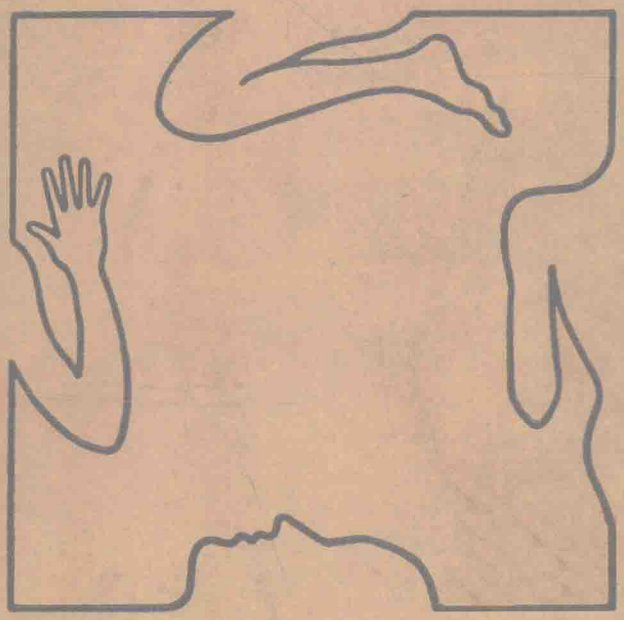
ESSENTIALS OF PLASTIC SURGERY

WILLIAM M. COCKE, JR., MD/RICHARD H. McSHANE, MD/& JOHN S. SILVERTON, MD



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Preface

It is impossible for students and rotating house officers to become familiar with—let alone digest—all the important and interesting literature on plastic surgery. Standard textbooks of surgery usually include a chapter or two on plastic surgery. Plastic surgery textbooks are excellent, but they are too detailed and technical and therefore are not appropriate for use by students and residents during a brief rotation through the plastic surgery service.

This text presents basic information about plastic surgery in a straightforward way. It is concise but informative. It does not overwhelm nor is it, we hope, too brief an overview. We would like the student to be able to pick up the text, read it in a few days, and feel that he or she has a grasp of the specialty. The presentation may appear didactic, but we feel that a reader at the graduate level is fully aware that all medicine, including surgery and particularly plastic surgery, is made up of variables and of varying opinions regarding the many problems that confront the physician. The student should realize that our direct approach is intended to serve only as a basis for further acquisition of information.

We hope that after reading this text the student will be better able to analyze and even to help solve basic reconstructive problems that will be encountered. If we succeed, we may stimulate some students to explore the literature more intensively, to come up with better techniques and ideas, and to record their findings.

W. M. C.
R. M. McS.
J. S. S.

In the preparation of any manuscript, especially a textbook, the efforts of many persons are necessary for the completion of the work. I would like to acknowledge the technical help of Christie Brown, Dianne Brock, Patrice McGrath, and Anita Zorn, all of the administrative section of the Department of Plastic Surgery, University of California, Davis, School of Medicine, who assisted me during the period of production of this manuscript. To Jacqueline Anna Cohen of Little, Brown and Company and her staff, a special note of thanks for bringing the manuscript to its final form, and I am grateful to Fred Belliveau, whose leadership, vision, and support have made it possible to publish this textbook.

W. M. C.

Introduction

What is plastic surgery? The word *plastic* comes from the Latin *plasticus* and the Greek *plastikos* which mean molded or formed. Webster's dictionary expands on the etymology by stating that the term *plastic surgery* refers to the molding or shaping of matter, particularly the renewal of destroyed or injured tissue. In a practical sense, plastic surgery is the specialty that deals with the correction of congenital and acquired externally visible defects. As plastic surgeons, our aim is to improve function or the appearance of the deformity or both. The boundary lines of the specialty are vague because deformities, either congenital or acquired, can affect any part of the body.

In general terms, the plastic surgeon has to be able to interpret and analyze whatever defect is present, to visualize what tissues are involved, and to determine what tissues are to be used or shifted around in the reconstruction. He must then decide how the tissues should be altered, removed, or added to in order to obtain the desired result or correction. The surgeon must have knowledge of the different tissues available for reconstruction (skin, dermis, fat, fascia, muscle, bone, cartilage, nerve, tendon, and combinations), their behavior under the surgical conditions present, and the effect that the proposed surgery would have on those tissues and the surrounding tissues.

