Tests of disinfection by heat in a bedpan washing machine

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SYNOPSIS Tests of effectiveness of disinfection of metal and polypropylene bedpans were made in a washer fitted with a steam generator. Broth cultures of *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, or *Streptococcus faecalis* (approximately $4 \times 10^8$ organisms) were sealed in lengths of capillary tubing and attached to the surface of the pans. In other tests, pans were contaminated with an artificial soil containing *Str. faecalis* ($10^9$ organisms/ml). In both series of tests, counts of surviving organisms were made at the end of the washing and disinfection cycle. The tests using capillary tubes showed that the Gram-negative bacilli were effectively killed, but not necessarily Gram-positive cocci. However, when incorporated in standard soil, *Str. faecalis* was killed or removed during the cycle.

The results indicate that the disinfection process was effective for metal bedpans, but less so for polypropylene. Possible disadvantages and modification of the machine are suggested.

Non-disposable bedpans are commonly disinfected in washing machines by means of hot water or steam. Steam is usually supplied from a central source, but in new hospitals this is often no longer available in most of the wards and alternative methods are required. Disposable bedpan systems may be used, but the destructors can be used only when the drainage system is appropriate, and they have deficiencies that may be an infection hazard. However, these deficiencies may be considerably reduced by simple modifications and the use of completely disposable pans so that holders are no longer required (Gibson 1973a and b). Non-disposable bedpans may still be preferred and a machine with an electrically heated steam generator for disinfection is available.

Tests of bactericidal efficiency are difficult to interpret on machines which involve washing as well as disinfection. The evaluation of a new method (Nilén, 1972) in which the effects of washing are excluded is reported in this paper. In the test, suspensions of organisms are sealed in lengths of heat-stable polythene tubing and applied to the surface of the bedpan. The reduction in numbers of viable organisms after completion of the cycle may be used as an indication of the efficiency of disinfection of the machine. Cleaning efficiency is also an important requirement in a washing machine, and additional tests to assess this property in a bedpan washer with a steam generator are described here.

**Methods**

Tests were made in the laboratory on a Dent and Hellyer bedpan washer/disinfector (B55 SG). This is a standard model fitted with an atmospheric steam generator (see fig) for use where main steam is not available. The cycle includes a cold-water wash of 20 seconds, a hot-water wash of 15 seconds, and a steam process of 115 seconds with the option of a final rinse of eight seconds. The generator is filled

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from the hot water tank at the start of the hot-water wash and steam is produced by heating the water with an electric coil. Steam is introduced into the bowl through two pipes from the top of the generator. A modification included in the test machine is a temperature probe in the chamber which operates a green light on the control panel at the end of the cycle if a temperature of 80°C is reached. Tests were made with polypropylene and stainless steel bedpans, and the reliability of the probe and the green light as an indication of adequate disinfection was assessed.

**Bacteriology**

**ORGANISMS**
Organisms used in the tests were *Pseudomonas aeruginosa* NCTC 6749; *Escherichia coli* NCTC 8196; *Staphylococcus aureus* NCTC 9717; and *Streptococcus faecalis* (KR).

**POLYTHENE CAPILLARY TUBE TESTS**
The test organisms were grown on plates containing nutrient agar and 10% horse blood for 18 hours and washed off into 10 ml nutrient broth (Oxoid no. 2). After thorough mixing, 0.1 ml of the suspension was injected with a sterile syringe into heat-resistant polythene capillary tubing (Portex) of length 130 mm and internal diameter 1.4 mm. The filled capillaries were heat sealed and attached to the bedpan by means of autoclave tape in the following sites: (1) the internal surface of the base; (2) the external surface of the seat; and (3) under the rim. Thermocouples were also attached to three adjacent sites on the pan. After completion of the disinfection process the organisms were washed from the polythene tubing into 10 ml of nutrient broth and viable counts of the survivors were made. The nutrient broth was also incubated at 37°C for 48 hours and subcultured. Similar control counts were made of organisms in untreated capillary tubes. Twenty-five stainless steel and 26 polypropylene bedpans were tested with one or more organisms. The probe reached the required temperature of 80°C in 35 of the cycles; in the other 16 cycles, cold water was deliberately introduced into the steam generator so that the probe did not reach 80°C during the cycle.

