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A hospital study of ice-making machines: their bacteriology, design, usage and upkeep

I. A. Burnett*, G. R. Weeks† and D. M. Harris*

**Departments of Bacteriology and †Pharmacy, Royal Hallamshire Hospital, Sheffield, UK*

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Summary: Ice-making machines have occasionally been implicated in nosocomial infection. We have examined the ice-making machines in our hospital both bacteriologically and for their general state of cleanliness and repair. Results were variable but, in most cases few organisms of significance were found. Some design features are considered and recommendations for the purchase, maintenance, cleaning and use of these machines are included.

Keywords: Ice; ice-making machines; bacteriology.

Introduction

Ice is used in hospitals for a number of purposes, e.g. for cooling drinks, for making ice packs for inflamed tissues, for patients on restricted fluids to suck, and for culinary purposes.

A relatively small number of reports incriminate ice-making machines in the colonization[1] or infection[2] of hospitalized patients. Organisms involved include *Mycobacterium fortuitum*, *Enterobacter cloacae*, *Pseudomonas aeruginosa*,[2] *Legionella pneumophila*[3] and *Mycobacterium gordonae*.[4] Sources of contamination were postulated variously to be: seeding from the mains supply;[1,3] faulty plumbing allowing backflow from the drains;[2] and irregular cleaning of ice machines.[4] Two papers[4,5] advise against routine cultures of ice machines, since meaningful microbiological standards for ice, ice-making machines and ice storage compartments do not exist. The Center for Disease Control (CDC) Atlanta has suggested guidelines[5] for reducing the likelihood of contamination, including hygienic practices and an arbitrary schedule for cleaning the interior of the ice machine. One paper[2] suggests that ice destined for patients with tracheostomies, on antibiotics, or on immunosuppressive therapy should be held in chlorinated water [2 parts per million (ppm) free chlorine] before dispensing it into glasses of water, as a means of maintaining sterility during dispensing. We have investigated

Correspondence to: I. A. Burnett, Department of Microbiology, 'F' Floor, Royal Hallamshire Hospital, Glossop Road, Sheffield S10 2JF.

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the situation at the Royal Hallamshire Hospital (RHH) with regard to the number and type of ice-making machines available, their state of cleanliness and repair, and the existence of arrangements for cleaning and maintaining them. We have considered the use they are put to and have taken samples for bacteriological testing.

Methods

All ice-making machines within the RHH were examined by the Senior Registrar in Microbiology and the Principal Pharmacist over a 3-month period. As no list of machines was available, the researchers asked each ward and department whether they had an ice-making machine and constructed a list from the information obtained. Each machine was then visited, inspected and samples taken for bacteriological examination. The type and design of each machine was noted, its age if known, its situation, its state of cleanliness and repair, the filling and drainage mechanisms, the temperature of the reservoir, and the purpose for which the ice was used. Enquiries were made regarding the regularity and method of cleaning, and whether written records were kept. The type of patient for whom the ice was used was noted. Samples were taken for bacteriological examination. These consisted of a sample of ice sufficient to give approximately 20 ml of water. This was collected in a sterile container immediately taken to the laboratory and as soon as it had melted, plated with a 10 µl loop onto blood agar (Oxoid Columbia agar with 5% horse blood) and MacConkey agar (Oxoid MacConkey CM7B). Plates were incubated aerobically at 37°C for 48 h, at room temperature for 5 days, and at 4°C for 14 days in the refrigerator. Plates were inspected at 1, 2 and 5 days and also at 7 and 14 days in the case of the refrigerated plates. Swabs were taken from any area of the machine that appeared dirty and were plated onto the above media and onto Legionella selective medium (Oxoid CYE base with growth supplement and BMPA selective supplement) for 10 days. One millilitre of each sample was inoculated into Oxoid Kirschner broth at 35°C for 6 weeks and then subcultured onto a Lowenstein–Jensen slope and incubated for a further 6 weeks at 35°C; a second set of Kirschner broths and their subcultures was incubated at 30°C. Gram-negative bacterial isolates were identified by multipoint inoculation using a Denley inoculator system and the range of biochemical substrates routinely in use at the RHH. An attempt was made to identify any yeasts isolated by API (ATB 32C) (Bio Mérieux, France); other fungal isolates were sent to Dr D. Fraser (University of Sheffield) for identification.

