AMERICAN COLLEGE OF SURGEONS

Committee on Control of Surgical Infections
of the Committee on Pre- and Postoperative Care

MANUAL ON

Control of Infection in Surgical Patients

SECOND EDITION

Editorial Subcommittee

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Preoperative Preparation of the Patient

The objectives of preoperative preparation of the patient are to improve his resistance to infection, reduce the total number of bacteria in sites of potential contamination and infection, and decrease the opportunities for bacterial entry into the physiological interior of the body. At the same time it is to be kept in mind that the gentle handling of tissues and accurate hemostasis are as important as asepsis in the prevention of most wound infections (Chap. 9).

These preoperative goals may not be reached in all surgical patients since many of the techniques require substantial periods of time and, therefore, their application to patients requiring an emergency operation may not be possible. In patients who are candidates for elective surgical procedures, careful implementation of the following principles should be considered.

PREADMISSION PREOPERATIVE PREPARATION AND HYGIENE

There are a number of measures that should be considered in the preoperative period for the prevention of postoperative infections in patients scheduled for elective surgical procedures. Among the possible methods of achieving this goal are shortening the preoperative period of hospitalization, controlling the patient's weight, correcting malnutrition, identifying and treating established remote infections, treating associated diseases, and maintaining general cleanliness.

Weight Control

The increase in the rate of wound infection and the increased hazard of pulmonary complications in the obese patient is proven. In obese patients preparing for elective surgery, it may be advisable to invest the time necessary to return the patient to acceptable weight prior to operation. It is noteworthy that severe obesity was found to be associated with an increased postoperative infection rate of 18.1% in

the National Academy of Science/National Research Council (NAS/NRC) five-university ultraviolet collaborative study, confirming the belief of many experienced surgeons in this regard (Howard).

Conversely, for the *malnourished* patient, improvement in the patient's state of nutrition is mandatory prior to elective surgery, since host resistance to infection may be impaired by starvation and by vitamin and protein deficiencies. In 67 severely malnourished patients who underwent surgery in the collaborative ultraviolet wound study, 22.4% developed wound infection, indicating the higher risk to infection of this type of patient. For those malnourished or undernourished persons whose usual route of food intake is blocked, calories, protein, vitamins, and other essentials should be provided parenterally until any metabolic deficits have been corrected. Fischer has pointed out that the relationship between nutritional support and the prevention or therapy of infections is a newly opened therapeutic field. There is evidence that in severely injured or burned patients, nonspecific host resistance is enhanced by the administration of an increased amount of protein. Similar data have been obtained in renal failure in the study carried out by Abel and co-workers and in a recently completed study by Cerra and co-workers in patients with hepatic disease, a finding supported by a multi-center Italian trial reported by Fiaccodori, and associates. The exact mechanism of such enhancement of resistance to infection is not clear; it may involve specific amino acids and their effects on specific host defense functions, or it may be a more nonspecific effect.

Remote Infections

The presence of any active infection should be searched for and identified prior to operation by detailed preoperative evaluation of the patient who is to undergo an elective operation. These infections may be entirely unrelated to the disease of concern, but they may contribute substantially to the risk of operative wound infection or to systemic infectious complications if unrecognized and untreated. The mechanism of spread may be either by dispersal over skin routes or by systemic routes. In both instances attempts at production of a barrier to its spread are less successful than eradication of the infection prior to operation. The presence of an acute upper respiratory infection, chronic ear infections, active skin infections such as furuncles, chronically draining sinuses, chronic dermatologic disease, acute or smouldering urinary tract infection, active peridontal disease, or chronic respiratory infections are strong reasons to consider deferring elective operations until control of such remote infections is accomplished.

In the unimmunized patient who has sustained trauma or burns, immunization against tetanus should be carried out according to guidelines of the American College of Surgeons (Walt).

Associated Noninfectious Conditions

A significant measure of benefit may also be gained by the correction or treatment of certain associated noninfectious conditions. Diabetes mellitus, uremia, and cirrhosis

require special attention. As indicated earlier, chronic malnutrition states require dietary correction, judicious use of medication, and possibly hyperalimentation.

Specific training and advice can be offered on an outpatient basis. This includes deep breathing and coughing exercises to assist in postoperative pulmonary toilet, instruction on relaxation during micturition to help prevent the need for urinary bladder catheterization postoperatively, and instruction to avoid air swallowing to help reduce gastric distention postoperatively.

More specific disorders, such as benign prostatic hypertrophy, may require surgical correction to avoid urinary tract instrumentation and possible infection during the postoperative period. In patients with chronic pulmonary disease, thorough respiratory toilet and training in the use of intermittent positive pressure breathing devices, chest percussion, and postural draining techniques may do much to reduce respiratory tract infection. Specific advice and training can be offered the preoperative patient to enhance ventilation, initiate micturition, and correct aerophagia. When a patient is known to be a carrier of pathogenic microorganisms, control of this carrier state is of considerable importance (Chaps. 3, 4, and 10).

General Cleanliness

It is important to remove any dirt or soilage from the body surface through bathing or a shower, with special attention being given to the fingernails and toenails. The use of antiseptic soaps may be of additional value, as shown by Cruse; for example, his evaluation of the benefit of a preoperative shower with hexachlorophene soap in patients undergoing clean operations has shown a statistically significant improvement in infection rate. Such a study comparing three groups—those who had no preoperative shower, those who showered with ordinary bar soap, and those who showered with hexachlorophene soap—revealed infection rates of 2.3, 2.1, and 1.3% respectively.

POSTADMISSION PREOPERATIVE PREPARATION

After admission, it is important to continue the various measures described for the preadmission preparation for each patient. In addition, the possible effects of hospital environmental exposure of patients preoperatively should be kept in mind.

Exposure to the Hospital Environment and Length of Preoperative Stay

Consistent with the proper general care of the patient, his preoperative hospital stay should be as brief as possible. A direct correlation between the duration of preoperative hospital stay and the rate of postoperative wound infections has been demonstrated. For example, patients with electrolyte disorders, water imbalance, significant anemia, urinary or intestinal tract obstruction, or cardiac decompensation may require several days or more of treatment in the hospital before operation. Since

bacteria migrate passively about hospitals on the hands and hair of hospital personnel, linens, air currents, and equipment, they may become part of the patient's flora and be implicated later in wound or other nosocomial infections. In the NAS/NRC ultraviolet study, the data showed that the rate of infection was approximately two times greater after 2 weeks' hospitalization and three times greater after 3 weeks' hospitalization, as compared with the rate in patients admitted 1 to 3 days preoperatively. Opportunities for contact spread from patients with existing infections to the preoperative patient must be kept to a minimum (Chaps. 7, 8, 10, 13, 14, and 17).

The patient approaching elective operation following long-term hospitalization and preparation may have had the bacterial flora of his various tracts significantly modified. Baseline cultures taken from the respiratory, genitourinary, or gastrointestinal tracts may be helpful in revealing the identity of microorganisms with unusual potential or capability for producing postoperative infections.

Immediate Preoperative Preparation

Management of Hair at the Operation Site. Difference of opinion exists as to the most appropriate method of dealing with hair in the area of the proposed operative incision. The influence of hair management on the incidence of postoperative wound infection has been scrutinized by several observers.

In 1971 Seropian and Reynolds, studying 406 patients, reported that the postoperative wound infection rate was 5.6% in those shaved with a razor; 0.6% in those not shaved; and 0.6% in those in whom hair was removed by a depilatory cream. Two years later Cruse and Foord reported that the clean wound infection rate in patients who were shaved was 2.3%; in those not shaved but who had only pubic hair removed, 1.7%; and in patients who were neither shaved nor clipped, 0.9%.

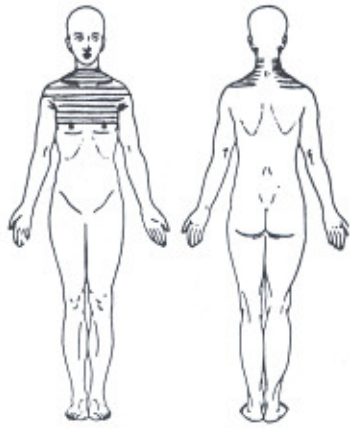
By means of observations on 1013 patients reported in 1983, Alexander and his colleagues compared the influence of razor shaving and of clipping on the incidence of postoperative wound infection. Hair was removed from the operative area by one of four methods: shaving the night before operation; shaving the morning of operation; clipping the evening of operation; or clipping the morning of operation. The incidence of postoperative wound infection at time of discharge from hospital and at 30 days following operation is indicated in Table 6-1. Within the framework of this study, clipping the morning of operation is the preferred method.

If hair is to be removed, it should be done with care, avoiding skin injury or irritation. Shaving or even clipping may destroy some of the natural integumentary defenses, and may produce multiple superficial lesions containing exuded tissue fluids that favor or contain bacterial growth. This probability is the basis for the practice of shaving or clipping immediately prior to the time of the operation.

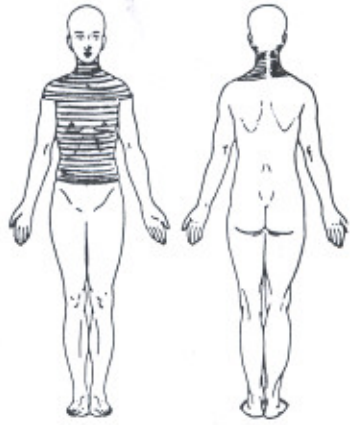
The area prepared must be adequate for the incision planned and for any possible extensions of it, as well as any possible additional incisions or points of exit of drains or tubes, the use of which may be necessitated by the procedure. An additional factor

(Text continues on p 81)

Thyroid prep. Extends from chin line to nipples, including axillary region. Extend to back of neck and upper shoulder as sketched.



Parathyroid prep (as for sternal splitting). Extends from chin line to umbilicus, shoulder to shoulder in the front. Extend to back of neck and upper shoulder in back as shown. Prep laterally for chest tubes if so ordered.



Thoracotomy prep. Extends from chin line to iliac crest, from nipple on unaffected side to at least 2 inches beyond the midline in back. Include axilla and entire arm to elbow.