**CLEANING AND DISINFECTION**
A suspension of *Str. faecalis* was added to standard soil (BS 2745, 1966) to give approximately $10^7$ organisms/ml. The standard soil was a mixture of 10 ml of serum, 6 g of dried milk powder, and 1 ml of 1% nigrosine. The mixture was spread over the internal surface and seat area of the bedpan and allowed to dry at room temperature for one hour. Areas of approximately 50 sq cm from each of these sites were sampled with a moist cotton wool swab before and after treatment in the machine. Swabs were cultured on 10% blood agar and incubated at 37°C for 18 hours. Tests were made with three stainless steel and one polypropylene bedpans. Other tests were made with eight stainless steel and six polypropylene bedpans coated with a similar suspension of *Str. faecalis* in a 1% solution (Mostafa and Chackett, in preparation).

**Results**
Table I shows the overall results of the polythene capillary tube tests when the probe in the chamber reached 80°C during the cycle. Since cultures from many of the tubes after heating showed no growth the highest viable count of each organism and the number of tubes showing no growth are reported rather than the mean count. Gram-negative bacilli were effectively killed by the heat treatment in the machine. In 21 tests with *E. coli*, growth occurred after treatment in two tubes only, one of which showed growth in the broth only, ie, less than $10^8$ organisms; 1/30 tests with *Ps. aeruginosa* showed more than $10^8$ organisms after treatment. However, only 1/33 tests with *Str. faecalis* and 9/30 with *Staph. aureus* showed no growth, although a reduction of at least $10^4$ (99-99%) was obtained with all metal bedpans. Results with plastic bedpans were less good.

<table>
<thead>
<tr>
<th>Organism</th>
<th>Type of Pan</th>
<th>Number of Tests Showing No Growth after Treatment</th>
<th>Highest Count of Surviving Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Staph. aureus</em></td>
<td>Stainless steel</td>
<td>9/18</td>
<td>$3 \times 10^4$</td>
</tr>
<tr>
<td><em>Str. faecalis</em></td>
<td>Stainless steel</td>
<td>1/15</td>
<td>$3 \times 10^4$</td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>Polypropylene</td>
<td>0/18</td>
<td>$4 \times 10^4$</td>
</tr>
<tr>
<td><em>Ps. aeruginosa</em></td>
<td>Stainless steel</td>
<td>11/12</td>
<td>$3 \times 10^4$</td>
</tr>
<tr>
<td></td>
<td>Polypropylene</td>
<td>8/9</td>
<td>$&lt;10^4$</td>
</tr>
<tr>
<td></td>
<td>Stainless steel</td>
<td>12/12</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Polypropylene</td>
<td>13/18</td>
<td>$5 \times 10^4$</td>
</tr>
</tbody>
</table>

Table I *Reduction of organisms in polythene capillary tubing after steam disinfection of bedpans*¹

¹Mean control counts $4.5 \times 10^4$;
²Four other tests showed $<10^4$ organisms.
Table II  Mean temperature and reduction of organisms in polythene capillary tubing at various sites of bedpan after steam disinfection

<table>
<thead>
<tr>
<th>Type of Pan</th>
<th>Site on Pan</th>
<th>Mean Temperature (°C)</th>
<th>Staph. aureus Numbers of Tests Showing No Growth</th>
<th>Highest Count of Surviving Organisms</th>
<th>Str. faecalis Numbers of Tests Showing No Growth</th>
<th>Highest Count of Surviving Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel</td>
<td>1</td>
<td>88</td>
<td>4/6</td>
<td>&lt;10^3</td>
<td>1/5</td>
<td>10^4</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>81</td>
<td>2/6</td>
<td>3 x 10^4</td>
<td>0/5</td>
<td>4 x 10^3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>84</td>
<td>3/6</td>
<td>&lt;10^3</td>
<td>0/5</td>
<td>3 x 10^4</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>1</td>
<td>88</td>
<td>0/4</td>
<td>2 x 10^3</td>
<td>0/6</td>
<td>10^4</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>77</td>
<td>0/4</td>
<td>6 x 10^4</td>
<td>0/6</td>
<td>4 x 10^3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>83</td>
<td>0/4</td>
<td>3 x 10^4</td>
<td>0/6</td>
<td>3 x 10^4</td>
</tr>
</tbody>
</table>

