

# Perioperative Nursing

## Introduction

The term perioperative nursing refers to all activities before, during and after a surgical procedure, which ensure the best possible care of an animal. Both the international and the German regulations consider it a responsibility of the research or teaching institution to ensure that all personnel, regardless of academic degrees, are qualified and trained to conduct surgical procedures. Personnel who perform surgery, as well as staff members who manage the operating rooms, must be qualified and trained for the assigned procedures or functions. In this chapter a brief description of the fundamental concepts of perioperative nursing is given, to facilitate the training of the MPIK personnel. Firstly, the topics of surgical asepsis, sterilization and disinfection, attire, and tools, are discussed; and secondly the MPIK operating room and the protocol of surgery-preparation is described in some detail. Finally, a brief description is given of premedication and of the factors that may greatly influence the presurgical state of the animal.

## Surgical Asepsis

At MPIK all survival surgical procedures are performed under aseptic conditions. It is therefore imperative that all personnel is familiar with the principles of asepsis.

## Terms and Definitions

**Micro-organisms or microbes:** Bacteria, viruses, fungi, algae, protozoa, and spores, that is, all those organisms that are generally considered too small to be seen clearly with the naked eye, are known as microbes or micro-organisms. The study of such organisms is known as Microbiology. Most microbes are unicellular, that is, they consist of only one cell which carries out all the functions necessary for life. Microbes are named according to the binomial system. The first part is the generic name, indicating the **genus** to which the organism belongs, and the second is the specific name indicating the **species**.

**Parasites:** A parasite is an organism which lives on or in another living organism (the **host**) and derives nourishment from it.

**Pathogen:** Pathogen is a parasite that harms the host by causing disease.

**Bacteria:** Bacteria are single-celled organisms. Three basic shapes are generally recognized: cylindrical or rod-shaped called **bacilli** (singular bacillus), spherical cells that are called **cocci** (singular coccus), and spiral or helical cells called **spirilla** (singular spirillum) if they have rigid cell wall or **spirochaetes** (singular spirochaeti) if the cell wall is flexible. Some cocci exist singly while others remain together in pairs after division and are called **diplococci**. For our purposes important is the classification of bacteria on the basis of their reaction to a combination of stains developed by Gram. Gram's method enables us to divide bacteria into two groups: (a) **Gram-positive**, which stain purple, and (b) **Gram-negative**, which stain red.

**Spores:** Some species of bacteria (most common in the genera *Bacillus* and *Clostridium*) produce dormant forms called **spores** (or endospores) that can survive in unfavorable conditions. Such spore-forming bacteria exist almost everywhere, including dust, and are extremely resistant structures, remaining viable for many years. They can survive extremes of heat, pH, desiccation, ultraviolet radiation, and exposure to toxic chemicals such as some disinfectants.

**Viruses:** Viruses are much smaller and simpler than bacteria. They are all obligate parasites depending on host cells for reproduction (replication), and for carrying out other vital processes. Once a virus begins to replicate, the host cells do not usually continue to function normally. Sometimes cells are damaged and killed, other times infected cells show no visible change but do not function properly. Viral infections are usually difficult to control and

treat because any drug that interferes with viral replication is almost certain to also have a harmful effect on the host cells.

**Fungi:** Fungi range in size from microscopic, unicellular forms to large multicellular organisms which can easily be seen with the naked eye. Some fungi are pathogenic. They can be classified in (a) **yeasts** that are unicellular fungi usually round or ovoid reproduced by a process called *budding*, and (b) **molds** that are multicellular organisms composed by long filaments called **hyphae** (singular hypha).

**Toxins:** Toxins are poisonous substances that have a damaging effect on the cells of the host. Because the toxin can be transported through the tissues the effects of the toxin are felt not only in the affected cells and tissues but also elsewhere in the body. Two types of toxins are recognized: (a) **exotoxins** that are manufactured by living microorganisms and released into the surrounding medium, and (b) **endotoxins** which are retained within the microorganism and only liberated when it dies. Endotoxins are part of the cell wall of certain Gram-negative bacteria and released only when the cells die and disintegrate. Blood-borne endotoxins are responsible for a range of non-specific reactions in the body, such a fever. They also make the walls of blood capillaries more permeable, causing blood to leak into the intercellular spaces, which in turn can result in a serious drop in blood pressure.

**Epidemic Disease:** Epidemic diseases are those diseases whose incidence increases sharply and involves large numbers of individuals in an area.

**Zoonoses:** Zoonoses are diseases that can be transmitted directly to humans by animals. Examples of zoonotic agents that are known to be transmitted from monkeys to humans, and which present serious health hazards, are rabies, b-virus, filo-virus, Q-fever, tuberculosis, toxoplasmosis, and others.

**Inflammation:** In general inflammation is the reaction of normal tissues to an irritant. More specifically inflammation is the process which begins following injury to a tissue and ends with healing or the eventual death of the tissue. The signs that characterize inflammation (called the **cardinal signs**) are: (1) Redness, (2) Swelling, (3) Heat, (4) Pain, and (5) Loss of normal function. The pain is associated with inflammation is due to increased pressure on the nerve endings because of the swelling. Loss of functions results from pain-induced inhibition of muscle activity; the mechanical effects of swelling and tissue distraction. Inflammations may be acute or chronic. Chronic inflammations may occur in the laboratory because of the recording hardware implanted on the animals' skull. The treatment of such inflammations is discussed below.

**Resolution:** Resolution is the return of a tissue to its state prior to the onset of an inflammation.

**Regeneration:** Regeneration is the replacement of tissue destroyed by the inflammatory process with similar functional tissue.

**Organization:** Organization is the replacement of tissue destroyed by the inflammatory process with connective (scar) tissue.

**Sepsis:** The presence of pathogens or their toxic products in the blood or tissues of an animal. More commonly known as **systemic infection**.

**Asepsis:** Freedom from infection by excluding all micro-organisms and spores.

**Antisepsis:** Prevention of sepsis by destruction or inhibition of micro-organisms using an agent that may be safely applied to living tissue.

**Sterilization:** The destruction of all micro-organisms and spores.

**Antiseptic:** A chemical agent that either kills pathogenic microorganisms or inhibits their growth as long as there is contact between agent and microbe. Antiseptics (in contrast to disinfectants) are applied to the body. The antiseptic may actually be a disinfectant used in dilute solutions to avoid damage to tissues.

**Drain:** any device by which a channel or opening may be established and maintained for the exit of fluid or purulent material from any cavity, wound or infected area.

**Drainage:** the systematic withdrawal of fluid from any wound, sore, or cavity in the body.

**Penrose Drain:** the most commonly used drain, made of soft, thin-walled rubber tubing 0.64 to 2.54 cm in diameter.

**Sump Drain:** a large tube with a second smaller tube in the wall or within the lumen of the larger tube. The smaller tube allows air to enter and facilitates drainage of fluid from cavity.

## Infections

Aseptic and sterile techniques, based on sound scientific principle, are carried out primarily to prevent transmission of microorganisms that can cause infection. Microorganisms are invisible, but they are present in the air and on animate and inanimate objects. To prevent infection, all possible measures are taken to create and maintain a therapeutic environment for the patient.

Infection that is acquired during the course of surgery or general health care is known as a *nosocomial infection*. The infection may occur in the postoperative wound or as a complication unrelated to the surgical site. Postoperative infection is a very serious, potentially fatal complication that may result from a single break in aseptic technique. Therefore knowledge of causative agents and their control as well as the principles of aseptic and sterile techniques is the basis of prevention.

Infections may be caused by one or several types of microorganisms. Types are numerous and vary in incidence and significance of infection produced. What follows is a very short list of the pathogens causing infections in laboratory primates.

## Bacterial Infections

Bacteria are classified by the environment that sustains their life with oxygen (aerobic) or without oxygen (anaerobic), and as gram-positive or gram-negative. Gram's stain (Gentian violet) is a laboratory technique for identifying a primary characteristic of bacteria. Those that stain blue/purple are gram-positive while those that do not stain are gram-negative. Infections may be caused by aerobic, microaerophilic, or anaerobic bacteria or can be mixed bacterial infections. Microaerophils require less oxygen than present in air. The following are the most common bacterial pathogens:

### Aerobic Bacteria

(a) *Gram-positive cocci*, such as *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Streptococcus* Group B, *Streptococcus* Group D, methicillin-resistant *Staphylococcus aureus* (MRSA). Infections caused by *Staphylococcus aureus* are unfortunately very common in monkeys. In particular, if the animals are brought back to their home cage immediately after the surgical procedures. *Gram-negative cocci*, such as *Neisseria gonorrhoeae*. (b) *Gram-positive bacilli*, such as *Bacillus* species *Mycobacterium tuberculosis*. (c) *Gram-negative bacilli*, such as *Escherichia coli*, *Klebsiella* species, *Pseudomonas aeruginosa*, *Pseudomonas cepacia*, *Proteus* species, *Serratia marcescens*, *Salmonella* species, *Enterobacter cloacae*, etc.

### Microaerophilic bacteria

*Gram-positive cocci*, such as hemolytic and nonhemolytic streptococci.

### Anaerobic bacteria

(a) *Gram-positive cocci*, such as peptostreptococcus, peptococcus. Gram-positive cocci cause often problems with the animals' implants. (b) *Gram-positive bacilli*, such as *Clostridium tetani*, *Clostridium welchii*. (c) *Gram-negative bacilli*, such as *Bacteroides* species, *Bacteroides fragilis*.

### ***Nonbacterial Infections***

Infections may be caused by fungi, protozoa, or viruses. With nonhuman primates the most of the nonbacterial infections are caused by viruses. Possible pathogens are the hepatitis virus, simian immunodeficiency virus, herpes B virus, cytomegalovirus, Epstein-Barr virus, etc.

### ***Viability of Organisms***

Microorganisms need moisture, food, proper temperature, and time to reproduce. When transferred from one place to another, they pass through a dormant or lag phase of about 5 hours or longer. Then each organism divided itself about every 20 minutes. Most bacteria, fungi, and viruses are killed easily by the processes of sterilization and disinfection, but bacterial spores are not.

Spores are the resting, protective stage of some rod-shaped bacilli. Dense layers of protein form within the cells that can be compared to the shell of a nut. The thicker the wall, the more resistant the spore is to destruction. When conditions suitable for bacterial growth are reestablished, the spore releases cells for active growth and reproduction. Although spores are formed by only about 150 species of bacilli, they are universally present in the environment.