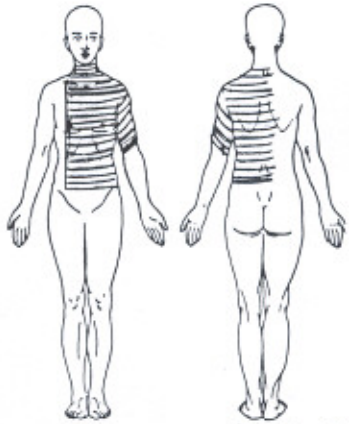


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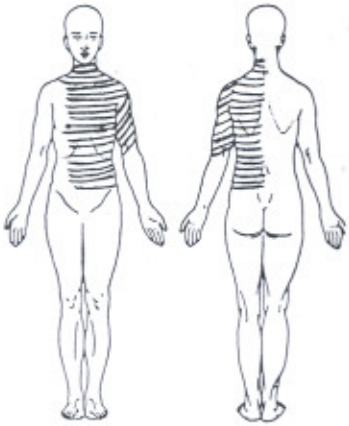
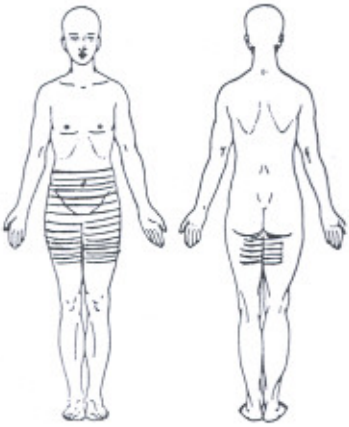
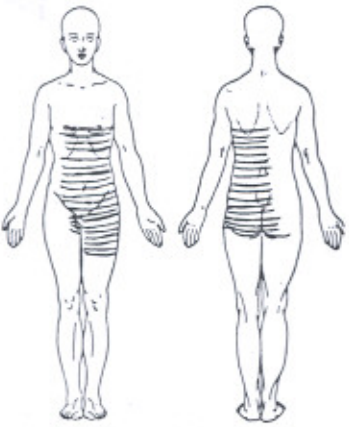
Fig. 6-1. Skin preparation recommended for surgical procedures. (Modified from Walter CW: In Current Practice Bulletin No. 7-2-5. Boston, Massachusetts, Peter Bent Brigham Hospital, March, 1975)



Mastectomy prep. Extends from upper neck to iliac crest, from nipple line on unaffected side to midline of back (affected side). Prep axilla and entire arm to elbow on affected side.



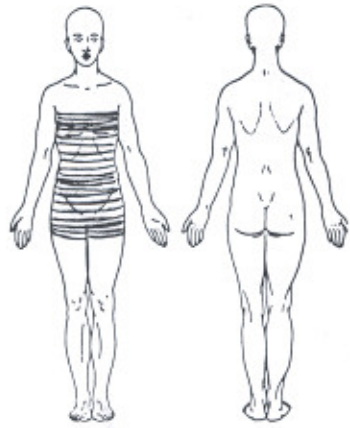
Lower abdominal prep (as for hernia, femoral vein ligation, femoral embolectomy). Extends from 2 inches above the umbilicus to mid-thigh, including the pubic area. Femoral ligation—prepare area to midline of thigh posteriorly. Hernia and embolectomy—prepare to costal margin and down to knee as ordered.



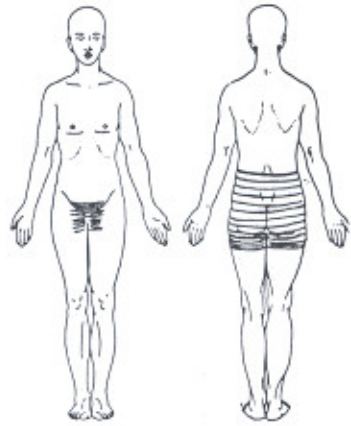
Flank prep (as for renal procedures, adrenalectomy, sympathectomy). Extends from nipple line to pubis and 3 inches beyond the midline in back. Prepare pubic area. Prepare upper thigh on the affected side.

Fig. 6-1, Cont.

Abdominal prep. Extends from 3 inches above the nipple line to upper thighs, including pubis.



Perineal prep (as for hemorrhoidectomy, fistula-in-ano, pilonidal sinus). Extends from pubis, perineum and perianal area, from the waist in back to at least 3 inches below the groin.



Spine prep. Extends from entire back including shoulders and neck to hairline and down to knees and to both sides, including axillae.

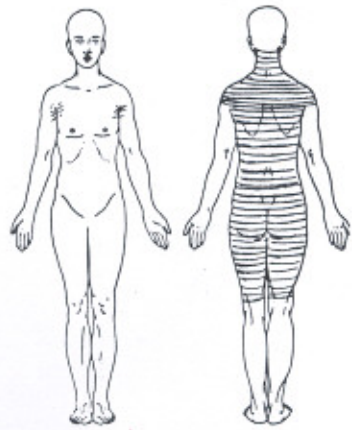
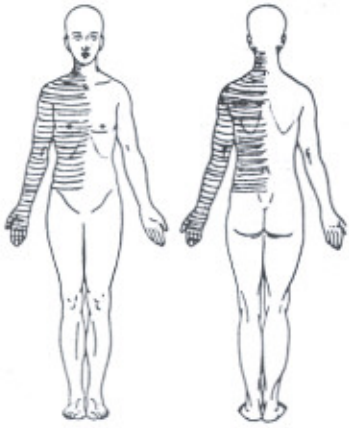
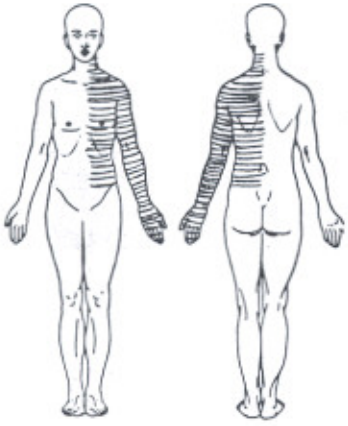


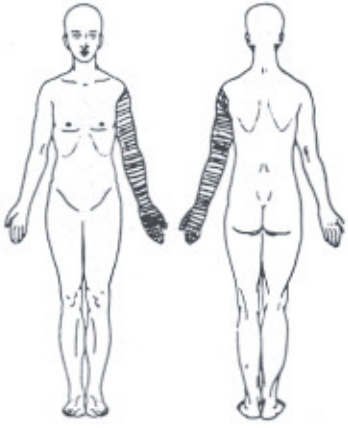
Fig. 6-1, Cont.



Shoulder prep. Extends from fingertips to hairline, midline chest to midline spine on operative side and to iliac crest, including axillae.



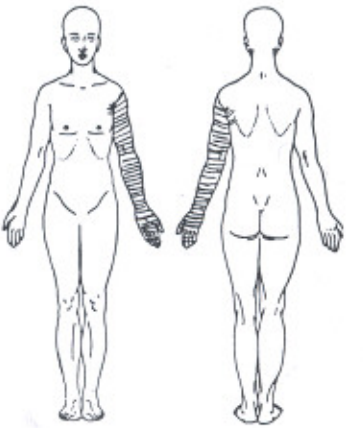
Upper arm prep. Extends from fingertips to neckline (hairline), on operative side from midline chest to midline spine, on operative side from axilla to iliac crest. Trim and clean fingernails. Use brush on hand and nails.



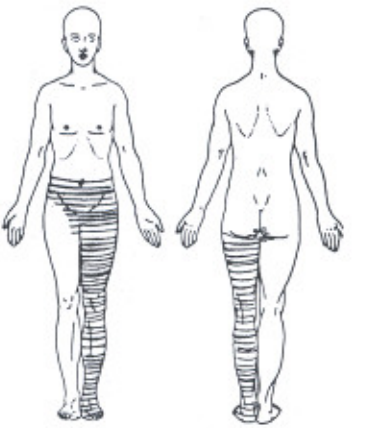
Hand prep. Extends from fingertips to shoulder. Trim and clean fingernails. Use brush on hand and nails.

Fig. 6-1, Cont.

Forearm and elbow prep. Extends from fingernails to shoulder including axilla. Trim and clean fingernails. Use brush on hand and nails.



Saphenous vein ligation prep. Extends from umbilicus to toes of affected leg, or both legs. Include pubis and perineal area. Prep entire leg posteriorly.



Thigh prep. Extends from toes to 3 inches above the umbilicus, midline front and back, including complete pubic area. Clean and trim toenails. Use brush on foot and nails.

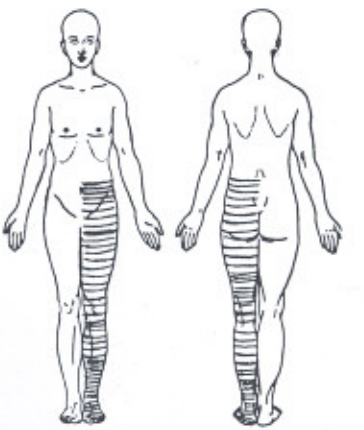
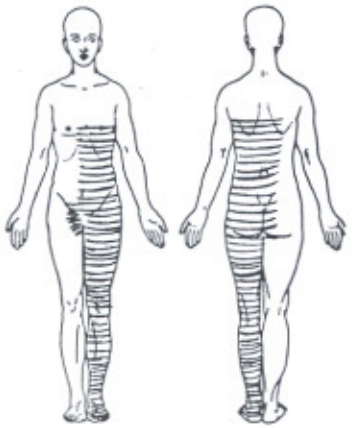
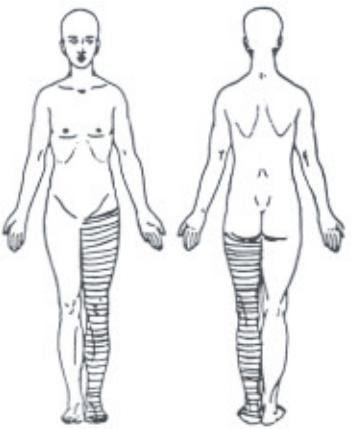


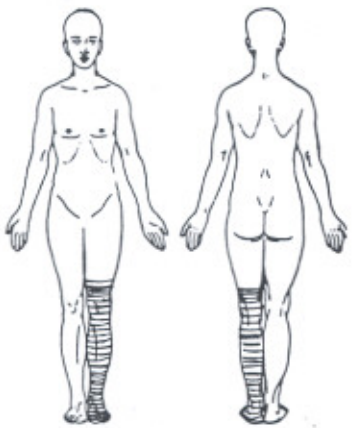
Fig. 6-1, Cont.



Hip prep. Extends from toes to nipple line to at least 3 inches beyond midline back and front, including complete pubic area. Clean and trim toenails. Use brush on foot and nails. Hip fractures—all preps done in the operating room.



Knee and lower leg prep. Extends from entire leg, toes to groin. Clean and trim toenails. Use brush on foot and nails.



Ankle and foot prep. Extends from entire leg, toes to 3 inches above the knee. Clean and trim toenails. Use brush on foot and nails.

