THE SURVIVAL OF STAPHYLOCOCCUS AUREUS ON WATER TAPS

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Introduction
STAPHYLOCOCCI must be classified among the most successful microparasites of man. They are ubiquitous and constitute one of the serious public health problems of today, particularly among hospital populations (Langmuir, 1957). To diminish the incidence of a cross-infection by the staphylococcus in hospitals, it has been suggested by Brown (1957) that hand washing is possibly the most important single control measure, and he adds that foot, knee or elbow control for water taps and a mechanical soap dispenser are to be recommended.

Information regarding the incidence of staphylococci on hospital taps is incomplete, and the survival time of these micro-organisms on water taps does not appear to have received much attention. The investigations described here were devised to determine whether pathogenic organisms, particularly staphylococci, are commonly present on water taps, and, if so, for how long staphylococci survive there.

Presence of pathogens on taps
Materials and methods. The bacteriological flora of taps, in various departments and wards of a military hospital, was examined by culturing aerobically, in liquid and subsequently on solid media, absorbent cotton-wool swabs rubbed on the surfaces of the taps.

Results. From 19 out of the 20 taps so tested, micro-organisms of one species or another were isolated, as shown in Table 1. Coagulase-negative staphylococci were found on ten taps, and coagulase-positive staphylococci were isolated from three taps. This result was not unexpected, since it is well known that staphylococci are widely disseminated in hospitals.

Survival of pathogens on taps
Materials and methods. A survey of water taps in the hospital showed that the taps are manufactured either from brass throughout or are chromium plated. A series of experiments was devised to investigate the survival of Staphylococcus aureus (Oxford) on artificially contaminated, chromium-plated or brass, taps and flat metal plates. Various concentrations of the Staphylococcus aureus suspension were used from 500,000 organisms per ml. to 600 million organisms per ml. Some suspensions were prepared in nutrient broth, other suspensions were made in sterile tap water.

Specimens were obtained from the taps and plates by swabs made up from absorbent cotton-wool, non-absorbent cotton-wool or calcium alginate wool.
Species of bacteria isolated from taps in various departments and wards of a hospital.

<table>
<thead>
<tr>
<th>Species of bacteria</th>
<th>Departments or Wards</th>
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</thead>
<tbody>
<tr>
<td>1. Staphylococcus (coagulase-negative)</td>
<td>Maternity wing; families wing; male medical wing; male surgical ward, casualty department, operating theatre, central sterilizing department and kitchen.</td>
</tr>
<tr>
<td>2. Staphylococcus (coagulase-positive)</td>
<td>Maternity wing; male surgical ward.</td>
</tr>
<tr>
<td>3. Streptococcus</td>
<td>Maternity wing; male surgical ward.</td>
</tr>
<tr>
<td>4. Micrococcus tetragnus</td>
<td>Maternity wing; families wing; male medical ward.</td>
</tr>
<tr>
<td>5. Coliforms</td>
<td>Kitchen; casualty department.</td>
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<tr>
<td>7. Neisseria</td>
<td>Kitchen; central sterilizing department.</td>
</tr>
<tr>
<td>8. Diphtheroids</td>
<td>Maternity wing.</td>
</tr>
<tr>
<td>9. Aerobic spore bearers</td>
<td>Kitchen; male medical ward; central sterilizing department.</td>
</tr>
</tbody>
</table>

Experiment 1

Two sterile taps (one brass and the other chrome plated) were contaminated with the staphylococcal suspension at a concentration of 600 million organisms per ml. prepared in nutrient broth. Specimens were taken at hourly intervals by rubbing over random sites on the surfaces of the taps with swabs made with absorbent cotton-wool. The cotton-wool plugs were then incubated overnight in nutrient broth and subsequently transferred to nutrient agar plates.

