Infections associated with the administration of anesthesia

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The author takes a pathologist's look at the problem of nosocomial infections; and after a basic review, he specifically concentrates on the problems that are inherent in the administration of anesthesia.

Nosocomial or hospital acquired infections occur in a patient after admission to the hospital. Such infections, as far as can be determined, were not incubating or present at the time of admission.

The overall incidence of hospital acquired infections throughout the United States varies from hospital to hospital, depending upon the population involved, and to perhaps an even greater extent, the effectiveness of surveillance. In general, approximately 5% of all patients admitted to hospitals in the United States will develop hospital acquired infections.

In this article, we will discuss the hazards faced by uncompromised patients; however for thoroughness, we will briefly mention the problem of the compromised patient.

Diabetics, of course, are known to be more prone to infectious disease of all types. In addition, with current advances in immunotherapy, chemotherapy, radiotherapy, and advanced surgical techniques, individuals whose immunological systems are already greatly compromised and who are more susceptible to infection by the usual pathogens are seen more frequently in the hospital. Also, these patients are susceptible to infections due to the so called opportunistic organisms, microorganisms which are ordinarily thought not to cause disease in humans.

Such individuals deserve special attention, and in many institutions, people with severely compromised defense systems are treated by reverse isolation. The identification of these patients is important in order that proper techniques may be utilized.

The anesthetist spends more time in the surgical suite than any other person and is often more aware of needs of improvement in this area.

Reducing the incidence of infection in surgery should begin with an overall look at the general cleanliness in the surgical suite and adjacent storage areas, the work rooms, and recovery rooms. Special attention should be given to conditions furthering the presence of insects and vermin, since there is a tendency for hospital personnel to bring lunches and store them without refrigeration for later consuming in the locker room.

For some time now, the hazards of infection in the operative suite, even in the uncompromised patient, has been well known. We shall discuss these hazards, how to evaluate them, and what steps to take to prevent infection of patients. It goes without saying, all efforts should be pointed towards assuring patients that they will not develop a disease in the hospital that they did not already have upon admission.
Securing the operating room against infection

One of the realities of life is that there are a certain number of hospital acquired infections that are unavoidable, such as those found in patients who have extensive burns. It is *avoidable* hospital acquired infections that we must strive to prevent. The following are a series of recommendations for improving the general cleanliness of the operating room:

1. The operating room should be kept free from unnecessary traffic. Frequently, individuals walk unnecessarily back and forth between operating rooms “passing the time of day,” so to speak, and otherwise dragging microorganisms in with them.

2. Conversation should be kept at a minimum in the operating room. Granted, a long surgical procedure becomes a rather dreary experience, but surgical masks, after a period of 20-30 minutes, become permeable to microorganisms because of moisture. Thus, conversation should, therefore, be kept at a minimum.

3. The air in the operating room should be changed 12 times per hour to keep clean filtered air in the room.

4. Dry sweeping of the operating room should not be permitted. The operating room should be mopped between cases, with water containing detergent and germicides.

5. The room, following a dirty case, should be thoroughly and completely cleansed, pus should never be allowed to reach the floor, and contaminated linens should be placed in a plastic bag. Shoe covers and gowns should be removed when leaving a dirty operating room and placed in a plastic bag.

6. The laundry procedures of the hospital should be evaluated to make sure that adequate procedures are used.

7. Masks should be worn by all personnel whenever they are in the operating room, and not merely during the operation.

8. Masks should be changed between operations, clothing should also be changed after an operation on an infected patient.

9. If operating room clothing is worn outside the operating suite, clothes should be changed when an individual returns to the operating suite.

10. Skin preparation with a colored solution is not satisfactory. Skin requires mechanical scrubbing with germicidal soap.

11. Shaving the operative area should be done only a short time before the surgical procedure. This minimizes the possibility of infection developing in the minute cuts.

I have noted, with interest, that some senior surgeons seem to believe that among their many qualities is bacteriologic sterility. These men often tend to operate with their masks somewhere below the nose. They will frequently visit the patient in the operating room before anesthesia is started, entering the operating area in street clothes without a cap or mask.

It is recognized that to expect an anesthetist to call this to the senior surgeon’s attention is much like suggesting a person volunteer for a suicide mission. This type of information, however, can be passed on to the Infection Committee; and its members can either take action themselves or recommend action to an appropriate committee, which will hopefully pursue the issue.

