STERILIZATION IN HOSPITAL PRACTICE*

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In recent years there have appeared in the medical press a significant number of reports on cross-infection in hospital patients. Certain of the outbreaks have been so serious as to necessitate the temporary shutting-down of hospitals or parts of hospitals. In some cases the organisms have been spore-bearers (see below), but by and large the commonest organism implicated has been the staphylococcus. An annotation in the *Lancet* (1957) rightly refers to the problem as a hospital plague. The position has become so disturbing that in some hospitals it is almost routine practice to administer 'prophylactic' antibiotics after operation. This in effect is a return to the antiseptic Listerian techniques of almost a hundred years ago.

As Perkins (1956) points out, the factor responsible for the major percentage of failures in sterilization is the present old-fashioned method of hospital sterilization, i.e. a decentralized system of 'sterilization' on several floors and in several departments by many people. It is a case of everybody's business being nobody's business. The term 'sterilized' or 'sterile' means one thing only, namely that all micro-organisms have been killed, whether spore-bearers or not; this cannot be done by the sterilizing equipment usually supplied to wards.

Adequate sterilization of instruments, syringes, dressings, etc. for use in hospital practice can only be achieved by means of a central sterilizing unit designed to serve the whole hospital, both theatre units and wards. It is stated by Perkins (1956) that this idea of central sterilizing units for hospitals derived from a report issued by the American College of Surgeons in 1928, but in point of fact a form of central sterilizing service has been operative in almost all hospitals for many years in that it has always been customary for ward and theatre drums to be sterilized in one unit. The present so-called 'central sterilizing department' is a logical but surprisingly late extension of this principle. We describe below our experience in the application of this extended system to a large non-European hospital in South Africa.

The hospital, Edendale, is a new 750-bed general hospital. It serves the non-European population of Pietermaritzburg and district, all in the Natal Midlands. The work is roughly similar to that of a hospital of similar size in Britain.

STERILIZING AGENTS

Available methods of sterilization include: moist heat, which kills organisms by coagulation of their proteins; dry heat, thought to sterilize by oxidation; and chemical disinfection, which probably kills by direct poisoning.

Moist Heat

With certain exceptions detailed below moist heat is the most satisfactory and widely used method of sterilization. Dubos (1952) claims that syringes, needles and instruments for minor surgery can be sterilized adequately by boiling for 15 minutes in a dilute solution of washing soda. 'Sterilization' by boiling is the method at present in use in hospitals where each ward and other unit is responsible for its own sterilization. There are serious drawbacks to this method: excluding the obvious and common mistakes of failure to adhere to time and to immerse the equipment in the boiling water, it is to be remembered that at heights such as are found in South Africa water does not boil at 100°C; further, temperatures obtained by boiling water do not kill spores in spore-bearing organisms. Viruses may also not be killed by such temperatures; this applies particularly to the virus of homologous serum jaundice and may apply to poliomyelitis virus (Lenard 1951). In fact American workers no longer use the term 'sterilization' in relation to cleansing by boiling; they have introduced the term 'sanitization' in its place.

There is no place in hospital practice for boiling as a method of attempted sterilizing. To obtain true sterilization it is accepted that the minimum necessary is 121°C moist heat for 30 minutes. Even this will not be sufficient to sterilize the contents of drums which have been badly packed. The steam to be effective must circulate freely to and through the packages since it kills by condensing upon the material to be sterilized. The suggested temperature of 121°C can readily be obtained in the modern type of steam sterilizer fitted with a thermostatic valve to prevent a steam-air mixture. With this type of machine the necessary pressure to reach this temperature is about 17 lb. to the square inch above atmospheric pressure. The steam which condenses on the materials must be dried off after sterilization is complete. Drum containers are bad; the steam penetrates slowly; and the drums are generally not dust-proof after being removed from the sterilizer. All drums should be replaced by the package system. In all methods of sterilization materials to be sterilized should be free from grease and dirt. It is to be remembered that no tubed or bottled equipment or material can be sterilized by moist heat because the steam cannot condense upon the contents.