Artificial substitutes for tissue, such as the silicone derivatives, are available. These substances have a valuable place and have given the plastic surgeon a greater number of options and technical possibilities. The materials have been used in reconstruction about the face, chest wall, breasts, and extremities.

Although the plastic surgeon has many options, he should be able to select the procedure or procedures that are the simplest and most successful solutions to a specific problem. Operations require precise attention to detail and much patience on the part of the surgeon and the patient. That observation is especially true in the correction of deformities requiring multistage procedures.

There is an element of artistry in plastic surgery, and students who are exposed to and participate in a plastic surgery service should find the experience rewarding. We hope that this text presents information that will make it more so.

1

Basic Techniques of Plastic Surgery

Principles of Plastic Surgery

The plastic surgeon is consulted by a patient with a deformity. The deformity can be congenital or acquired. If it is acquired, it can be the result of inflammation, degeneration, trauma (injury), a tumor, or an operation performed for one of these. The plastic surgeon must have an artistic sense because he is rebuilding or remodeling living flesh and tissues in an attempt to improve on nature or fate. The plastic surgeon must have a full knowledge of the body's tissues and where and how he can use them effectively. He or she must realize that more than one operation may be needed to give the desired result. Therefore he must be able to plan an orderly series of operations. The surgeon must be aware of the psychological aspects of plastic surgery and plan his surgery accordingly.

Sir Harold Gillies (1882–1960) was an extraordinary combination of surgeon and artist. Although reconstruction of maimed parts is an ancient surgical art, modern plastic surgery owes its start to Gillies, who developed and brought to the fore many procedures and techniques to correct deformities that resulted from injuries suffered in World Wars I and II.

The following list of principles of plastic surgery was outlined by Sir Harold Gillies and Dr. D. Ralph Millard, Jr., in their textbook *The Principles and Art of Plastic Surgery*:

1. *Observation is the basis of surgical diagnosis.*
2. *Diagnose before you treat.*
3. *Make a plan and a pattern for this plan.* The principle is especially true for plastic surgery in which there is a recognized deformity that requires shifting of tissues. The surgeon must make a concise plan and a pattern before the operation, because once the incision is made it cannot be redone.
4. *Make a record.*
5. *Prepare a lifeboat.* This is an important principle to remember because even with careful planning an operation sometimes does not go well. The plastic surgeon is dealing with human tissue, and what appears to be a good design may not work. If it does not, the plastic surgeon, using his imagination and his knowledge of the tissues, must be able to turn to an alternate plan (a lifeboat) that he can use at the operating table.
6. *A good style will get you through.* Dexterity and gentleness in handling the tissues are important.
7. *Replace what is normal in normal position and retain it there.* The principle is clear, but it deserves expansion. In most cases, a large amount of normal tissue has been retracted, pulled, avulsed, or contracted out of position. That tissue must be identified and placed back in a normal position. The tissue can be held in its normal anatomic spot by the appropriate technique (such as suturing).

8. *Treat the primary defect first.* One must not forget that to rebuild an injured part, it is often necessary to borrow from a normal or uninjured part. The surgeon should not plan and execute an operation that will result in a donor site deformity that is as bad as or worse than the defect to be corrected. Borrow from Peter to pay Paul only when Peter can afford it.
9. *Losses must be replaced in kind.* In reconstructive surgery, tissues that are to be replaced should, if possible, be replaced with tissues that are similar in texture, color, and quantity.
10. *Do something positive.* When confronted with a severe deformity or severe injury, look for a first step, or surgical move. Often a small anatomic landmark can be recognized and moved to and placed in its normal position. It is important to make a first definitive move. Then, step by step, the surgeon can convert what appears to be an impossible problem into a series of basic surgical maneuvers and thus achieve a good result.
11. *Never throw anything away.* In plastic surgery even the most insignificant piece of tissue may prove to be useful. Before it is debrided or discarded, the surgeon must be sure that he will not use it. It is wise not to throw away anything until the operation has been completed.
12. *Never let routine methods become your master.*
13. *Consult other specialists.* The surgeon should consult any and all experts who could help him achieve a more desirable result for his patient.
14. *Speed in surgery consists of not doing the same thing twice.* If the surgeon repeats parts of the operative procedure, he extends the operation unnecessarily. A steady, methodical progression during the operation is more efficient.
15. *The after-care is as important as the planning.* In plastic surgery, a tight dressing or a misplaced adhesive strip can often jeopardize an operation. A small hematoma under a skin graft or under a composite graft can result in the loss of the tissue. Therefore it is important that the surgeon check his patients and their wounds in the early postoperative period to make any adjustments in the dressings and sutures. Attention to such details can make the difference between success and failure.
16. *Never do today what can honorably be put off until tomorrow.* Time is often an ally in plastic surgery. If time is allowed to elapse, the wound or the scar may mature, thus obviating the need for further surgery.
17. *When in doubt, don't.* Because some plastic surgery is elective, the surgeon does not always need to operate immediately. For example, surgery for the infant with a cleft lip is elective in regard to time. If the infant has an infection of the upper respiratory tract or if there is the slightest possibility that an anesthetic could endanger the infant, it would be better to delay the operation until a more favorable time.

