

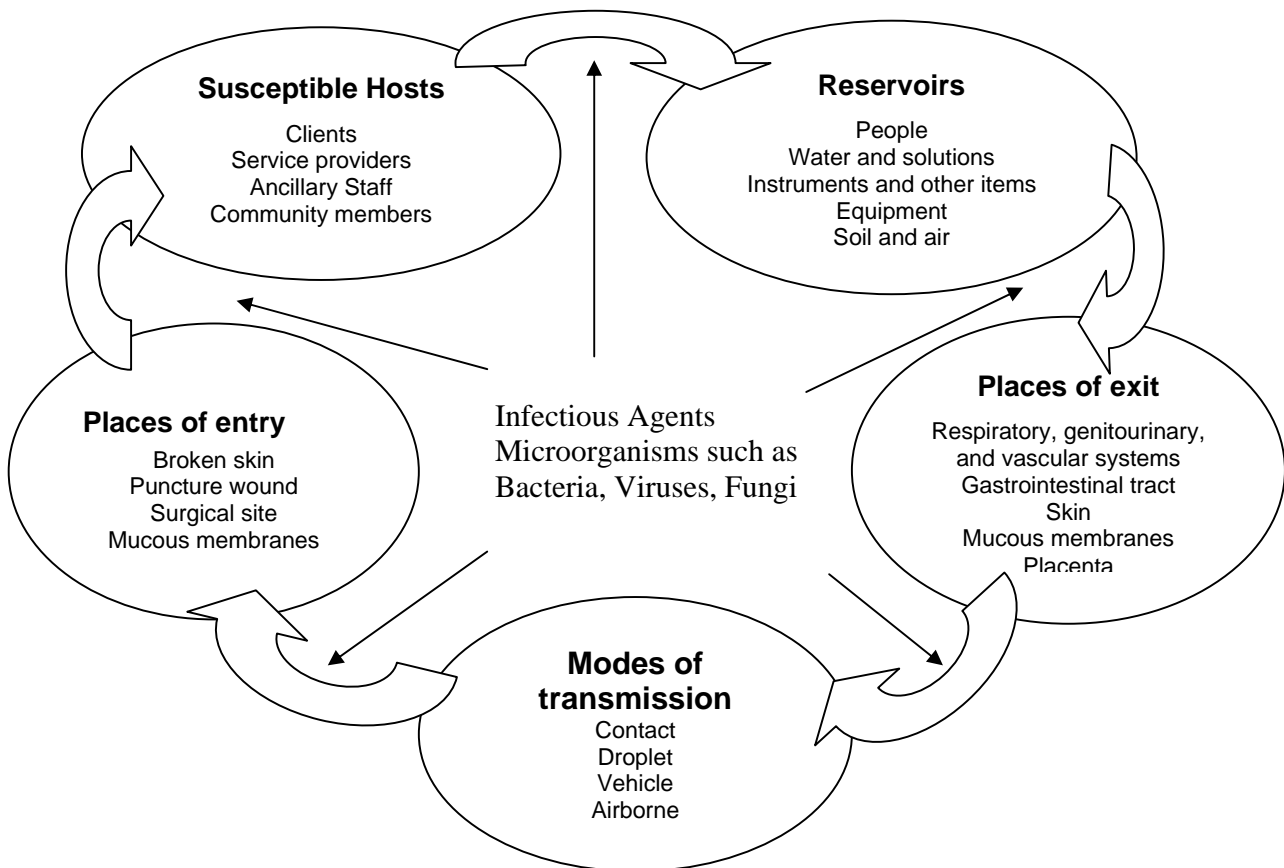
Operating Theatre

Introduction

Surgical site infections (SSIs) are the second to third most common site of health care associated infections (HAIs). These complications of surgical procedures cause considerable morbidity and, when these occur deep at the site of the procedure, can carry mortality as high as 77%. As illustrated below there are several key steps or “chains” that have to be connected to result in infection. However, for SSIs, the initial introduction of microbial pathogens occurs most often during the surgical procedure performed in the Operating Theatre (OT).