### ***Sources of Contamination***

Many sources contaminate the OR environment. Most microbes grow in a warm, moist host, but some aerobic bacteria, yeasts, and fungi can remain viable in the air and on inanimate objects. People and animals themselves are also major source of microorganisms in the surgical environment. Everything on or around a human being and of course anything on and around the monkey is contaminated by them in some way. In additions, the actions and interactions of personnel and animals contribute to the prevalence of various microorganisms. The most critical area for the introduction and spread of microorganisms is obviously the area occupied by the operated animal and the surgical team. Usual sources are:

#### ***Skin***

The fur and skin of the animals, as well as the skin of the OR team members constitutes a hazard. Hair follicles and sebaceous and sweat glands contain abundant resident microbial flora. An estimated 4000 to 10,000 viable particles are shed by an average individual's skin per minute! Some people disperse up to 30,000 particles per minute. Shedders are persons who present an additional hazard, and must be therefore always appropriately dressed when close to operated animals. True shedders are estimated to be 1 in 50 persons. Major areas of microbial population on all persons are the head, neck, axillae, hands, groin, perineum, legs, and feet.

#### ***Hair***

Hair is a gross contaminant and major source of various species of Staphylococcus. Hair follicles and filaments harbor rich resident and transient floras. The extent to which the microbial population is attracted to and shed from hair is directly related to the length and cleanliness of the hair.

#### ***Nasopharynx***

Organisms forcibly expelled by talking, coughing, or sneezing give rise to bacteria-laden dust and lint as droplets settle on surfaces and on the skin. Persons known as carriers harbor many organisms, notable Group A Streptococcus and Staphylococcus aureus, which may be carried pharyngeally or rectally. Such organisms are usually transmitted by direct contact. Surgeons and anesthesiologists can be often carriers because of intimate contact with the animal's respiratory tract (intubation, etc.). Carriers do not present a real threat in the absence of an overt lesion. However, they can be a serious source of infection in presence of an open surgical wound.

#### ***Fomites***

Contaminated particles are present on inanimate objects such as furniture, OR surfaces (walls, floors, cabinet shelves), equipment, supplies, and fabrics. Covert contamination may result from improper handling of equipment

such as anesthesia apparatus or intravenous (IV) lines and fluids. Contamination may also result from the administration of unsterile medications or use of unsterile water to rinse sterile items.

### **Air**

Thousands of submicron sized particles per cubic foot of air are present in the OR. During a long surgical procedure particle count can rise to more than a million particles per cubic foot. Air and dust are vehicles for transporting microorganism-laden particles. Air movement and thermal currents entrain dust and microbial particulates. The OR lights and other heat-generating equipment produce convective upcurrents. Particulates that become airborne can then settle on an open wound. Between 80% and 90% of microbial contamination found in an open surgical wound comes from ambient (room) air. Because airborne contamination is generated by personnel, every movement increases potential for wound infection.

Microorganisms have an affinity for horizontal surfaces, of which the floor is the largest. From it, they are projected into the air. Endogenous flora from the patient's skin, oropharynx, tracheobronchial tree, and gastrointestinal tract, as well as exogenous flora, are significant. Microorganisms from patients or carriers settle on equipment and flat surfaces, then become airborne. Airborne particles increase significantly during activity before incision and after wound closure. An effective ventilation system is essential to prevent patients and staff from breathing contaminated air, which would predispose them to respiratory infection and could increase the incidence of microbial carriers among OR personnel.

### **Infection of Prosthetic Implants**

A common phrase in both research and clinical situation is "infected implant". This is a misnomer, since it is the tissue surrounding the implant that is infected rather than the implant itself. Three types of infection are associated with prosthetic implants.

The first type is the superficial immediate infection, which is due to the growth of organisms on or near the skin in association with an implant. Examples include the head fixation devices, the recording chambers, as well as burn dressings and simple sutures that have not been removed in time. The second type is the deep immediate infection, which is a low-frequency infection commonly seen immediately after surgery. The bacteria responsible are usually skin residents carried into the implant site during the surgical procedure. The third type is the deep late infection, which may occur years after the surgery in sites with no history of infection. The latter type of infection may sometimes occur in monkeys that have implanted electrode guide-tubes, or infrequently around the search eye coil.

### **Principles of Asepsis**

Modern surgery is based on aseptic technique. Asepsis means the absence of any infectious agents, and therefore aseptic technique is aimed at eliminating microorganisms present in the surgical environment. This includes those microorganisms living harmlessly on the body surface or within it. Aseptic technique is always applied in combination with sterile techniques, which prevent the transfer of microorganisms from the environment into the body tissues. The words aseptic and sterile although sound very similar they are very different in practice. Aseptic techniques control the environment while sterile techniques prevent the contamination of an item or area from the environment by maintaining sterility of that item or area.

*Aseptic technique*, for example, includes the control of the OR's air system, the traffic and movement within the OR, the establishment of aseptic barriers, such as the usage of caps, hoods, and gloves, and the appropriate housekeeping practices that include the cleaning and disinfecting of the operating rooms and suite, the handling of soiled laundry, and the disposing of solid wastes.

*Sterile technique* on the other hand includes the sterilization of instruments, the creation, maintenance, and termination of the sterile field, the draping of the patient or animal with sterilized drapes, etc.

Principles of bacteriology and microbiology are applied in developing infection control programs to be followed by all operating room personnel. Such programs involve specific guidelines for OR attire, sterilizing and packaging supplies,

scrubbing, gowning and gloving, and methods of original infection control principles:

housekeeping. The following practices stem from the

1. All items used within a sterile field must be sterile. If there is any doubt about the sterility of an item, it is considered unsterile.
2. A sterile barrier that has been permeated must be considered contaminated. In other words, you have to change gown, drapes, or gloves if any of them is permeated.
3. Gowns of scrubbed team members are considered sterile in the front from shoulder to waist level, and the sleeves to approximately 5 cm above the elbow. Unsterile areas of gowns are shoulders, neckline, axillary region, and back. If you are scrubbed, do not allow your hands or any sterile item to fall below waist or table top level.
4. Tables are sterile at table level only. Any item that extends over the table edge is considered contaminated and cannot be brought back up to table top level.
5. Scrubbed persons must stay close to the sterile field and if they change positions. If you need to change position while scrubbed, you must move by turning back to back or face to face with other sterile team members.
6. The edges of a sterile container are considered unsterile once the package is opened. Because sterile boundaries are not always well defined, follow the rules below:
 

Cap edges of a bottle of sterile solution are considered contaminated once the cap is removed. Because the cap cannot be replaced without contaminating the pouring edges, the sterility of the bottle contents is not longer certain and the remainder must be discarded.

Package wrappers are usually considered to have a 3 cm safety margin around the edge. The flap ends are secured in the hand of the person opening them to avoid dangling the flap ends loosely.

Peel-back packages should not be torn open but rather pulled back to expose sterile contents. The inner edge of the heat seal is considered to be the boundary between sterile and unsterile.
7. The sterile field should be created as close to the time it is going to be used as possible. The degree of contamination is proportional to the length of time items are left uncovered. Sterile areas are kept continuously in view and once supplies are opened, someone must remain in the room to ensure sterility.
8. Sterile persons and items touch only sterile areas; unsterile persons and items touch only unsterile areas.

Finally one has to keep in mind that the more people in the surgical suite, the greater the likelihood of infection. In our facility surgical procedure may be observed through our internal video system. There is no need for people to be directly present in the OR unless they absolutely have to. In all cases visitors should also prepare their hands aseptically and wear sterile gowns and gloves.

## Decontamination of Surgical Supplies

Decontamination is the first step toward reducing the potential hazard of direct contact with blood, fluids or tissues left on OR surfaces, equipment, or instruments. Decontamination refers to the process by which the contaminants are removed, either by manual or mechanical methods, using specific solutions capable of rendering blood and debris harmless and removing it from the surface of an object or instrument.

The instruments, along with the other nondisposable supplies exposed to the patient/procedure are placed in a proper receptacle and covered for transference to the decontamination room. It is important to note that the contaminated instruments and nondisposable equipment must be covered when traversing hallways leading into the decontamination area. All instruments used during the procedure should be inspected for gross dirt and debris, and cleaned with water and/or a scrub brush, and soaked with an antimicrobial or bleach solution. This process must be done under the water level, preventing splash dissemination of harmful microorganisms.

Once the instruments have undergone the initial washing, the second step in the process begins, which involves the terminal cleaning of the instruments and initial sterilization before the assembly of the tray. A manual cleaning procedure, for delicate and heat sensitive items, is recommended to preserve the life of the instruments and to decontaminate them before the sterilization process. If manual washing is required, all personnel must be protected from exposure to contaminants during the cleaning process.

The most common cleaning method is mechanical cleaning which can be accomplished using several different tools: ultrasonic washer, washer-sterilizer, or the washer-disinfector.

### **Ultrasonic Washer**

The ultrasonic cleaning process removes blood and debris left on the instrument by a process known as cavitation, which occurs when sound waves are passed through water, creating within it cavities ranging in size from submicroscopic to very large. These bubbles expand until they implode. This implosion generates minute vacuum areas on the instruments, which (vacuums) are responsible for the actual cleaning process. During this process the small particles float to the top, while the larger particles settle on the bottom of the tank and are eventually flushed away. The particles will remain in suspension as long as the water and detergent are fresh. It is for this reason that the water must be changed if the ultrasonic cleaner is used for the initial cleaning process.

### **Washer-Sterilizer**

When the washer-sterilizer is used, the soiled instruments are cleaned by mechanical agitation in a bath containing a detergent, rinsed, and then sterilized for 3 minutes. in one process. However, it must have a cold cycle or the items must be washed by hand first.

### **Washer-Disinfector**

The newest method for decontaminating instruments is the washer-decontaminator, which removes excess amounts of dried debris from the instruments, eliminating the hand-cleaning phase of the decontamination process. The numerous water jets and the increased pH of the detergent allow for thorough cleaning of even grossly soiled instruments. Initial cleaning is followed by a neutralizing rinse to restore the pH to its neutral state. Since the agitation of the water is minimal, it cleans without tossing the instruments around in the tray, thereby reducing the risk of damage to even delicate instruments. The washer-contaminator cleans instruments so thoroughly that it not only eliminates the need for hand cleaning, but it can also replace the ultrasonic washer.

