Surgical Sterilization

As it relates to veterinary practice

*Ernest C. McCullough, D.V.M., M.A., Ph.D.**

SURGICAL sterilization as it now is practiced in Veterinary Medicine varies from careful technics carried out in an environment which would do credit to a human hospital, to the dipping of unclean instruments into a bucket of sheep dip solution of unknown strength. Even though economic considerations militate against the employment of expensive equipment and time-consuming technics, attention to a few simple details will greatly assist our approach to surgical asepsis.

Operating Room

Plain ordinary cleanliness is by far the most important factor in sanitizing the operating room. Because animal operations must be performed at a reasonable cost, and professional standards require asepsis, the operating room must be of a functional design. The walls and ceilings should be smooth, of impervious materials, and easily washed. The floors should be smooth, and preferably slope slightly, but uniformly toward the drain. Shelves should be avoided, as they invariably turn out to be dust catchers and places for debris to accumulate. Materials should be stored behind closed cabinets.

Cleaning requires first the dry removal of gross contamination and should be followed by scrubbing. Here, an alkaline detergent compatible with the local water is indicated. In very soft water, sodium carbonate (sal soda) and an institutional grade of soap granules are economical and sufficient. For harder waters, trisodium phosphate, sodium metasilicate (Metso), or sodium tetraborate (borax) should be added previous to the soap in making the solution. Very hard waters which contain excessive amounts of calcium are best presoftened by the addition of a small amount of sodium hexametaphosphate (Calgon) before the alkaline detergents are added. Thorough mechanical cleanliness is the all-important factor. Some veterinarians add one of the saponified cresols or a pine oil emulsion to the alkaline detergent and soap solution. This adds nothing to the germicidal efficiency, since alkalinization or admixture with excessive amounts of soap tend to render these disinfectants inert. In the opinion of the writer, an operating room which has been cleaned thoroughly, and then allowed to dry has little need of additional disinfection.

Disinfection of Air

Air-borne surgical infections now are recognized as a definite hazard, and many human operating rooms are equipped with ultra violet sterilizing lamps. These low pressure mercury arcs emit radiations of 2537 Angstrom units in length. This is in the germicidal range although slightly shorter than the most actively germicidal radiations, which are approximately 2600 to 2650A. long. Sterilizing ultra violet lamps should not be confused with the "Vitamin D activating" or sunlight lamps, which use a high pressure mercury arc to produce radiations in the ranges of 3129, 3022, and 2967 A. The germicidal radiations of ultra-violet light do not have a significant effect in activating the precursors of Vitamin D, while the sunlight lamps exert but little germicidal effect.

The germicidal lamps efficiently disinfect those clean surfaces which they directly irradiate. They do not penetrate

*Professor of Bacteriology in the College of Veterinary Medicine and Research Veterinarian in Agricultural Experiment Station, of the State College of Washington, Pullman, Washington.

beneath the surface so that pathogens contained in the blood, discharges and filth are but little effected by reasonable amounts of irradiation. Furthermore, ordinary glass is opaque to these rays. They are not reflected from ordinary walls, which limits their effectiveness to surfaces directly irradiated. Pathogens contained in air are readily killed by exposure to the rays of germicidal light, although if they are protected by large dust particles, much longer periods of exposure are required.

The disinfection of air by means of ozonators has not proven practical. Concentrations of ozone sufficient to kill pathogens also are toxic to animals and people who breathe the air. While germicidal ultraviolet lamps do convert a small amount of atmospheric oxygen into ozone, the concentration is much below either the germicidal or toxic levels. The small ozonators frequently found in veterinary hospitals are reasonably efficient in producing sufficient ozone to oxidize many of the doggy odors, but have no significance in killing microorganisms. When used in small, closed kennel rooms, it is possible that they might produce sufficient ozone to be toxic to the hospitalized animals, or to attendants spending many hours in these rooms.

Aerosols of propylene glycol, hypochlorites or other chemicals can be vaporized into the atmohphere to reduce the number of microorganisms. They do not appear to have practical application in Veterinary Medicine.