Fig. 8: Transmission cycle in OT



Thus, to reduce the risk of SSI, a systematic but realistic approach must be applied with the awareness that this risk is influenced by characteristics of the patient, operation, personnel, and health care facility. For most SSIs, the source of pathogens is the endogenous flora of the patient's skin, mucous membranes, or hollow viscera. When mucous membranes or skin is incised, the exposed tissues are at risk for contamination with endogenous flora. These organisms are usually aerobic gram-positive cocci (e.g., staphylococci), but may include fecal flora (e.g., anaerobic bacteria and gram-negative aerobes) when incisions are made near the perineum or groin. When a gastrointestinal organ is opened during an operation gram-negative bacilli (e.g., *E. coli*), gram-positive organisms (e.g., enterococci), and sometimes anaerobes (e.g., *Bacillus fragilis*) may become typical SSI isolates.

Exogenous sources of SSI pathogens include surgical personnel (especially members of the surgical team), the operating room environment (including air), and all tools, instruments, and materials brought to the sterile field during an operation. Exogenous flora are primarily aerobes, especially gram-positive organisms (e.g., staphylococci and streptococci). Interventions to prevent SSIs therefore are aimed at reducing or preventing microbial contamination of the patient's tissues or of sterile surgical instruments. Other interventions include preoperative antibiotic prophylaxis, careful surgical technique, adequate ventilation of the OT, etc. Of the variables involved in the "equation" of SSI, operative characteristics such as preparation of the patient's and health care worker's skin, appropriate timing of antibiotic prophylaxis, and preparation of the OT are easier to control than patient risk factors such as presence of underlying diabetes, age, smoking history, and obesity. Therefore the balance of this chapter will focus on the operative characteristics associated with infection prevention.

Infection Prevention in the Operating Theatre

Infection prevention in the operating room is achieved through prudent use of aseptic techniques in order to: ¹⁵

- Prevent contamination of the open wound.
- Isolate the operative site from the surrounding unsterile physical environment.
- Create and maintain a sterile field in which surgery can be performed safely.

Although all infection prevention practices contribute to this effort, aseptic technique refers to those practices performed just before or during clinical procedure including:

- Properly preparing a client for clinical procedures
- Handwashing

Operating Theatre

- Surgical hand scrub
- Using barriers such as gloves and surgical attire
- Maintaining a sterile field
- Using good surgical technique
- Maintaining a safe environment in the surgical/procedure area

Principles and maintenance of aseptic practices are imperative in the operating room. Each facility should develop policies and procedures pertaining to aseptic technique.²²

Table 9: Preoperative Care and Preparation of the Patient²³

Preoperative processes	Instructions
Assessment for infection	<ul style="list-style-type: none"> • Whenever possible, identify and treat all infections remote to the surgical site before elective operation and postpone elective operations on patients with remote site infections until the infection has resolved. • Adequately control serum blood glucose levels in all diabetic patients and particularly avoid hyperglycemia perioperatively. • Encourage tobacco cessation. At minimum, instruct patients to abstain for at least 30 days before elective operation from smoking cigarettes, cigars, pipes, or any other form of tobacco consumption (e.g., chewing/dipping). • Do not withhold necessary blood products from surgical patients as a means to prevent SSI.
Preoperative showering	<ul style="list-style-type: none"> • Require patients to shower on at least the night before the operative day. (note: this intervention has been shown to lower concentration of skin flora but not frequency of SSI.)

Table 9: Preoperative Care and Preparation of the Patient²³ (continued)

Preoperative processes	Instructions
Preoperative hair removal	<ul style="list-style-type: none"> • Do not remove hair preoperatively unless the hair at or around the incision site will interfere with the operation. • If hair is removed, remove immediately before the operation, preferably with electric clippers. Only the incision area is cleared of hair. This is done in the anesthetic room. Shaving is not recommended.
Patient skin preparation in the operating room	<ul style="list-style-type: none"> • Thoroughly wash and clean at and around the incision site to remove gross contamination before performing antiseptic skin preparation. • Use an appropriate antiseptic agent for skin preparation (see below). • Apply preoperative antiseptic skin preparation in concentric circles moving toward the periphery. The prepared area must be large enough to extend the incision or create new incisions or drain sites, if necessary. • Keep preoperative hospital stay as short as possible while allowing for adequate preoperative preparation of the patient.
Management of infected or colonized surgical personnel	<ul style="list-style-type: none"> • Surgical personnel who have acute communicable infections (see chapter on Occupational Safety and Employee Health) or who are colonized with a pathogen that can be transmitted during surgery should be excluded from surgery until cured.²²