## **Sterilization**

*By Torsten Trinath*

### **Theoretical and Practical Considerations**

If any practical or theoretical questions remain after reading this document, please contact the Hygiene Institute of the University of Tübingen (Tel.: 07071 / 29 23 54), the director of the Central Sterilization Facilities of the University Hospitals of Tübingen, Mr. Zanette (Tel.: 07071 / 298 00 95, Fax: 29 57 16), or the hygiene director of the University Hospitals of Tübingen, Priv. Doz. Dr. Heeg (Tel.: 07071 / 29 20 26, Fax: 29 58 67).

### **Basic Concepts and Definitions**

To sterilize means to render an item totally free of all living microorganisms, including spores, through one of three processes: (1) steam sterilization, (2) chemical sterilization or (3) physical sterilization. Each method has its own characteristics and requires specific parameters for effective completion of the process. Additionally, the process must be continuously monitored to ensure that all procedural parameters and specifications have been met, assuring the sterility and traceability of the item as well as the proper functioning of the equipment.

Steam alone is incapable of sterilizing an item. However, when steam is placed under pressure, its temperature rises, and the moist heat produced destroys the protein within the cell, rendering it harmless. It is, therefore, the

relationship between temperature, pressure, and time of exposure that becomes the crucial factor in destroying microbes, and it is these principles that are used in the operation of the steam sterilizer. Sterilizers designed to use steam under pressure are referred to as autoclaves and are generally manufactured to perform this task by one of three methods: (1) gravity displacement, (2) prevacuum, or (3) high-speed pressure.

### **Gravity displacement sterilizer**

The gravity displacement sterilizer uses the principle that air is heavier than steam. It has an inner chamber where the goods are sterilized and an outer heated jacket that ejects steam into the chamber. When the sterilizer is activated, pressurized steam enters the top of the inner chamber from the jacket, and exerts pressure on the air inside the chamber, displacing the air downward to the bottom of the chamber where it is released through a temperature-sensitive valve. When the valve closes, the pressure inside the jacket chamber increases, raising the temperature to the required level. At this point, the timing of the sterilization cycle begins. The length of the cycle depends on the temperature reached inside the jacket. Most gravity displacement sterilizers work in a range from 250°F (121°C) to 254°F (123°C) at 15 to 17 pounds per square inch (psig), and take anywhere from 15 minutes for a conventional pack to 55 minutes for large, tightly packed containers. The higher the temperature, the shorter the cycle duration required.

### **Prevacuum (high-vat) sterilizer**

The automatic prevacuum, high-temperature sterilizer has generally replaced the gravity displacement method, since it does not rely on gravity to remove the air from the chamber. Instead, the air is removed by a venturi valve that uses water movement to create the vacuum, which simultaneously draws the air out while steam is injected into the chamber, replacing the air. This mechanism reduces the time necessary to accomplish the sterilization cycle to as little as 5 minutes, but the time varies with the size of the sterilizer, the adequacy of the steam, and the supply of water. This sterilizer, if efficient in preventing air pockets, has a greater penetrating ability than the gravity displacement type. The recommended exposure time for prevacuum steam sterilizers is four minutes at temperatures ranging from 250°F (121°C) to 274°F (134°C). This sterilizer, like the gravity displacement sterilizer, is used primarily for wrapped items.

### **Preparing Goods for the Autoclave**

Although sterilization with high-pressure steam is a very safe, effective method, certain rules must be observed to ensure sterility. The first rule is that before any instrument is put into the autoclave it must be absolutely clean.

For this reason all instruments are cleaned and dried in the laboratory dishwasher (Miele Desinfektor) before being sterilized. If the instruments are extremely soiled, they must be washed by hand before being put into the dishwasher. The dirt can also be loosened with ultrasound to make the task of hand washing easier. Caution! Not all instruments are suited for ultrasonic cleaning. Problems can be caused especially by glued parts and certain cheaper surface finishes such as most chrome plating. Each instrument must be inspected closely before it is put into the dishwasher, especially at any joints or teeth.

Once they have been washed and dried in the dishwasher, the instruments may no longer be touched with bare hands. Each fingerprint, each drop of water and each calcium deposit on an instrument is an excellent hiding place for potential germs and can jeopardize the success of the subsequent sterilization.

The empty sterilization containers, which have also been washed, are fitted with the appropriate filters in the lid and sometimes on the floor. Now they can be loaded with the instruments to be sterilized. Do not pack too tightly. The appropriate indicator strip (which changes color when the sterilization temperature has been maintained for a certain length of time) is put into the container. To be safe, an indicator strip is also put along with the instruments into the cloth roll, if one is used. After the container is closed it is sealed with the indicator clamp made for this purpose.

We use the MMM Vakulab HP 446 with a chamber volume of 140 liters. This autoclave may only be operated by persons who have been instructed in its correct use.



Our autoclave has four sterilization cycles:

**Cycle 1:** Solid materials. 134°C, cycle duration approx. 35 minutes. For heat-resistant instruments without cloth instrument rolls.

**Cycle 2:** Solid materials. 121°C, cycle duration approx. 50 minutes. For temperature-sensitive materials such as steam-resistant plastics. No cloth.

**Cycle 3:** Porous materials. 134°C, cycle duration approx. 45 minutes. For packaged instruments, laundry and materials which are difficult to deaerate.

**Cycle 4:** Porous materials. 121°C, cycle duration approx. 1 hour. For firm, temperature-sensitive materials with a porous surface.

Before the autoclave is filled a vacuum test (cycle 8) must be run and, if this is the first time the sterilizer is being used on that particular day, a pre-heating phase (cycle 7). Pre-heating is particularly important when sterilizing heavy, tightly packed containers.

After this has been done the chamber can be filled with the goods to be sterilized. The cycle is started by pressing the appropriate number and then the “start” button. Once the cycle is complete the door must be opened **all the way**. Otherwise the autoclave is not released for the next cycle, even when the door is closed. Careful - the freshly sterilized containers are hot! Wear protective gloves!

Right after the sterilization cycle is completed the batch documentation is printed (pressure and temperature). Since the air in the sterilization room is quite humid, the printer paper should be stored outside the room. The paper is put into the printer one sheet at a time and checked to make sure that it feeds properly. The documentation should be completed by filling in the name of the operator, date, and a brief description of the sterilized goods and then filed in the appropriate notebook.

If the sterilized containers are stored in a clean place it is safe to assume that they will remain sterile for several months. Airtight cabinets can extend this period of sterility to 2 years and longer.

### Chemical (gas) sterilizers

Gas sterilization using E.T.O. (ethylene oxide) gas, is dependent upon (1) the concentration of the gas being used, (2) the temperature inside the chamber, (3) the humidity level, and (4) the exposure time. In general, E.T.O. gas concentrations range between 450 and 800 mg/L of chamber space, and operating temperatures range from 108°F (42°C) to 132°F (55°C) with at least 50% humidity, but not less than 30% percent in order to hydrate the items during the process (forty (40%) percent is recommended during the sterilization cycle). The duration of the cycle varies; it usually takes 2 to 6 hours for the sterilization cycle to be completed. However, the process does not end here. The items must be aerated before returning the item for animal use.

### Preparing items for ethylene oxide sterilization

Items to be sterilized by E.T.O. require special preparation before being exposed to the gas sterilant. All items must be cleaned and completely dried, as water may unite with E.T.O. to form ethylene glycol, which is not eliminated by aeration and may result in toxic reactions in animals and personnel. Lumens of tubings, needles, and so on should be air dried and left open at both ends to avoid any accumulation of gas inside the item.

Some of our instruments and several items related to the implants must be sterilized in ethylene oxide because autoclaving can cause blunting, corrosion, and/or deformation due to extreme heat. Only those objects are to be sterilized in the gas sterilizer that cannot be reliably sterilized by any other method and whose sterility and desorption characteristics are known. As a rule, this information must be supplied by the manufacturer. Goods sterilized with ethylene oxide can only be used without posing a risk to us and the animals if the mandatory desorption times are observed.

All items that are to be ethylene oxide sterilized must be washed and dried. If atmospheric humidity is less than 30%, rewash the items or place them in a closed pack with a wet towel for an hour. Items to be sterilized are packed in the paper/plastic pouches made for this purpose. These are available in a variety of sizes. One indicator strip is placed in one of the pouches and another is put in loose with the entire batch. The indicator changes color when exposed to E.T.O. After being filled, the pouches are carefully sealed with a heat sealer. Do not overstuff the packages and always be sure that sharp items are packaged in such a way that they do not puncture the pouch while being handled. Since condensation can form that has to be able to drain, hollow objects must be placed in the sterilizer basket with the open end down. Tubes are to be placed so that both ends face down. If at all possible, everything should be placed upright, foil to paper, and not packed too tightly in the open wire basket. The goods to be sterilized must not touch the walls of the sterilization chamber.

For gas sterilization we use the MMM Kombimat 349 with a chamber size of 110 liters. It is fully automatic and uses the negative pressure method with a combustion unit to dispose of the E.T.O. This makes it substantially safer than older models. The door can only be opened after the completion of the program cycle. This safety feature functions even with a power outage.

The gas sterilizer may be operated only by persons trained in its correct usage and under supervision of an expert!

We use two sterilization cycles:

**Cycle 1:** E.T.O. sterilization at approx. 42°C (duration approx. 5 hours excluding aeration)

**Cycle 2:** E.T.O. sterilization at approx. 55°C (duration approx. 3 ½ hours excluding aeration)

The mandatory aeration following sterilization takes about 6 hours.

To start the cycle, press the numbered button for the desired cycle and open the chamber door. The ethylene oxide gas cartridge (up to 20 cartridges may be stored under the sterilizer) is carefully placed in the holder on the inside of the door. *Do not puncture!* Place two one-liter bottles of distilled water in the dispenser compartment and snap into place. Close the door.

The sterilizer heats up automatically. When the “ready” light comes on (“betriebsbereit”), press the start button. The cycle will now run automatically until the aeration period is completed. The display will then show the message “Ende-Taste betätigen” (“press stop button”) and a buzzer will sound off for 5 seconds. When the stop (“Ende”) button is pressed the sterilizer is quickly evacuated and ventilated one more time. The buzzer will sound again. The door unlatches for two minutes, after which it locks again and another aeration cycle starts.