Fig. 6-1, Cont.

Table 6-1. **Infection Rates and Preoperative Hair Management: Data from Alexander, Fisher, and Co-workers**

	Infected At Discharge	Infected At 30 Days
P.M. Razor	14/271 (5.2%)	23/260 (8.8%)
A.M. Razor	17/266 (6.4%)	26/260 (10.0%)
P.M. Clipper	10/250 (4.0%)	18/241 (7.5%)
A.M. Clipper	4/266 (1.8%)	7/216 (3.2%)
Overall	45/1013(4.4%)	74/977 (7.6%)

(Data from Alexander JW, Fisher JE et al: The influence of hair removal methods on wound infections. Arch Surg 118:347–352, 1983)

to consider is the area to be covered by adhesive tape, which will adhere poorly to hair-bearing skin and may cause pain when removed.

Skin Degerming. There is also considerable confusion and difference of opinion about the most effective methods of preparing the skin of the operative area and the most efficient types of degerming agents to be used. It must be kept in mind that while it is possible to sterilize all, or virtually all, of the instruments and other equipment used at operation, one cannot sterilize the skin either of the surgeon or of the patient's operative site without damaging or destroying it (Lowbury). The most that can be done to prevent contamination of wounds from these sources is to disinfect the skin by methods that usually leave some bacteria in the disinfected area. These bacteria, as Price showed many years ago, can be divided into "transient" and "resident" flora. The important practical distinction, though, is between superficial organisms, which can be almost completely removed either by washing with soap and water or by disinfection, and the more adherent organisms, which are much more effectively removed by disinfection than by washing. Most of the latter are undoubtedly residents, but some, for example *Clostridium perfringens,* are unlikely to multiply on the skin; these organisms are not residents, although they are undoubtedly adherent.

Heavy fecal contamination of the skin of the thighs and buttocks presents a hazard of gas gangrene in patients with poor blood supply having operations involving muscle and bone (*e.g.,* amputation for diabetic gangrene). In this situation a large proportion of *C. perfringens* spores can be destroyed on the skin by preoperative application of a compress soaked in povidone-iodine (Betadine) solution.

In 1965, 195 university and nonuniversity hospitals of wide geographic distribution were surveyed about their skin degerming practices. A significant change in the practices for degerming the *patient's* skin from the time that Price completed his

study in 1948 had occurred. The use of the organic mercurials had decreased markedly, particularly in the university hospitals. The use of ethyl alcohol had also decreased considerably, and the use of Zephiran and quaternary ammonium compounds had to some extent diminished. Also, although the bis-phenols (hexachlorophene), of which pHisoHex and Septisol are probably the best known, are not bactericidal on contact and require a fairly protracted period to alter the bacterial floras, they were used without other degermers in a surprising percentage of instances. Another point of interest was related to *benzalkonium chloride* (Zephiran). The quaternary ammonium compound is a cationic degermer, and many have felt that the anionic environment left by washing with soap would vitiate the activity of Zephiran. Yet, in a surprisingly high percentage of institutions where Zephiran was used, there was no effort to rinse the skin of soap that had previously been applied.

On the basis of the presentations and discussions at the second and third symposia which it conducted, the Committee on Control of Surgical Infections prepared the following recommendations for the preparation of the operative area.

1. The preparation of the operative area should be done by a physician, a member of the operating team, a nurse, or an operating room technician who is knowledgeable and specially trained for this purpose. Sterile gloves should be worn during this procedure and sterile supplies used (Fig. 6-2 and 6-3).
2. The areas should initially be cleansed with soap, with a nonirritating detergent solution, or with a fat solvent.
3. A degerming agent should then be applied. Degerming agents commonly used for this purpose include iodine solutions, chlorhexidine, alcohol, quaternary ammonium compounds, and hexachlorophene.

Commonly Used Degerming Agents

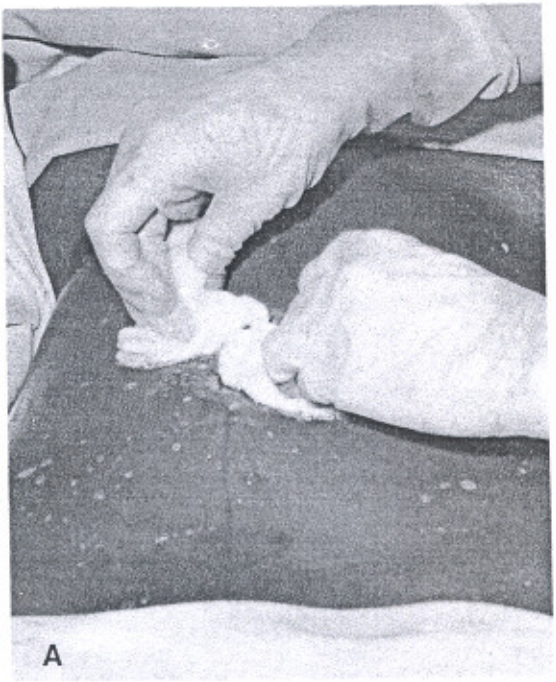
Iodine and iodine compounds. Tincture of iodine is a time-honored degerming agent for skin preparation, but, because of sensitivity reactions and dermatitis, it has been largely replaced by iodine compounds known as iodophors. These compounds contain 1% to 3% elemental iodine. Release of the iodine accounts for germicidal action and also may cause hyperplasia of the thyroid. Iodine compounds are bactericidal and are effective against gram-positive and gram-negative organisms. Combined with a detergent, they are now popular and considered to be effective.

Chlorhexidine gluconate. Chlorhexidine gluconate (Hibiclens) is now approved by the U.S. Food and Drug Administration and is used widely. Chlorhexidine is for topical use only, and it offers a wide range of bactericidal activity, being effective against a wide spectrum of microorganisms. Its activity is reported not to be affected adversely by organic material (Lowbury).

Hexachlorophene preparations. Unlike the iodines, hexachlorophene (bis-phenol) preparations exert most of their effect on gram-positive organisms. They are often not bactericidal and require more prolonged contact to alter the bacterial flora. Their germicidal action depends on *p*H and solvent. They are being used less frequently.

Ethyl alcohol. Ethyl, or isopropyl, alcohol may be used as a 70% solution and is bactericidal for many gram-negative and gram-positive organisms.

Quaternary ammonium compounds. Benzalkonium chloride, cetylpyridinium chloride, and other quaternary ammonium compounds (cationic degerming agents) may be inactivated by anionic soaps, and they are more bacteriostatic than bactericidal. These solutions are not used frequently at this time.



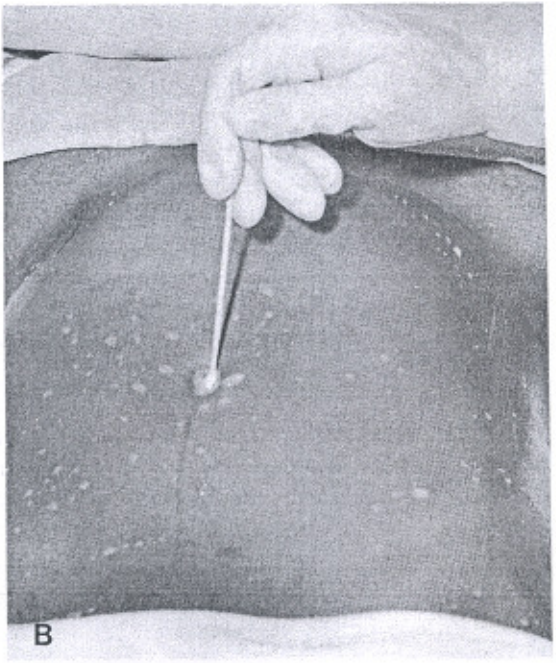


Fig. 6-2. *(A)* Preparation of the operating area is being done by a physician, using sterile gloves and sponges soaked in a detergent solution or liquid soap. In this case the "scrub" of the abdominal operative area lasted 10 minutes and was in preparation for a cholecystectomy. *(B)* The umbilicus frequently harbors dirt or other foreign material. This should be removed during the "scrubbing" preparation with sterile applicators soaked in the cleansing solution.

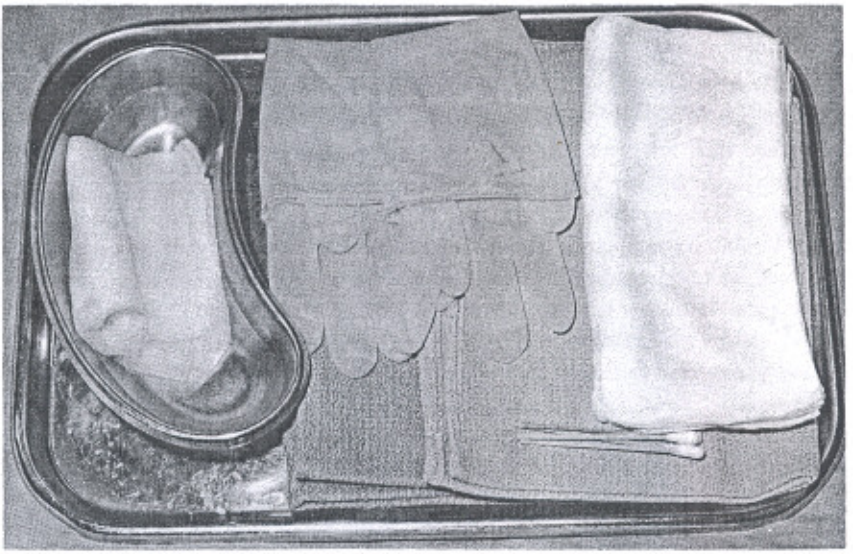


Fig. 6-3. A "prep" table with sterile cleansing solution, gauze sponges, and applicators ready for use by the physician, nurse, or operating room technician.

Most of the currently popular agents are acceptably benign if used in the prescribed manner, but certain persons develop allergic or atopic reactions to them. *Degerming agents may produce irritative effects on normal skin.* It should also be emphasized again that it is impossible to sterilize the skin of the patient's operative site without damaging or destroying it.

Improved removal and killing of bacteria on the skin of the operative site can be directly translated into a decrease in operative wound sepsis. For example, Cruse has reported data from a large number of patients. In the period 1967 to 1971, using a green soap and alcohol "skin prep" in the operating room, an infection rate of 2% was reported in 12,849 clean operations. In the 1971 to 1972 period, with the use of a povidone-iodine scrub on the ward, followed immediately by a preoperative paint with tincture of Hibitane, the infection rate fell to 1.2% in 1810 patients.