1Mean control counts 4.8 x 10^5 organisms
2Sites: 1 Internal surface of the base
   2 External surface of seat
   3 Under the rim

Table II shows the mean temperatures reached on different sites on the bedpan and the corresponding reduction of Staph. aureus and Str. faecalis in polythene capillary tubes attached to adjacent sites. The mean temperature was lowest on the outside of the pans, and was below 80°C on plastic pans. These results confirm that disinfection was less effective with plastic pans; the highest count in the tests (4.5 x 10^5) was on the outer surface of a polypropylene bedpan after completion of an apparently adequate steam cycle. In similar tests on bedpans when the probe failed to reach 80°C, growth occurred from all tubes including E. coli and Ps. aeruginosa. Total counts were much higher, although a satisfactory reduction in counts was often obtained in tubes attached to internal surfaces.

After washing and disinfecting in the machine, no Str. faecalis was grown from metal or plastic bedpans coated with the standard soil or albumen solution. Growth was obtained from all pans inadequately treated, ie, in which the probe failed to reach 80°C although there was a substantial reduction in numbers of surviving organisms. Results of the tests for cleaning of pans coated with the standard soil varied and depended on how long the pans were dried before washing. If pans were washed immediately after coating, cleaning was satisfactory, but if dried for some hours residual soil remained on the seat and under the rim. Soil was more effectively removed from steel than from polypropylene pans. No organisms were isolated from residual soil on the steel or polypropylene pans after a satisfactory cycle in the machine.

Discussion

Bacteriological tests for efficiency of sterilization by heat are readily available if required, eg, spore strips, but a reproducible bacteriological test for heat disinfection of equipment has long been required. The test using polythene capillary tubing described by Dr Niléhn enables a reduction in numbers of organisms caused by heat and not by the washing process to be measured. The use of tubing increases the severity of the test, and the additional penetration of heat required ensures a safety margin corresponding to organisms protected by organic matter. The test is also flexible; a range of different organisms varying in numbers and in resistance to heat can be used, and more than one surface of a bedpan can be tested at the same time. Nevertheless, cleaning is an important prerequisite to effective disinfection and additional tests with contaminated natural or artificial soil are also required.

Since it was suggested by the manufacturers of the bedpan washer that adequate disinfection should be obtained if a probe in the chamber reached 80°C, the tests for efficiency of the bedpan disinfector were based on this temperature as indicated by a green light on the panel. The bacteriological tests demonstrated that the steam cycle was adequate under most circumstances and that the probe is a reliable indicator of disinfection of metal pans. Heat penetration of plastic pans was less good and the interpretation of tests was more difficult. Although the results indicate that polypropylene pans are more difficult to disinfect reliably in this machine, the tests made were particularly stringent. A higher temperature in the chamber or a longer exposure time may be required for plastic pans although tests with soil (B.S. soil contaminated with Str. faecalis) suggested that if the process included washing, disinfection of both plastic and metal pans was satisfactory. This view of metal pans was also supported by Dr Keith Rogers in tests on six bedpans inoculated with a suspension of organisms in faeces.