Results

On inspection we discovered that there were two basic types of machine; the type that is filled manually with a jug from the nearest tap, and those

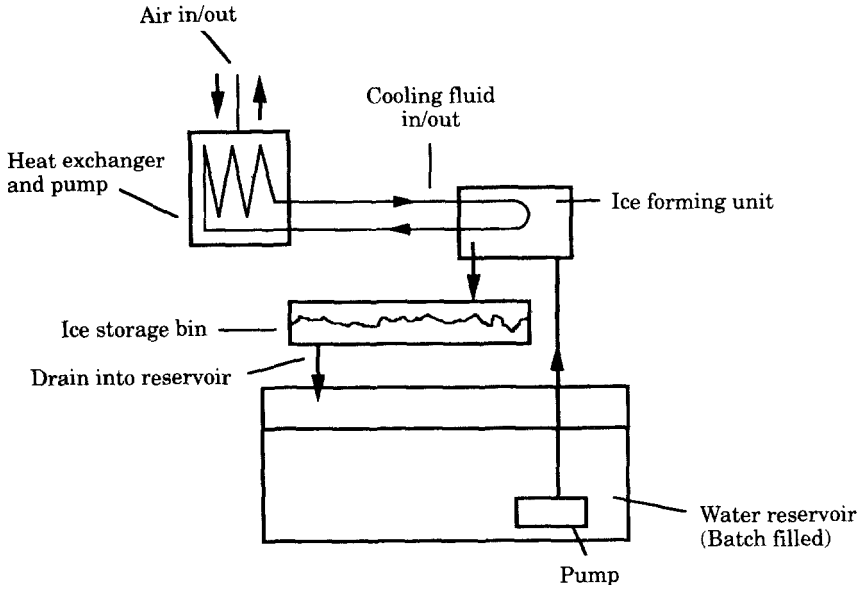

Figure 1. Ice-making machine: manual filling.

that receive their water supply directly from the mains. Diagrams of the general workings of an ice machine are shown in Figures 1 and 2.

Table I gives the details of the inspection. Eight ice-making machines were examined bacteriologically. Of these only one resulted in no growth from the sites sampled, or a growth of purely saphrophytic organisms which failed to identify on testing and are not known to be of medical significance. The latter also predominated in the cultures obtained from the remaining seven machines, but these additionally produced a growth of identifiable organisms that may be associated with infection in hospital patients: these are listed in Table II. Organisms isolated were usually in small numbers. Any identifiable isolates, except for the fungal ones, grew at 37°C.

It was discovered during the course of the inspection that bowls of ice were being placed beneath fans to increase their cooling efficacy in febrile patients. Further uses identified for the ice in patients care were as packs for inflamed joints or soft tissue, or as cubes for patients' drinks or for them to suck directly.

Discussion

Few guidelines exist on the care of ice-making machines, and there are apparently no microbiological standards by which safety or cleanliness can

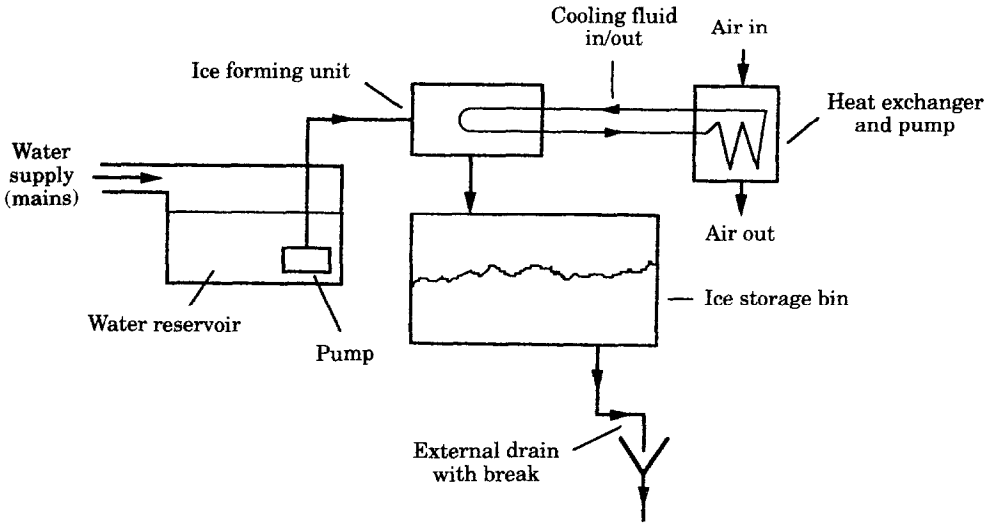

Figure 2. Ice-making machine: plumbed into mains.

be judged. The paucity of reports implicating ice-making machines in nosocomial infection suggests that they do not present a significant problem. This view is supported by our findings in that organisms isolated were mainly unidentifiable by our multipoint system and presumably were environmental organisms of little clinical significance. Isolates that were identifiable were usually organisms of low pathogenicity but ones which, nevertheless, may be associated with nosocomial infection, e.g. *Acinetobacter* spp. and *Enterobacter* spp. The only pseudomonad isolated failed to grow on subculture for definitive identification. Of the fungal isolates, the yeast failed to identify on examination by API (ATB 32C), and the other two isolates were identified as a probable *Chaetomium* spp. and *Geotrichum* spp, the latter being associated with geotrichosis in humans. There is, however, a clear potential for infection: such Gram-negative organisms are capable of causing nosocomial infections particularly in a situation where immunosuppressed patients are involved.