Techniques of Preparing the Operative Area. The Committee on Control of Surgical Infections has concluded that preparation of the operative area should include washing, but the method of "washing" or "scrubbing" may vary considerably. The methods used effectively by different authorities and different surgical centers vary considerably. For this reason several examples are described below. At the same time it is also recognized that other methods may be used effectively and safely.

1. The following method is one used at the Massachusetts General Hospital for the preparation of the operative field. It depends upon two steps that must be carried out exactly as outlined to be effective.

   In the *first step,* surface dirt, loose skin, and other debris are removed by the scrubbing of the skin of the operative field for 2 minutes with soap and water by a member of the scrubbed surgical team before gowning, using sterile gloves and gauze sponges held by sponge forceps. The gauze sponges are changed frequently. Although this step does not kill bacteria, it is effective in defatting and removing skin debris.

   The *second step* is the degerming step and is carried out by the application of 70% isopropyl alcohol containing a red dye for marking. This step is accomplished by scrubbing for 2 full minutes with frequently changed sterile gauze sponges soaked with the alcohol solution. Excess alcohol may be removed from the operative site by blotting with a dry, sterile towel.

   In preparing the skin over breast tumors or areas of cellulitis, gentle washing is necessary, but 2 minutes for each step is maintained. Skin surfaces adjacent to the prepared areas are protected from becoming wet by sterile "soak" towels discarded at the end of the skin prep procedure.

   An alternate method used at Massachusetts General Hospital consists of a scrub of the operative with iodophor solution for 2 minutes.

2. On the Surgical Service of the University of Cincinnati Medical Center, one method used in elective cases is a 5- or 10-minute scrub of the skin of the operative area with an iodophor (Betadine) solution followed by the painting of the skin with an iodophor solution. This time may be decreased, however, particularly when the operation involves the face, an area of cellulitis or other active infection where the possibility of the spread of bacteria exists, or a breast tumor where there is the possibility of dissemination of tumor cells. The site of operation may also dictate modification in the overall technique. The face requires particular gentleness and care, especially around the eyes.

   The type of preparation depends upon whether the procedure is an elective or an emergency one, since the nature of the emergency may necessitate modifications. As an example, an open traumatic wound, heavily infiltrated with dirt and foreign matter, may require not only considerably longer than 10 minutes for preparation but also irrigation with copious amounts of saline solution. Care must be taken to avoid the application of antiseptics and detergents to open wounds because of their local irritating effects and the possibility of systemic toxicity due to absorption(see Chap. 9).

   The routine skin preparation that has been used on the surgical service of the University of Cincinnati has included the following steps, as described by Altemeier:

   a. After careful placement of the patient on the operating table to provide maximal exposure and a safe position, towels are placed about the operative area to collect any excess of the "prepping" solution.
   b. The area is then gently "scrubbed" for a specified period of time using

iodophor solution, usually for 5 to 10 minutes, to remove surface debris, dirt, and desquamating skin and their microbial content.

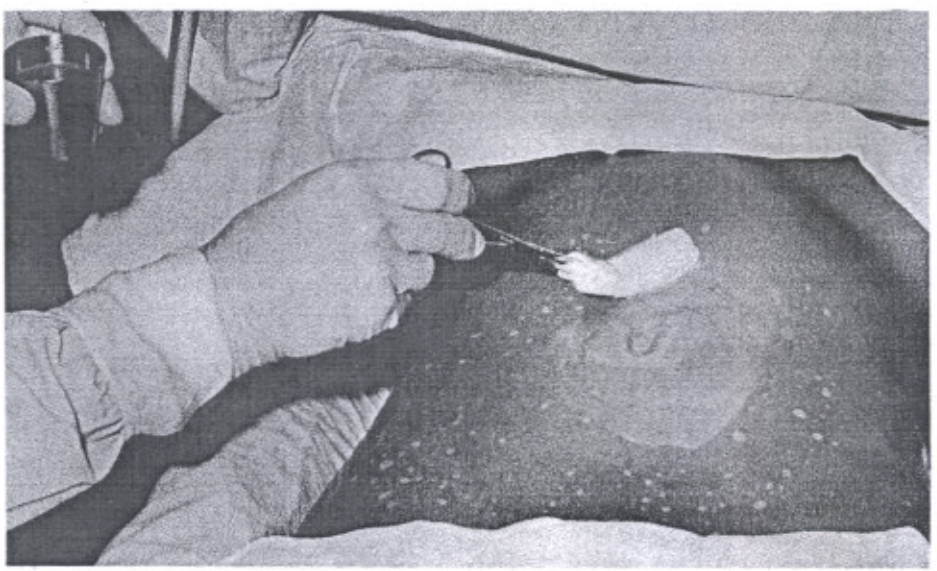
c. The scrubbing is usually done by an ungowned member of the scrubbed surgical team wearing sterile gloves and using sterile gauze sponges provided from a "prep table" (Fig. 6-3). A nurse or a technician may also be used in some instances as an alternate for this purpose if so trained and supervised. The gauze sponges are changed frequently. Care is taken to wash all areas evenly.

Prepackaged sterile disposable prep sets are commercially available and are in general use in most hospitals. They contain all the required dry material for preoperative scrubs and they contribute to the uniformity of the scrub technique. Application is started at the site of the incision and spread peripherally to minimize contamination from outside the field (Fig. 6-4).

With the above method, incorporated with appropriate draping described below and surgical technique discussed in Chapter 9, a consistently low rate of infection at 0.7 to 0.9% in clean elective operative wounds had been obtained on the surgical services at the University of Cincinnati hospitals.

Other methods used effectively at Cincinnati by some members of the surgical staff include a similar 5- to 10-minute scrub with hexachlorophene solution or a chlorhexidine solution with occasional modification.

Fig. 6-4. Application of antiseptic degerming solution to operative area in the circular manner, progressing peripherally. In this instance, tincture of Ceepryn is being applied over the residual solution of 1 : 100 aqueous Ceepryn used for the 10-min preoperative cleansing.



In the interest of *personnel training* and *cost effectiveness,* and for the purpose of developing a data base for clinical trials, it is considered desirable to establish one uniform technique within each institution if possible.

Draping. Appropriate draping is important as a means of demarcating, maintaining, and protecting a limited area prepared for the operation by cleansing and degerming techniques. It must be kept in mind that there are advantages to uniform drape design and application, including the saving of time, neatness, reduced contamination, decreased cost, and more accurate planning of required linen or other material. To accomplish a degree of standardization, each hospital should develop draping techniques and make them available to the operating team. The types of drapes in use include single-use prefabricated drapes (Fig. 6-5, *C*), and the conventional double-thickness linen towels and sheets (288-thread count) modified for use in various types of operations (Fig. 6-5, *A* and *B*). Plastic adhesive skin drapes may be particularly useful in excluding contamination from sinuses, fistulae, colostomies, and other contaminated or infected drainage tracts (Fig. 6-5, *E*).

Disposable or single use drapes. There exist considerable differences in opinion about the value and adequacy of disposable drapes for routine operating room use. Their use has increased considerably because of their ready availability, the escalation of costs of laundering and sterilizing linen drapes, and labor problems in providing a continuing supply of available linen drape material, especially for peak or unanticipated loads. Single-use drapes are gaining in popularity for the following reasons:

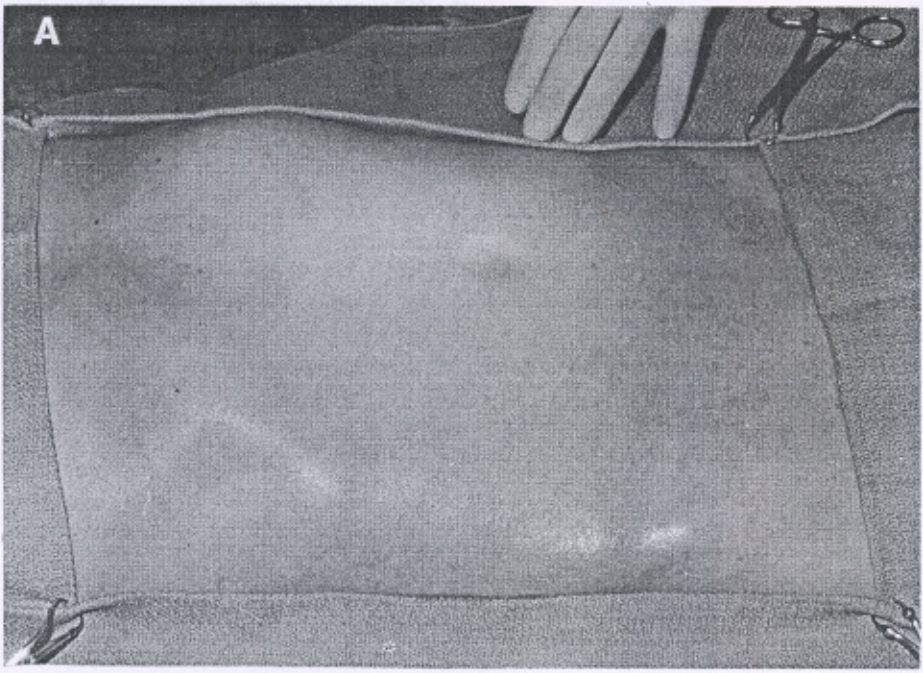
- Improved barrier properties
- Decreased linting
- Ready availability
- Competitiveness in cost
- Standardized application
- Ease in disposal of contaminated drapes
- Ease of stockpiling for use in unusual circumstances or in event of catastrophe
- Consistent packaging, and uniform supply and use procedures

The disadvantages of single-use drapes include the following:

- Proprietary variation
- Poor conformity to body contours
- Insufficient strength to permit manipulations of hip and extremities without tearing
- A possible fire hazard and an ecology problem presented by disposal
- Larger storage space needed because of increased bulk
- Hazard of electrification unless stored at the ambient temperature and humidity of the operating room

Linen drapes. Many surgeons continue to use "linen" drapes because of their conformity to body surfaces, their strength, and their adaptability to motion when required. When using linen drapes, consideration should be given to suturing to the

(Text continues on p 91)