These basic principles are clear, concise, and, because of their practicality and straightforwardness, easy to remember and apply in the day-to-day practice of plastic surgery.

Wound Healing

The Healing Process

Wound healing is best observed on the body's surface although the following observations on and principles of wound healing apply also to the internal organs. The healing process is a series of chemical and physical reactions that are triggered by the occurrence of the wound itself.

Basic Wound Healing

There is an orderly series of events in wound healing. Although wound healing is often said to proceed in disjointed phases that last so many days each, there are no such sharp demarcations. To simplify teaching, efforts have been made to divide and specifically define the individual phases. The first phase of healing is an inflammatory response in the area surrounding the injury. The body mobilizes its reparative forces through the inflammatory response and deposits the necessary raw materials into the injured area. The raw materials (enzymes, leukocytes, protein molecules, and connective tissue cells) arrive in the area as a result of increased capillary permeability. The fluid and cellular activity occur within a substance called ground substance (see under The Wound Milieu). Ground substance undergoes polymerization and is involved in the formation of collagen, which is important in establishing the tensile strength of the healing wound.

Once the inflammatory response occurs and fluid and cellular elements are deposited into the forming ground substance, the wound begins to heal. By this process the body closes the wound.

A wound can be caused by almost anything that comes in contact with the skin. Whatever the cause of the wound and its location, the healing process varies only slightly. The type and extent of the wound and how it is treated determine the type and length of the healing process. For example, a simple laceration or a surgical incision that is surgically closed heals by primary intention. The surgically closed wound is the type usually given as an example in reports regarding wound healing and wound strength (Fig. 1-1A). But not all wounds are clean surgical wounds. Some involve destruction of the tissue (by burning or crushing), some wounds have tissue loss (skin avulsions), and some wounds require surgical debridement (cutting away) that results in tissue loss. The more severe the damage and tissue loss, the more involved and lengthy the healing process.

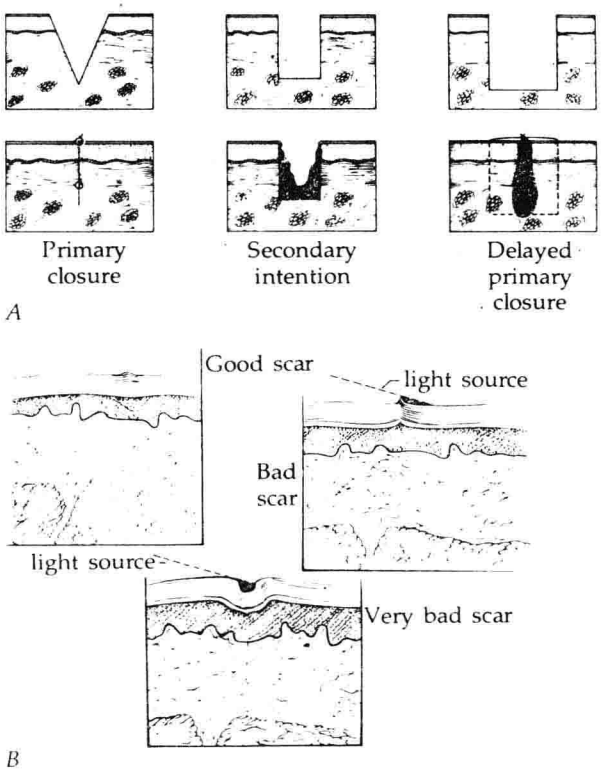


Figure 1-1
Types of wound closure. A. Primary closure of a wound by suture is the ideal. A wound not closed by surgical means closes by secondary intention—from the depths of the wound up by granulation tissue. A wound can be closed by delayed primary closure after several days of healing by secondary intention. B. The poor appearance of some scars is actually the result of variance in the way light strikes uneven surfaces. The very bad scar illustrated is a case in point. A deep shelled-out area has no light at the bottom, resulting in a darkened scar of poor appearance.

