ATRAUMATIC TECHNIC—THE SINE QUA NON OF OPERATIVE WOUND INFECTION PROPHYLAXIS

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CAN postoperative wound infections be avoided? A positive "yes" in answer to this question would relieve the surgeon of a great burden. It would eliminate physical discomfort and financial hardship for the patient, and it would abolish what has become a new source of litigation in the courts.

The incidence of postoperative wound infection has been reported to be from 1.0 to 37.0 per cent.[1-9] The 2.0 per cent infection rate reported by Meleney and Johnson[7] is used as the standard rate for clean cases. During the past year, in 1,248 consecutive operative procedures performed on the plastic surgery service of the Cleveland Clinic Hospital, only one wound infection occurred, an incidence of about 0.08 per cent. The infection occurred in a patient who had undergone a combined laryngectomy and radical neck procedure.

We believe that postoperative wound infections can be almost completely eliminated by the rigid application of sound surgical principles. The antibiotic era, however, has fostered a relaxation of these principles. The purpose of this paper is to outline the principles that we have found to be successful in the prevention of postoperative wound infection.

Conditions for Wound Infection

Three factors constitute the cycle that leads to wound infection *(Fig. 1)*; they

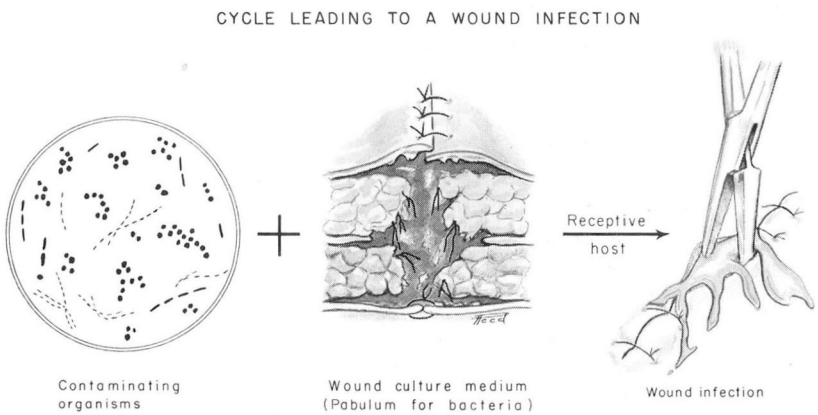

Fig. 1. Sketch of cycle leading to a wound infection. A traumatized, poorly closed wound acts as a culture medium in which even a small number of contaminating organisms can multiply and produce a wound infection.

are, in the order of increasing importance: (1) a receptive host, (2) contaminating organisms, and (3) a wound culture medium that acts as pabulum for the bacteria. This cycle can be broken by eliminating any one of the three factors, and a wound infection thereby will be avoided. The important question is "Which factor is the most vulnerable?"

Receptive host. With present-day preoperative correction of fluid and electrolyte imbalances, low blood volume, hypoalbuminemia, and avitaminosis, the host is not often the significant factor in the development of wound infections, and for practical purposes can therefore be disregarded.

Contaminating organisms. We believe that most wound infections have their genesis in the operating room at the time of surgery. It has been demonstrated[10] that only during the first few postoperative hours is a wound subject to become infected from the environment. It is important to realize that it is impossible to achieve asepsis and sterility, even in the operating room. These terms are only relative. All surgical wounds are contaminated.[9,11] Bacteria have such sources as: the operating room air; the air expired by all operating room personnel and the patient; breaks in the technic during the preparation and draping of the patient, the operation, and the application of the dressings; improperly sterilized equipment; holes in rubber gloves; and dressings. Even if absolute sterility could be achieved insofar as these factors are concerned, the wound still is flooded with organisms as soon as the skin incision is made. Histologically, the skin is not flat, but has millions of microscopic pits leading to skin appendages that are impossible to cleanse of all organisms, and the skin incision immediately permits the organisms to escape into the wound.[11]

Preparation of the operative site. The technic of preparing and draping the operative site is the most important variable in controlling the number of organisms that will contaminate a wound. For example, the back and forth motion of scrubbing as shown in *Fig. 2A,* is to be avoided. This method with every stroke drags organisms from a contaminated area into a clean area. The motion should proceed centrifugally, and should extend well beyond the confines of the intended operative procedure, as shown in *Fig. 2B.* We prepare the operative site thoroughly in this fashion for about 10 minutes, using Septisol for the initial scrubbing, followed by benzalkonium chloride aqueous solution. However, the technic and the duration of preparation are far more important than the specific agents used.

