hygiene (Maberley, Tuffnell, and Hill, 1970). Overnight soaking in disinfectant solutions, such as benzalkonium chloride and hibitane, produced only slight reduction of the already insignificant bacterial count. The importance of wet storage of hard contact lenses lies in the need to protect them from mechanical damage.

With the advent of hydrophilic contact lenses, sterilization and the method of sterilization became a major problem because of the loose molecular structure of this new material, which consists of long chains of 2-hydroxy-ethyl-methacrylate molecules (polymerized HEMA) (Gasset and Kaufman, 1970), with infrequent cross-links and large intercatenated spaces. These molecules imbibe water and water-soluble chemicals with ease and with difficulty retain them in high concentration, some of them for over 24 hours (Waltman and Kaufman, 1970.) They will also allow the spread of micro-organisms within days if left unattended. The cleaning of lenses affected by bacteria or fungi growing along their surface is difficult and, if etching occurs, their optical properties cannot be fully recovered. If fungi penetrate the hydrophilic plastic, the lens is destroyed (Ruben, 1966). Bacteria, even if they do not penetrate the substance, can produce toxic or pigmented metabolites (like the brown pigment of *Pseudomonas aeruginosa*), which, again, are difficult or impossible to remove without damaging the lens. Proper sterilization of hydrophilic contact lenses after wear is therefore of great importance both for hygiene and for the prevention of damage.

Chemical sterilization with watery solutions of disinfectants presents no problem, but protracted and repeated washings are required to eliminate the disinfectants, the traces of which can cause irritation, possibly severe, and corneal damage.

Of alternative methods of sterilization, the simplest would be by heat. Boiling, and particularly repeated boiling, affects the physico-chemical properties of hydrophilic plastics, but below 85°C. they are stable. We have therefore tried to achieve sterility by pasteurization at 70–73°C., using a thermostatically controlled water bath.

Apparatus

The pasteurizer (Fig. 1) consists of a water bath, 2 in. in diameter and 2.5 in. deep, into which the average plastic contact lens holder may be placed, both bath and holder being filled with normal saline. Evaporation is prevented by a hermetically closed lid. A low voltage heating element incorporated in the wall of the bath raises its temperature from ambient temperature to 72°C. in 35 minutes. The lidded bath is enclosed on its sides and base with a $\frac{1}{2}$ in. thick thermal insulation

layer and the design of the heating element is such that a uniform distribution of temperature is maintained throughout the bath and inner container at all times.

A small disc-type "thermistor" mounted on the base of the water bath is used to sense the temperature, and this controls, through a low gain transistor amplifier, an "SCR" solid-state switching stage feeding the power to the heating element. By this means the temperature of the bath and inner container holding the contact lenses is maintained within plus or minus 0.5°C . of the required 72°C .

To avoid any risk of damage to the lenses in the unlikely event of malfunctioning of the temperature controlling circuit, a second independent thermistor sensor is incorporated. Should the temperature of the bath reach 80°C . the circuit associated with this second sensor element will rupture the fuse in the mains supply to the pasteurizer.

Amber and green indicator lights are incorporated in the pasteurizer. When it is first switched on both lamps will show, the green indicating that the unit is switched on and operating satisfactorily, the amber indicating that the heater is operating to raise the temperature of the bath to the pasteurization temperature of 72°C . Both lights will remain on until this temperature has been reached and maintained for 10 minutes, at which stage the heater will switch off, which is indicated by the amber light going out. The green light will remain on indicating that the pasteurization cycle has been completed and the contents of the bath are sterile. When the unit is switched on again for a new pasteurization cycle, both amber and green lights will show again. In the event of a failure causing the fuse to blow, no lights will show when the unit is switched on, and the fuse will have to be replaced.

FIG. 1 The pasteurizer unit. Spectacles are shown to indicate relative size

Method

Five series of tests were done, Series 1 to 3 with bacteria, Series 4 with bacteria and fungi, and Series 5 with fungi only. *Staphylococcus aureus*, *S. albus*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Streptococcus faecalis* were chosen as a sufficiently representative variety of the more heat resistant pathogenic bacteria. The inoculum in each case was 10^7 – 10^8 organisms.