This means that at this point the sterile goods can remain in the sterilizer until they are needed. When the chamber has been emptied and the empty cartridge put into the garbage labelled “Restmüll”, the chamber door can be closed and the reset button can be pushed. The sterilizer is now ready for the next batch.

The sterilization parameters temperature (blue, given in °C) and pressure (red, given in mbar) are automatically recorded during the sterilization process. The printed protocol is to be labelled with name of operator, date and a short list of the good sterilized. It is then filed in the loose-leaf notebook provided for this purpose.

Gas sterilization requires at least 9 ½ hours and is usually started 48 hours before surgery to allow ample time for ventilation (including multiple aeration cycles). Metal and glass items do not need to air, but anything absorbent (plastic, rubber, etc.) must air out. If the manufacturer does not supply this information, the safe times for aeration of items sterilized in ethylene oxide can be found in the ‘Textbook of Small Animal Surgery’ by Slatter (Slatter, 1985).

Double packaging does not substantially prolong sterility and is not used by the University of Tübingen hospitals. Sterile shelf life is at least 4 weeks. According to studies carried out at the University of Heidelberg, it can be as long as 7 years.

## List of items to be E.T.O. sterilized for MPI procedures

1. Used 316L Regular Weck Stapler (if exists)
2. Used 316L Wide Weck Stapler (if exists)
3. Weck Staple Remover
4. All remaining hemostatic skin clips
5. DeBakey Felts
6. Plastic tweezers
7. Bulb syringes for irrigation
8. Eyecoil test leads
9. Used monopolar coagulator cord
10. Implants and eye-coil connectors
11. Allen wrenches (if not rust-free)

### Sterilizing by Soaking

Eyecoils can only be sterilized in a liquid such as Lysetol, because the Teflon coating does not respond well to ethylene oxide. If the procedure involves the placement of an eyecoil, the eyecoils should be placed into Cidex at the beginning of the setup procedure. They require 45 minutes to sterilize and will be ready to be rinsed and placed on the sterile field just before the start of the procedure.

## Disinfection and Disinfectants

### Basic Concepts

A *disinfectant* is an agent that kills growing bacteria and (to some extent) spores. The two major purposes for disinfection are to kill pathogenic microorganisms on inanimate surface and objects that cannot be sterilized, and to prevent or arrest growth of microorganisms on body surfaces through the application of an antiseptic solution. Disinfectants are identified as bacteriostatic, which act by inhibiting growth, or as bactericidal, which will kill bacteria (sporicides, virucides, fungicides). The terms germicide and bactericide may be used synonymously with disinfectant according to this definition.

Disinfection differs from sterilization by its lack of sporicidal power, and agents are labeled according to their efficacy in killing fungi (fungicide), viruses (virucide), and/or spores (sporicide). Disinfection can be accomplished with chemical and physical agents. The application of a disinfection agent depends on the level of risk of infection, and on the environmental contamination. Commonly the levels are:

*Low- to intermediate-level:* House keeping disinfection of surfaces such as floors, walls, furniture, and large equipment, and non-critical items that ordinarily do not touch the patient or contact only intact skin.

*High-level:* Disinfection of the semi-critical items that come in contact with non-intact skin or mucous membranes but do not penetrate body tissues (i.e., endoscopes, respiratory equipment, and thermometers). Critical items, that is, items that will penetrate body tissues must be sterilized; not disinfected.

High-level disinfection must not be confused with chemical sterilization. A record of the agent and time of exposure should be maintained for semi-critical items that have been high-level disinfected. The level of disinfection that can be achieved depends on the type and concentration of the agent, contact time, and bioburden (the organisms that must be killed).

The nature of microbial contamination influences the results of chemical disinfection. Bacteria, spores, fungi, and viruses are present in air and on surfaces throughout the environment. However, organic soil, blood, plasma, pus, feces, and tissue, absorbs germicidal molecules and inactivates some chemicals. Therefore good physical cleaning before disinfection helps reduce the numbers of microorganisms present and enhances biocidal action.

Items that are disinfected must be “patient safe” for their intended uses to minimize risks of infection for the patient. An all-purpose disinfectant does not exist. The best housekeeping agents are not the best instrument disinfectants and vice versa. All chemical disinfectants to be used in a surgical setting, however, must be effective against *Staphylococcus aureus* (gram-positive), *Salmonella choleraesuis* (gram-negative), and *Pseudomonas aeruginosa* (gram-negative), the most resistant gram-positive and gram-negative organisms.

Microorganisms differ markedly in their resistance to chemicals. Most vegetative bacteria, fungi, and lipoprotein viruses, including HIV are susceptible to such *low-level* disinfection agents such as Mercurial compounds, Phenolic compounds, or Chlorine compounds.

Intermediate-level disinfection agents are required to kill *Mycobacterium tuberculosis* which has a waxy envelope that makes it comparatively resistant to aqueous germicides. Agents effective enough to be tuberculocidal will kill HIV. Hepatitis B virus (HBV) cannot be adapted to lab testing, but it is known to survive exposure to many disinfectants. Alcohol (70% or higher, or isopropyl) and Alcohol/formalin (8% formalin with 70% isopropyl alcohol) are effective against the above-mentioned organisms.

Bacterial spores are tremendously resistant to disinfectants and a *high-level* agent, such as 2% activated alkaline glutaraldehyde aqueous solution, is required to kill them. The following table indicates the disinfectant, its classification, mechanism of action, and our particular application for the disinfectants used at the MPI-BC.

## Disinfectants Used at MPIK

<i>Agent</i>	<i>Classification</i>	<i>Mechanism of Action</i>	<i>Use at MPI-BC</i>
<b>Lysetol AF</b> (35%Phenoxypropanole, 2.5% Benzalkoniumchloride)  <b>AbcoCide S</b> (2% activated alkaline gluteraldehyde)(US,only temporary use)	Vegetative Microorganisms, Tubercle bacilli  Spores-10hr	Denaturation of proteins	Disinfection of instruments (10 min), sterilization of eyecoils (10 hrs).
<b>Terralin</b> (20% Benzalkonium-chloride,35% Phenoxypropanol)	Vegetative Microorganisms, Tubercle bacilli, Spores	Denaturation of proteins	Cleaning surfaces in the OR
<b>Betaisodona soap</b> (brown bottle, 7.5g polyvidone iodine=10% active iodine)  <b>EZ Scrub</b> (1% active iodine)  <b>Sterilium</b> (Propanol, Mecetronium etilsulfate)	Antisepsis: 1min  Bacteria, Fungi, Tubercle bacilli, Herpes type 1, 2, HIV, Hepatitis B (5min), Rotar-viruses(30 sec)	Oxidation  Denaturation	Human skin  Scrubbing of hands
<b>Skinsept F</b> (70% Propanol, 0,5% Chlorhexidindigluconat, 0,45% H <sub>2</sub> O <sub>2</sub> )	Bacteria, Tubercle bacilli, Fungi, Herpes, Hepatitis B, HBV, Aids	Denaturation	Skin, Dura
<b>Betaisodona</b> (11% active iodine, green bottle)  Dilutions: 1% iodine→Paint  0,75% iodine→Scrub	Desinfection: 5 min	Oxidation	Skin around implants, wounds, bites
<b>Betaisodona</b> (1% active iodine)		Oxidation	Implanted chambers and headposts
<b>Isopropylalcohol</b>		Denaturation	Prep benches in the setup rooms
<b>Deso Wash</b>			Normal medical soap

## Surgical Attire

Surgical attire is considered to be the appropriate head covering, shoe covers, gloves, gown, and surgical mask. All possible head and facial hair, including sideburns and neckline, should be covered before entering the operating room (O.R.). Long hair should be up, underneath the head cover, and men with beards should wear a full head cover, if necessary, to cover facial hair. Shoe covers should also be worn by all personnel entering the O.R.

Since large numbers of potentially pathogenic microorganisms reside in the respiratory tract, a high-filtration mask, covering both the nose and mouth, should be worn at all times while in the procedure rooms or nonsterile and scrub areas. Masks must be changed between each procedure, if they become moist or wet, or both. While wearing a mask, conversation should be kept to a minimum to prevent moisture build-up. Masks should be removed by the strings and properly discarded before leaving the procedure room. Masks are never worn outside the surgical suite. Masks should fit snugly around the nose and chin, and tied securely to prevent accidental slipping during a procedure.

## Scrubbing

All sterile team members perform a surgical scrub before entering the procedure room, to remove gross dirt from their hands and arms prior to applying their sterile gown and gloves. Scrubbing is the same for all members of the

sterile surgical team. Since the scrubbed team members receive sterile equipment from the circulator (nonsterile member), and since sterile can only touch sterile, a bacterial barrier is needed between the circulator and the sterile item. That bacterial barrier is the sterile gown and gloves.

The goals of the surgical scrub include: (1) mechanical removal of soil and transient microbes from the hands and forearms, (2) chemical reduction of the resident microbial count to as low a level as possible, and (3) reduction of the potential rapid rebound growth of microbes. All personnel should meet specific requirements prior to beginning the surgical scrub. The antimicrobial soap or detergent should be effective. The procedure used to accomplish the surgical scrub should be the same for all personnel. An anatomic time scrub or counted-brush-stroke method should be used for all surgical scrubs. The surgical scrub is performed after proper preparation by the person performing the scrub. Skin and nails should be kept clean and in good condition. Fingernails should be short (not reaching beyond the finger tips), and polish free. Jewelry, including watches, rings, and bracelets, should not be worn. Hands should be inspected for breaks in the skin, which could become an entry for microbial contamination. A clean scrub suit, a cap covering all hair, including facial hair, and a high filtration mask are required by all personnel prior to performing the scrub procedure. Both the iodophors and chlorhexidine gluconate are common agents used for the surgical scrub procedure. They are prepared in combination with detergent to give a cleaning action along with the antibacterial action.

According to the latest information, a 5 minute surgical scrub of the hands and forearms is adequate for removal of gross dirt and oils from the skin, as long as mechanical friction combined with an antimicrobial agent are present. We, therefore, practice a standard 5 minute scrub.