Paradoxically, a surgeon may wear two masks, scrub for 10 minutes, put on his gown and gloves, and then operate on a patient whose skin has been prepared for only 30 seconds with a colored antiseptic. Although the preparation of the operative site is far more important than is the preparation of the surgeon, the operative site is frequently prepared by an inexperienced junior resident whose instructions have been inadequate or who lacks close supervision. Fewer wound infections occur when an experienced senior resident prepares and drapes every

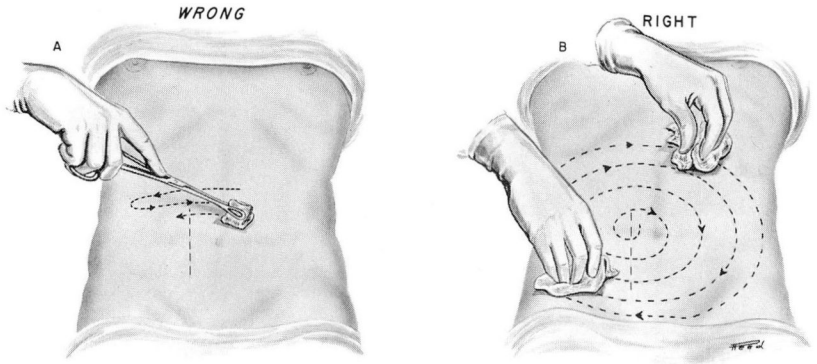

Fig. 2. A, The back and forth technic of preparation of a limited surgical field drags contaminating organisms into the clean field with every stroke. B, The centrifugal method of preparation of a large surgical field is better, aseptic technic.

operative site.

Most of the current papers on wound infections stress the paramount importance of reducing the number of the contaminating organisms. Much emphasis has been placed on such factors as: the use of special masks or two masks, and special gloves, gowns, and sutures; the direction and the amount of traffic in the operating room; the limiting of talking in the operating room; the use of bacteriocidal radiant energy in the operating room; the proper flow of air currents; the carrier status of operating room personnel; the use of a separate room for septic cases; the washing of shoes of all personnel in a bacteriocidal solution; the use of prophylactic antibiotics and special solutions for preparation; sterile technic for postoperative changes of dressings, and the avoidance of a common dressing cart.[1-3,6,8,12-18] We believe that these factors have been given theoretic importance far beyond their practical significance. We do not wish to imply that the contaminating organisms are unimportant. They are important, and we make every effort to keep them at an irreducible minimum; but special devices or schemes do not necessarily accomplish this. In our experience, a thorough scrub, careful preparation and draping of the operative site, and vigilance against breaks in technic, suffice. We should like to stress again that contaminating organisms are present in every wound, and rather than to try to find a way of eliminating all of these organisms, we must find a way to avoid wound infections in spite of them.

Wound culture medium that acts as pabulum for the bacteria. The goal should be to decrease the amount of culture medium left in the wound, to the point where the contaminating organisms have no chance to multiply. A healthy, viable wound produced by an atraumatic technic and meticulously closed by accurate approximation of all layers and with obliteration of all potential spaces is the greatest single deterrent to wound infection. It is the sine qua non of uncomplicated,

primary wound healing. Although this was pointed out 40 years ago by Bunnell,[19] this technic has not been stressed in most papers[1-3,6,8,11-13,15,18,20] dealing with wound infections.