The means of infection transmission by the anesthetist can generally be avoided through simple, although sometimes neglected, precautions. Clean hands are certainly not too much to expect from a professional anesthetist. There are horror stories in the literature concerning operating room epidemics caused by an anesthetist or anesthesiologist transmitting organisms with contaminated hands. I would certainly recommend that anesthetists wash their hands with surgical soap before the beginning of each case. Frequently, it is necessary to insert the hand and fingers into the patient’s mouth. Certainly, this calls for a thorough washing of hands before moving on to another patient.
Decontamination of anesthetic equipment

The equipment used offers many possibilities for infection hazards. The anesthetist can carry organisms to the patient by his or her hands, nose, throat, needle and syringes, tubing, masks, chimney Y-pieces, breathing bags, scopes, and fomites such as pillows and blankets.

In order to understand decontamination, we shall review the following definitions:

1. Sterilization—any agent or process which destroys all forms of life.
2. Disinfection—any process or agent which destroys all pathogenic organisms but not necessarily all spores.
3. Antiseptic—originally, this term applied to the inhibition of growth of organisms responsible for sepsis. Now, however, it has the same connotation as germicides, except when prolonged skin contact is involved.
4. Sanitation—the reduction of the number of bacteria to “safe levels” as judged by the Public Health Department.
5. Degermination—this indicates a decrease in the number of bacteria by the use of soap.
6. Bacteriocidal and germicide—agents used to kill bacteria.
7. Bacteriostatic—an agent used to prevent bacterial growth without necessarily killing the bacteria.

The properties of some of the agents and methods used for decontamination and sterilization of equipment in the operating room are as follows:

1. Autoclaving—this method is not practical for rubber or plastic, but is excellent for metal parts. It is time-consuming, however.
2. Boiling for three minutes—this destroys vegetative bacteria but not spores. This method is destructive to rubber and plastic.
3. Alcohol 70%—this concentration destroys many vegetative bacteria; however, alcohol loses its potency rapidly and must be changed often. There are many viruses that will not be killed. Tubercle bacilli will not be killed.
4. Iodine and its compounds—these agents have rapid microbicidal action where no organic material interferes with their action. They lose their potency at elevated temperatures, leave stains, and must be changed every day or two. However, if properly used, they are quite effective.
5. Mercurial agents—these are not good germicides.
6. Phenolic compounds—these are good germicides, and are sometimes viricidal but not sporicidal.
7. Quaternary ammonium compounds—these have a selected disinfection action which kill certain vegetative organisms. These compounds are easily deactivated by protein, sponges, hard water, and so forth. They have little to recommend them for hospital use.
8. Formaldehyde—this is an excellent disinfectant; however, it has a pungent odor and is toxic to tissues. Mixed with alcohol (Bard-Parker solution) it is very effective.
9. Buffered gluteraldehyde—this is used as a cold sterilization agent. It is an excellent preparation that kills vegetative microorganisms including tuberculosis and spores.
10. Gas sterilization with ethylene oxide—this is especially effective for sterilizing material which cannot be immersed in liquids or subjected to heat. It kills all organisms, though it cannot be used for some plastics, wet material or liquids. It is quite toxic, requiring cautious use. When used on equipment prolonged sterilization and prolonged aeration is necessary. When it is utilized as the main means of sterilization, one may be assured of excellent results; however, because of the time involvement to sterilize and to aerate, a large inventory of equipment must be kept on hand.

One method for preventing contamination of anesthetic equipment, that is finding some favor now, is the utilization of disposable materials. The advantages are readily apparent; however, there are some potential disadvantages in disposable equipment. First, such
equipment is expensive. Secondly, disposing of the disposables is becoming an increasingly vexing problem, the answer to which is not immediately on the horizon. Some types of plastics emit toxic vapors when subjected to high temperatures and burning. Furthermore, there are certain engineering problems inherent in the disposables, such as compliance of the materials and size of the breathing bags.