Steam pressure sterilization is suitable for all except sharp instruments, polythene tubes, blankets, catgut, and rubber goods. Utensils and instruments must be sterilized separately from other equipment and materials.

One query often raised is what happens when a surgeon drops an essential instrument. If the instrument is essential then a second such instrument should always be available sterilized in reserve. If this is not possible then the alternative is to fit an emergency sterilizer in the central supply centre. These emergency sterilizers are high-pressure autoclaves operating at 132°C; they are capable of sterilizing equipment in 3 minutes. To save time and instruments certain hospitals are experimenting with the use of such high-pressure autoclaves for all instruments, not merely for emergency work. This system in theory allows of the turn-over of all trays within 10 minutes, but it has certain disadvantages, e.g.: Firstly, there is no safety margin of time, the slightest cutting-down of time rendering the equipment non-sterile; secondly, the autoclaves in most hospitals cannot carry out this type of work; thirdly, such high temperatures can be used only for instruments and even they deteriorate rather more quickly than with lower temperatures. In other words this 'fast' method is really only of value as a sub-section of the work of a highly organized department.

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Dry Heat

Dry heat sterilizes by oxidation; it is a much less certain method of killing than pressure steam and its use in hospitals should be limited. Spore-bearing organisms are very resistant to dry heat and viruses are relatively resistant. Perkins (1956) states that the National Institutes of Health, USA, lay down that apparatus to be sterilized by dry heat must be held at 170°C for 2 hours. Such high and long-continued temperatures are highly destructive of equipment.

In this department dry sterilization is used only for sharp instruments such as scissors, blades and cutting needles. These are treated at 160°C for 1 hour. This is equivalent roughly to 121°C moist heat for 30 minutes.

Chemical Disinfection

To quote Perkins (1956): 'In many cases it is apparent that chemical disinfection methods are employed for convenience rather than bactericidal efficiency or surgical safety.' With the exception of certain formaldehyde preparations no chemical disinfection fluid kills spores, and their action on *M. tuberculosis* and some viruses is very variable and uncertain. In our work here we have grown staphylococci in 1/20 solutions of one well-known disinfectant. As with dry heat, organisms vary widely in their resistance to chemical disinfectants. One preparation with a satisfactorily wide and effective spectrum of activity is Hibitane (ACI), discussed by Calman and Murray (1956), but here also this substance fails to kill spore-bearing organisms.

In this department chemical disinfectants are used only for the sterilizing and storing of substances which cannot be treated by heat; e.g. polythene tubing, catgut containers, etc. The mixture used for this purpose is that recommended by Perkins (1956), namely sodium tetraborate (50·0 g.), formaldehyde solution (100 ml.) and distilled water (to 1000 ml.). We have found this to be sporicidal in dilutions up to 1/400. Material immersed in this solution is washed thoroughly in sterile distilled water before use.

METHODS

The perfect system of hospital sterilization is one in which sterile sets are immediately available when required for all ward procedures and for all commoner operations. This can only be achieved by a centralized system of sterilization in a department which replaces each used set of equipment by one sterile set within a short period of time. The contents of each individual set should be planned by the clinicians who are to use the sets; in this department we hold the following range of sets: syringes, gloves, various fluids, dressing sets for individual patients (cutting out drum sterilization), anaesthetic sets, packaged feeding bottles and teats, sets for lumbar puncture, paracentesis, catheterization, rectal examination, transfusion, aspiration, etc. The service is now being extended to include theatre needs.

Gloves are a specially difficult problem in sterilization because of the air trapped in the fingers; the air-steam mixture much reduces the effectiveness of the steam. In spite of this, gloves usually receive less treatment than any other equipment; sterility is sacrificed to keeping satisfactory the texture of the rubber. This is especially unfortunate and dangerous in that the absorbable glove powder now in general use—a starch product—contains many spore-bearing organisms which can only be killed by careful prolonged sterilization. Perkins (1956) recommends a very high temperature and pressure for gloves, namely 20 lb. pressure for 15 minutes, but this is highly destructive and in a large series of tests we have found 10 lb. pressure for 1 hour to be satisfactory, provided the glove powder is first sterilized separately under higher pressure.