Str. faecalis and, to a lesser extent, Staph. aureus were more resistant to heat than Gram-negative bacilli, but Str. faecalis is not an intestinal pathogen. Although Staph. aureus is rarely a cause of intestinal infection it is an important cause of cross infection and should be removed or killed on the seat area of
the bedpan. The proposed tests include both heat-
resistant and heat-sensitive vegetative organisms.
Spores were not included since they are not relevant
to intestinal infection, and killing of spores is not
generally required in a disinfection process. Viruses
are variable in their response to heat and bacterio-
phage was found to be moderately resistant (Niléhn,
1972). Since the heat resistance of *Str. faecalis* was
similar to that of bacteriophage, a virus was not
included in these tests but further tests with viruses
may be necessary in the future. It is suggested that
the following tests would be suitable for commis-
sioning machines:

1 standard soil test

Standard (BS 2745) soil mixed with *Str. faecalis* (10^7
organisms/ml) is applied to the bedpan and dried
for one hour before processing. After a satisfactory
cycle, viable organisms should not be recovered on
direct plating of blood agar from the base, under the
rim, or from any viable soil remaining after washing.

2 tests on internal surface

Suspensions of *Staph. aureus* and *E. coli* sealed in
polythene tubes should be applied to the internal
surface and base of the pan. No *E. coli* should be
isolated on direct plating, or at least a reduction of 10^4 (99.9999 %)
viable organisms should be obtained. The extent of reduction of *Staph. aureus* required is more difficult to assess, but a reduction of at least
10^4 (99.99 %) on the seat area should be obtained.

3 tests with dried faeces

Tests with dried faeces contaminated with known
numbers of *Str. faecalis* and *Staph. aureus* may also
be used to confirm test 1 (Rogers, personal com-
munication).

The assessment of the cleaning process is also
difficult owing to problems of standardization of the
application of soil. The British Standard, B.S. 2745,
describes the soil, but not how much should be
applied and how long it should be left before wash-
ing. If the bedpan is washed immediately after
application, the soil is readily removed but if left
overnight removal is difficult. In the tests described
here it was decided to allow the pan to dry for one
hour after application of the soil. Further work on
measurement of cleaning efficiency using radioactive
labelled albumen is proceeding and will be published
later (Mostafa and Chakett, in preparation). The
washing process did not always adequately clean the
seat area or under the rim, although disinfection was
effective. Some attempt to improve the washing
process and modify existing bedpans should be
considered by manufacturers.

The washer operates satisfactorily provided the
hot water supply system is maintained at 50°C or
above as recommended by the manufacturer. When
water below this temperature was introduced under
test conditions, the probe failed to reach the required
temperature by the end of the cycle. This could occur
in use when several pans are washed in quick succes-
sion and the temperature of the central hot water
supply is below 50°C. To overcome these possible
difficulties it is suggested that an additional indicator
light operating when the water in the tank is above
50°C could be fitted to the machine. A cycle would
not be started unless this light was showing. Since
the failure of other systems may also prevent the
completion of a satisfactory cycle it may be preferred
to fit an additional light indicating a ‘faulty’ cycle.

Since bedpan washers are expensive, the problem of
whether routine disinfection of bedpans in hospital
wards is necessary is all worth consider-
ration. In a 900-bedded acute general hospital
where many bedpan washing machines are not
fitted with a steam disinfection process, 20 initially
undiagnosed cases of Salmonella infection were
admitted to adult wards over a two year period and
there was no spread of infection. The risks of cross
infection by this route may, therefore, be small but
they cannot be discounted. If non-disposable systems
are installed in new hospitals it would seem reason-
able to use washers with a heat disinfection process.
The problem of whether to install disposable
systems or washer-disinfectors is difficult and has
been considered elsewhere (British Medical Journal,
1974). It seems reasonable that washer-disinfectors
should be installed at least in paediatric, maternity,
and infectious disease units. In these areas, existing
washers of the basic type described should be
modified, if necessary, either by fitting a steam
generator or with a mechanism for controlling the
steam process to ensure disinfection. Elsewhere the
choice between a system using completely disposable
bedpans with a safe disposal machine and washer-
disinfectors cannot be made on bacteriological
grounds alone, but should be made in collaboration
with engineers and nursing staff.

We wish to thank Dr Keith Rogers and Dr G.
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Hellyer Limited for the loan of a bedpan washer
and for their cooperation.

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