**Making a bacteriologic inventory of the air**

The question of how to properly obtain the bacteriologic inventory of an area frequently arises. The subject of the value of environmental culturing is one which can generate much more heat, shall we say, than light. One of the current goals of the Joint Commission on Accreditation of Hospitals, I believe, is to require increased culturing of the environment plus detailed records of such culturing. In my opinion, this is a step backwards.

The main reason for doing environmental culturing is to demonstrate that housekeeping is adequate or inadequate. Standards for bacteriologic inventories are hard to come by; and when individuals do propose standards, they are always careful to admonish the reader to utilize such standards only as a rough guideline, emphasizing the need to establish their own standards within their own institutions.

There are several methods for obtaining bacteriological samples for such an inventory. One of the more commonly utilized methods is to use a swab on various inanimate objects, such as floors, walls, masks, Mayo stands, and various parts of anesthetic apparatus. These swabs are then usually plunged into some type of broth, where one then isolates in large numbers the fast-growing organisms (which are not necessarily related to the quantity of organisms originally present).

Occasionally, the swabs are placed on plates, which then become streaked in the classic manner. However, I have never been really sure how one evaluates these types of findings. If it is necessary to "shake up" the housekeeping department, a show-and-tell program with plates presenting masses of organisms growing everything from plague to leprosy, may be of some value, although this is about where it stops, in my opinion.

Another means of assessing bacteriologic inventory is with Rodac plates. Properly used, this is a very expensive proposition, where large numbers of plates are placed over the floor and become imprinted on the surfaces. The colonies are enumerated, although not identified. When proper standards are obtained for an individual institution, this test has more value than the swab test in demonstrating the effectiveness of the various means of cleaning the floor—that is, in terms of a quantitative basis. Although, again, the value of the plate test is limited to demonstrating quality of housekeeping, and it does not serve as a very satisfactory early-warning system for impending hospital epidemics.

Another means frequently used to evaluate the number of organisms in the air is to open a plate of appropriate media and allow it to set for a period of time in the hope that organisms of significance will drop by and "set up housekeeping" on the plate. When one examines an operating room with its corners, walls, window-type air conditioning, or central air conditioning, it is not difficult to envision various types of air currents and eddies that will be present in different areas of the room. The number of organisms that will drop on these plates, will be dependent upon the air flow.

A more accurate and perhaps more pertinent means of evaluating the bacteriological quality of the air in the operating rooms is through an apparatus known as a slit air sampler. This method provides student nurses with an interesting project to show how many bacteria are in an operating room when there is talking and shuffling around, compared to when no one is there and
the counts are lower than those in a laminar flow room. In fact, such results are obvious even without such a study.

I am personally inclined to believe that the significance of the role that airborne organisms play in infections occurring within the surgical suite is probably greatly overestimated. Although airborne organisms doubtless play a role, hand-transmitted organisms appear to cause much more of a problem.

**Determining the quality of anesthesia equipment cleansing**

There are some fairly satisfactory methods which demonstrate the quality of cleansing that anesthesia equipment receives, such as the methods of Dr. Jay Sanford. Again, the basic thing these tests show is how effective is the cleansing of equipment. Particularly in respiratory therapy, this has been demonstrated to be of utmost importance. As evidence, consider the epidemics of gram-negative necrotizing pneumonia that have been stopped as a result of properly sterilizing respiratory therapy equipment.

Next, we should discuss the nature of the microorganisms which are of concern to anesthetists and their patients. First, let us mention anaerobic bacteria (those peculiar organisms, which in a world that otherwise requires oxygen for all living things, do not require oxygen, and find oxygen in varying amounts toxic or lethal). The organisms that form gram-positive spores, which can cause tetanus and commonly cause gas gangrene, are obtained in environments outside of the hospital or from the patient’s own flora. The other anaerobes are, for all intents and purposes, always obtained from the patient’s own flora. These organisms are not considered contagious and are only of limited interest to the anesthetist.

Aspiration of gastric contents may lead to an aspiration pneumonitis; however, this is predicated upon the acidity of the gastric contents, and the bacterial invasion that follows is usually secondary. It is worthy to note, though, that prevention of this type of situation is a matter of routine among anesthetists. Anaerobes are common pathogens in aspiration pneumonia.

What about viruses? The hazard of viruses in the anesthesia setting are not clearly understood, although influenza has been demonstrated to be transmissible by anesthesia equipment. The facilities for fully evaluating such a hazard are not available in most institutions, and little work has been done concerning this.

