

STERILIZATION

Modern aseptic surgery depends directly upon the principles of sterilization, and equipment and methods for efficient sterilization are readily available. It might seem on first thought, that the problem of keeping a sufficient supply on hand of sterilized supplies would offer no particular difficulty, and that is true in the average good hospital in civilian life. The more or less mobile, temporary army hospital; however, is faced with a different problem. Repairs may be difficult to make, insufficient sterilizing equipment may not be supplied, difficulty may be had with the water in certain localities, and many other factors must be taken into consideration when the sterilizing units do not function efficiently. It is the aim in this hospital to procure all the equipment needed for sterilization needs of the hospital, to keep it in good repair, and to have it operated ONLY by persons who are thoroughly trained in its use.

This manual is not intended to furnish a text-book discussion of the topic of sterilization; adequate printed matter with full instruction in theory and practice is kept in the possession of the chief nurse and may be had for reference by any member of the operating room personnel. The work entailed in the sterilizing of supplies for General Hospital #12 will be done by the enlisted personnel in the operating rooms after they have been trained in this work by the nurses and the medical officer in charge of the surgical suite. This means not only an understanding of the mechanics of sterilizing and the handling of the machinery, but also an appreciation of the theories and purpose of sterilization in a broader sense.

The actual manner in which certain materials are sterilized, and various procedures of sterilization in the operating room, will vary from time to time with what facilities there are at hand, with the volume of work to be done, with the materials to be sterilized, and, in some instances, with the preference of the operating surgeon. Therefore, some of the procedures herein outlined will not necessarily hold in all cases, and this brief outline is to serve merely as an example of the usual way in which sterilization is done in an operating room.

The effective sterilization of materials for use in surgery is the direct responsibility of the surgical nurse in charge of the department.

The sole purpose of the sterilization of surgical supplies is to render them free of living bacterial forms, both vegetative and spore. This can be done by any one of several means, but the method chosen is usually dependent upon the nature of the material to be sterilized. These methods are:

1. Autoclave: live steam, under pressure.
2. Dry heat: as in a hot-air oven.
3. Boiling water: as in a large covered cauldron.
4. Chemical: so-called "germicide" agents.
5. Cautery or the open flame.
6. Gaseous: as in decontamination with the fumes of certain chemicals.

For practical purposes, a short discussion will be given only of the first 4 named methods.

a) The Autoclave:

The construction and operation, as well as the efficiency of autoclaves vary widely according to the manufacturer of the machine, its modernity, and the means of steam supply. However, the principle is the same, and in no case is it as complicated or difficult as is commonly supposed.

The autoclave is composed of a chamber within a chamber, with a steam supply which can be led first into the outmost one, and then when desired into the innermost one. Because of its firm construction, this steam can be introduced into the chambers with great pressure, and certain gauges measure the pressure of the steam, the temperature of the inner chamber (where supplies are put to be sterilized), the vacuum produced in the chamber when air is driven out, and other variables upon which effective sterilization depends. The actual operation of the machine depends upon its own individual construction.

of pressure, for the prescribed period of exposure. Some typical supply materials are listed below, together with their recommended exposure period for the above stipulated conditions:

Dressings in normal size packs in double muslin cover	30	minutes
Moderately loaded drums with double muslin liners	30	"
Fully loaded drums with double muslin liners	45	"
Utensils, nested, in double muslin covers	15	"
Utensils, single, in double muslin covers	10	"
Instruments in trays with or without muslin covers	10	"
Instruments wrapped for storage	15	"
Transfusion, intravenous, catheter sets	15	"
Rubber gloves in double muslin covers, not stacked	15	"
Solutions (2000-3000 cc. Thin glass flasks)	20	"
" (1000-1500 cc " " "	15	"
" (500 cc. " " "	12	"
" (125-250 cc. " " "	8	"
" (50 cc. " " "	6	"

The autoclave must be treated as any other fine piece of machinery. All drains, gauges, supply lines, etc. must be kept in perfect order and directions for such care accompany the machine. It is not a mysterious "gadget", but it must be understood to furnish good results. Also, materials to be sterilized must be so arranged and prepared that the autoclave will be able to exert its full sterilizing powers. Other than these simple facts, only a few technical ~~sub-sterilizing~~ points need to be known to make the process of sterilization entirely effective.