Results

TEST 1

This was designed to find the temperature required to kill off the test organism. The most heat resistant organism, *Streptococcus faecalis*, was placed in broth in a plastic tube 2.2 cm. high and 1.4 cm. wide at the side of the lens container in the cold water bath which was then switched on; samples were taken at intervals as the temperature rose.

The results were as follows:

<i>Time from switching on bath (min.)</i>	<i>Temperature reached (C°.)</i>	<i>Results of culture</i>
0	22	Growth
10	34	Growth
25	67	Growth
35	70	Sterile
45	71	Sterile

When the temperature of the broth in the pasteurizer reached 70°C. the streptococcus was killed, but at lower temperatures it survived (Fig. 2).

FIG. 2 Time required to kill bacteria at various temperatures

TEST 2

This was designed to find the time necessary to kill off all the test organisms mentioned above when exposed to 70°C. The water bath was pre-heated to its working temperature of 70°C. and the broth containing the test organism was placed in the pasteurizer as in Test 1. It was found that all the test organisms were killed in 2 minutes.

TEST 3

This was designed to find out how long it took to sterilize a contaminated contact lens within its plastic holder filled with normal saline. Smears of *Str. faecalis* and *Pseudomonas* from a solid medium, 10⁷ organisms on each occasion, were made on the lens surface with a wire loop; the lens was then placed into its plastic holder and the holder was immersed in the water bath which was at its working temperature of 70°C. It was found that all the samples were sterile after 5 minutes.

TEST 4

This was designed to study the effect of fungal and bacterial growth on the surface character of the lens. Sample lenses were embedded in agar in Petri dishes and the exposed upper surface was inoculated. After incubation at 37°C. overnight for bacteria, and for 4 days at room temperature for fungi, the lenses were rinsed under running water and examined by phase-contrast microscopy for evidence of etching or of penetration of the lens by the bacterial and fungal colonies. *Gliomastix convoluta* and *Candida albicans* were used in this test.

No alteration of the surface was detected, but in the case of *Pseudomonas aeruginosa* the pigment stained the plastic brown. The fungal hyphae grew only along the surfaces of the lens, as they do when grown on glass. All the organisms were killed in 2 minutes.

TEST 5

Three lenses were exposed to air in normal saline in a shallow dish for a fortnight at three different locations to find out the effect of spontaneous contamination.

The first lens was found to be contaminated with the mould *Gliomastix convoluta*, a

common organism in house dust. This grew on the surface of the lens without penetrating. It was killed, placed in the bath for the standard time of 2 minutes at the working temperature, and rinsed off leaving the surface of the lens unaffected.

The second and the third lenses grew the mould *Thrichotecium roseum* which is sometimes present in tap water. Fig. 3 shows the general appearance of these lenses. The hyphae passed deeply into the substance of the plastic, being detectable at all levels and passing in any direction.

FIG. 3 General appearance of two lenses contaminated by *Thrichotecium roseum*. The hyphae have passed into the surface of the plastic. $\times 4$

Fig. 4a-c shows optical sections made without altering the field, merely focusing on different planes. It is easy to distinguish the surface growth from those deeper in, since the phase-contrast properties are altered by the mould, in one case being surrounded by air and the other by plastic when it is notably refractile.

FIG. 4. Optical sections through hydrophilic plastic contact lens contaminated by *Thrichotecium roseum*. $\times 480$

(a) Surface appearance	(b) Refractile hyphae in lens substance
(c) Mould in the depths of the lens	(d) Spores deeply embedded in the lens

Discussion

These tests show that broth cultures of pathogenic bacteria contained in a small plastic tube and placed in the pasteurizer have become sterile by the time it has gradually heated up to its working temperature of 70°C . If the same cultures are placed in the pasteurizer pre-heated to 70°C ., it takes 2 minutes to obtain sterility, whereas it takes 5 minutes to sterilize a lens contaminated with the same organisms if held in its saline-filled container. The extra 3 minutes were required to raise the temperature of the lens within its holder from ambient room temperature to 70°C .