Antiseptics For Preoperative Preparation of Skin and Hands

Definition

“An antiseptic is a substance that prevents or arrests the growth or action of microorganisms, either by inhibiting their activity or by destroying them.”²⁴ The term is used especially for preparations applied topically to living tissue. Antiseptics are not meant to be used on inanimate objects, such as instruments and surfaces.

Antiseptics are used for:

- Surgical hand antisepsis.
- Skin, cervical and vaginal preparation before a clinical procedure.

Notes on Antiseptics:

- Antiseptic solutions should **never** be used to:
 - Disinfect inanimate objects, such as instruments
 - Clean surfaces, such as floors or countertops
- Instruments and items such as pickups, scissors, scalpel blades, and suture needles should never be left soaking in an antiseptic solution; they should always be stored dry. In addition to the fact that antiseptic solutions are made for killing microorganisms on the skin and mucous membranes, and not on objects; microorganisms can live and multiply in antiseptic solutions and contaminate the instruments and other items, leading to infections.

Table 10: Common antiseptics used in OT

1. Alcohol (60-90% ethyl or isopropyl)

Antimicrobial Spectrum	Effective against a broad range of microorganisms e.g. bacteria, and mycobacteria,
Advantages	<ul style="list-style-type: none"> • Rapidly active • Effective in reducing vegetative microorganisms • Effectiveness is only moderately reduced by blood or other organic material • Non-staining • Less expensive
Disadvantages	<ul style="list-style-type: none"> • Has a drying effect on skin • Cannot be used on mucous membranes • Evaporates rapidly and makes contact time difficult to achieve • No prolonged activity however the reduction in skin flora is so pronounced that regrowth on the skin does not occur for several hours
Comments	<ul style="list-style-type: none"> • Cannot be used when skin is dirty; area should be washed before applying • Must dry completely to be effective • The 60-90% strength is most effective • Very effective surgical hand antiseptic when used in waterless alcohol handrub formula

2. Chlorhexidine gluconate (4%)

Antimicrobial spectrum	Effective against a broad range of microorganisms, but less so against gram-negative bacteria and fungi and minimal efficacy against <i>M. tuberculosis</i>.
Advantages	<ul style="list-style-type: none"> ● Has a good, persistent effect; remains effective for at least 6 hours after being applied. ● Effectiveness is not reduced by blood or other organic material.
Disadvantages	<ul style="list-style-type: none"> ● It stains fabrics brown (in the presence of chlorine-based disinfectants). ● Effectiveness can be reduced by hard water, hand creams, and soaps.
Comments	<ul style="list-style-type: none"> ● Recommended antiseptic for surgical hand antisepsis and skin preparation. ● Preparations without cetrimide are preferable to those with cetrimide. ● <i>Caution:</i> Savlon™ or Citiel products containing at least 4 % chlorhexidine are appropriate for use as antiseptics; Products containing less than 4 % chlorhexidine in an alcohol base are also adequate, but should not be used on mucous membranes. Chlorhexidine is relatively non-toxic. It must not be allowed to come into contact with the brain, meninges, eye or middle ear.

3. Iodine compounds, including tincture of iodine (iodine and alcohol)

Antimicrobial spectrum	Effective against a broad range of microorganisms (same as alcohol)
Advantages	<ul style="list-style-type: none"> ● Fast-acting (tincture preparations only)
Disadvantages	<ul style="list-style-type: none"> ● Can cause skin irritation. ● Effectiveness is markedly reduced by blood or other organic material. ● Less persistent activity.
Comments	<ul style="list-style-type: none"> ● Can cause contact dermatitis therefore has limited usefulness as an OT hand antiseptic. ● Because of the potential to cause skin irritation, when iodine is used for preprocedure skin preparation, it must be allowed to dry; then is removed from the skin with alcohol.