We have long observed clinically that a healthy wound can withstand many times the number of contaminating organisms necessary to infect a traumatized wound. This clinical observation was recently corroborated in an experimental study[21] on dogs, in which it was demonstrated that healthy, nontraumatized wounds will heal uneventfully even in the presence of heavy contamination. The converse of this principle was also demonstrated. A granulating wound, such as a burned surface with healthy granulations, is most resistant to infection. There is no magic in the granulations; they are merely indicative that the underlying tissues are healthy. These healthy tissues, then, do not provide a culture medium in which the contaminating organisms can multiply. However, when the granulating surface becomes traumatized, it no longer has the same power to resist infection: a culture medium is established; organisms begin to propagate; and infection may result.

A similar example is that of the child who in the country lacerates his foot. Even though the laceration is made with a highly contaminated object through a contaminated field, and the wound is never sutured, an infection rarely occurs because the wound is healthy. It is only when the dirty wound is traumatized by hemostats, forceps, needles, and sutures that infection is likely to occur.

Atraumatic Operative Technic

Handling of wound tissues. Even with the most gentle handling of tissues, millions of normal cells are killed in every operative procedure. The cut of the sharpest scalpel or scissors destroys many cells. Rough handling of tissues, as shown in *Fig. 3A,* leaves a wound with an ideal culture medium for postoperative infection. The magnitude of this problem becomes clear when one considers the microscopic relationships of tissues. Histologically, tissues are composed of millions of succulent cells held together by a delicate framework of elastic and collagenous fibers, nourished by fragile nerves, lymphatics, and capillaries. Tissues that are torn, pinched, crushed, twisted, pulled, rubbed, scraped, picked, and harshly retracted with a calloused disregard for their histologic structure hardly can be expected to heal uneventfully. Rough handling of tissues produces edema, which impedes normal wound healing. The edema fluid (a) physically separates the tissues that need to unite in healing; (b) causes congestion and sometimes necrosis at the operative site by compressing the venous return; and (c) interferes with tissue metabolism, resulting in an increase in the waste products in the healing tissues.

Constant sponging of living tissue is analogous to sandpapering the conjunctiva. A dry sponge is a harsh abrasive and should be used as such. Repeated sponging

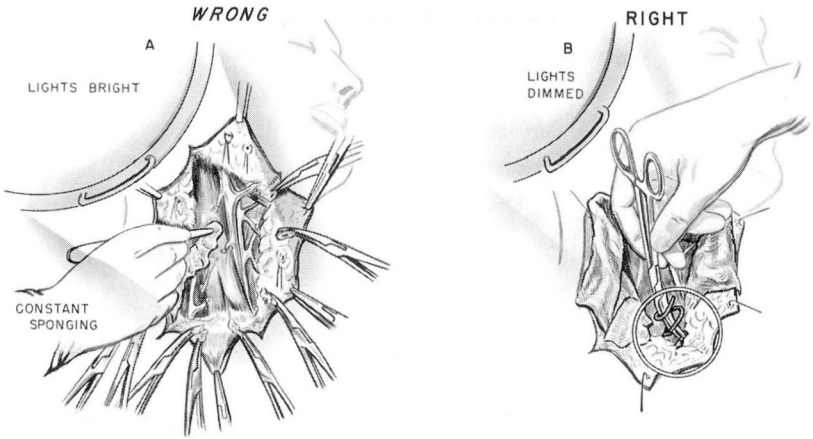

Fig. 3. A, Bright lights, rough handling, constant sponging, drying of exposed tissue, crushing clamps on the skin, too many hemostats with large bites of tissue, and coarse ligatures with long ends, all add to the surgical trauma and increase the possibility of a postoperative wound complication. B, Dimmed lights, gentle technic, moist sponges on exposed tissue, atraumatic hooks on the skin, minimal sponging, few hemostats, and little foreign material increase the likelihood of uneventful healing.

becomes a conditioned reflex, most noticeably exhibited by the operative assistant who immediately after cutting a suture with one hand, sponges with the other hand, whether or not there is blood to remove. Crushing forceps and hemostats should never be used on skin flaps, as they leave areas of devitalized skin. Atraumatic skin hooks should be used to hold the edges of skin flaps during dissection.