Considering the variations in size and material of current contact lens holders, it is recommended that the lenses, immersed in normal saline, should be placed within their holding container at room temperature in the pasteurizer, and that they should then be heated up gradually to 70°C . For practical (overnight) use, it is advisable that the plant

should take 2 or 3 hours to reach 72°C., which is somewhat higher than required, and should stay for 30 minutes at this temperature, which is also longer than necessary.

It should be noted that both the pasteurizer and the contact lens holder are filled with normal saline, and that the hermetically closed lid of the apparatus ensures constant osmotic environment for the lens. As the apparatus switches itself off after sterilization is completed, it cools off, so that the lenses can be inserted as soon as required the following morning.

Considering the vulnerability of the hydrophilic plastic to fungal invasion, frequent, preferably daily, prophylactic sterilization of hydrophilic contact lenses is imperative.

Summary

Hydrophilic contact lenses can be instrumental in bacterial contamination of the eye, and are themselves prone to destructive invasion by fungi. In order to prevent infection, regular sterilization is imperative. A simple pasteurizer is described for the routine overnight sterilization of hydrophilic contact lenses in preference to chemical methods of disinfection.

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Obituary

Mary Agnes Pugh, M.R.C.S., L.R.C.P., 1900–1972

Miss M. A. Pugh, formerly attached to Moorfields Eye Hospital and the Institute of Ophthalmology and in private practice, died on January 21, 1972, in her 72nd year.

Born in Cardiff in 1900, Mary Pugh was educated at Cardiff High School and entered Cardiff Medical School in 1918. Her clinical training was at Charing Cross Hospital, London, where she qualified in 1926. She was House Surgeon at the Birmingham and Midland Eye Hospital and later at the Western Ophthalmic Hospital and was appointed to the newly formed Squint Department at Moorfields Eye Hospital, City Road, in 1928, shortly afterwards being made Medical Officer in Charge. She held this post until 1948 when she became a part-time research worker at the Institute of Ophthalmology, which she continued until she retired. Throughout she conducted a successful private practice.

Miss Pugh's work at Moorfields led her to devise the Pugh Orthoptoscope. This was the most advanced instrument of its time for the investigation and treatment of squint and heterophoria incorporating most of the elements of our modern instruments. It enabled every known aspect of a squint or heterophoria to be observed, measured, and corrected; its versatility and its many novel features proved to be invaluable aids to treatment.

Although she had the help of only one nurse in her Department at Moorfields, her work was notable for the breadth and depth of her medical assessment of all her patients—of their general health and social conditions and of their relation to their families—in addition to meticulous ophthalmic investigation and supervision while under treatment. Investigation of each case by a specialist medical officer with the necessary support is expensive and time-consuming but, especially in psychologically determined squints, we still lag behind her pioneer work. Her experience as Medical Officer in Charge of the Squint Department at Moorfields led to her book "Squint Training" published in 1936. After a detailed statement of her clinical approach she gave a clear classification of a thousand cases and laid down the appropriate line of treatment to be followed, together with indications for surgery as she saw them. The results of treatment in each group were discussed and set out statistically. The book cleared the ground for a new systematic approach, laid down sound guidelines, and introduced much new material.

Up to 1948 Mary Pugh's work had been essentially individual and pioneering. The Squint Departments of the post-war Moorfields were envisaged in terms of a different approach and organization and she moved to the Institute of Ophthalmology where she worked on a part-time research basis until she retired. She investigated the nature of visual distortion in amblyopia associated with heterotropia and evolved a theory as to the retinal changes that might account for her findings. The theory has not been confirmed, but the clinical evidence upon which it is based is of importance to our understanding of amblyopia.

Mary Pugh was a bright, friendly person, shy and self-effacing, and intensely interested in the arts, especially painting and literature. She travelled widely and had an international circle of friends both medical and lay; indeed her ability to detach herself completely from her profession was remarkable. She will rank as a pioneer in her field and will be remembered with warm affection by all who knew her and with gratitude by a host of patients.

Correction

In the paper by J. Dallos and W. Howard Hughes (*Brit. J. Ophthalmol.*, 1972, **56**, 114) on the sterilization of hydrophilic contact lenses, on p. 119, line 1, for 72° please read 60°. This is the acceptable temperature for overnight sterilization, see Graph (Fig. 2)