The region to be scrubbed extends from the finger-tips to 2 inches from the elbows. The arms, bent at the elbows, must remain vertical with the hands always being above the elbows. This prevents contaminated water from the region of the elbows and upperarms from flowing down over the scrubbed region. Before scrubbing, all jewelry, watches, etc., must be removed. It is best if finger nails are clipped short, and they should extend no farther than the tip of the finger. It is a good idea to wash one's hands up to the elbow with soap and water before beginning.

Open a scrub pack, remove the sponge/brush and nail cleaner but do not set either down. While cleaning under the nails, let the water run over the hands and down, dripping off the elbows. It is best to position oneself so as not to get one's scrubs wet. Once the nails are clean, discard the cleaning spear and work up a lather on the sponge by squeezing it several times. Then, starting with the palm of one hand, beginning lathering the region to be scrubbed. The hand can be divided into 4 surfaces, as can each of the fingers, and the arms. Each is considered to have a top, bottom, and two sides. Each surface of all three regions needs to receive an equal amount of attention, about 5-10 strokes of the sponge. The lathering should proceed from fingers to elbow of one arm, and then from fingers to elbow of the other. The sponge is then flipped over, and the brush is used from this point on.

The brush is placed in the starting hand, and each of the surfaces of the first hand are scrubbed again, spending the same amount on each as mentioned above. This time, however, scrubbing proceeds only until 5 cm below the wrist. At this point the brush exchanges hands, and the opposite hand is scrubbed from finger-tips to 5 cm below the wrist. Then the brush is changed back and the first arm is scrubbed from below the wrist to the elbow. The brush again changes hands and the second arm is scrubbed from wrist to elbow. The brush is then discarded. While still holding the hands upright above the elbows, the hands are rinsed such that the water flows from finger-tips down the forearm and drips off the elbow. If at any point at starting the scrub procedure the scrubbed region comes into contact with anything nonsterile, the entire procedure must be redone. Once scrubbed, the scrub person must gown and glove themselves.

## Gowning

The gown must already be open on a sterile field. The scrubbed person approaches the sterile field and must now be careful not to touch anything unsterile and not to drip on anything. The towel is picked by an exposed corner (or handed to a nonsterile person by a sterile person) and opened by gentle shaking in an area of the room where there is no danger of contamination. The hands are dried, one at a time, by using one half of the towel to pat one hand

dry from fingers to elbow. Do not rub the towel around or up and down the arm. Dry around and between the fingers first, then proceed down the arm to the elbow, patting only, and do not move back up the arm. After one arm is dry, use it to grab the other half of the towel in a sterile region. Flip the towel over so the used portion is on the bottom, and repeat the drying procedure on the other arm using a sterile part of the towel. Then discard the towel into a waste bin or onto the floor. If one is being assisted during gowning, the gown will be held up so that one's arms can be slid directly into the sleeves. The person assisting must be certain to keep their hands on the sterile front of the gown at all times and protect themselves from contamination. The neck snap will always be fastened by a nonsterile member of the team. If, however, one is gowning themselves without assistance, the following must be done.

Identify the sleeve openings of the gown, place your hands in the openings, pick up the gown without letting it unfold, and back away from the sterile field into a clear area of the room. Hold the gown up, with your hands in the sleeve openings, and allow it to unfold while slipping your arms into the sleeves. Do not go all the way to the end of the sleeves as the outer aspect of the sleeve ends must remain sterile to manipulate the gloves and tie off. The circulator should now snap the neck snap and tie the secondary tie in the back of the gown. With the hands still in the sleeves, offer one end of the primary tie (the end with the card) to the circulator while holding onto the other end of the tie. Spin around and pull the end of the tie (which is in the card held by the circulator) free from the card and tie the gown closed. Always be aware of your surroundings to avoid contamination.

The parameters of sterility for the gown have been established: (1) The gown is considered sterile in front from chest to the level of the sterile field. (2) The sleeves are considered sterile from 2 inches above the elbow to the stockinette cuff, and therefore the cuff must be covered, at all times, by sterile gloves. The areas not considered sterile, for various monitoring reasons, include the neckline, shoulders, areas under the arms, and the back of the gown. To preserve the sterility of the gloved hands, they should be kept within the sterile boundary of the gown, and since the axillary region is not sterile, the arms should never be crossed with hands positioned into the axilla. Should either of these barriers be compromised, they must be discarded, and a new gown, gloves or both applied, depending on the nature of the break in technique.

## Gloving

Sterile gloves can be applied using one of two methods: the open method or the closed method. The closed-glove method should be used anytime the person is initially applying sterile gown and gloves, while the open-glove method should be used when changing a glove during a procedure (self or team member), or when a sterile scrub or gown is not required (aseptic procedures). The scrub person must perform unassisted gowning and gloving, while the rest of the sterile team members will be assisted by the scrub person (assisted gowning and gloving).

When gloving oneself using the closed glove method, the procedure goes as follows. With your hands still in the sleeves of the gown, open the glove package completely. The fingers of the gloves should be pointing toward you. You will glove your preferred hand first. Reach across the field with your preferred hand to the appropriate glove, and slip your thumb under the cuff with your fingers extended toward the opening (away from the fingers of the glove). Pick up the glove, and grabbing the opposite side of the cuff with the other hand, slip your fingers into the opening while pulling the glove onto your hand with the opposite hand. Always touching the surface of the glove through the gown (not the stockinette cuff, as it is considered unsterile), pull the glove onto your hand, maneuvering your fingers and thumb appropriately. It is best to touch the distal regions of the glove as little as possible. The gown can be pulled out from under the glove in order to help get it on, however, the stockinette should not be exposed. Once the first hand is gloved, the second glove can be picked up by slipping the fingers of the gloved hand under the cuffed region of the other glove. The fingers of the second hand are now exposed from the gown sleeve and slipped into the glove opening, being careful not to touch any external sterile surface (in particular the hand doing the gloving). Now the glove can simply be pulled on and over the stockinette cuff of the gown sleeve.

When gloving another member of the team, the sterile internal package containing the gloves is offered to the sterile member of the team who will do the gloving or is transferred, maintaining sterility, onto the sterile field where it can be accessed by a sterile member of the team. The package is opened, and a glove is removed. The glove is held by the cuff with the fingers of the sterile person under the fold. The glove is held with the fingers

dangling downward, and the cuff is stretched open allowing the nonsterile member of the team to reach into the glove without danger of touching the fingers of the sterile member. The glove is pulled up over the stockinette of the gown and then released. The procedure is repeated for the other hand.

## Surgical Tools

### Instrument Metals

Today, all quality surgical instruments are fabricated from medically graded stainless steel. Of the standard stainless steels produced, only a few are used in hospitals. Of these, the 300 and 400 series stainless steels are most often selected for surgical instrument production.

Stainless steels consist primarily of iron, chromium, and carbon, with other elements such as nickel combined in different proportions to achieve desired properties. The higher carbon, lower chromium 400 series (martensitic) stainless steels provide greater hardness through heat treatment. This imparts wear resistance which is especially important for cutting surgical instruments; they must maintain fine edges and exhibiting the strength and durability of stainless steel. The hard martensitic stainless steels are used most commonly in the manufacture of surgical instruments.

The austenitic, or 300 series, stainless steels are not hardenable by heat treatment but are occasionally used for surgical instrument manufacture. The lack of hardness exhibited by these alloys is offset somewhat by their higher resistance to corrosion. Austenitic steels are of greatest value when some degree of malleability in an instrument is desired.

A few surgical instruments are made primarily of titanium alloys. They are used most commonly in microsurgical instruments. They are said to have excellent corrosion resistance (comparable to that of stainless steels) and high temperature strength (comparable to that of austenitic stainless steel). The internal structure makes these alloys somewhat brittle, and this can present manufacturing problems. Its greatest use may be as a substitute for stainless steels when weight saving is important.

Tungsten carbide inserts add a new dimension to gripping and cutting surfaces. These substances are very hard and very resistant to wear. The inserts are attached to the stainless steel instruments by various means and can be removed and replaced by the manufacturer.

### Resistance To Corrosion

Producing a surgical instrument that is resistant to staining and corrosion begins with selecting the proper steel. A smooth surface is desired and is achieved by buffing and polishing. Three types of instrument finishes are presently available. The highly polished finish seems most resistant to spotting and discoloration; however, it reflects light easily and can cause mild eye irritation. More recently a dull or satin finish has become popular; its greatest advantage is reduced eye strain. The dull finishes are applied by silicone or glass-bead sandblasting or by fine abrasion using various types of polishing wheels. The third type of finish, a (black) ebonizing finish, is achieved by coating the instrument in a chemical bath.

The final process instruments go through to become corrosion resistant is passivation. This process (nitric acid bath) removes any foreign particles (iron) imbedded on the instrument surface. Additionally, a thin layer of chromium oxides forms on the stainless steel surface, providing more corrosion resistance. A subsequent polishing is usually needed to produce a very smooth surface, removing any rough sites where corrosion could begin.

Once an instrument is used it can further passivate itself. Exposure of an instrument to the atmosphere or to certain oxidizing agents during its handling and use can continue this oxidation process, building and maintaining the continuity of the chromium oxide layer. Certain cleaning and handling processes can damage this protective layer and should be avoided. Abrasive cleaners and instrument marking with vibrating etching equipment can disturb the oxide layer, promoting the development of corrosion. Once the chromium oxide layer is altered and corrosion begins, repassivation and repolishing by the manufacturer become necessary.



## Instrument Cleaning

Instrument cleaning and handling technique is extremely important for either hospitals or laboratories, as it saves enormous sums of money in yearly instrument replacement. Proprietors of hospitals and laboratory technicians are usually aware that surgical instruments are expensive, delicate, and must be handled correctly in the operating room to ensure longevity. A sometimes forgotten fact, however, is that inappropriate cleaning and sterilizing have a significant impact on instrument life. Most instrument manufacturers provide detailed information on the cleaning and handling of their product. Their recommendations should be followed. Here we give a brief description of the techniques that will be used in our laboratory.

### Manual Cleaning

Gross visible debris should be removed from the instruments immediately after their use. Saline solution is very corrosive to stainless steel; consequently, distilled or de-ionized water should be used for the initial removal of debris. Subsequent instrument cleaning will then be easier, as blood and tissue debris do not have a chance to dry in serrations and box locks. If further processing is not immediately possible, instruments should be submerged in warm de-ionized water that contains a mild noncorrosive, low-sudsing, neutral detergent. Adequate soaking time allows the detergent to loosen inaccessible soil films. Prolonged soaking must be discouraged, however, as detergent action on the instrument surface may cause damage.