Certainly from a theoretical standpoint, one could expect that viruses would present a significant hazard as far as transmission of disease through improperly cleansed anesthesia equipment. Further, one could expect that viral infections would be a real problem. For example, the problem of MS2 or serum hepatitis virus that is associated with a contaminated needle is well known.

Fungi are not transferable from person to person under the ordinary circumstances. The types of fungi that we will concern ourselves with are those that could be a hazard to compromised patients. We noted earlier that compromised patients require more exacting care, especially to prevent devastating or fatal infections with fungi that are normal inhabitants of the air. To the uncompromised patient, fungi offer very little hazard, but do deserve some attention. For example, one would not like to give IV solutions of fungi. Yet, I have seen this happen on occasion when the IV solutions and bottles were not carefully checked.

There are instances of transmission of tuberculosis by anesthesia equipment. But, if the patient with tuberculosis is properly identified and proper steps are taken, there is very little hazard. The real danger, of course, comes from the patient who enters surgery with active pulmonary tuberculosis, and not having had the benefit of any chest x-rays, contaminates the equipment. Here, the most important point is the identification of the patient with tuberculosis prior to surgery.
The gram-positive aerobic rods are of little significance in the uncompromised patient. The gram-positive cocci are another question. Our old enemy, the Staphyloccus evokes considerable interest. This is a well known organism associated with hospital acquired infections and, frequently, operating room acquired infections.

Sometimes, in a state of enthusiasm, the nasopharynxes of various hospital personnel are cultured to discover "carriers". The problem is that once the carriers are identified, unless they have been shown to be part of an epidemic problem, there is really nothing you can do about them. One of the real problems is that not all carriers are shedders. Many people carry the organisms (as is demonstrated on cultures by appropriate nasopharyngeal swabs), but these same people do not shed the organisms in the atmosphere.

I personally think that secondary infection from Staphylococcus carriers most often occurs, not because the organisms charge out of the nasopharynx, but because the individuals contaminate their hands with them and spread them by hand transmission. In my opinion, transmission of significant pathogens by hands due to inadequate attention to hand washing is probably the major source of wound infection that we see following surgery. Again, it is impossible to stress too strongly, the importance of appropriate hand washing techniques.

The other gram-positive cocci of interest is the group-A beta hemolytic Streptococci. Here again, a nasopharyngeal carrier state is common. I have seen some really devastating infections that occurred postoperatively in wounds as a result of group-A beta hemolytic Streptococci. It is not always clear what the mode of transmission was, but I suspect the patient's own flora is often the culprit. Still, the organisms could come from an individual who is a carrier, rubs his hands on his nose, and then fails to properly cleanse them. Perianal carriers have also caused infections, which can be rapidly fatal. Gram-positive cocci, such as pneumococci, probably have little significance as far as the anesthetist is concerned.

Gram-negative cocci, including such organisms as meningococci and the gonococcus, could possibly be hospital acquired, but not in the usual manner that we think of hospital acquired infections occurring.

On the other hand, gram negative rods (the enterics) which are facultated anaerobes, are probably our number one problem in hospital acquired infections. As these organisms can cause quite violent infections, it is important to consider the means of transmission. They are most often acquired as urinary tract infections secondary to catheterization.

Another inflammatory problem that may be initiated in the operating suite, but may not actually be observed there, is post-infusion phlebitis. Serious effects are uncommon, although there are reports of pulmonary embolism, and on occasion, septicemia following phlebitis when the needle for administering intravenous fluids is left in place for 48 hours or more. Infectious and/or inflammatory complications of intravenous therapy may be avoided by replacing the needle every 48 hours.

Such replacement is frequently difficult to accomplish in children and in burn patients; however, more often than not, the problem lies not in the patient, but is due to lack of motivation on the part of the staff. The plastic catheters currently used for the long-term administration of fluids are probably more hazardous than others as far as setting up the inflammatory reaction that precedes infection. Depending upon the clinical circumstances, it may not be possible to utilize anything other than the vascular catheters.

Infection transmission through intravenous equipment

Frequently, the anesthetist may be called upon to start and administer intravenous fluids. Careful attention should be paid to the preparation of the skin surface, which should be vigorously
cleansed and followed by the application of an iodine solution, (if the patient is not sensitive to iodine). The iodine should be removed after drying by 70% alcohol.