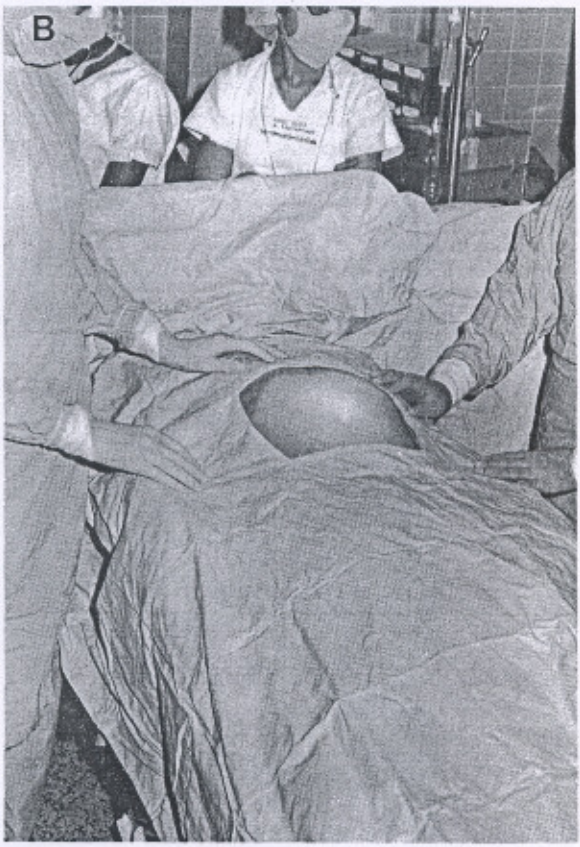
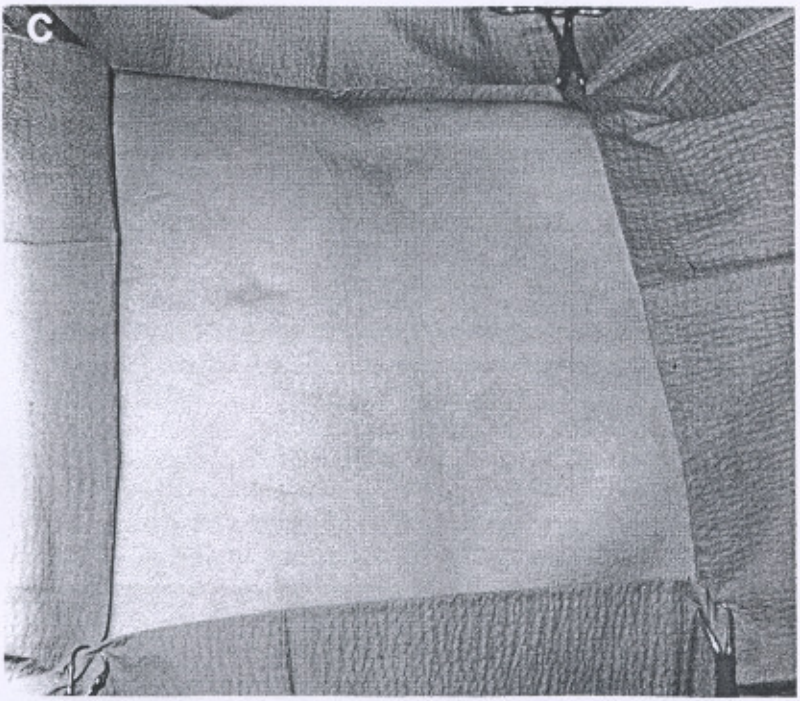


Fig. 6-5. *(A* and *B)* A patient is draped with sterile conventional double-thickness linen drapes and towels. *(C)* Single-use prefabricated drapes are used for an abdominal operation. They are particularly adaptable. *(D)* Plastic adhesive skin drapes (Steridrapes) may be applied over an area previously prepared by conventional linen draping. *(Continues on p 90.)*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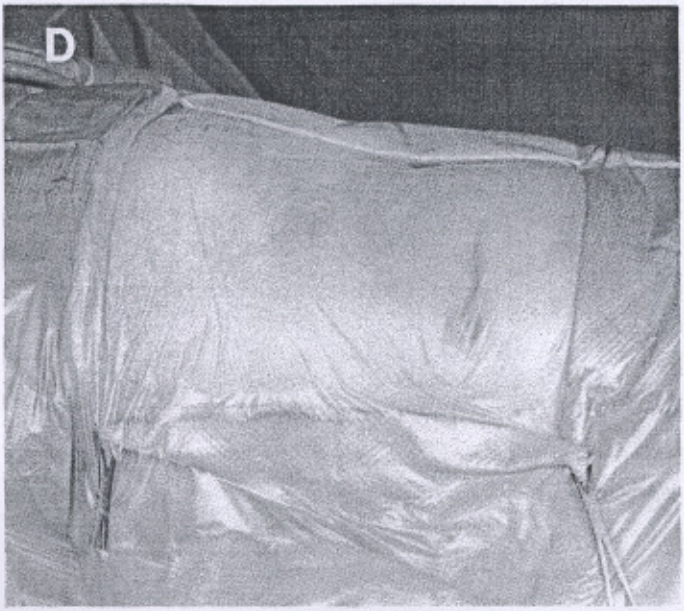
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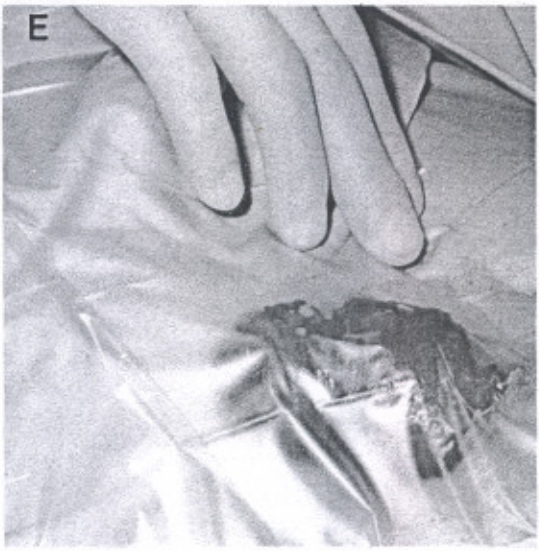

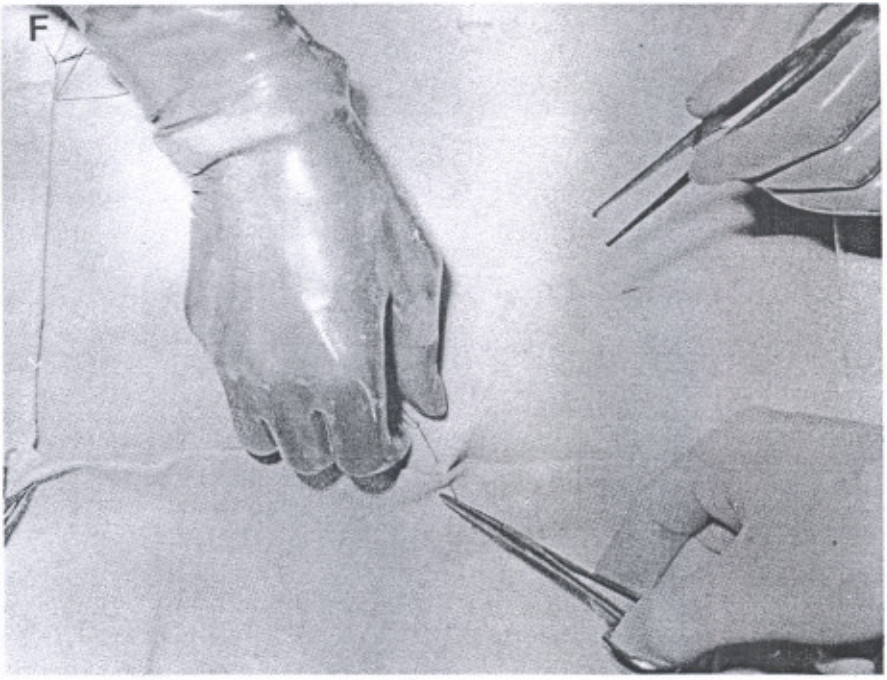

Fig. 6-5, Cont. *(E)* A plastic adhesive skin drape is used for the exclusion of fistulae, colostomies, and other contaminated or infected drainage tracts from the area of the operative incision. *(F)* The central edges of linen drapes bordering the operative area are sutured with interrupted silk sutures to prevent displacement of the drapes during the operation and consequent contamination of the operative wound.

Table 6-2. Drapes and Clean Wound Infections

	Number	Number Infected	Percent
Cloth	11,893	186	1.5
Plastic	5,714	140	2.4

(Cruse PJE, Foord R: A five year prospective study of 23, 649 surgical wounds. Arch Surg 107:206, 1973)

skin the central edges bordering the operative area with interrupted silk sutures. This technique helps prevent displacement of the drape edges and resulting contamination of the operative wound (Fig. 6-5, *F*).

Another consideration is the avoidance of wetting linen drapes, since this may result in migration of bacteria from unprepared areas with contamination of the operative field. If the drapes should become wet during the surgical procedure, they should be covered promptly and effectively by another layer of sterile draping material. This is particularly true in long surgical procedures associated with ascites, hemorrhage, or other fluid transudates, or which require irrigation with saline solutions. Linen drapes must be laundered, kept in good repair, sterilized, and packed for use as needed in such a manner that their sterility is guaranteed (Chap. 16).

Adhesive drapes. Adhesive drapes are adhesive sheets of transparent plastic. Their use provides the opportunity of making the incision through the drape, the cut edges of which should remain adherent to the skin and keep the operative field sealed off from bacterial contamination arising from the adjacent skin edges.

It is hoped that the decrease in the number and types of skin bacteria, resident or transient, in the operative area after preoperative washing and degerming can be maintained and further decreased by the additional use of the adhesive drapes. Many surgeons have used, and are using, plastic skin drapes for this and other purposes (Fig. 6-5, *D*). One problem with their function as a protective barrier is that the edges loosen with time, allowing exposure to blood, tissue fluid, and sweat. Thus their effectiveness at the immediate wound edge is negated, since leakage of fluid may occur. Adhesive drapes have been found useful in some types of orthopaedic, neurosurgical, and plastic surgical procedures. They have also been found useful in isolating bacterial reservoirs, such as the stoma of a colostomy, a fistula, or infected areas from the surgical wound.

A number of reports, however, have noted no decrease in the number of wound infections occurring after the use of adhesive drapes when compared with conventional linen drapes (Cruse and Foord; Table 6-2; and Wheeler).

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7

Preparation of the Operating Team and Supporting Personnel

The strict enforcement of intelligent rules governing aseptic and antiseptic techniques within the operating room suite is of obvious importance in the prevention and control of infections in surgical patients. Although experienced operating room personnel are well aware of these rules and regulations, they must be ever mindful of them and alert to violations of any kind that might endanger the patient. Not only must they be aware of the necessity of setting an example by their own compliance with these rules, but they must also guard against violations by others, particularly inexperienced personnel such as students, consultants, observers, and various technicians whose exposure to the operating room and its rules may be limited or whose motivation toward adherence to those rules may be underdeveloped. All personnel who enter or work in the operating room should be given appropriate supervision and be governed by the same rules and regulations as the members of the surgical team.