The final cleaning process should be conducted with care. Each instrument is carefully scrubbed, including the box locks, ratchets, serrations, and other areas not easily exposed. A hand brush with stiff plastic bristles is appropriate for cleaning. Abrasive tools or cleaners should be avoided, however, as repeated cleanings can damage the instrument's surface and promote corrosion. A moderately alkaline (pH<8), low-sudsing detergent is most satisfactory. Ordinary soap should not be used, especially with hard water, as insoluble alkali earth films can form on the instruments, protecting trapped bacteria from sterilization.

The final rinse should be carried out thoroughly with distilled or de-ionized water. It has a pH of 6.7 to 7.2 and leaves a neutral surface pH as the alkaline wash water residue is rinsed away. Alkaline earth deposits (calcium, magnesium, phosphate) and metals (iron, copper, cadmium) will not deposit themselves on the surface to promote corrosion. Distilled water also contains no dissolved or undissolved solids to adhere to the instrument surface.

The instrument must be dried completely, especially if it is to be stored for a period of time prior to sterilization. The heat of hot rinse water may aid the drying process. Inadequate drying will result in rusting during storage.

### Washer-Sterilizer

Institutions that process large volumes of surgical instruments have adopted mechanical methods for routine cleaning. The washing process is accomplished in an instrument washer-sterilizer by means of a vigorously agitated detergent bath, the result of a combination of high-velocity jet streams of steam and air, which produces violent underwater turbulence. The machine has presoak, wash, and sterilize cycles, after which the instruments may be removed and immediately used or stored for future use. Many factors influence the effectiveness of soil removal from surgical instruments cleaned in a washer-sterilizer, including the kind of soil, quality of water, type of detergent, concentration of detergent, types of instruments to be cleaned, time the detergent solution is permitted to act, and efficiency of the washer-sterilize

Blood, tissue fats, and other organic matter are common types of soil encountered on surgical instruments. Better cleaning in the washer-sterilizer is achieved when soil is not allowed to dry on the instruments and processing occurs shortly after use.

Water plays a major role in cleaning and alone accounts for much of the solvent action that occurs during instrument cleaning. The quality of tap-water in many areas is poor, and careful consideration should be given to matching water quality with the appropriate detergent. Softened, demineralized, or distilled water should be considered to eliminate the deposition of hard water salts on instruments.

A good, low-sudsing, neutral to slightly alkaline detergent is strongly recommended. According to Perkins, some of the common phosphate detergents recommended for mechanical dishwashers are ineffective in washer-sterilizers. Cleaning of the instruments is not adequate, and the polyphosphated detergents have a solubilizing effect on internal copper in the washer-sterilizer. The result is a brassy metallic staining of the instruments due to copper deposition by electrolytic action.

The type of surgical instrument, its configuration, and its condition play a major role in cleaning effectiveness. It has been demonstrated quantitatively that soil retention is greatest with instruments with a poor geometric configuration and those whose serrated tips showed visible corrosion. They showed that corroded serrations and cavities near the hinges of worn joints were particularly effective in retaining soil and that there is a clear correlation between soil retention and the microscopic state of the instrument surface.

Finally, the washer-sterilizer affords a degree of protection to those who clean surgical instruments. Manual cleaning contributes to the dissemination of microorganisms by aerosols and droplets during the cleaning process, whereas automated mechanical cleaning controls this problem.

### *Ultrasonic Cleaner*

Ultrasonic cleaners can remove up to 90 per cent of instrument soil in five minutes and far surpass manual cleaning procedures. This is demonstrated by the effective removal of soil from areas that are inaccessible to brushing such as box locks, deep grooves, serrations, and even cracks in the instrument. Ultrasonic cleaners do not sterilize.

Ultrasonic instrument cleaners produce sinusoidal energy waves at either of two frequencies. If metallic transducers are used, the frequency of vibrations is 600 per second. If crystal transducers are used, the frequency of vibrations is 38,000 per second. The latter unit is believed to be the more efficient.

The effectiveness of ultrasonic cleaning is based on a process called *cavitation*. Ultrasonic energy forms minute bubbles from gas nuclei within the cleaning solution. These minute bubbles form on every surface of soiled instruments. The size of the gas nuclei and subsequent bubbles formed depends on the surface tension of the liquid, temperature of the solution, wetting action of the detergent, and the frequency of the ultrasonic energy used. These bubbles continue to expand until their surface becomes unstable. They then collapse by implosion (bursting inward). The bubbles implode as fast as they form, creating small vacuum areas. This process releases energy that breaks the bonds that hold soil to instrument surfaces. The soil and binding material are dislodged or dissolved into the solution.

The effectiveness of an ultrasonic cleaner can be altered by many variables, including temperature, gas content of the solution, and the detergent used. The temperature of the bath solution should be kept below 60°C to prevent protein coagulation. Coagulated protein tends to absorb ultrasonic vibrations, which reduces the energy available for bond breaking and makes the soil more difficult to remove. Bath solutions containing too much dissolved gas lose cleaning effectiveness because the gas fills the cavitation bubbles. This cushions the shock due to implosion and reduces the energy released. Water can be de-aerated by running the ultrasonic cleaner for five minutes before use or letting the water stand overnight. Detergent specifically formulated for ultrasonic cleaners should be used because they decrease aeration problems. In addition, the detergent is chosen for its cleaning abilities and its chemical effects on the instruments being cleaned. Highly alkaline or highly acid detergent should not be used, as they can induce corrosion or cracking, which can lead to early instrument failure. The detergent should have a neutral pH, contain a wetting agent, and be low sudsing and free rinsing. Finally, the proper concentration of cleaner should be employed, since the heat of the ultrasonic cleaner increases the strength of the cleaner. If too much detergent or heat is employed, the cleaning solution can become very caustic. This leads to removal of the chromium oxide layer, which is so important in corrosion resistance. The impassivated instrument is then susceptible to rusting and breakage.

Instruments removed from an ultrasonic cleaner must be rinsed thoroughly. The cleaner effectively removes the soil into solution or suspension, and when the instruments are removed they become covered with this finely dispersed soil. This soil, although not always visible to the eye, must be rinsed away. Rinsing also removes residual

detergent that may be present. Dissimilar metals should not be processed together in an ultrasonic cleaner. Stainless steel should not be mixed with brass, copper, or aluminum, otherwise electrolytic etching and redeposition may occur. Chrome-plated instruments that show pitting or flaking can be further damaged in an ultrasonic cleaner.

### **Instrument Lubrication**

Surgical instruments with box locks often become stiff with repeated use, especially if cleaned inadequately. Dried blood, alkaline deposits, and debris can build up in box locks and serrations. Autoclaving bakes this material on the instrument, further retarding movement. Cleaning procedures, when employed properly, help to prevent this problem.

Instrument lubrication is commonly practiced but can present problems if not properly performed. Mineral oil, machine oils, grease, and some silicones must be avoided, as they leave an oily film on the instrument surface. This can prevent adequate steam contact with organisms, and spores can become trapped in the oil film during steam sterilization. Continuous use of these materials can also leave undesirable residues on the instruments that become gumlike and retard box lock movement.

Instrument manufacturers recommend the routine lubrication of instruments with antimicrobial water-soluble lubricants (instrument milk). These lubricants are water-oil emulsion preparations that do not interfere with steam sterilization. Many also contain antimicrobial materials inhibiting organism growth in bath preparations. Rust-inhibiting agents provide an additional measure of protection by retarding electrolysis and preventing mineral deposition on instrument surfaces.

Mechanical instrument processing especially with ultrasonic cleaners, removes all traces of lubricant. Lubrication should therefore be carried out after cleaning. The lubricant bath should be prepared with de-ionized or distilled water at the manufacturer's recommended concentration. Instruments should be dipped in the bath for 30 seconds with box locks open. After removal from the bath, the lubricant solution should be allowed to drain away without rinsing or manual drying. The lubricant remains on the instrument during steam sterilization and storage. This gives added protection against rusting, staining, and corrosion.

### **Instrument Packaging**

Proper instrument packaging and storage are important considerations for veterinary institutions and small clinics. Universally accepted standards for instrument packaging have not been established. Problems are compounded by manufacturers who are continually developing new and often better packaging products. Packaging materials used frequently today are classified as textiles (linen and muslin), nonwoven fabric, paper, plastic, and paper and plastic combinations.

#### ***Textiles***

Linen or muslin wrappers are most commonly used for instrument set packaging. Standard, double-thickness, 140-thread count linen is flexible, easy to use, memory free, and long lasting. The weave of one thickness is perpendicular to the other, and the wrap is sewn at the edges only. Linen packs are easily contaminated by contact with moisture, and the contamination becomes undetectable after the moisture dries. Laundry procedures must be carefully monitored. If harsh detergents not adequately rinsed from the fabric come in contact with stainless steel instruments, staining and corrosion can be induced.

The necessity of double wrapping surgical packs with two-layer linen has been repeatedly demonstrated. Photographs of a single-thickness standard muslin at 40 X magnification demonstrate a small opening at almost every thread junction. Single wrapping with two-layer linen can allow microbial penetration of the pack within three days. Double wrapping with two-layer linen increases safe storage time to three to four weeks. Longer storage time may be obtained by using outside (dust cover) wraps of water-repellent paper drape fabrics or sterile 3-ml plastic bags.

Open shelf storage of sterile packs has been shown to allow up to ten times more viable microbial contamination of the outside of the pack than closed shelf or cabinets storage, thus reducing safe storage time. Other factors also have been incriminated in surgical pack contamination. Unnecessary handling and vibration should be minimized along with rapidly changing atmospheric conditions.

Finally, double wrapping of sterile packages provides a margin of safety during package opening. Microbiological contamination that has settled on a package is thrown into the surrounding air during opening making contamination of contents very likely. A second wrap greatly reduces this risk.

Consideration can be given to the use of 288- thread count linen. This material has twice the thread per inch as the standard 140-thread count general use linen. A single thickness of this material can replace the standard double-layer wrappers. This wrap is a good moisture retardant and is an improved barrier to microbiological and liquid penetration over 140-thread count linen. Good penetration of sterilants is allowed, although as a general rule the higher the thread count the less penetration by steam. The major disadvantage of this moisture-retardant linen is its higher cost.