Experiment 2

Two taps (brass or chrome plated), on the surfaces of which areas of 1 sq. cm. had been mapped out by filing, were contaminated by a weak staphylococcal suspension at 500,000 organisms per ml. in sterile tap water. Specimens were taken at hourly intervals, from one of the defined areas in sequence, by means of swabs prepared from non-absorbent cotton-wool (Buchbinder et al., 1947). The cotton-wool plugs were placed in 10 ml. quarter-strength Ringer’s solution and thoroughly shaken for five minutes; an enumeration of the bacteria present was then attempted on solid media, using the Miles and Misra (1958) technique.

Experiment 3

Two taps and two metal plates, brass or chrome plated, with their surfaces mapped out in 1 sq. cm. areas as before, were contaminated by a staphylococcal suspension of 60 million organisms per ml. in sterile tap water. Specimens were taken by swabs made with calcium alginate wool swabs (Higgins, 1950). To ensure optimum bacterial recovery two swabs were used for each marked area; the first swab was moistened with Ringer’s solution and the second was used in a dry state to mop up all the liquid left on the surface by the first swab. Moreover, each swabbing operation was limited to 15 seconds, i.e. 30 seconds’ total swabbing time per each ruled area. The technique recommended by Higgins and Hobbs (1950) was adopted. The two swabs from each area were placed in 9 ml. of quarter-strength Ringer’s solution and the plugs dissolved by adding 1 ml. of a 10 per cent solution sodium hexametaphosphate; 1 ml. was then removed and cultured on a nutrient agar plate.

Experiment 4

The two plates (used above) were contaminated with a strong staphylococcal suspension of 600 million organisms per ml. Specimens were then taken and examined as in previous experiments.

Results

Experiment 1. The *Staphylococcus aureus* was recovered from both taps up to seven hours after contamination with the strong preparation of this organism suspended in nutrient broth.

Experiment 2. No staphylococci were recovered from the taps after contamination with the diluted bacterial suspension prepared in water.
Experiment 3. The results are reproduced in Table 2. It was found that using the standardized and much-improved technique adopted in this experiment, the staphylococci were rapidly eliminated from both brass and chromium metal surfaces.

Experiment 4. The results obtained in this experiment, using a strong concentration of the contaminating organism in tap water, follow the same pattern as those recorded in the previous experiment; the staphylococci were not recovered two hours after contamination. Results are also shown in Table 2. In these experiments it was observed that brass appeared to be a more unfavourable environment than chromium to the staphylococcus.

**Discussion**

Heavy metals have bactericidal properties (Wilson and Miles, 1955). Delepine and Greenwood (1914) drew attention to the bactericidal effect of copper, and Pilod and Codvelle (1932) tested the germicidal effect of water when a piece of copper was shaken in it. Karunakaran and Pillai (1952) showed that copper, brass and other metal vessels exert a bactericidal action against bacteria present in water and other fluids stored in them.

However, *Staphylococcus aureus* has been isolated from metallic objects (i.e. forks, spoons, etc.) in numerous investigations into the hygiene of butchers' shops, restaurants and other communal eating places (Hutchinson, 1947) (Thomas, 1950); on one occasion, after an outbreak of food poisoning, *Staphylococcus aureus* was isolated from a mincing machine in a butcher's shop, although the organism could not be

<table>
<thead>
<tr>
<th>Concentration of staphylococcal suspension—60 million organisms per ml.</th>
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<tbody>
<tr>
<td>Brass tap</td>
<td>Brass plate</td>
</tr>
<tr>
<td>Before contamination (negative control)</td>
<td>0</td>
</tr>
<tr>
<td>After contamination (positive control)</td>
<td>10,000</td>
</tr>
<tr>
<td>One hour after contamination</td>
<td>0</td>
</tr>
<tr>
<td>Two hours after contamination</td>
<td>0</td>
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<tr>
<td>Three hours after contamination and upwards</td>
<td>0</td>
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</table>
demonstrated on any of the shop workers (M.O.H. Bull., 1950). Regarding the effects of the suspending media on bacterial survival, Lowbury and Fox (1953) tested, *inter alia*, the survival of *Staphylococcus aureus* suspended in four different menstrua, i.e. horse serum, distilled water, physiological saline and a solution of sodium oleate, when placed on cover slips. These investigators found that after 100 minutes of drying, the viability counts in the case of strain PS 3C increased to 122 per cent and decreased to 87 per cent, 47 per cent and 2.4 per cent of their original counts for the respective menstruum.