It is a proven fact that most resistant pathogenic organisms are destroyed in direct contact with steam in 10 minutes at 230 degrees F; in 4 minutes at 240 degrees; and in 1 minute at 250 degrees. Upon analysis it becomes immediately apparent that 240 to 250 degrees is a highly potent sterilizing range, and that there is little purpose in maintaining temperature higher than 250 to 254 degrees, because sterilization occurs almost instantly at this range. There are excellent reasons for limiting the temperature to this range. It has been shown conclusively that about 250 degrees may be considered the critical temperature for most surgical supplies. Exposure to temperature materially higher brings about more or less speedy disintegration and even at this range it is necessary to restrict the period of exposure for rubber goods to 15 to 20 minutes, else they will withstand only a few trips through the sterilizer. Coarser fabrics also react badly to higher temperature or to prolonged exposure, more slowly perhaps but none the less surely. Browned muslin covers are the direct result of oversterilization. This does not occur in one performance but is the result of repeated over-sterilization and it means a loss to the hospital in permanent replacement costs.

Remember: 250-254 degrees F., 15-17 pounds pressure, at proper exposure time.

Increased pressure alone has very destructive actions on certain materials, so that pressure routinely above 15 to 17 pounds is discouraged. Whenever the autoclave requires pressure over 17 pounds to attain the desired temperature of 250 degrees, then something is wrong with the machine. It should not be forced to higher pressure at such times, to attain the desired temperature, but should be properly repaired.

b) Hot air sterilization

Hot air sterilization is used for those materials which because of their very nature will not allow direct contact with steam, as oils, or which would be ruined by the presence of any moisture. It is the ideal medium when metal ware is being sterilized and the danger of rusting is to be avoided, and it is also useful in the sterilization of some articles of glassware where residual condensation droplets of moisture must be avoided. It is frequently used in laboratories for the preparation of media, glassware, and other laboratory equipment.

The electrically heated oven is preferable to the gas heated one, but either one can be made to work efficiently and the principle is more complicated than an oven used for household baking.

The effective sterilizing temperature in a hot air sterilizer is 320 degrees, F., but a control should allow this to be dropped in the sterilization of certain material

c) Boiling water:

The use of boiling water as a sterilizing agent is time tested and generally quite effective, though it is claimed that some spore forms are with difficulty if at all affected by this method of sterilization. There are many different kinds of boilers available, but the principle of all is the same. They should be adequately deep, have a removable tray on which to place materials to be sterilized, they should have a firm fitting cover, ideally they have a vent for the steam so that it does not come out around the cover into the room, and as in the case of the hot air oven, either electricity or gas can be used for the source of heat.

Though the reason is not explainable, it is proved that instruments are more rapidly and effectively sterilized in 1% sodium carbonate solution than they are in plain boiling water.

Glassware, small pieces of metalware, sutures, and metal instruments are the commoner materials sterilized by boiling. The water does not need be boiling furiously, for once boiling its temperature is 212 degrees F. and it will not rise with harder boiling. In fact, it is better to have the water only gently boiling, for in that manner less water will be lost through escape of steam and additional water will not have to be added as frequently. If all materials are completely submerged, boiling should be continued for 20 minutes, and the timing should begin with the appearance of the boiling, not with the time the instruments were dropped into the hot water, (this is never desirable), then boiling should continue for 30 minutes, so that the unsubmerged parts can be thoroughly sterilized by the surrounding steam.

d) Chemical sterilization

Clinical and experimental data do not furnish us with conclusive facts as to the efficacy of various chemical sterilizing agents, and because of the element of general uncertainty, chemical sterilization is resorted to only where the materials to be sterilized cannot be treated in any other manner, or in the event of an emergency where rapid sterilization by whatever method is imperative. The dangers of this method lie in the fact that strengths of solutions vary through use or time-deterioration; the tendency is to remove the object to be sterilized before a proper time interval has elapsed; it is limited to a relatively few materials; and, most of all, we actually do not know the specific sterilizing action of the various agents on bacteria. This field of sterilization is wide open for further investigation.