### *Nonwoven Fabrics*

Nonwoven wraps are a product of disposable surgical drape programs and offer some advantages over general use linen, including reduced labor and laundry costs. Nonwoven wraps are water resistant, strong and tear resistant. Sterilants such as ethylene oxide and steam penetrate readily and do not change the handling characteristics or quality of the material for use as a wrapper or drape. Although product quality excellent, nonwoven fabrics should be used as disposable items. Repeated sterilization can result in breakage of fibers, especially along folds in the material, which could result in pack contamination.

Nonwoven fabrics are available in light, medium, or heavy weight. The lightweight material does not withstand handling well and is not recommended for operating room packaging. The medium-weight wrapper material is best suited for sterile packaging wraps.

### *Paper Wraps*

Paper wraps have come into wide use as replacement for linen. Several disadvantages are recognized, however. Like linen, paper has good wick action and can absorb moisture and dry quickly, making it difficult to detect a contaminated pack. Also, paper has memory and will not open flatly. The paper flips back along fold lines, often resulting in contamination during opening. Paper wraps should not be re-used, as minute cracks in the paper fabric are difficult to detect and can easily compromise sterility. Personnel should be aware of these sources of contamination when using paper drapes.

### *Plastic Wraps*

Plastic wraps usually come in pouches pre-sealed by the manufacturer on two or three sides. Their greatest use is in individual article packaging. Polyethylene, polypropylene, and polyvinyl chloride pouches are produced only for ethylene oxide sterilization, as they may be heat sensitive and impermeable to steam. Detailed opening instructions are necessary, as sterile removal of items from these pouches is difficult. Plastic wraps can also be used as dust covers on previously sterilized muslin- or paper-wrapped surgical packs that are stored for variable periods before use. Any plastic cover used for this purpose that has accumulated dust should be removed before the surgical pack is placed inside the clean zone of the operating room.

### *Plastic and Paper Wraps*

Plastic and paper combinations are used extensively. They offer several advantages. Materials are available that withstand steam and ethylene oxide sterilization. Good steam penetration and aeration is evident through the paper backing, and the article is visible through the plastic. Peel-back opening for presentation of sterile items lessens the possibility of contamination. Sealing of the pouch can be accomplished by sterilizer indicator tape or heat.

Dating and labeling of these packages with felt-tip markers should be done on the plastic side only, as puncture or ink bleed through the paper is possible. Also, sterile indicator tape should be placed on the plastic side, as the sterilize indicating device incorporated into the paper is often overlooked during opening.

## Neurosurgery Instruments

### *Surgical Knife Handles*

Surgical knife handles (Figure IV-1) with detachable blades are most popular. The Bard-Parker #3 medium handle is available with various scalpel blade attachments (#10, 11, 12, 15). This handle seems to be the most applicable for small animal surgery. The #3 handle is also available in a longer form. Fine handles #7 and #9 receive the same blades. The #4 Bard-Parker handle is larger and uses detachable blades #20, 21, 22. This handle-and-blade combination is more appropriate for large animal surgery.

### *Scissors*

Many types of surgical scissors are available for many different uses (Figure IV-2). Those most applicable for general surgical use in veterinary surgery are the Mayo and the Metzenbaum. Each surgery pack should have a scissors designated as a suture scissors. Repeated cutting of suture material with delicate tissue scissors, such as the Metzenbaum, leads to dulling and/or misalignment of blades. A short (5 inches) straight Mayo dissecting scissors without tungsten carbide inserts can function well. It is durable and will last a long time. Special wire-cutting scissors should be employed for orthopedic wire cutting. Tissue dissecting (blunt and sharp) requires a high-quality tissue scissors.

The curved Mayo dissecting scissors with or without tungsten carbide inserts is excellent for connective tissue dissection and separation of tougher facial plains. The Metzenbaum tissue-dissecting scissors is more delicate and should be reserved for less strenuous dissecting and cutting. It would seem inappropriate to use a fine Metzenbaum to open the linea alba. Fine, delicate cutting, as required in hollow organ surgery or controlled delicate dissecting, would be more applicable to Metzenbaums. Tungsten carbide inserts and gold-colored handles designate the finest quality surgical scissors.

### *Retractors*

Many types of soft tissue retractors are available (Figure IV-3). A most useful classification would distinguish between hand-held and self-retaining retractors. The greatest disadvantage of hand-held retractors is the need for an assistant to manually retract the tissue. This inconvenience is significant in veterinary surgical procedures, where extra surgical assistants are often not available.

Self-retaining retractors offer the advantage of maintaining tissue separation once placed without additional assistants. The Finochietto rib retractor for thoracic surgery and the Balfour retractor for abdominal surgery are sturdy and very effective. These self-retaining retractors are necessities if adequate exposure to thoracic and abdominal viscera is to be achieved and maintained. The Gelpi and Weitlaner retractors are two smaller self-retaining retractors that offer versatility in tissue separation and exposure during surgical procedures.

### *Forceps*

#### *Halsted Mosquito Hemostatic Forceps*

Mosquito forceps are available in 3- and 5-inch lengths in both curved and straight configurations. These instruments are very delicate and should be used only for the control of point bleeders. Stump or pedicle ligations, where additional tissue is often included in the ligature, should be avoided, as damage to the instrument can result. Mosquito forceps have been recently introduced with rat tooth (1 X 2) teeth located at the very tip of the gripping blades. This modification prevents the instrument from slipping from the tissue it is holding. If the instruments are in good working order and are used for their intended purpose, this addition may be unnecessary.

### Kelly or Crile Hemostatic Forceps

These two forceps are very similar in design and use. The only difference is in the extent of the transverse grooves on their gripping surfaces. The Kelly forceps has only the distal half of its tips grooved. The intended use of these hemostatic forceps is similar to that of the mosquito forceps. However, they are larger (5,5 inches) and much sturdier so that they can withstand more aggressive use.

### Rochester-Carmalt Hemostatic Forceps

The Rochester-Carmalt hemostatic forceps is primarily used in veterinary surgery in stump or pedicle ligations. It is sturdy and the grooves on the gripping blades run longitudinally (with a few cross grooves at the tip), allowing for easy removal during ligation. When a Carmalt clamp is placed on a pedicle of tissue for crushing prior to ligation, the tissue is forced outward in the clamp and is, in effect, spread. When ligation occurs, the clamp must be loosened before the ligature is secured or the tissue cannot be drawn together to collapse the vessel being ligated. One must also keep this spreading effect in mind when ligating close to a second Carmalt clamp that has been placed. This spreading effect on tissue by the clamp can result in loose ligatures.

### Tissue Forceps

Tissue forceps of various sizes, shapes, and uses are available. Several have found extensive use as general surgical tissue forceps in small animal surgery.

### Allis Tissue Forceps

Allis tissue forceps (Fig. IV-5, bottom) are very popular in veterinary surgery. The plane of grip is perpendicular to the direction of pull. The tip of the Allis forceps has intermeshing teeth that provide a secure grip on tissue. The Allis is said to be atraumatic to tissue; however, this feature seems to be commonly abused. The Allis should be used to grip connective tissue and facial planes only. It should never be used to grasp the skin or to grip hollow organs such as the stomach. The crushing effect of this grip is too traumatizing for these delicate tissues.

### Babcock Tissue Forceps

The Babcock forceps is similar in design to the Allis except that there are no gripping teeth. Its uses would be similar to those of the Allis. The Babcock has received some use in hollow organ surgery; however, its grip may be excessively traumatizing. The more appropriate use of stay sutures to manipulate hollow organs would seem prudent.

### Kocher-Oschner Tissue Forceps

The Kocher-Oschner tissue forceps (Fig. IV-5) is very sturdy and can withstand aggressive use. The 2 x 1 rat tooth tip allows secure gripping of tissue. This instrument has very limited soft tissue use; however, orthopedic surgeons find the instrument helpful in manipulating bone fragments in fracture repair.

### Alligator Tissue Forceps

This special instrument is very delicate but provides a needed capability. The long shaft and pivot point near the tip or its jaws allow introduction and grasping through a small narrow opening. Removal of foreign bodies from ear canals and disc material during thoracolumbar fenestrations are appropriate applications.

### Right-Angle Tissue Forceps

The right-angle tissue forceps (Lahey gall duct forceps has longitudinal grooves on its gripping surface. It is very suitable for delicate dissection, especially in hard to visualize areas. The instrument is excellent for dissecting behind a patent ductus arteriosus and is used extensively in other thoracic surgeries.

### Adson Tissue Forceps

The Adson (delicate) (Fig. IV-6) is probably the most common tissue forceps in use. The 2 x 1 rat tooth tips are small and provide good tissue grip with minimal pressure on the blades. It is most applicable when suturing skin and facial planes. Although it is relatively atraumatic when used properly, better tissue forceps are available for hollow organ surgery.

### Brown-Adson Tissue Forceps

The Brown-Adson (Fig. IV-6) also has extensive use. It is similar to the Adson except for its tip. Multiple intermeshing fine teeth provide a broad tip for secure gripping. When suturing, this feature makes gripping of a needle being pulled through tissue easier than with the Adson. The Brown-Adson is relatively atraumatic if used properly i.e., on skin and facial planes only.

### DeBakey Tissue Forceps

Every surgery pack should have a delicate thumb forceps for atraumatic work. The DeBakey tissue forceps was initially developed for cardiovascular surgery. The tips are slightly ribbed in a longitudinal direction. Various widths (1 to 2 mm) on the tip and weights (delicate to regular) are available. This instrument is excellent for thoracic and abdominal surgery. Very delicate handling of a tissue being sutured is possible.

### Towel Forceps

The Backhaus towel forceps (Fig. IV-7) is used for securing surgical drapes to skin. It is also used to secure suction lines, electrocautery cables, and power equipment lines to drapes. Two sizes are commonly seen, and the smaller (3% inches) is more appropriate for small animal surgery. Some towel forceps (Roeder) have a metal bead or ball stop on their tips to prevent the drapes from moving up. The Jones towel forceps may be used in more delicate applications.