HEALTH AND HYGIENE

Patients, professional members of the surgical team, anesthetists, consultants, or supporting personnel, such as attendants and technicians, with active infections may present complex problems of control. It is a generally accepted practice that the members of the operating team and others working in the operating room must be free of transmissible bacterial infections. These include furuncles, carbuncles, dermatitis, psoriasis, draining sinuses, osteomyelitis, hydradenitis, ulcers of the skin, and unhealed wounds. Symptomless carriers of pathogenic organisms and personnel with obscure or hidden staphylococcal and streptococcal lesions may be difficult to identify and restrict (Walter).

As indicated in Chapter 4, many hospital personnel carry coagulase-positive staphylococci in the nose and throat. Although approximately 10% to 70% of hospital personnel in the operating room area have been shown to carry coagulase-positive *Staphylococcus aureus* in their nasal passages at various times, they are not necessarily dangerous as dis-

seminators of this microorganism. With the careful and routine use of the precautions elaborated in this chapter, it is believed that most carriers are usually not hazardous to patients. However, a few persons will shed the organism in infectious numbers, and these individuals may become a hazard. Such carriers must be searched for when an obvious source of a cluster of infections is not found. The evidence indicates that the greatest danger lurks in the permanent heavy carrier or shedder who has evidence of active disease, such as furunculosis. Routine nasopharyngeal cultures of all personnel are not considered to be necessary unless an unusual number or "cluster" of infections occur in patients under their care (Chap. 4). If a staff member or other employee is found to be carrying staphylococci of the same phage type and antibiogram as that causing clinical infection in the cluster of patients with infections, he should be temporarily restricted from contact with patients until effectively treated. Care must be taken, however, not to label him as the source of the infections, since he may have contracted the carrier state or his infection from the patient.

A surgeon who has dermatitis on his hands and forearms cannot effectively reduce the bacterial count on his skin by scrubbing. If the second line of defense against infection is broken (*e.g.*, perforation of rubber gloves), increased and significant inoculation of the wound with many pathogenic microorganisms may occur. In addition to the upper respiratory tract and skin, the enteric tract and the genitourinary tract may be the sites of obscure infection and may harbor pathogenic bacteria such as *Staphlococcus aureus, Streptococcus,* or *Salmonella.*

In cases of demonstrated active and significant carrier states, the person should be treated not only for acute or chronic infections, but also for predisposing or contributing factors, such as diabetes, dermatitis, diarrhea, nasal abnormalities, or allergies. Antibiotic therapy and surgical treatment may be required in some instances. The advice of consultants with special expertise in the field of infections and infectious diseases may be useful.

In instances in which significant carrier or shedder states cannot be cleared up even with the most expert treatment, special individualized preventive measures or reassignment to duties without patient contact must be instituted.

OPERATING ROOM ATTIRE

Personnel in the operating room are considered to be the most common source of bacterial contamination. People exhale bacteria-laden droplets from their noses during forced respiration and expectorate them from their mouths when they talk. Desquamated epithelium is exfoliated from exposed areas of skin, and dandruff and bacteria are shed from exposed hair-bearing areas. Their clothing gives off lint, dust, and threads that carry viable microorganisms. The longer the hair, the more talking, or the more frequent coughing and sneezing, the greater the dissemination of bacteria.

For these reasons and others, it is generally recognized that barrier attire and draping against bacterial contamination of the surgical wound are necessary to minimize postoperative surgical infections from exogenous sources. Surgical drapes

and gowns designed to reduce contamination of the operative site are essentially barriers to prevent nosocomial and exogenous infections.

With the advent of new materials, and particularly disposable attire and drape material, there has been further recognition that uniform methods for evaluating and testing the characteristics of the barrier are desirable. Materials should be tested for imperviousness to microorganisms under pressure, as well as for their folding, stretching, and comfort characteristics affecting their practical use. Additionally, the design and use of barrier materials must permit the exercising of good technique to prevent wound infection. The problems of inflammability and electrostatic charge deserve special consideration.

At the present time, the Committee on Control of Surgical Infections recommends that operating room clothing (including caps and masks) should be made of nonlinting material, must constitute an effective bacterial barrier, must be comfortable and allow free movement, must transmit heat and water vapor, must not be flammable, and must not have dangerous electrostatic properties.

All persons working in the operating suite must be appropriately attired and wear clean surgical scrub suits (in place of their street clothing); caps, masks, and shoe covers; and regularly cleaned boots or shoes whose use is restricted to the operating room (Fig. 7-1, *B*). Surgical scrub suits should be designed for maximum skin coverage as well as comfort. Sleeves of the operating room scrub suits must be short enough or turned up to allow adequate scrubbing above the elbows (Fig. 7-1, *A*). The scrub shirttail and pants drawstring should be tucked inside the pants before gowning to prevent contamination by contact with sterile items in the operating room and to decrease the dissemination of bacterial shedding from the thoracic and abdominal skin of the wearer. If it becomes necessary for anyone to leave the operating suite, he should be required to change into a clean scrub suit before reentering the operating room. Furthermore, it is recommended that scrub suits be changed between operations whenever they have become soiled or wet.

It is important that there be adequate locker rooms and facilities for changing clothing and that adequate supplies of clean scrub suits and scrub dresses in good repair be readily available. In hospitals having a great number of dirty and infected cases (such as infected burns), separate locker facilities and gowning areas for the personnel working with these contaminated cases may be desirable.

Traditionally, women have worn one-piece scrub dresses with high necklines, short sleeves, and skirts extending slightly below the knees. Some authorities have recommended that to reduce the possibility of shedding, women also wear scrub suits. Current practice favors their wearing scrub suits to reduce leg and perineal shedding.

For others, such as consultants and technicians who enter the operating room, a one-piece jumpsuit (Fig. 7-2) with snug bands at wrist, neck, and ankles is an appropriate and convenient type of attire. Another type of jumpsuit, which includes attached hood and boots, may be particularly adaptable to consultants and technicians for relatively short visits to the operating room. Visitors of any type should be restricted and should always wear caps, masks, and shoe covers before entering the operating room.

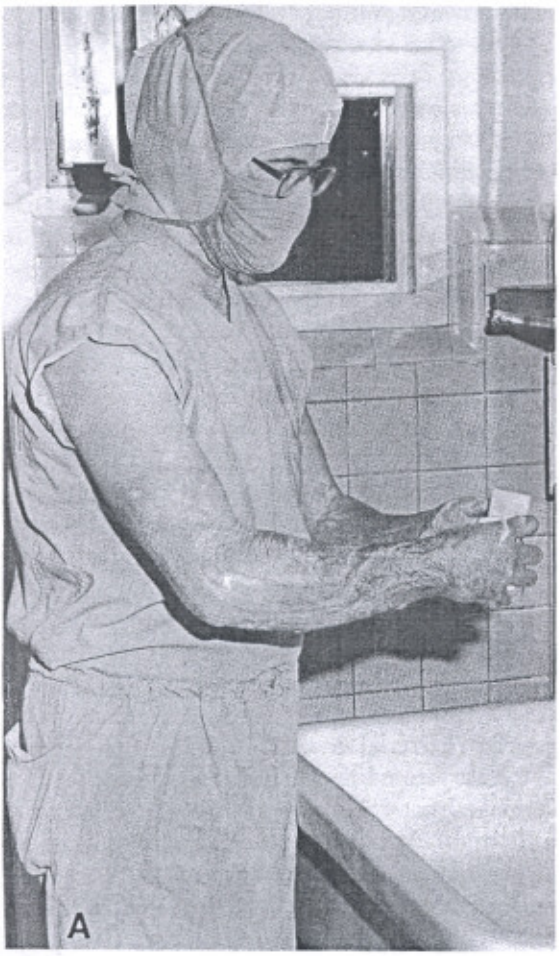

Fig. 7-1. (*A*) Recommended operating room attire and scrubbing techniques for surgical team member. Note that the nose, mouth, and all hair are carefully covered, the shirt and drawstrings are tucked in the trousers, the sleeves are rolled up to the shoulders, and the areas being scrubbed include the forearms, hands, and lower third of the upper arms.

Head Coverings

Hair is a source of bioparticulate matter. All head and facial hair should be covered by a clean operating room cap or, if necessary because of quantity of hair, a cap and hood. In cases of sideburns, beards, or long hair, a hood should be used that exposes only the eyes and ties around the neck.

The Committee on Operating Room Environment of the American College of Surgeons has reported that there is no acceptable standard for testing hoods and masks and that there is a need for further consultation between manufacturer and surgeons, as a joint venture, to design acceptable standard tests. Special aspirating devices now available have not been evaluated by standard methods, and it seems reasonable at the present time to restrict the use of aspirator hoods for specialized purposes.

Fig. 7-1. Cont. (*B*) Recommended completed operating room attire. Note the wraparound gowns to provide sterile back surface. (See Fig. 7-5.)