In the first experiment described in this paper it was found that *Staphylococcus aureus* (Oxford) can survive for a considerable number of hours on metals commonly used in the manufacture of taps, i.e. chromium and brass (the latter is an alloy of copper and zinc). Thus the organism was recovered up to seven hours after contamination of both taps. This experiment suffers from the drawback that the contamination of the taps was made by a strong suspension of organisms in a nutrient medium; the presence of the nutrient material in the contaminating inoculum was perhaps the most undesirable feature, as in general one would expect little of such material to be transferred in the course of naturally occurring contamination. Moreover, the technique used was too rough to afford strict quantitative evaluation, as plating was made after growth in broth, and again the sampling procedure itself would have been expected to lead to a more or less continuous fall in the number of organisms recovered, as contamination was progressively washed off by each sampling.

In the second and later experiments, efforts were made to obtain more valid quantitative results. The suspensions were made in sterile tap water; the concentration of the contaminating organism varied from 500,000 organisms per ml. to 600 million organisms per ml., the absorbent cotton-wool swabs were replaced by non-absorbent cotton-wool swabs and finally by calcium alginate wool swabs; specimens were taken from defined areas in rotation, while the manual operations of swabbing were standardized to a definite period of time. By this technique it was observed that the viability of *Staphylococcus aureus* depends on the degree of contamination, on the nutrient material introduced with the process of contamination, or otherwise available in the environment, and the chemical nature of the metallic surface; thus the presence of these pathogenic organisms can be expected on taps, given a high initial contamination and presence of nutrients, despite the remarkable bactericidal properties of chromium and brass. Brass appears to be more inhibitory to the staphylococcus than chromium.

These observations are of importance not only in hospitals but also in catering establishments, service canteens and other communal places. In medical establishments extra care has to be taken, as several workers have shown that the finding of staphylococci, resistant to various antibiotics, is in direct proportion to the extent to which the latter are used (Clarke *et al*. 1952; Gould 1958); the widespread or indiscriminate use of antibiotics hinders the control of sources of infection (Report, Medical Advisory Committee, 1959). Very little experimental work with staphylococci and human subjects is recorded in medical literature, but it has been shown by Foster and Hutt (1960) that multiplication of staphylococci on skin lesions, with production of significant sepsis, could be affected with as few as 15 organisms.
Conclusion

Pathogenic staphylococci can survive for an appreciable period of time on metal taps given favourable conditions. It is therefore suggested that water taps, in communal places and more especially in medical establishments, should not be operated by the hands, in order to discourage the transfer of these potentially dangerous organisms from one person to another.

Summary

An investigation was undertaken to detect the presence of staphylococci (and other micro-organisms) on water taps in a military hospital, and experiments were devised to determine the survival of staphylococci when taps are artificially contaminated. Staphylococci were found on 13 out of 20 taps tested in various departments and wards of the hospital.

When water taps were artificially contaminated with a suspension of *Staphylococcus aureus* (Oxford), these micro-organisms could be recovered for varying periods of time after contamination, depending on environment and initial concentration. It appears advisable to avoid installation of taps which are hand operated in order to reduce the transfer of staphylococci from one person to another.

ACKNOWLEDGMENTS

I wish to thank Colonel M. H. P. Sayers for suggesting this investigation, General G. T. L. Archer for his advice and Colonel J. N. Threlfall for his permission to visit the Military Hospital, Tidworth. My thanks are due also to Messrs. Medical Alginates Ltd. for their supply of calcium alginate wool.

REFERENCES


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