One paper[3] reported the isolation of *L. pneumophila* from the cold water dispensers of hospital ice machines. Clearly, the aerosolization of this, by placing a bowl of ice beneath a fan to augment cooling of patients, would be highly undesirable. This practice was felt to be dangerous, and an instruction was issued to all personnel to stop this immediately. Against the potential for infection from ice-making machines must be balanced the benefit that patients derive from them: nursing staff feel that it provides great comfort to patients to be able to suck ice cubes, and their role in tissue cooling is of importance. Our view is that, with correct plumbing

Table I. *Details of ice-making machines inspected*

Machine	Usage	Type of patient using ice	Filling mechanism	Drainage	Comments on design	Reservoir temperature	Cleaning	Scoop	State of cleanliness
1	Cooling of transplant kidneys	Not relevant	Plumbed into mains	Plumbed into mains	Chest type machine. Heat exchange system well separated from ice storage compartment. Latter is well insulated	No reservoir	No schedule. No records	Sterile jug used on each occasion	Grill within heat exchanger dusty
2	Packs for inflamed joints (intact skin only)	Outpatient and inpatient	Plumbed into mains	Plumbed into mains	Chest type machine without reservoir	No reservoir	Occasional. No schedule. No records	Metal scoop kept inside storage compartment but often on sink drainer	Ice storage compartment door does not close properly. Boxes left on top of machine
3	Ice for cold drinks or for cooling aspic. Ice for wards for cooling fans—removed in buckets	Uncontrolled access to wards	Plumbed into mains	Plastic pipe into gutter in kitchen floor	Chest type machine without reservoir	No reservoir	No cleaning or maintenance schedule	Scoop left inside storage compartment	—
4	For patients on restricted fluids and for placing in water jugs	Gastrointestinal surgery. Some total parenteral nutrition patients	Reservoir filled from kitchen tap as necessary. Clean jug used	No formal drainage. Residues drip into reservoir and are recycled	Heat exchange system dispells warm air beneath the uninsulated water reservoir	11°C	Weekly schedule pinned on wall. Written records not kept	None	Film of dust on pump dipping into water reservoir

Table I. (*cont'd*)

Machine	Usage	Type of patient using ice	Filling mechanism	Drainage	Comments on design	Reservoir temperature	Cleaning	Scoop	State of cleanliness
5	Patients' drinks	General medical	Tap water into ice cube trays	No formal drainage. Overflow drips into ice cube storage compartment	Simple freezing compartment without moving parts. Ice cubes made into trays and stored in base of compartment	No reservoir	Weekly cleaning. Schedule not available	None	Satisfactory
6	Ice packs for inflamed areas (intact skin only). Patient's drinks	Includes patients with lung cancer	Plumbed into mains	No formal drainage. Overflow drips into ice cube storage compartment	Ice generating area contains numerous moving flanges which eject ice. These render this part of machine virtually uncleanable. Cold and warm air inlets well separated	No reservoir	Cleaning carried out by domestic staff on an undefined basis	None	Facing at rear of machine broken. Air inlet grille at front broken. Plastic of ice storage compartment cracked
7	Patients' drinks. Ice packs	General medical. Leukaemic, haemophiliac	Plumbed into mains	Plastic hose into main drain with U-bend and break preventing backflow	Chest type machine without reservoir. Air-inlet and air-outlet well separated. Ice storage compartment properly insulated	No reservoir	Weekly cleaning. Schedule on wall. Records available	Scoop inside chest	Good
8	For patients on restricted fluids. Ice packs. To increase cooling efficacy fans	General intensive care unit patients	As with machine no. 4	As with machine no. 4	As with machine no. 4	5°C	Cleaning as with machine no. 4	Plastic cup, changed irregularly	Flange attached to door separates warm and cool air—broken