Various agents which may be employed are:

1. Alcohol, usually 70% to 80% concentration. This is a very poor, unreliable method, has nothing to recommend it, and should be discarded. It is useful for the storage of certain materials, as tubes of sutures, after those materials have first been sterilized by other agents.
2. Lysol is mentioned only to decry its use in general. It has little to recommend it, and its offensive odor alone is sufficient to make it generally undesirable.
3. Bard-Parker solution: (formaldehyde, ethyl alcohol, methyl alcohol) Generally accepted as the most effective of the commercial products.
4. Phenol 95%, followed by a rinse in alcohol, followed by a rinse in water. A commonly used and highly effective agent, but moderately destructive even to metal.
5. Borax-formalin (5% solution of sodium tetraborate in 10% formalin).
6. ~~Mercuric-chloride-solution, 1:500, strength. This is a common agent, but cannot be entirely relied upon to kill organisms attached to rubber, glass, hair (brushes), gauze, paper or wood.~~

6. Mercuric chloride solution, 1:500, will not kill spores, but will kill any vegetative bacterial form.
7. Potassium-mercuric-iodid solution, 1:500, strength. This is a common agent, but cannot be entirely relied upon to kill organisms attached to rubber, glass, hair (brushes), gauze, paper or wood.

When this "cold" of chemical sterilization process is used, 20 minutes should be the minimum time allowed, and preferably anything up to an hour. Complex instruments obviously require longer time than to simple smooth, flat surfaces. Anything placed in such solutions must be frequently moved and turned to allow complete contact with all surfaces. Solutions must be renewed from time to time before deteriorated. Anything that will kill spores may be relied upon to kill vegetative forms. Any solution containing formaldehyde in usual concentration, as above, can be depended upon to kill spores if the period of sterilization is sufficiently long. For special instruments the operating room technicians and pharmacy will be asked to prepare special formulae according to the desires of individual surgeons insofar as such supplies are available. Medical officers working in surgery are urged, however, to limit such special requests and to content themselves with the standard supplies, such supplies in most instances being satisfactory.

Effective sterilization depends not only upon the basic factors of the autoclave, the temperature of the hot air oven, the boiling of the water, or the accuracy of the chemical formula, but also upon the preparation of the materials to be sterilized. Packs must be carefully made up, the autoclave must not be overloaded or tightly packed full, materials must be sterilized by the method suited to their physical make-up, linens must be clean, foreign material of all sorts must be washed off instruments and other metal and galssware, and other steps must be taken by the operating room personnel to insure the effectiveness of sterilization. The details of these procedures are known to all surgical nurses and surgeons, and it shall be the responsibility of the chief surgical nurse that all enlisted personnel, entrusted with duties of sterilization, now all the necessary facts for the safe accomplishment of such duties.

Above all, those persons entrusted with duties of sterilization of surgical materials must be meticulous, attentive to detail, willing to accept proved rules without experimentation on their own part, and be intellectually honest. Men or nurses not fulfilling these requirements have no place in this operating room.

The following table is not intended to cover absolutely each and every ~~detail~~ material which enters into the problem of sterilization. It does, however, offer a guide to the sterilization of the commoner surgical problem, the chief nurse or medical officer in charge of surgery should be consulted.