Skin Disinfection

The preoperative disinfection of the site of operation is of extreme importance. Preliminary clipping removes some organisms and shaving removes many more. A careful and thorough soap scrub is highly efficient in reducing the number of survivors. Ordinary soap is practically as germicidal as surgical soap and less expensive. The so-called germicidal soaps which contain 1 or 2 per cent potassium mercuric iodide are somewhat more effective against staphylococci, but show no appreciable increase in efficiency against pathogens. The soaps which contain cresols have no advantage over ordinary soaps. Hard water coconut oil soaps are somewhat better germicides although the lather they produce is inclined to be weak and thin. A thorough scrub is too frequently neglected in veterinary surgery and often attempts are made to compensate by using strong, harsh chemical disinfectants. This is an error. The final scrubbing of the skin with a sterile cotton pledget saturated with ether is a distinct contribution to surgical safety, not because ether is an especially active germicide, but because ether is a good fat solvent and allows for more thorough cleaning.

Iodine Most Effective

For the pre-incision disinfection of the scrubbed skin, iodine appears to be the most effective. The U. S. P. tincture has no superior as an effective skin germicide. However, it must be applied only to dry skin because when the tincture is diluted with water the very irritant nascent iodine is liberated. This is because the amount of metallic iodine in the tincture is too great to be held in aqueous solution by the small amount of iodide which is present. Mild tincture of iodine is nearly as efficient as the older tincture and much less irritant. It has the following formula:

Metallic iodine .....2 Gm.
Sodium iodide .....2.4 Gm.
Diluted ethyl alcohol, approximately 46 per cent—100ml.

Here, the proportion of iodide to iodine is sufficient to hold the iodine in solution in any dilution, so that nascent iodine cannot be liberated.

The complex mercurials, such as mercurochrome, merthiolate, and metaphen, usually as the alcoholic tincture, are employed in many hospitals with success. However, the tendency of mercurials to be bacteriostatic rather than bactericidal and the ability of a mercury-treated organism to recover when carried into the tissues, where competitive absorption will remove much of the mercury coating, has tended to make bacteriologists skeptical of the use of mercury compounds.

Vaichulis and Arnold have recommended the following colored alcoholic solution

of mercuric chloride as an economical skin disinfectant:

Ethyl alcohol	525.0 ml.
Acetone, U.S.P.	100.0 ml.
Mercuric chloride	1.0 Gm.
Hydrochloric acid	7.5 ml.
Chrysoidin Y	2.0 Gm.
Distilled water	367.5 ml.

Since the amount of hydrochloric acid is sufficient to hold alkaline minerals in solution, tap water in most areas should serve as well as distilled water. The colored solutions have the advantage of indicating the areas treated.

Zephiran, which is a cationic detergent, also is a recognized skin disinfectant. Very careful operators used the aqueous solution first, then the tincture. For skin distinfection, the less refined and cheaper Roccal can be substituted. These products have the great advantage of being nearly non-toxic and non-irritating. However, cationic detergents are incompatible with soaps. If any soap remains on the skin, the germicidal action of the Zephiran or Roccal is apt to be nullified. If a cationic detergent is used instead of soap in the preliminary scrub, a cationic skin disinfectant would prove ideal. The writer believes this combination may be the technic of the future.

Alcohol, 70 per cent by weight, is used satisfactorily where the presurgical scrub has been properly carried out. Isopropyl alcohol is a more efficient germicide than ethyl alcohol. It usually is applied full strength.

A common error is to apply one of the milder skin disinfectants with unsterilized or even unclean cotton. Sterilized gauze packs should be used.