4. Iodophors

(Solutions such as povidone iodine (e.g., Betadine) that contains iodine in a complex form, making them relatively nonirritating and nontoxic)^{25, 26}

Antimicrobial spectrum	Effective against a broad range of microorganisms (mainly gram +ve and gram –ve bacteria. Less effective against mycobacteria).
Advantages	<ul style="list-style-type: none"> • Less irritating to the skin than iodine tincture. • Can be used on mucous membranes.
Disadvantages	<ul style="list-style-type: none"> • Effectiveness is moderately reduced by blood or other organic material. • Release of active ingredient, free iodine, takes relatively long time therefore it needs to be applied to skin and left on for > 2 minutes prior to initiating procedure. • Less persistent antimicrobial activity compared to chlorhexidine.
Comments	<ul style="list-style-type: none"> • Recommended for surgical hand antisepsis and pre-operative skin preparation. • Best antiseptic for use in the genital area, vagina, and cervix. • Becomes effective >2 minutes after application; for optimal effectiveness, wait several minutes after application. • Most preparations should be used full strength; do not dilute. • Distinctly different from iodine but can be confused for iodine tincture. <p>Note: If any antiseptic solution is received from the facility's pharmacy or central supply that is labeled simply "iodine" the pharmacist or person in charge of supplies should be asked what the solution contains. For example, if a brown liquid in a bottle is received, a small amount has to be put in hand and be rubbed. If it seems more sudsy than usual, it is an iodophor, not iodine.</p>

Table 11: Antiseptics Appropriate for Use in Clinical Procedures

Antiseptic	Use		
	Surgical Hand antiseptic	Preprocedure Skin Preparation	Mucous Membranes, e.g., Vagina and Cervix
Alcohol	Yes	Yes	No
Chlorhexidine gluconate with or without cetrimide	Yes	Yes	Yes. However, products containing chlorhexidine may not be the best antiseptics to use in the genital area because of the small potential for irritation. If an iodophor is not available, a product containing chlorhexidine is the best alternative
Hexachlorophene	No	No	No
Iodine, including tincture of iodine (iodine and alcohol)	No	Yes	No
Iodophors	Yes	Yes	Yes

Note:

Avoid using the following:

- Hydrogen peroxide is available in antiseptic preparations to prevent infections due to minor cuts, burns and abrasions. These preparations are not appropriate for use in surgical hand antiseptic and client/patient skin preparation.
- Products containing quaternary ammonium compounds, such as benzalkonium chloride (e.g., Zephiran), are disinfectants, and should not be used as antiseptics. These products are easily contaminated by common bacteria, easily inactivated by cotton gauze, and incompatible with soap.
- Compounds containing mercury (such as mercury laurel) should not be used because they are highly toxic, cause blisters, and cause central nervous system disturbances or death when inhaled. They also be absorbed through the skin and can cause birth defects in a pregnant woman who is exposed to small doses.

Tips on using antiseptics:

- Never leave cotton balls, cotton wool, or gauze sponges soaking in an antiseptic.
- Never dip cotton or gauze into the antiseptic container. Instead, pour some antiseptic into a small container, dip the cotton or gauze into this small container, and discard the unused antiseptic after patient preparation.
- If an antiseptic is provided in a large container, small amounts (enough for one shift) should be poured in small clean disinfected containers.
- At the end of the shift, left over quantities should be discarded and the container should be appropriately cleaned, disinfected and dried before subsequent use.
- Never leave antiseptic in opened containers.

Preoperative Antimicrobial Prophylaxis

Principles to maximize the benefits of antibiotic prophylaxis:

1. Giving antibiotics before a procedure to prevent infections is not a substitute for good infection control practices and surgical technique.
2. Use antibiotics for procedures in which use has been shown to reduce surgical site infections (SSI) or for patients for whom a surgical site infection would be catastrophic.
3. Use antibiotic agents that are safe, inexpensive, and bactericidal with a spectrum that covers the most probable intraoperative contaminants.
4. Administer the initial dose of antibiotics at the time of surgery.
5. Maintain therapeutic levels of the antimicrobial agent in both serum and tissues throughout the operation and until a few hours after surgery.²²
6. Do not prolong prophylaxis through the postoperative period. There is no evidence that prolonged use of antibiotics offers any advantage and instead encourages development of antibiotic resistant microorganisms.
7. Randomized controlled trials of preoperative intranasal mupirocin have not demonstrated efficacy in lowering frequency of SSIs but does decrease other HAIs due to *S. aureus* if the patient is colonized with *S. aureus*.^{27, 28}

[For more information see Part I: "Control and Prevention of Antimicrobial Resistant in Health Care Facilities"]

Preoperative Skin Preparation of OT Personnel

Hand hygiene

Hand hygiene by OT personnel is one of the most effective ways to reduce the risks of infections.