Table II. *Identity of bacterial/mycological isolates*

Source	Machine no.	Identity and growth of organism (time for growth)
Ice cubes	6	*Acinetobacter* spp.*(+) (24 h)
Ice cubes	5	Aerobic spore bearer (+) (48 h) Coagulase-negative staphylococcus (+) (48 h)
Ice from bottom of storage compartment	2	Pseudomonad (++) (48 h)—failed to grow on subculture
Drain outlet	8	Aerobic spore bearer (+) (24 h) Coagulase-negative staphylococcus(+) (48 h)
Drain plug	7	Coagulase-negative staphylococcus (+) (24 h)
Flanges	6	*Acinetobacter* spp. (+) (24 h) *Enterobacter agglomerans* (+) (48 h)
Debris in reservoir	4	Aerobic spore bearer (+) (48 h)
Drain in machine	3	Aerobic spore bearer (+) (24 h) *Mycobacterium gordonae*
Drain in machine Drain inside ice cabinet Flanges Machine roof	3	Yeast (+++) (5 days). Grew at 4°C and room temperature. Failed to identify on API *Chaetomium* spp. (+++) (5 days) Probable *Geotrichum* spp. (+++) (5 days)

*(+), Growth confined to the well; (++), growth beyond the well but within the first set of streaks; (+++), growth beyond the first set of streaks.

and regular cleaning and maintenance, the problem of bacterial contamination can be considerably diminished. The one machine that was heavily contaminated (machine no. 3 in Table I) was drained by a plastic pipe into a gutter in the floor, and had no cleaning or maintenance schedule. In addition some machines apparently had construction problems, e.g. proximity of the cold reservoir to the heat exchange system, thereby raising the reservoir temperature, and inadequate insulation of the water reservoir and the ice storage compartment. Clearly multiple types of ice-making machine had been purchased haphazardly over the years, with no cogent plan for their installation, cleaning or maintenance. Involvement of the hospital engineer and the microbiologist before actually purchasing a machine would help to obviate such problems. The recommendations that follow are based partly upon those of CDC as reported in the article 'Don't culture ice machines',[5] with some additions from ourselves:

1. The Infection Control Officer should keep an inventory of all ice-making machines in the hospital.
2. The advice of the Infection Control Officer and the hospital engineer should be sought before purchasing a new ice-making machine.
3. Recycling of excess fluid into the reservoir or the ice storage compartment is not recommended. Machines should be plumbed directly into the mains if possible, both for filling and for drainage. A U-bend and break in the drain is desirable to prevent reflux.
4. Adequate separation of air-inlet and air-outlet in the heat exchange mechanism should occur to permit efficient cooling. The siting of the machine should be such that these areas are not obstructed.
5. The water reservoir and ice storage compartment should be well insulated. All moving parts should be easily removable for cleaning.
6. The ice storage compartment should be cleaned weekly with fresh soap or detergent solution and a disposable cloth. Any ice cubes within it should be discarded. After cleaning, the compartment should be rinsed thoroughly with potable water and then with sodium hypochlorite, 100 ppm ($100\,mg\,l^{-1}$), after which it should be dried before being returned to use. Cleaning records should be kept.
7. On a quarterly basis, the removable parts of the machine should be disassembled for cleaning and checking for breakage, according to manufacturer's instructions. Records of this should be kept.
8. A contract for maintenance should be set up with the hospital engineering department. Maintenance records should be kept.
9. Ice handlers should wash their hands frequently and not handle ice with their hands or return unused ice to the storage compartment. A scoop should be provided that is smooth and impervious. This should be kept on an impervious tray, on top of the machine if possible. Both tray and scoop should be put through a dishwasher or sterilized daily. The door of the ice storage compartment should be kept closed except when removing ice.
10. All extraneous equipment and items should be moved from on or around the ice-making machine.
11. Under no circumstances should ice from the machine be used for placing beneath fans to increase cooling efficacy by evaporation. An acceptable alternative is to seal the ice in a plastic bag and to place this beneath a fan, so that the ice-water is not in direct contact with the air stream.

With regard to the bacteriological testing of specimens from ice-making machines, we know of no microbiological standards by which to assess results, and cannot recommend routine cultures. It is suggested that sampling is performed only if a problem is perceived. For sampling we recommend the use of blood agar and MacConkey agar. No advantage was found in incubating bacteriological plates at temperatures other than 37°C

or for longer than 48 h. Depending on the nature of the perceived problem, Legionella selective medium incubated at 37°C for 10 days, or a Sabourauds plate incubated at 30°C for five days, may prove helpful; mycobacterial medium may also be inoculated, as is felt appropriate, in the manner described previously in the text. In general, however, it is felt that regular cleaning and maintenance of machines with proper record keeping should obviate problems before they arise.

We thank Dr D. Fraser of the Mycology and Plant Pathology Laboratory, University of Sheffield, Western Bank, Sheffield, for identifying the two fungal isolates for us.

Editorial addendum

Xanthomas, recently renamed *Stenotrophomonas maltophilia*, has also been implicated in contamination of ice-making machines [Hazard (93) 42].

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