Syringes form another major problem in hospital sterilization. Even when sterilization is centralized and controlled, replacement costs are very heavy when glass syringes are used in routine work. Here we use nylon syringes for all ward routine; there are minor disadvantages but they are much outweighed by the great saving in breakages and losses in other ways.

Here it should be mentioned that the system whereby trays are set and sterilized centrally when required is not true central sterilization and represents very little advance on the old decentralized method.

Sterility Test

Perkins (1956) rightly points out that regardless of the degree of mechanical perfection of modern sterilizers, sterilization of the load is still dependent upon correct methods of packaging and correct methods of loading the sterilizers. The modern sterilizer not only exhausts itself of air automatically but also maintains a record of sterilizer-chamber temperature through the whole cycle of operation. Such an arrangement is essential in large-scale work; control of sterilizing by reading of pressures is insufficient; e.g., high pressures can develop without high temperatures in the presence of certain defects of the machine. In all machines without temperature-recording apparatus, and in every type as an occasional check, sterility checks must be employed. We use two methods of checking; the first method is the 'time-temperature' system, where the indicators are tubes (supplied by Becton Dickinson of New Jersey) containing a metal alloy which melts only after the desired temperature has been reached and *held* for the required period of time. One such indicator goes through with each cycle of sterilization. The other method of checking techniques is that of 'test strips'. Such strips consist of slips of absorbent paper which has been soaked in a fluid culture of a safe spore-bearing organism and then allowed to dry. With each cycle of sterilization one such strip goes through, and is then cultured to test whether the spores have been killed. With this method the answer is not available until 24 hours after the material has been sterilized.

OUTPUT

We give below our average monthly output of certain of the more important stock items; the list does not include items recently introduced to the range:

Syringes	18,344
Needles	37,000
Sterile sets for ward work	600
Distilled water, ampoules	640
Distilled water, bottles	584
Sterile normal saline, bottles	592
Drums autoclaved (to be replaced by individual sets)	2,864
Gloves (still a limited circulation only)	800 pairs
Feeding bottles	3,440
Teats	3,440
Glove powder, packets	10,000
Miscellaneous	410
	78,714

Probably the most surprising figure is the tremendous increase in the use of syringes, largely the result of the introduction of antibiotics. From the patient's point of view this increase alone justifies the introduction of central sterilization, for wards cannot adequately sterilize the large numbers of syringes now required in hospital treatment.

STAFFING AND COSTS

Central sterilization is not without its disadvantages; all the hospital eggs are in one basket as regards sterilization. The staff of the central department must therefore be trustworthy, well-trained, permanent staff. The department must function about 18 hours daily. In any large hospital this will necessitate 3 key-staff working shifts. Ex-policemen or army staff on pension are the best type; they can learn their duties in a few weeks. The subordinate staff required are about 6 individuals per 250 beds. This junior staff should not be drawn from trainee nurses; the central sterilizing department is a factory, and nursing staff not only learn very little but are changed so frequently as to interfere with the work of the department. The best individual for this subordinate work is the hospital-porter type.

One difficult staff problem is the question of who should be in charge of the sterilizing department. The person chosen must be medically qualified and the choice would seem to lie between the pathologist, who has much to do with sterility testing, etc., and the medical superintendent's department. A third alternative arises from the suggestion by Colebrooke (1955) that each hospital should have an infection-control officer; this officer would be a good choice for the running of the central sterilizing department.

Space is the next difficulty generally; fortunately, contrary to general belief, there is no need for the central sterilizing department to be anywhere near the operating theatre. Space available anywhere in the hospital area will serve the purpose; for instance, in the rebuilding plans for Guy's Hospital (Annotation, Brit. Med. J., 1957) the central sterilizing department for the whole hospital is placed in the semi-basement of the new 11-storey surgical block. The lay-out needs must include provision for a receiving and wash-up room, a distilled water and saline room, a clean packaging room, a sterilizing room, and a storage and issue room. Perkins (1956) gives detailed diagrams of lay-outs on a basis of 4 square feet per hospital bed. This we would regard as the maximum amount required.