Instrument Disinfection

The ideal method of properly sterilizing clean instruments in an adequate steam pressure sterilizer, such as is used in human hospitals, is beyond the practical reach of most veterinary practitioners. Some compromises must be made between what we would like to do and what we can do under practical conditions. Fortunately, most pathogens are not extremely resistant to either heat or chemical sterilization. The spores of the *B. anthracis*, the only sporulating aerobe which is pathogenic, are not liable to appear as instrument contaminants. This leaves only the spores of the pathogenic anaerobes to cause especial concern. In other words, if the bactericidal treatment given instruments is sufficient to destroy spores of *Cl. septicum, Cl. novyi, Cl. welchii* and *Cl. tetani*, a reasonably satisfactory degree of sterility has been obtained. This is not difficult. Attention to a few simple rules is sufficient. Cleaning is by far the most important step. It is almost impossible to destroy spores embedded in pus or tissue debris held in the joint of a surgical instrument without applying such heroic measures that the value of the instrument is injured. Even subjecting such an instrument to steam pressure sterilization in a properly designed autoclave or steam pressure instrument sterilizer at a steam pressure of 15 pounds, with a temperature of 121°C. for 20 minutes will not assure sterility. This is because the dry debris surrounding the organisms may protect them from direct contact with moist heat. It is well known that a short period of exposure to dry heat at 121°C. is not always sufficient to sterilize.

Trisodium Phosphate

The first and most important step in making instruments surgically safe is cleaning. All locked instruments must be unlocked to allow cleaning. Contaminated instruments can be placed in a previously boiled solution containing trisodium phosphate and brought to a boil. When removed onto a clean cloth, the instruments will be found to be bright and free from debris. They can be stored in a clean, but nonsterile condition until just prior to the operation.

The ideal technic of sterilization is to place them in a suitable tray, protected on both top and bottom by a clean cloth, and subject them to autoclaving or sterilizing in a steam pressure sterilizer for 15 to 20 minutes, at a temperature of 121°C., which is attained in a properly operated sterilizer with 15 pounds pressure at sea level, with one pound added for each 2000 feet elevation. After the required period of

exposure, the steam is released rapidly, leaving the instruments dry.

A pressure cooker can be substituted for the sterilizer. Here, care must be taken that the pressure gage is accurate, since the majority of gages on cheap pressure cookers register fictitiously high pressure. Moreover, the air is exhausted at the top of the cooker, which makes the necessary complete air removal difficult to attain. When only a minimum of water is used in the bottom of the pressure cooker and the instruments are held off the bottom by means of a rack, dry instruments can be obtained by releasing the steam rapidly.

Boiling, while lacking some of the theoretical advantages of steam pressure sterilization, is rapid, requires little equipment and is reasonably satisfactory, providing the instruments have been subjected to previous cleaning. Placing dirty, contaminated instruments, containing dried deposits of pus and debris, into boiling water cannot insure satisfactory disinfection.

Rusting during boiling is partially controlled by first bringing the water to a brisk boil to remove the dissolved O_2 before immersing the instruments. Even better results are obtained by adding an anti-rust tablet or a few crystals of sodium nitrite.

Chemical Sterilization of Instruments

Chemical sterilizing solutions are widely used, especially for instruments used in minor surgery. Their use definitely represents a compromise between surgical safety and convenience. The ideal chemical sterilizing solution for instruments would be stable, non-corrosive to cutting blades, not injurious to finished surfaces, be highly germicidal without leaving any toxic residues, be rapid in action even in cold solutions, be able to penetrate small amounts of tissure debris and be transparent. No product approaches these requirements.

If "cold sterilization" is to be even reasonably safe, four steps are required:

1. Thorough mechanical cleansing of the instruments to remove all blood, pus or materials which might protect pathogens.
2. Prolonged periods of immersion, preferably with the solution rather warm. Placing the container over a 10 watt electric lamp by means of rack, so that the solution is maintained at approximately 110 to 120°F. will greatly add to the efficiency of the sterilizing agent and allow much shorter periods of exposure and weaker solutions to be used.
3. Rinsing of the instrument in sterile or at least non-contaminated water after it has been in the solution.
4. Drying under sterile conditions. There is no reason why acetone cannot be used to facilitate rapid drying.

Isopropyl Alcohol

Most of the "sterilizing solutions" contain isopropyl alcohol, ethyl alcohol, formalin or a cationic detergent, such as Zephirin or Roccal. The most frequently employed and the least reliable are the solutions of ethyl alcohol; 70 per cent by weight being the most effective. Isopropyl alcohol is somewhat more effective; is obtainable without revenue restrictions and is economical.