[For more details see Part I: “Hand Hygiene”]

Surgical hand wash

Definition

Surgical hand wash or surgical handrub must be performed preoperatively by surgical personnel to eliminate transient and to reduce resident hand flora. The warm, moist conditions inside surgical gloves provide an ideal environment for the growth of microorganisms. Surgical hand wash with antiseptics before beginning surgical procedures will help prevent this growth of microorganisms for a period of time and will help to reduce the risk of infections to the patient if the gloves develop holes, tears, or nicks during the procedure. Waterless alcohol handrubs have more immediate activity after application and they lower the quantity of skin flora to such an extent that it takes several hours for regrowth.



Fig. 9: Surgical hand wash facility

Indications of surgical hand wash

Surgical hand wash is needed for any invasive surgical procedure. All personnel (e.g., doctors, anesthesiologists, and nurses) should perform surgical hand antisepsis before any procedure.

Steps for surgical hand wash:

Fig. 10: Steps for Surgical hand wash

1. Remove all jewelry on hands and wrists.

2. Adjust water to a warm temperature and thoroughly wash hands and forearms to 5 cm above the elbows in order to remove dirt and transient flora.

3. Clean under each fingernail and around the nail bed with a nail cleaner prior to performing the first surgical scrub of the day.

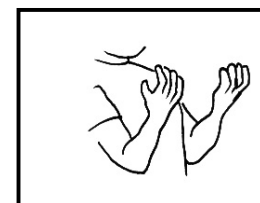
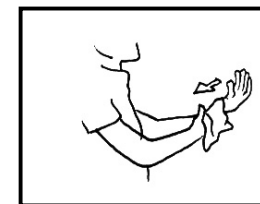
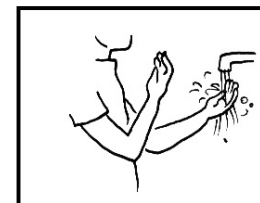
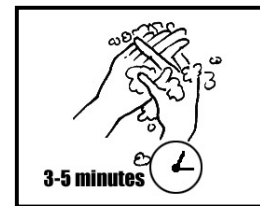
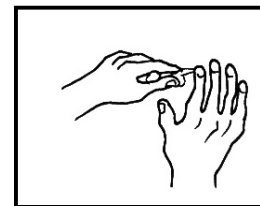
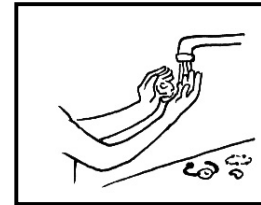
Keep nails short and do not wear artificial nails or fingernail polish.

4. Holding hands up above the level of the elbow, apply antimicrobial agent to hands and forearms up to the elbows. Using a circular motion, begin at the fingertips of one hand and lather and wash between the fingers, continuing from fingertip to 5 cm above the elbow. Repeat this process for the other hand and arm. Continue rubbing for 3-5 minutes.

5. Rinse each arm separately, fingertips first, holding hands above the level of the elbow.

6. Using a sterile towel, dry the fingertips to 5 cm above the elbow. Use one side of the towel to dry the first hand and the other side of the towel to dry the second hand.

7. Keep hands above the level of the waist and do not touch anything before putting on sterile gown and surgical gloves.²⁹



Steps for Alcohol-Based Surgical Handrub:

1. At the beginning of the list of cases for the day follow the wash procedure above using plain soap.
2. Make sure hands are dried completely and then apply 5 ml of alcohol handrub into palm of one hand.
3. Rub into the hand making sure to rub the alcohol product under the nails and up the forearm. Continue rubbing till alcohol is dry.
4. Repeat for the other hand and forearm.
5. Put on sterile gloves.