Equipment represents an initial heavy expenditure, much of which is later offset by savings, e.g., a longer life of equipment, etc. Mechanization of processes is important, machines being used for needle cleaning, syringe and glove washing, glove powdering, needle sharpening, etc. The equipment should include large modern steam sterilizers of about 25 cubic feet capacity, with one such sterilizer allowed per 250 beds, subject to a minimum of 2. Glove sterilizers should be a separate fitting, together with a high-pressure sterilizer capable of sterilizing instruments within 3 minutes; this last piece of equipment is used for the instrument which has been forgotten or even as a routine method of treating all instruments.

It must be realized that a central sterilizing department is expensive to launch and expensive to run. The advantages must be considerable to outweigh the disadvantages, even when due allowance is made for the immeasurably greater protection afforded to the patient. Perkins (1956) summarizes the advantages of such a system as being efficiency, economy and safety; the first and the last are self-evident; the question of cost requires analysis. The initial cost of equipping the central sterilizing department with increased stocks of instruments, etc., may be discounted in that the equipment is so much better cared for and lasts so much longer that the savings in the recurrent replacement charges discount the initial costs. The only remaining costing problem is one of staff costs. In a hospital of 750 beds the staff required for sterilizing would be 3 supervisors and 18 subordinate staff, a total wages bill of £450 monthly, the subordinate staff being drawn from Bantu staff at £12 each per month; this does not include the salary of the officer in charge.

The only way this amount can be justified is by savings in wages elsewhere in the hospital. In this hospital of 750 beds an analysis of our monthly production shows it to represent a work total of 30 individuals in wards and theatres. Very roughly, for each person employed in the central sterilizing department 2 nurses can be cut from the ward staff. There are also 3 other important savings to be considered: Firstly, by centralization of sterilization there is a large saving in steam and in routine maintenance by the withdrawing of steam and other sterilizers from theatres and wards; secondly, with sterilized complete sets immediately available for all ward procedures there is a substantial saving in the time of the medical staff; lastly, experience has shown that losses from breakages and certain other causes are much reduced when all equipment and instruments are centrally controlled.

ADDENDUM

Although central sterilization provides certain important safeguards against the spread of infection in hospital, there still remain pressing problems in addition to the question of clean instruments. Among other important sources of sepsis we must remember the following:

Air contamination, especially in theatres, is the cause of a significant amount of sepsis, especially staphylococcal. Blowers *et al.* (1955) quote the closing of a thoracic-surgery unit on this account. Generally speaking, the ventilation system of the theatre is at fault in such 'outbreaks'.

Blankets. Frisby (1957) discusses the problem of the infected hospital blanket. He shows that the average blanket in use harbours 48 million organisms and he shows that ordinary methods of laundering affect only a small proportion of this population of pathogens. He suggests that the answer is a blanket made of some substance which can easily be frequently laundered, e.g. Terrylene.

Gauze masks as used in theatres are a poor precaution against the spread of organisms from the nose and throat, even when worn properly and interlaced with a substance like cellophane. At present the Ear, Nose and Throat department of his hospital is experimenting with a new type of mask.

Infant feeding. The only safe method of preparing infant feeds and feeding utensils is by individual packaging of the utensils, with terminal sterilization of the feeds in a central infant-formula department on the same lines as a central sterilizing department. Pending the establishment of such a system in this hospital the infant bottles and teats are sterilized centrally. This has led to a great reduction in the incidence of infantile gastro-enteritis.

CONCLUSION

The above notes show how unsatisfactory is the situation at present in hospital practice and how well justified is the *Lancet's* description (1957) of hospitals as plague houses. The time has come for us to re-appraise our techniques. In the appraisal we should not overlook the present low standards of work in theatres and wards.

SUMMARY

Details are given of the functioning of a central sterilizing department in a large general hospital. It is shown that only by this method can the hospital patient receive the protection to which he is entitled. The extra expenditure necessary to launch and run such a central unit is more than covered by subsequent savings in staff and equipment.

Mention is also made of other factors to be taken into account in any attempts to control sepsis in hospital practice.

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