DO NOT EXPERIMENT WITH STERILIZATION

Materials sterilized by the autoclave:

- Packs of linen, dressings, gowns, and other cloth materials.
- Jars, cans, pans, cups, and their contents, the lids being removed or the openings being plugged only lightly with cotton or gauze.
- Rubber sheets, specially folded.
- Surgical rubber gloves
- Brushes, placed on perforated trays
- Cellulose napkins and pads, abdominal and arm pads, and other heavy absorptives.
- Lambs wool.
- Cotton and silk sutures.
- Silkworm gut: this is best submerged in distilled water in a flask and autoclaved for 30 minutes at 250 degrees F.

Horsehair, immersed in glycerine or oil

Silver leaf

Metal surgical instruments

Delicate sharp instruments, especially wrapped to protect the points

Lumber puncture needles

Paper bags, cups, etc.

Cotton in any form.

Tongue blades, applicators, and any other wooden material.

Aqueous solutions.

Glassware.

Rubber tubing, rubber catheters, rubber dams, rubber crains, gutta percha

all types of glass syringes.

Suture needles of all types.

Injection needles of all types.

Materials sterilized by hot air:

Sulfa drugs in crystalline form: $1\frac{1}{2}$ to 2 hours at 140 degrees centigrade

Talcum

All Oils

Bone wax

Vaseline and vaseline gauze

Glycerine

Suture needles

Sharp instruments where all possibility of rusting must be avoided

Glassware for the laboratory

Zinc peroxide powder - 270 to 280 degrees F. for 1 hour.

Hypodermic needles, and all other needles where rusting is to be avoided.

Glass syringes.

Artificially waxed sutures.

Materials sterilized by boiling:

All instruments except those with fine edges or points.

All metal, glass, and enamel ware.

All rubber goods, except that for most rubber goods boiling is a messy procedure adds to the technical difficulties, and shortens the life of the rubber.

Lumbar puncture needles.

Suture needles.

Injection needles

All types of glass syringes.

Silk and cotton sutures.

Materials sterilized by chemical means:

Ivory bone pegs, plates and screws: should be immersed for one hour in a suitable solution, following which they should be autoclaved for one hour.

Pitkin type syringes.

Tubes containing suture materials

Sea sponges: soaked in and wrung out of bichloride solution.

All fine, sharp instruments.

Fine catheters, and all shellac ware.

Cystoscopes

Ventriculosopes, and other such instruments for visualization of body cavities.

Non-boilable mirrors.

NEVER PUT RUBBER OR SHELLAC WARE IN SOLUTIONS CONTAINING FORMALDEHYDE OR PHENOL.

From the foregoing lists it will be seen that some materials can be sterilized in more than one way. Our own operating room-set-up determines the preferred method in this operating room. The exact exposure period and vacuum period, and other details of sterilization of individual materials are found posted in the sterilizer room

An important part of the equipment of the operating room is the tank for the storage of sterile water. The boiler-tank apparatus will vary somewhat with the manufacturer, but the principle is the same in all. The valves, gauges, drains, supply lines, vents, etc., must be thoroughly clean at all times of all foreign material, however, sterile that material may be, and for that reason the apparatus should be drained and completely cleansed at least once a week, and once a week a culture should be made of the water to test its sterility.

Water actively boiled for ten minutes is free of vegetative forms of bacteria, but sufficient pressure must be obtained to raise the temperature to 250 degrees F., and kept there for a minimum of ten minutes, to guarantee the destruction of spore forms.

It must be remembered that sterile water is not the same as distilled water. Sterile water may contain all sorts of foreign material, minerals, drugs, pyrogens, etc., whereas these are eliminated in distilled water. Nothing but distilled water is ever used for intravenous or hypodermic use.

Strong smelling chemicals are not necessary for the cleansing of bed frames, furniture, floors, bed pans, sinks, etc. Soap and water, airing in the sunlight, and proper drying out are usually all that is required. Special equipment will be devised when and if it is needed for the sterilization of mattresses, bed pans, etc.