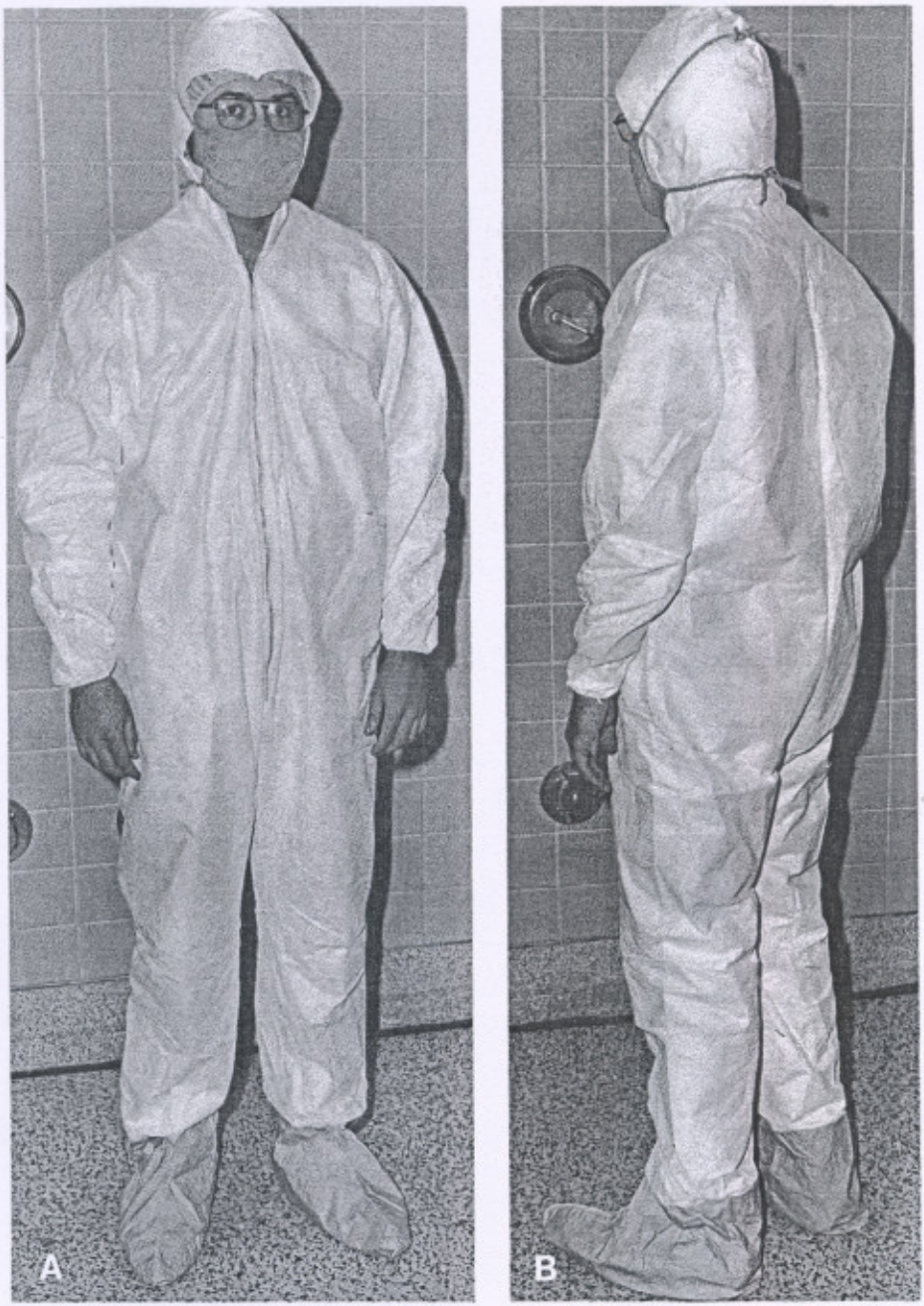

Fig. 7-2. (*A* and *B*) Anterior and posterior views of a jumpsuit that has been developed as acceptable operating room attire for pathologists, consultants, technicians, and others whose presence is required briefly during operations. Note that the hood and boots are attached to the coveralls. The wristlets are elastic. These jumpsuits can be donned over street clothes.

Masks

All personnel in the restricted area of the operating room should wear masks at all times. The type will vary among institutions. A filter type is mandatory and should be constructed to prevent leakage around the edges. Disposable masks are currently popular in many hospitals because of their convenience and the elimination of troublesome laundry problems. Some types have been shown to be highly effective in preventing the passage of oral and nasal bacteria. Reports on their efficiency must be carefully evaluated, because with some masks the expired breath may be prevented from passing through the mask and thus will be exhausted beneath its edges, allowing bacteria to settle on the operative field. It is recommended that a fresh mask be used for each case.

Operating Room Footwear

Some form of protective foot covering should be worn in the operating room area to prevent transmission of bacteria from shoes and to provide electrical grounding of personnel. Specially designed cloth, paper, or plastic shoe covers are available (Fig. 7-3). Disposable, single-use types are in general use in this country. The shoe covers are worn over regular shoes to decrease the number of bacteria that might be transmitted to the operating room from other areas of the hospital. At the same time, they allow the surgeon the comfort of his own footwear. An alternative is to keep special conductive operating room shoes or boots in the operating suite and change

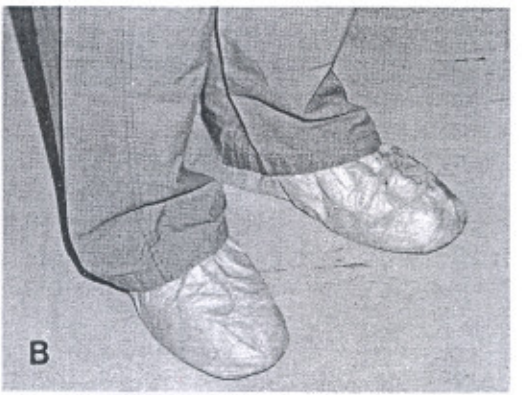

Fig. 7-3. (*A*) One type of reusable canvas shoe covers recommended for shoes of surgical team in the operating room. (*B*) One of various other types of single-use shoe covers now available.

into them in the locker room. This method is less desirable because such shoes must be washed and cleaned regularly to prevent any accumulation of virulent bacteria. Operating room shoe covers or operating room shoes should not be worn outside the operating suite. Conductive shoe covers or conductive shoes must be worn if combustible anesthetic agents are used.

Sterile Gowns

To prevent contamination of the wound or operative field by direct body contact, each member of the scrubbed surgical team must wear a sterile gown extending from the neck to below the knees and to the wrists (Fig. 7-4). The gown should have snug-fitting wristlets that can be overlapped by the cuff of the gloves. The gown is usually tied behind at the neck and waist. The most commonly used gown is one designed to remain sterile in front from the upper chest to the level of the operating table, including the sleeves. Wraparound gowns, designed to provide sterile fields in front and back, are recommended. These have an inside sterile tie in the back at the waist, and a large flap of the gown can be advanced to cover effectively the exposed unsterile back of the scrub suit. These gowns are tied in front by the wearer or the sterile scrub nurse by means of a sterile sash (Fig. 7-5). A vestlike gown back, however, may be used as an alternative to provide a sterile back.

Conventional surgical gowns are made of cotton or muslin and have several thicknesses of cloth in front and over the forearms. These are not impermeable to water and must be changed when they become wet. Several varieties of disposable gowns that meet the above specifications are also available and have come into general use in most hospitals throughout the United States (Fig. 7-6).

Gloves

Many types of gloves are available to the medical profession in plastic, vinyl, and rubber. Plastic and vinyl gloves are useful in preventing the transfer of organisms to or from the wearer. Rubber gloves are the only ones that are suitable for use in the operating room. They may be made of natural latex or synthetic rubber. The light-colored latex gloves are most commonly used. Brown latex gloves are available, and some are slightly thinner than the light-colored ones. Hypoallergenic gloves are also available. The gloves must cover the fingers and hands and extend over the wristlets of the gown in a smooth, unbroken, thin sheet of latex. At the proximal end, a thickened band of rubber discourages the wrist of the glove from rolling back. A flat wide band is more efficient than a small round one.

The majority of gloves currently in use are disposable, but reusable gloves are still available. All gloves are packaged with the cuff turned back so that they can be handled by the exposed part of the inside of the glove (Fig. 7-7). Wet hands will not slip into the glove; therefore, the hands are usually dried (either with a towel or air dried before gloving).

The purpose of scrubbing and disinfection of the hands prior to operation is to reduce the bacterial population to the vanishing point with reasonable assurance that

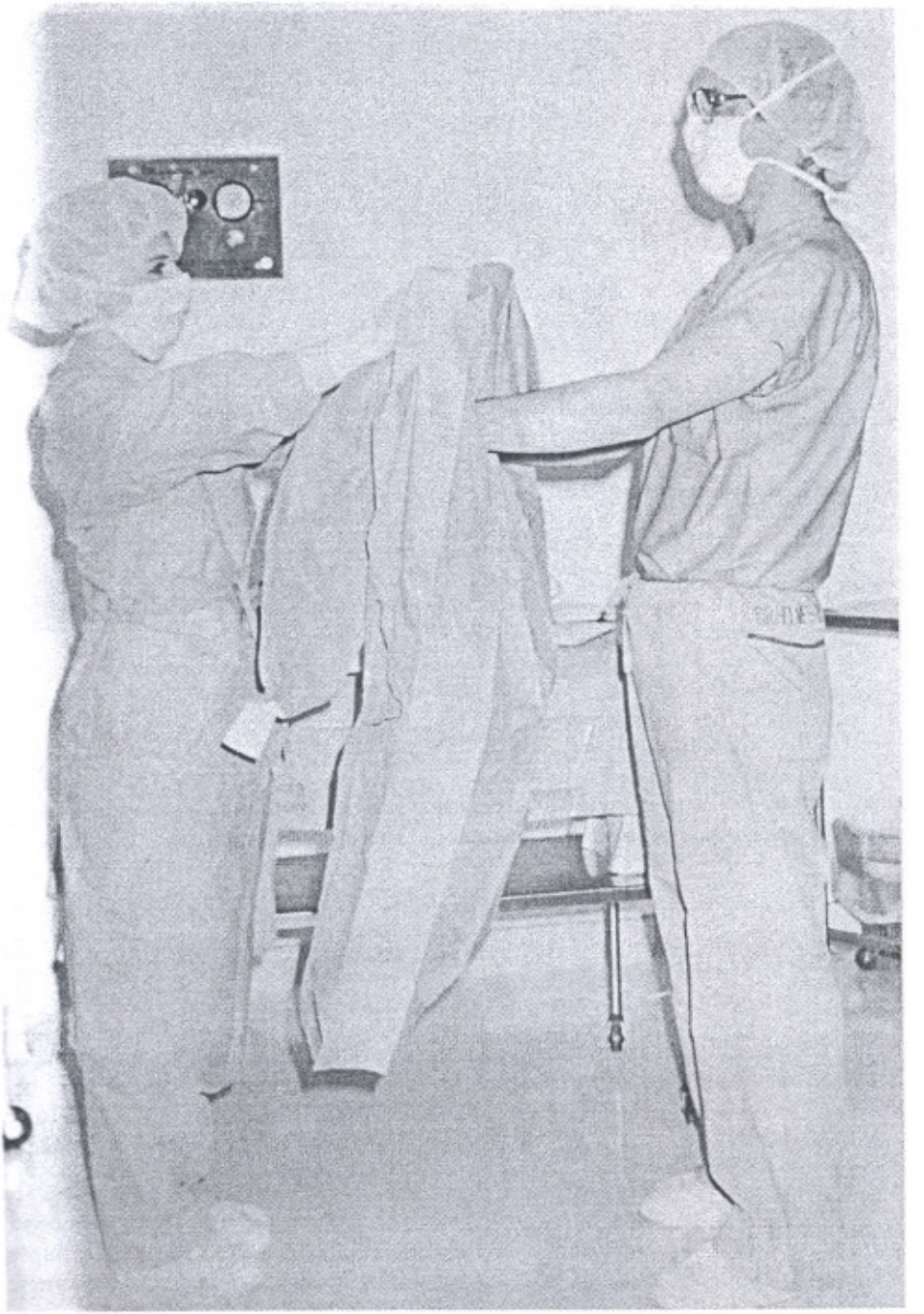

Fig. 7-4. A scrub nurse assisting a surgeon in donning his sterile operating gown to avoid contamination. Note coverage of noses, mouths, and all head and face hair. Nurse's attire includes trousers.