Some people feel that when long-term intravenous therapy is anticipated and it is unlikely that the site will be changed every 48 hours, the addition of a broad-spectrum topical antibiotic dressing is of value. The drawback comes with organisms that become resistant to an antibiotic. And, also from the practical standpoint, I have been told that the dressing acts as a lubricant, making it very difficult for needles to stay in place. Obviously, grossly inflamed sites or skin lesions should not be utilized for intravenous therapy.

Examination of the bottles of intravenous fluid themselves is important. We often have child-like faith in the manufacturer’s ability to make no errors, coupled with a faith that the bottles we use will somehow not crack during the many travels between preparation and administration. It is important to make a careful examination first of the fluid to see if there is any haziness or any contaminating organisms growing as macroscopic clumps, and second, to see if there are any minute cracks in the bottles. It should also be remembered that any time a bottle is entered with a needle and syringe, there is a chance of contamination. Materials that are premixed should be utilized for administration only during the day that they are mixed.

**Conclusions**

Problems resulting from operating-room acquired organisms usually occur at least a day after surgery. As they are administered to by the floor personnel, the operating room personnel are not often even aware of these problems. Also, it is difficult to prove just where or how postoperative infections develop, although we know that there are certain real hazards associated with the use of anesthesia equipment.

In studies, airborne clouds of mixed salivary organisms were blown through 3 feet of anesthesia rubber tubing. The result was that 50% of the organisms were retained in the tubing and 50% transversed the length of the tubing. Further, the representative organisms (including Staphylococci, Streptococci, and enteric organisms deposited in tubing) would survive at least 7 hours if kept in a warm, dark environment.

Technicians also found Coxsackie virus can survive on a face mask for at least 3 hours. One group rinsed endotracheal tubes in saline and found high bacterial counts that included various pathogens, such as Streptococci.

Two significant factors emerged: first, those pieces of apparatus which actually come in contact with the skin, the mucous membrane of the patient’s face, airway and endotracheal tubes, and suction catheters are all liable to become totally contaminated and should be sterilized or disposed of after use. Secondly, although pathogens were found after swabbing the inner surfaces of the anesthetic apparatus, it is difficult to be sure how many organisms may be picked by the gas stream and actually cause infection in the subsequent outbreak. Although there is only peripheral evidence, technicians have found that organisms may be expelled up to 32 feet by well known respiratory therapy equipment, suggesting that the potentiation hazard is quite real.

Most studies, in my opinion, would indicate that such items of equipment tending to come in contact with the skin and the mucous membrane of the patient should be sterilized after use and stored under clean, if not sterile, conditions. This would of course include face masks and tubing. Certainly, endotracheal tubes, airways, and the blades of endotracheal scopes deserve particular attention between cases. No one would be expected to have a large inventory of blades for an endotracheal scope; however, special attention can be given by washing them with surgical soap or gluteraldehyde followed by a thorough rinsing with water.
If special apparatus is kept for use in known infected cases, it is probably not really necessary for the anesthesia machine to be sterilized, except after known cases. Cleansing and sterilization of airways and endotracheal tubes is made more effective when one prevents the secretions dropped on these objects from drying. For this reason, it is recommended that immediately after airways and endotracheal tubes are removed from patients, one should immediately cleanse this equipment with tap water and soap so that all secretions are rinsed off. If this is not possible, the equipment should be immersed in some type of cleansing agent or, at least, water so the secretions will not have a chance to harden.

Secretions that are permitted to harden are extremely difficult to remove, and proper attention may not be given to their removal. Suction catheters are likewise a significant source of bacterial contamination during general anesthesia. Suction catheters should likewise be maintained so that secretions will not be allowed to dry, and then should be properly cleansed and sterilized before being used on another patient.

Again, gas sterilization is an effective means of sterilization, because it can be used for most of this type of anesthesia equipment; however, it does have the drawback of requiring a very large and an expensive inventory of equipment, as a result of the time required for proper sterilization and proper aeration.

Paying close attention to details and utilizing knowledge that is currently available can, in the long run, keep nosocomial infections associated with anesthesia to a minimum.

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