The healing of any wound results in a scar (Fig. 1-1B). The more extensive the damage, the greater the scar formation, and a more conspicuous deformity will result. Also, if the wound is not cared for properly, it may not heal correctly, resulting in a more conspicuous deformity (Fig. 1-2). That outcome is likely even if plastic and reconstructive surgical procedures, such as skin grafts or pedicle flaps, have been used.

Wounds heal by contraction and by epithelialization. *Wound contraction* is the process by which the edges of a wound are drawn toward each other by myofibroblasts in the base of the wound. *Epithelialization* is the process by which the wound is resurfaced with epithelium that moves in from the edges of the healing wound. Both processes may result in a smaller wound

Figure 1-2
The configuration of the scar has resulted in a trap-door deformity, in which edema fluid is trapped behind the line of the scar. Scar revision would be helpful.

in injured areas where there is actual tissue loss. *Wound contracture* is a pathologic condition that can result from wound contraction. The degree of contracture depends on the location, size, and shape of the wound.

The Wound Milieu

For healing to occur, the body provides a milieu that consists of ground substance—the amorphous substance that permits diffusion of cell fluid, metabolites, and electrolytes between the blood vessels and the developing cells. Ground substance is structureless and gel-like. It is composed of nonsulfated mucopolysaccharides (hyaluronic acid and chondroitin) and sulfated mucopolysaccharides (chondroitin sulfate A, B, C, heparin sulfate, and keratosulfate). It is a complex substance that is involved in constantly occurring reactions. The reactions result in polymerization and bonding of the forming molecules, and thus in increasing strength of the healing wound. Ground substance is the milieu for fibrous protein synthesis, which ultimately provides wound strength.

Epithelialization

Epithelial closure of a wound seals the open area, making the body's covering watertight and impervious to contaminants. Epithelialization occurs by cellular activity that resembles embryonic cellular activity. New cells approach the center of the wound by extending pseudopodia. The farther the epithelial layer advances from the wound edges, the thinner it becomes. This cellular activity, including cell division, continues until the

developing cells come into contact with normal cells. Chronic wounds that do not heal (especially wounds caused by burns, x-rays, and chemicals) can develop into malignant skin ulcers.

Many aspects of the healing process closely resemble embryonic activity. Cells active in the healing process resemble new or embryonic cells and may be analogous to those responsible for organ regeneration observed in lower life forms, such as hydras. Even though those cells involved in healing exhibit mitosis and pleomorphism, there are an order and a control (of the healing process), such as are seen in the embryo. (Mitosis and pleomorphism are observed in malignancies also, but in malignancies they are uncontrolled and without order.) On the surface, epithelium covers the granulation tissue, the raw, uncovered portion of the wound. Contraction is a major influence, and it proceeds as the tensile strength of the wound increases, but never quite reaches the strength of normal tissue.

Wound Contraction

Wound contraction reduces the size of a wound by centripetal movement. There appears to be a waiting period while the necessary cellular and chemical substances accumulate in the proper ratio. Active cells in the healing wound contract. The cells are located in the granulation tissue. Recent studies have identified a cell containing elements of smooth muscle. The cell, termed a myofibroblast, creates a force that mobilizes the skin edge, resulting in contraction (Fig. 1-3). It then manufactures collagen filaments, which hold the wound in its new, contracted, shape. Then other myofibroblasts contract and produce collagen, and the process is continually repeated. Contraction is another way nature has of making the wound smaller, attempting to close the gap. Research on wound contraction is continual and changing.

Collagen

Collagen is the most important structural component in wound healing. Collagen joins the edges of the wound with a latticework of fibers. The network gives healing wounds their tensile strength.

Fibroblasts form collagen. Wound strength results from cross-linking between collagen molecules. Scurvy (vitamin C deficiency) is a disease caused by a collagen deficiency, in which effective hydroxylation of proline does not occur. As a result, wounds in persons with scurvy cannot achieve proper strength.