Fig. 7-5. Method of surgeon, with the assistance of the scrub nurse, tying wraparound gown to provide sterility of its back.

it will remain miniscule during the operation. If a hole should develop in the glove, bacterial contamination of the wound should therefore be minimal.

The Committee on Control of Surgical Infections and the Committee on Control of Operating Room Environment have heard evidence that the incidence of puncture holes developing during operations may reach levels of 50% to 70%. Moreover, it was reported that a significant number of gloves have been found with holes when first put on by the surgical team. It has been determined that as many as 40,000 organisms can be liberated through a glove pinhole in a 20-minute period. Better testing methods are needed to eliminate this potential hazard. In addition, it has been recommended that stronger gloves for special operative procedures be developed that would have greater resistance to puncture but retain utility and comfort.

Indications for Change of Attire

Scrub suits, if soiled or wet, shoe covers or operating room shoes, and head coverings should be removed on leaving the operating suite, and new ones put on before returning to the operating room. It is also recommended that masks and head coverings be changed after treating every case.

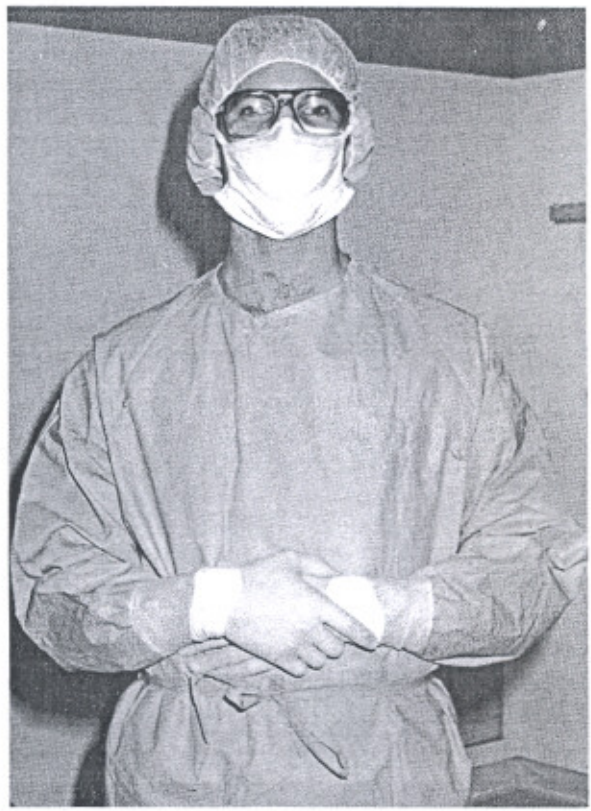

Fig. 7-6. Completed operating room attire with sterile single-use gown, gloves, cap, and mask. Note that gloves cover gown wristlets.

In treating dirty or infected cases, persons wearing special operating room shoes should also put on shoe covers. At the end of the operation, surgical team members should remove the shoe covers in the operating room and step into the hall immediately. Cap and mask should be removed just before leaving through the operating room doorway. Scrub suits (or scrub dresses) should be changed promptly, certainly before entering any clean operating room.

PREOPERATIVE DISINFECTION OR DEGERMING OF THE HANDS: THE SURGICAL SCRUB

As indicated earlier in this chapter, one must be properly attired in scrub suit, cap or hood, mask, and shoe covers prior to preoperative hand scrubbing. Current practice requires the surgeon to scrub his hands, fingernails, and arms meticulously, using an appropriate degerming method, immediately prior to the operative procedure. This aids in the reduction of the possibility of transferring microorganisms from the hands to the wounds. Thereafter, he puts on a sterile gown and sterile gloves in an aseptic manner to complete the bacterial barrier between him and the patient's

Fig. 7-7. Method recommended for members of a surgical team to prevent contamination when putting on sterile gloves.

operative wound (see Fig. 7-1, *B*). The surgical scrub is practiced to remove or destroy as many bacteria as possible on the skin and under the fingernails of the surgical team members.

The skin flora of the hands and forearms may be divided into "resident" and "transient" populations, as pointed out by Price. Lowbury has reported that the important practical distinction, however, is between superficial organisms, which can be almost completely removed either by washing with soap and water or by disinfection, and the more adherent microorganisms, which are much more effectively removed by disinfection than by washing.

The resident and transient groups of microorganisms represent contamination from the hospital environment and may include the beta-hemolytic *Streptococcus, Staphylococcus aureus, Pseudomonas, Escherichia coli,* and *Klebsiella,* among others. The coagulase-positive *Staphylococcus* is the most common potential pathogen of the deep or resident flora of the skin and fingernails. The gram-negative bacilli have been observed less frequently as part of the resident flora.

Resident bacteria form a comparatively stable flora. Protected skin has, as a rule, a somewhat larger resident flora than exposed skin (Price). After reduction (*e.g.,* by disinfection), reestablishment of the resident flora appears to proceed at a rate represented in general by a sigmoid curve, as is true of bacterial growth in cultures. Hands and arms thoroughly degermed may require a week or more for complete

reestablishment of the usual flora. Beneath clothing the generation time is slightly shorter. Under sterile rubber gloves, it is much shorter, the existing flora increasing rapidly until they may exceed by far the ordinary flora.

Transient microorganisms lie free on the surface or are loosely attached along with the dirt by fats; hence, they are removed or killed with comparative ease. Resident bacteria are more firmly attached, and are far more resistant to attack by either detergents or germicides.

The transient flora may contain any number of pathogenic bacteria, the resident flora relatively few as a rule. Certain contaminating organisms, however, seem able to change status slowly and become permanent residents of the skin. Consequently, prolonged or frequent exposure of the skin to contamination may result in a resident flora containing many pathogenic organisms. Such skin is not easily disinfected, and hands may thus become chronic carriers of pathogenic organisms.

Scrubbing with a brush, degerming agent, and water removes the transient flora readily but the resident flora far more slowly. The most effective period of hand scrubbing is still debatable, but is thought to be between 5 and 10 minutes.

As indicated in Chapter 6, there is considerable difference of opinion about the best methods of preparing the skin of the operative area and the most effective types of degerming agents. The same differences of thought exist about the most efficient methods for the preoperative scrubbing and disinfection of the hands and forearms of the surgical team. It has been shown that many antiseptics remain on the skin after the scrub and continue to suppress the growth of bacteria, acting as a "chemical glove." Iodophors, chlorhexidine, and hexachlorophene are the antiseptics most frequently used for the surgical scrub. Such antiseptics, however, are often inactivated by blood, probably by the sulfhydryl groups in the blood cells. This is less evident in iodine solutions. Bernard and Cole have shown that blood from the operative wound may enter the glove through such holes and inactivate residues of antibacterial preparations left on the skin.

Antiseptics Most Frequently Used for the Surgical Scrub

Iodophors

Iodophors are both good antiseptics with a quick and lasting effect and cleaning agents for the skin. They rarely irritate the skin or cause allergic reactions. They are free from irritating odors, are easily washed off, and do not react with metals. These characteristics have made the iodophors one of the three most commonly used degerming hand-scrubbing agents in use now.

Chlorhexidine

Antiseptic solutions containing chlorhexidine compounds were used effectively in Great Britain (Lowbury 1972) and in Canada (Cruse 1972). Since its recent approval in the United States by the Food and Drug Administration (Hibiclens, Hibitane), chlorhexidine has been widely used here. It offers a wide range bactericidal activity for the skin, forearms, and hands of the surgical team. Its extensive use in Great Britain indicated that it could be used frequently without causing irritation, dryness, or skin discomfort.

Hexachlorophene

Hexachlorophene takes time to work. There is less measurable reduction in microbial counts immediately after scrubbing with it, but an appreciable reduction is obtained after 1 hour. Used repeatedly over days, hexachlorophene will markedly reduce the bacterial counts on the hands by 99%, and it is very effective when used properly.

There is evidence that the successive use of two degerming agents can create a state of cleanliness and disinfection in which the hands of about half of those so treated do not transfer any bacteria to a washing fluid. Such specialized disinfection plus the use of two rubber gloves, one on top of the other, may be appropriate for operations on high-risk patients, such as those having immunosuppressive treatment for organ transplantation or for patients having total hip replacement. The Committee has decided to describe two selected effective methods of hand-scrubbing techniques that are in current use. These will provide the surgeon with alternatives to meet different circumstances.

Iodophor Hand Scrub Technique

1. Remove all jewelry and nailpolish.
2. Wash hands, forearms, elbows, and lower one third of upper arms with soap and water, using a sterile brush to remove surface dirt, oils, and other debris. (2 minutes)
3. Discard brush and use nail file or orange stick to thoroughly and meticulously clean the fingernails under running water. Fingernails should be kept short. (1 minute)
4. Using a clean, sterile brush and 2.5 ml of iodophor compound, scrub the entire surface of fingers, hands, forearms, elbows, and distal 2 inches of the upper arms, in that order (3 minutes). Rinse thoroughly with running tap water, always allowing excess water to drip from elbows, with the hands and forearms held higher than the flexed elbows.
5. Repeat #4. (2 minutes)
6. Repeat #5 without brush, and washing fingers, hands, and forarms only, below the elbows. (2 minutes)

A modification of the above iodophor compound scrub also in use is as follows:

1. Same as above
2. Same as above
3. Same as above
4. Using a sterile brush or sponge impregnated with iodophor compound, scrub the entire surface of the fingers, nails, hands, forearms, and distal 2 inches of the upper arms for 2½ minutes. Rinse thoroughly with running tap water, allowing excess water to drip from elbows with hands held higher than the flexed elbows.
5. Repeat #4 for 2½ minutes using the same technique; a 5-minute scrub is recommended between cases.

Chlorhexidine Hand Scrub Technique

There are several modifications in technique that are in active use at this time:

1.
2. } The same as recommended for the iodophor compound scrub
3.

4. Using a sterile brush or sponge impregnated with chlorhexidine compound, methodically scrub the entire surface of the fingers, fingernails, hands, forearms, and distal 2 inches of the upper arms at the elbow for 2½ minutes; follow this by thoroughly rinsing with running tap water. Allow the excess antiseptic and water to drain from the elbows with the hands held higher than the flexed elbows.
5. Repeat #4 for 2½ minutes.

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