A 5 per cent solution of Lysol, Amphyl or Liquor Cresolis Saponatus will prove reasonably satisfactory, especially if the solution can be used warm.

The following has been used satisfactorily, and makes a transparent solution:

Amphyl	20 ml.
Alcohol	100 ml.
Glycerin	50 ml.
Water to make	1 liter

A borax formalin solution consisting of a 5 per cent solution of sodium tetraborate in 10 per cent formalin is being widely used. Spaulding found that none of the "sterilizing solutions" which he tested was efficient in killing the spores of *Cl. tetani*, when protected by pus or blood.

Rusting can be delayed by adding 0.5 per cent sodium nitrite to these solutions.

Flaming

Flaming sometimes is practiced with small instruments. If the instrument is held in the flame until thoroughly heated, it is both sterilized and ruined as a surgi-

cal instrument. Merely passing the instrument through a flame does not attain surgical sterility. Dipping the instrument into alcohol and then burning off the alcohol is reminiscent of the carnival trick of "fire eating." The rapid evaporation of the alcohol from the surface provides effective refrigeration, because the vapors must move away from the surface to mix with the air before combustion can take place. The surface so treated usually escapes adequate heat treatment.

Steam Sterilization

Where steam pressure sterilizers are available, gowns and other fabric materials to be sterilized are placed in drums and these are wrapped and subjected to steam pressure sterilization. After sterilization has been completed, the steam is released rapidly which leaves the materials in a relatively dry condition. Where such sterilizers are not available, ordinary pressure cookers can be used to give almost equivalent results, providing only the minimum amount of water necessary to generate steam is used, the materials are held above the water level by a rack, and the steam is rapidly released to give a drying action.

The modern laundry does a reasonably efficient job of disinfecting operating gowns. White cotton fabrics are washed in alkaline, soapy waters at increasing temperatures up to 140 to 160°F. and are rinsed at 160°F. Only sporulating organisms can survive this treatment, and unless the previous contamination has been excessive, their numbers would have been so reduced by washing that the hazard would be very small. It is the writer's opinion that a fresh gown from a modern laundry is reasonably free from pathogens and does not introduce a significant hazard in animal surgery.

Baking overnight at 125°C. (257°F.) has been found effective as a bactericidal treatment and does not scorch cotton. An ordinary electric stove oven is adequate providing some insulation, such as an asbestos shingle, is placed under the wrapped bundle of clothes to be sterilized.

Glass syringes usually are cleaned and the plunger and barrel placed side by side on a cloth and wrapped and tied. These can be sterilized in an ordinary oven over night, at 140 to 150°C. Surgical needles are sewn into a cloth and subjected to similar treatment. Scalpel blades can conveniently be placed in small vials, the bottom being filled with cotton. These require prolonged exposure to dry heat, and rapid sterilization should not be attempted.

The writer does not know how to sterilize the syringes which have rubber or leather packings, although thorough cleaning, washing with hot Roccal solutions, followed by thorough rinsing, will lessen the hazard of infection.

Rubber Gloves

The disinfection of rubber gloves is difficult, and gloves which have been grossly contaminated with sporulating pathogens should be discarded. If this is not practical, overnight soaking in a 3 per cent sodium hydroxide (household lye) solution will minimize the hazard. They should be rinsed in running water before being subjected to the sterilizing processes recommended for clean gloves. Gloves lightly contaminated should be washed in an alkaline detergent, as alkaline solutions have little deleterious effect upon gloves. Following this, they should be placed in a glove envelope and held in a steam sterilizer at 121°C. for 15 minutes. Good quality surgical gloves will withstand this technique, which gives a good degree of protection. Soaking in a 1:1000 solution of Zephiran or Roccal or in a 2 per cent solution of Amphyl also has been recommended.

Foot and mouth disease in man is a direct counterpart of that in cattle. The infection in man is transmitted through the ingestion of raw products from animals suffering from foot and mouth disease.

No definite immunity is rendered by an attack of foot and mouth disease. The period of incubation is variable, usually from 2 to 6 days or longer, exceptional cases being prolonged to 15 or even 18 days.