Once the wound has closed by the processes of epithelialization and contraction, the scar (made of collagen) matures and remodels itself. The scar is actually a realignment of the linkage between the collagen fibers. When the maturation of collagen has reached its peak, the tensile properties of the injured tissue are similar to the properties of normal skin and the healing process has ended. Depending on the age of the patient, the type of skin involved, and the nature of the injury, the total process can take months, even as long as 2 years.

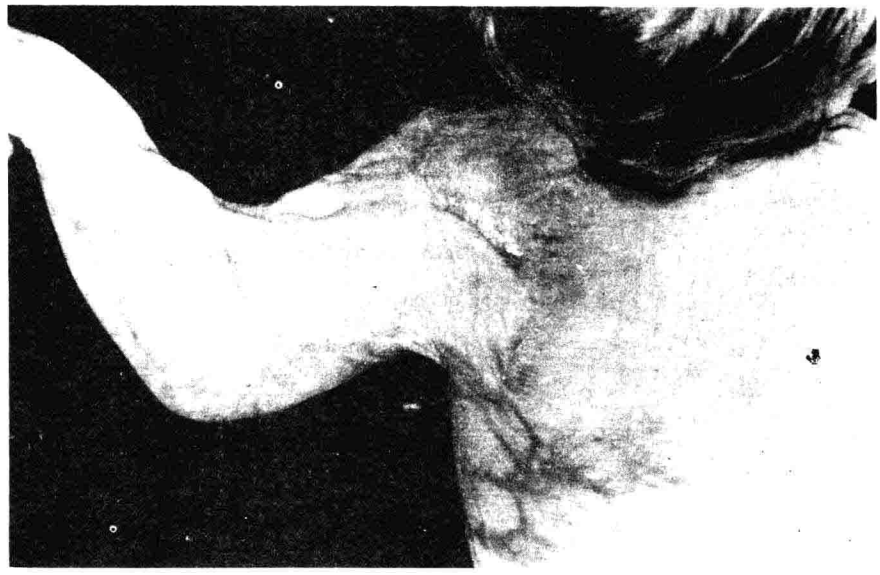


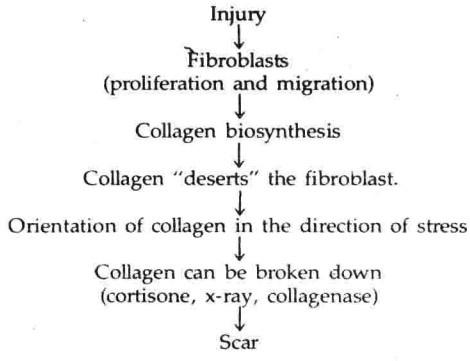
Figure 1-3
When a wound heals by secondary intention, there is a tendency for the raw surfaces to coapt, thus pulling structures together. In the wound-healing process everything is done to close the wound, including contracture. As shown, a wound healing by secondary intention and contracture can result in severely limited function. The scar contracture shown here should be released, and the scar tissue should be replaced with the kind of tissue that was lost, in this case skin tissue.

The basic surgical techniques regarding wound care and management have been well documented. However, even with the most meticulous surgical technique, the problem of the scar still remains. Many wounds, depending on their location, type, and initial care, heal with a very fine scar. But wounds in some areas of the body (for example, the shoulder and chest regions) take longer to heal and mature. They usually heal with heavier and more unsightly scars. Although much is known about wound biology, the knowledge has yet to be applied clinically to obtain the best possible results.

The Formation of a Pathologic Scar

In an abnormal scar, the metabolic activity of the fibroblast is not as well controlled in the remodeling phase as it is in the scar that heals in a normal manner. Infection and internal factors, such as metabolic disorders (e.g., diabetes, uremia, clotting abnormalities, endocrinopathy) and nutritional deficiencies can affect the normal healing process. Internal problems related to the body's immunologic system can predispose the patient to wound infection and improper healing.

Table 1-1
The Healing Process



"Overheal"

The age, health, and vigor of the patient and the location of the scar also influence the final appearance of the scar. Young, healthy patients heal faster and better than do older or chronically ill people.