Picking up each capillary with a hemostat does more damage than good. The use of too many hemostats, by crushing gross amounts of tissue, produces an excess of suture material and necrotic debris, which acts as a foreign body and increases the wound pabulum. The bleeding from most vessels in the skin and subcutaneous tissues can be controlled by the application of saline packs, at room temperature, to the wound edges, as shown in *Figure 3B.* Other vessels can be individually controlled by picking up the end of the vessel and twisting it several times. Mass ligatures with heavy ties and long ends aid and abet the cycle leading to a wound infection *(Fig. 4A).*

Vessels that bleed persistently must be clamped and must be ligated. They should be picked up with the tip of the hemostat, as shown in *Figure 4B,* and the ligature should be tied directly beneath the hemostat. The finest sutures possible should be used, but it probably makes little difference of what material this tie is made. The ligature should be cut directly on the knot. This technic obviates the inclusion of a large quantity of foreign material in the wound. The unnecessary inclusion of surrounding fat in the hemostat increases the wound culture medium.

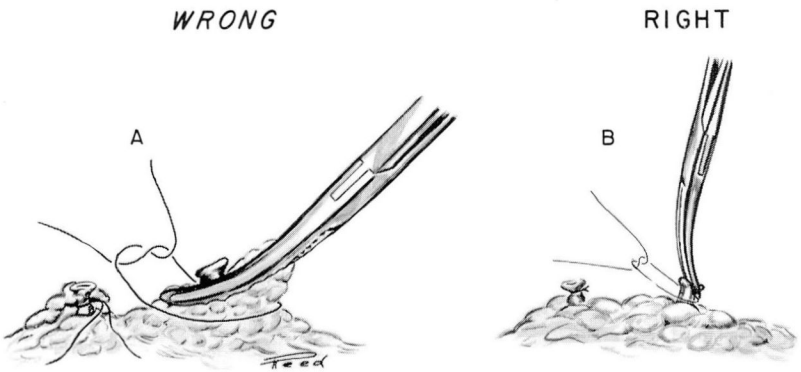

Fig. 4. A, Large bites of tissue, coarse ligatures tied too far underneath the hemostat, and long ends on the ligatures leave an excess of necrotic and foreign material in the wound. B, Fine ligatures tied directly beneath the hemostat and cut close to the knot decrease the amount of wound pabulum for the contaminating organisms.

Bright operating room lights contribute significantly to tissue desiccation. Dimming the lights protects the viability of the wound tissues *(Fig. 3B).* The application of saline packs to wound edges also helps to prevent tissue destruction by desiccation. Exposed tissues as those in a neck or a breast operation, should be moistened frequently with saline solution.

Technic of wound closure. The surgical technic used in closing the wound is vitally important in the prevention of wound infections. Poor hemostasis, much dead space, devitalized tissue, the presence of foreign bodies, crushing forceps, coarse needles, heavy suture material, coarse ligatures, too many ties with long ends, too much tension on sutures, and overlapping of wound edges, as shown in *Figure 5A,* increase the wound culture medium and therefore the likelihood of wound infection. A careful closure facilitates uneventful, primary healing *(Fig. 5B).*

Figure 6A shows a wound that is ripe for infection. A minimal number of contaminating organisms will flourish in the wound pabulum and will produce an infection. *Figure 6B* illustrates an ideal wound, showing the benefits of atraumatic technic, meticulous closure, and the application of a pressure dressing. The tissues are healthy and vital. There is a conspicuous absence of potential spaces, hematoma, excessive suture material, and tissue edema. It is difficult to infect such a wound, because the contaminating organisms can find no culture medium in which to grow.