### Needle Holders

The most common needle holder used in veterinary surgery is the Mayo-Hegar needle holder (Figure IV-8). Various lengths (5 to 12 inches) are available. The smaller needle holders are more delicate and probably find greater use in small animal surgery. No surgical instrument receives greater abuse than the needle holder. Its use requires constant metal- to-metal contact. The size and weight of the needle holder selected should match those of the needle being used. Small needle holders can be damaged when used to grip large needles. If the ratchet is tightly applied the box lock or shank can be damaged. Small needles can be damaged or inadequately gripped if large needle holders are used. There is a great tendency, especially in orthopedic procedures to use the needle holder inappropriately. Using the needle holder to twist wire or as pliers leads to early failure.

The better-quality needle holders can easily be identified by the tungsten carbide inserts of their gripping jaws. These inserts greatly crease grip and durability. Some manufacturers also identify their better-quality instruments by gold- colored handles. Olsen-Hegar needle holders are a combination needle holder and scissors. They may have an advantage for the individual who is doing surgery alone. The suture material can be cut after placement without a suture scissors. The disadvantage of accidental cutting of suture material during suturing can be troublesome. Tungsten carbide inserts are available with the needle holder portion of the instrument.

### Maintenance of Neurosurgery Instruments

Periodic evaluation of instrument performance may indicate that preventive maintenance is needed. Instrument manufacturers stress the economics of preventive maintenance programs. Costs for restorations vary but can be as low as one-fifth replacement costs and one-half repair costs. A preventive maintenance program includes evaluating, refurbishing, adjusting, and refinishing each instrument. Carbide inserts are replaced if worn or cracked, tips of instruments are re-aligned, shanks and springs are adjusted for proper tension and conformation, ratchets and jaws are redefined and reset, cutting edges are sharpened, and all missing parts are replaced. After this complete

refurbishing each instrument is ultrasonically cleaned. Preventive maintenance programs for good-quality surgical instruments reduce costs and increase instrument longevity.

## Ophthalmic Surgery Instruments

### *Eyelid Specula*

Eyelid specula are designed to retract the eyelids and maximize the opening of the palpebral fissure. The ideal eyelid speculum should be strong, lightweight, and should not contribute to direct pressure on the globe. Part of each blade should extend over the eyelid margin along the palpebral conjunctiva for several millimeters to avoid the untimely dislodgment of the speculum. The larger eyelid specula usually have slightly curved arms to conform to the palpebral fissure. Occasionally the curvature of these specula is altered slightly to obtain the best fit for the monkey. The pediatric size Barraquer speculum may be usually appropriate for monkeys.

### *Tissue Fixation Forceps*

A large number of special tissue forceps have been developed to minimize traumatic handling of the ocular tissues. Their handles are usually flat with serration or knurling to facilitate grasp and are usually 50-100 mm long. These instruments are held like a pen during surgery. Several different tips have been developed for these fixation forceps. The handle or the tips of most fixation forceps for microsurgery have some angulation to prevent blockage of the surgeon's view during use. For handling of the eyelids at least two different types of tissue fixation forceps are useful. When handling large amounts of tissue, the Graefe fixation forceps with 3.5 or 4.5 mm jaws with fine teeth are useful. When manipulating small amounts of eyelid and conjunctival tissue, one of several types of fixation forceps with a 1 x 2 teeth tip is recommended. The bulbar conjunctiva is handled with fine, plain forceps without teeth to avoid excessive trauma and tearing. If the tissue is slippery or is handled at its margin, such as the edge of a corneal wound, tissue forceps with fine teeth (Colibri or Bonn type) are indicated.

### *Knives*

The most frequently used knives in ophthalmic surgery of small animals are the Bard-Parker and Beaver handles. The Bard-Parker scalpel handle with Nos. 10 and 15 blades is used primarily for orbital and eyelid surgery. The smaller Beaver handle with Nos. 64, 65 and other special purpose blades is used for eyelid, conjunctival, and corneal surgery. Both types of handles are positioned in the hand like a pen, for best results.

### *Ophthalmic Scissors*

There are a large number of ophthalmic scissors available, and several have been developed for specialized purposes. No single pair of scissors can perform adequately on the wide range of ocular tissues that one commonly confronts. For the majority of eyelid and conjunctival dissections, the Steven's tenotomy scissors are recommended. The standard size ring handle with straight or slightly curved blunt tips is the most versatile. The overall length of the ring handles is about 100-110 mm, and the blades are about 18-20 mm long. For cutting and dissection of the bulbar conjunctiva, curved scissors conform to the globe's curvature and are less likely to buttonhole the conjunctiva. Cutting with these scissors should be reserved for the distal tip of the blades. These conjunctival scissors are also used to cut 4-0 to 12-0 ophthalmic sutures.

### *Ophthalmic Needle Holders*

The majority of the ophthalmic needle holders possess a design very similar to corneal and corneosclera scissors. The serrated flat or round knurled handles are 100-120 mm long and are designed to be held like a pen. The proximal portions of the handle are highly flexible and function as a spring, thereby maintaining the needle holder's jaws open. The straight or gently curved jaws are 7-12 mm long and have either smooth or serrated surfaces. The locking mechanisms are mounted on the inside of each handle and are durable to provide long-term use. Compressing the handles locks and closes the tips; compressing the locked handles a second time releases the lock and opens the tips. In models without the locking mechanism, a pin stop is usually added to prevent excessive compression of the handles.



For general extraocular surgery, the Castroviejo needle holder with flat serrated handles and a lock is recommended. The jaws are about 9 mm long and may be straight or gently curved. For microsurgery involving the cornea, the Storz or Barraque needle holder with curved jaws and no lock preferred. All ophthalmic needle holders are designed for only the small ophthalmic needles and sutures; large needles and sutures larger than 4-0 will gradually distort the jaws of these needle holders, rendering the instrument useless.

### *Spatulas*

Spatulas are semi-sharp to dull instruments designed to manipulate the iris from the cornea, for example in iris prolapse, or tease the vitreous from the posterior lens surface during intracapsular lens removal. Three basic types of spatula tips are available with a fairly standard round or flat serrated handle of 120-140 mm in length. Some spatulas possess special tips at both ends of the handle. The most versatile spatula, designed to sweep the iris from the cornea or the vitreous from the posterior lens, has a round blunt tip that is 10-12 mm long. These spatulas have also been incorporated into cannulae that permit the injection of solution or air with the same instrument.

### *Calipers*

Occasionally in eyelid, corneal and intraocular procedures, precise measurements are needed. Either the Jameson or Castroviejo caliper permits measurements in 1 mm increments and both are relatively inexpensive.

### *Sutures*

As in general soft tissue surgery, continued refinement of the swaged needles and sutures permitted use of progressively smaller sutures with less tissue reactivity but excellent holding strength. These smaller needles and sutures have also been vital for the development of ophthalmic microsurgery. For surgery of the orbit, suture size approximates that of general soft tissue surgery, with 2-0 to 4-0 absorbable sutures used for ligation and closure of the deeper orbital fascia tissues. Skin closure is usually with non-absorbable 3-0 to 4-0 nylon, polypropylene, polyester, Dacron, or silk.

For surgery of the eyelids 3-0 to 4-0 sutures are recommended with the absorbable sutures buried and the skin apposed with non-absorbable 3-0 to 4-0 single interrupted sutures. Most conjunctival and corneal sutures are absorbable (to eliminate the need for suture removal), and 3-0 to 7-0 in size to minimize tissue reaction. Buried sutures involving the nictitating membrane may be either absorbable or non-absorbable depending on the procedure.

The general rule stating that the strength of the suture should approximate the surrounding tissues also pertains to ophthalmic sutures. Often the choice of the skin sutures is personal preference and nearly always the non-absorbable type. Silk skin sutures are usually black, soft and pliable; if suture contact with the eye occurs ocular irritation is unlikely. Unfortunately silk sutures are braided and bacteria can penetrate the sutures, hence suture removal should be performed 10-14 days post operatively. When nylon and polypropylene monofilaments are employed for skin sutures, the surgeon and square knots are usually combined to secure each knot. As these sutures are fairly stiff, suture contact with the conjunctiva and/or cornea usually causes ocular irritation. This stiffness can however be an advantage during parotid duct transposition when these sutures are inserted into the duct's lumen to facilitate its detection and handling. The Dacron polyester suture is more pliable than nylon or polypropylene sutures, but its knots tend to loosen.

Absorbable sutures are most frequently used for the deeper layers of the eyelids, all layers of the conjunctiva and nictitating membrane, and the cornea. Our preference is polyglactin, a multifilamentous suture, with strength and resorption rates that approximate surgical gut (about 6 weeks). This suture, dyed violet, is non-antigenic and produces minimal tissue reaction. The uncoated polyglactin is associated with excessive tissue drag during suturing; coating greatly reduces this drag but additional ties are indicated for knot security. Polyglactin sutures are stable in septic wounds, and can be used in infected corneas.

### *Needles*

In general, reverse cutting semi-circle needles are recommended for the majority of the extraocular surgical procedures. Skin closure generally employs the conventional cutting needles; the subcutaneous and deeper orbital fascial layers are apposed using spatula and taper needles. Corneal and scleral tissues require reverse cutting needles, and the G-6 semi-circular needle is the most useful.

## **Maintenance of Ophthalmic Surgery instruments**

### *Care and Storage*

All ophthalmic instruments are quite delicate and whether in storage and not sterile, or ready for use and sterile, special ophthalmic holders are recommended. All fixation forceps should be covered, with small pieces of intravenous tubing, to protect their delicate tips. Flat felt-lined trays provide inexpensive storage and several trays can be accommodated in an instrument storage box.

Special stainless steel trays, with either foam or rubber linings, provide the most convenient method for safe handling of sterile ophthalmic instruments. The liners hold each instrument separately and prevent contact with other instruments that could damage the delicate tips and blades. These trays are easily sterilized and can be used indefinitely.

### *Cleaning and Sterilization*

Because of the delicate tips of ophthalmic instruments, cleaning is generally achieved by ultrasound and the appropriate cleaner. Each instrument is carefully placed on the bottom of the ultrasonic cleaner (and not piled on top of other instruments). Some of the larger soiled instruments can be easily cleaned manually, usually using a small toothbrush. The instruments should be dried using a hot air blower rather than risking damage by hand drying with towels. Occasional treatment with instrument milk will preserve the instrument's finish, and lubrication of the scissors' and needle holders hinges will facilitate long-term use. Sterilization of all ophthalmic instruments is usually achieved by the standard methods using hot air, autoclaving (steam), or ethylene oxide gas.