Facial wounds usually heal with less scarring than do extremity or sternal wounds. A scar may "overheal," resulting in a hypertrophic scar, or a keloid. (A keloid is a mass of scar which grows abnormally large on an otherwise normally healing wound.) It is not known why some people form these abnormal scars. It could be that the collagen turnover is accelerated. It could be that an enzyme (such as collagenase) is not as plentiful in the wound of the patient that forms a keloid as it is in the patient that develops a normal scar. In other words, it is possible that there is a decrease in collagenase and collagen destruction in the person who forms keloids (Fig. 1-4). The decrease results in an overabundance of collagen, and a more severe scar results.

The overproduction of collagen can be inhibited by injecting steroids into the upper dermis and by the use of pressure dressings on the healing wound. Pressure on the maturing scar can be of help in realigning the collagen fibers in a longitudinal manner (such as is seen in a normal scar) and reducing the whorllike arrangement that appears in the hypertrophic scar.

Collagen synthesis can be controlled by minimizing the tension on the wounds, by placing excisions along the natural lines, and by redirecting scars from perpendicular to the lines of skin tension to parallel to the lines of skin tension (Z-plasty). The width of a scar is related indirectly to its tensile strength. Proper closure can reduce the width, leaving a better-looking scar and one that has adequate wound tensile strength.

Figure 1-4
This patient has a keloid, which is a typical example of the body's repair processes overdoing themselves. The keloid could have been caused by an overproduction of a collagen or an inability of the body to destroy collagen formed in the normal wound-healing process.

Immunology

The broad meaning of *immune* is "exempt from," as from taxes or military service. People may become immune (or exempt from) a disease, such as smallpox or plague, after they have contracted the disease once. The immune state is achieved through a series of biochemical processes that form the basis of modern immunology studies.

It is believed that there is a single hematopoietic stem cell which first appears in the extraembryonic yolk sac. The stem cell migrates to hematopoietic centers and differentiates into two basic immunologic systems—the cell-based system and the humoral system.

Lymphoid System

The lymphoid cell series appears in the thymus in mammals and governs the development of cellular immunity. These thymus-dependent cells are called T cells. The T cell represents the immunocompetent cell population. The thymus atrophies in the adult, but its function is maintained by bone marrow and peripheral lymphoid tissue.

Humoral System

The B cell descends from the stem cell in the bone marrow, and it is responsible for the circulating immunoglobulins (humoral immunity). It is believed that the lymphoid system is the seat of the body's immunologic response and that the small mature lymphocytes or plasma cells are responsible for the response. T cells must migrate to the periphery in order to neutralize the antigens, whereas the B cells move less and are located within the germinal centers of the lymphoid tissues of the lymph nodes and spleen.

If the foreign or antigenic substance is administered intravenously, there is an early lymphoid response, but one that produces a less profound and less persistent state of immunity. The intradermal avenue of injection gives the body more time to respond, which makes this route a more efficient immunizing one. (This phenomenon accounts for the fact that vascularized organ transplants, such as a kidney transplant, withstand rejection better than nonvascularized grafts do.)

The lymphocytes apparently react with the antigen, usually in a direct interaction with the antigen or its products. The interaction seems to be specific. The reaction of the antigen with the antigen receptor triggers the cellular response necessary for antibody production or cell-mediated immunity. Both the T and the B cells seem to complement each other's competence.

The immunocyte-antigen interaction triggers the inflammatory response. The response involves enzyme systems, including those connected with complement and clotting, and a number of cellular reactions that involve lymphocytes, macrophages, platelets, and polymorphonuclear leukocytes. All these agents work within the inflammatory response to remove foreign material or protein from the body.

Autografts are tissues transferred from one part of an individual (donor site) to another part (recipient site) of the same individual. *Isografts*, or isogenic grafts, are grafts between identical twins. Isografts survive indefinitely once vascular supply has been established by the host. The body identifies grafts that are not isografts or autografts as foreign material, and its antibody system rejects the antigen or foreign tissue. *Homografts*, or allografts, are tissues or organs transferred between individuals of the same species. *Xenografts*, or heterografts, are grafts transferred between individuals of different species. Xenografts are rejected even more vigorously and rapidly than are homografts.