Application of the surgical dressing. The technic of applying the surgical dressing should be considered an important part of the operative procedure. Often it is only a means of hiding the wound from the patient's view. Too frequently the dressing is applied by someone who does not fully understand its purpose

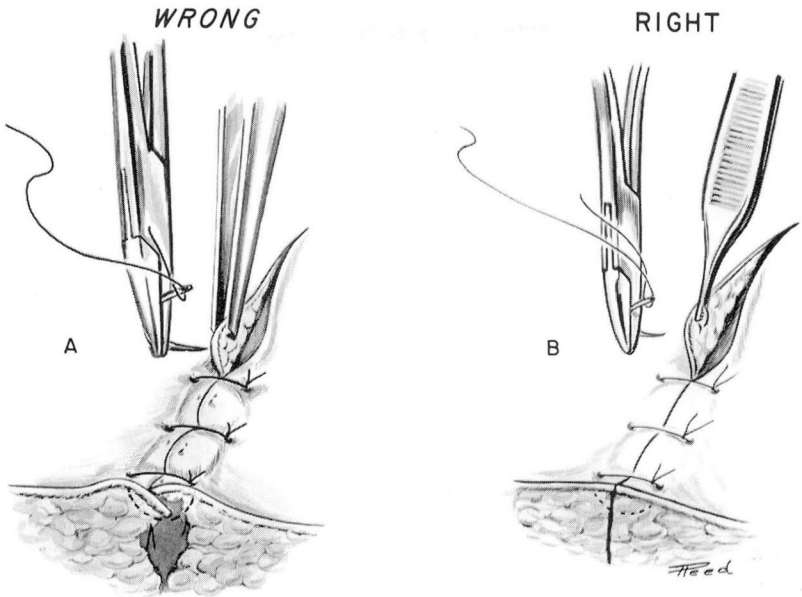

Fig. 5. A, Improper closure with poor hemostasis, crushing forceps, unnecessarily large needles and sutures, overlapping of skin edges, sutures tied too tightly, presence of dead space and tissue edema are conducive to wound infections. B, Proper closure with atraumatic forceps, fine needles and sutures, meticulous approximation of all wound layers, absence of dead space and tissue edema are conducive to uncomplicated healing.

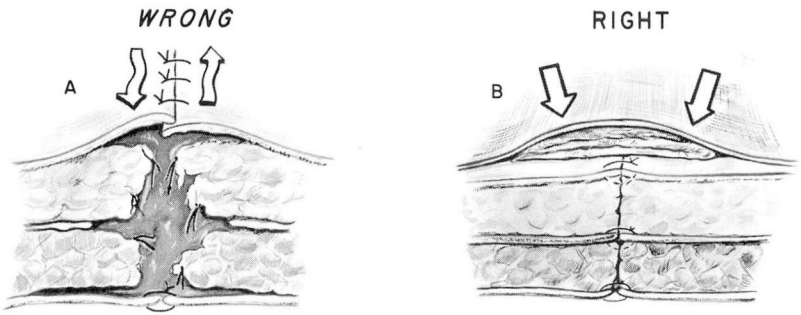

Fig. 6. A, Diagrammatic cross section of a wound that will become infected with a minimal number of contaminating organisms. B, Cross section of a wound atraumatically managed, meticulously closed, and properly dressed with a pressure dressing. Such a wound is most resistant to even heavy contamination.

or usefulness. A properly applied pressure dressing serves many functions that promote uneventful healing: immobility of wound edges; hemostasis; abolition of potential spaces, tissue edema, hematoma formation, and serum collections; and exclusion of the wound from the outside environment.

Summary and Conclusions

1. Postoperative wound infections have been reported to range in occurrence from 1.0 to 37.0 per cent.

2. During the past year 1,248 operative procedures were performed on the plastic surgery service at the Cleveland Clinic Hospital, and only one wound infection occurred, an incidence rate of about 0.08 per cent.

3. Occurrence of a wound infection has three requisites: (1) a receptive host, (2) the presence of contaminating organisms, and (3) a wound culture medium.

4. The application of sound surgical principles with particular emphasis on atraumatic technic, is stressed as the sine qua non of operative wound infection prophylaxis. Special devices and procedures are not necessary.

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