To transfer tissue between individuals of the same species (homografts) or different species (xenografts), the antigen-antibody reaction must be prevented. Prevention can be effected by one of the following measures:

1. Destruction of the competence of the immune cell by
   a. Antimetabolites

   b. Alkylating agents
   c. Steroids
   d. Toxic antibiotics
2. Extirpation of the immunologic cell mass by
   a. Extirpation of lymphoid tissue
   b. Thymectomy
   c. Thoracic duct cannulation and drainage, which depletes the body of a large portion of the circulating small lymphocytes
3. Destruction of the immune cell and its stem cells by
   a. Irradiation (extracorporeal or radioactive isotope)
   b. Antilymphocytic globulin

Grafts may be used as temporary free grafts. They may die and leave an inert strut that provides a framework for ingrowth of host tissues, such as are used in bone, cartilage, nerve, tendon, and fascial grafts. The grafts may be useful as temporary dressings (e.g., pigskin or human amnion). Some privileged free grafts, such as corneas, blood vessels, and heart valves are able to survive without immunosuppression.

Clinically, autotransplants have been done with hair, skin, teeth, veins, arteries, heart valves, bone, cartilage, fat, fascia, nerves, tendons, arms, legs, fingers, hands, ovaries, testes, adrenal glands, and bone marrow. Homografts have been done with corneas, teeth, thyroid glands, parathyroid glands, ovaries, testes, spleens, lymph nodes, skin, bones, cartilage, fascia, tendons, nerves, arteries, heart valves, bone marrow, pancreases, kidneys, lungs, and hearts. Xenografts have been carried out using heart valves, hearts, livers, kidneys, bones, cartilage, and skin.

The Wound and Infection

The first line of defense against infection is a combination of cellular and tissue mechanisms (mechanical barriers). The second line of defense is the inflammatory response, in which the polymorphonuclear leukocytes migrate through the walls of the blood vessels at the site of inflammation. The intensity and length of the inflammatory process depend on the number and virulence of the invading microorganisms, the extent of the injury, the amount of associated tissue damage, and the type of microorganism involved. Invasion past the second line of defense results in a regional lymphadenitis, which indicates a systemic involvement.

Pathophysiology of Infection: General Factors

Clinical infection is manifested by invasion of microorganisms. The most important defense against infection is the host's properly functioning immune mechanism. The normal host defense mechanisms may be weakened by systemic diseases, such as leukemia, lymphoma, or other malignancies, diabetes mellitus, and Cushing's syndrome. If other prob-

lems (thermal injury, uremia, vascular failure, malnutrition, major trauma, immunosuppression) are present at the time of bacterial invasion, the wound is likely to become infected.

Bacteriology and Wound Infections

Surgical infections are usually polymicrobic and initially localized. They are invasive, with rapid growth and spread of bacteria into surrounding tissues or systems that may result in suppuration, necrosis, gangrene, prolonged morbidity, and death. The treatment of surgical infections can be medical or surgical (debridement and incision and drainage if an abscess has formed). Antimicrobial agents play an important secondary role in treating surgical infections.

If surgical infections are untreated, systemic involvement may occur. The scope of infection may range from a simple temperature elevation to the development of persistent bacteremia or septicemia originating in an abscess. The average rate of infection on university surgical services is 7.5 percent of patients hospitalized. The percentage of infection on plastic surgery services should be, and usually is, lower than the average.

A wound that contains more than 10^5 bacteria per gram of tissue is likely to become infected. The type and virulence of the invading bacteria are also important, as is the depth of the bacterial invasion. For example, in a burn wound, a small number of bacteria that invade deep into the tissue can rapidly bring about sepsis.

Dirt and soil contain specific agents that encourage infection by chemically impairing the wound's resistance to infection. Therefore all contaminated wounds must be thoroughly cleansed and debrided before they are closed. To fail to do so is to invite the complications of wound infection, resulting in delayed wound healing.

All wounds should be examined and treated under sterile conditions. Any factors that increase the number of bacteria present in the wound to 10^5 or more per gram of tissue will make overt infection more likely. Human saliva is heavily contaminated by bacteria, and droplets from the physician's or the nurse's mouth in the emergency room may be sufficient to tip the balance.

Since wounds are usually painful, it is better to anesthetize the wounded area before cleansing it. Anesthesia may be induced by local infiltration of anesthetic agents, nerve block, or general anesthesia. Lidocaine, the most commonly employed anesthetic agent, does not interfere with tissue defenses or invite infection. It does not have any known effect on infection. The effects of lidocaine last approximately 2 to 2½ hours. Epinephrine, by its vasoconstrictor action, increases the duration of the local anesthetic. Since it reduces local blood flow, it could temporarily impair the mobilization of the inflammatory response that initiates the wound-healing process.

After adequate local anesthesia has been achieved, the wound is