Surgical hand scrub tips

Brushing: Recent studies have shown that using a brush during surgical scrub provides no greater reduction of microorganisms on the hands than washing with antiseptic soap alone. Surgical hand antiseptics wash may be performed using either a soft brush or sponge or using an antiseptic alone. Avoid using a hard brush, which is not necessary and which may irritate the skin.

The brush should be single use and should be discarded (if disposable) or sent for autoclaving (if reusable). Do not share brushes between personnel.

Allergy. When surgical staff develop sensitivity to the available antiseptic solutions or when antiseptics are not available, then perform a surgical scrub with soap and water followed by an alcohol handrub:

- Perform a surgical hand wash with plain soap and warm, running water and then dry hands thoroughly.
- Apply 3-5 ml of alcohol or of alcohol handrub solution.
- Rub hands together until they are dry.

Note: An alcohol handrub does not remove soil or organic material such as blood. If gloves are torn or punctured or if there is blood or other body fluids on your hands after you remove your gloves, a surgical scrub should be performed.

Water temperature: Warm water makes antiseptics work more effectively. Avoid using hot water, which removes protective oils from the skin.

Care of hands: Persons who perform surgical procedures should:

- Keep fingernails short.
- Keep hands above their elbows during and after scrubbing.
- Avoid using a hard brush during scrubbing.²⁹

Protective Clothing for Use in the Operating Theatre

The use of barriers minimizes a patient's exposure to microorganisms that might be shed from the skin, mucous membranes, or hair of surgical team members as well as protects surgical team members from exposure to blood and to blood-borne pathogens.

Surgical attire can include such as items as sterile gloves, caps, masks, gowns or waterproof aprons, and protective eyewear.



Fig. 11: Protective Barriers in OT

Issues Related to Surgical Attire

Masks: Standard surgical masks are sufficient for OT personnel. Except for the need to protect the mucous membrane of HCP there is some controversy on whether masks play any role in prevention of SSI.³⁰ Masks should cover the mouth and nose at all times. The mask *should not* be worn hanging around the neck or be put in pockets to be reused. Masks should be changed frequently, when they become moist, and in between cases. Cotton masks are not considered protective. High efficiency masks should be available for surgical procedures on patients with suspected or proven active disease caused by *M. tuberculosis*.

Gowns: Gowns and waterproof aprons prevent contamination of the OT personnel's arms, chest, and clothing with blood and body fluids. They also minimize shedding of microorganisms from the personnel thus protecting the patient. Sterile gowns should be worn by all personnel in the operating suite.

Sterile drapes: Sterile drapes are used to create a barrier between the surgical field and the potential sources of bacteria. These are placed over the patient.

Scrub suits: Surgical members often wear a uniform called a "scrub suit" or "theater suit" or clothes that consists of pants and a shirt. This should be viewed as a uniform over which a sterile gown or apron is worn. There is no evidence that scrub attire worn by personnel prevents SSI. If available, scrub suits are convenient for personnel to change in the event there is penetration of blood or body fluids through the surgical gown. Scrub suits should be changed when they become visibly soiled.

Surgical caps/hoods: Hair on the face and head must be covered completely either by disposable or recyclable coverings. Coverings reduce contamination of

the surgical field by organisms shed from the hair and from the scalp. Hair covering is donned first in order that hair does not fall onto clean scrub clothing. Veiled personnel should remove their veils and put on a sterile cover.

Eye protection and face shields: Eye protection and/or face shields should be worn to protect OT personnel's eyes, nose, and mouth from splashes of blood or other fluids.

Footwear: A change of footwear while in the operating theatre is recommended. Surgeons dealing with heavy blood or body fluids contamination are advised to wear boots that are adequately covered by the plastic apron in order to avoid fluid from going into the shoes/boots.²⁹ Shoe covers have not been shown to prevent SSIs.

Surgical gloves: Well fitting latex sterile surgical gloves should be worn by all OT personnel involved in a surgical procedure in order to minimize the transmission of microorganisms from the hands of OT personnel to patients and to prevent contamination of team members' hands with patients' blood and body fluids. Gloves must be changed if they become contaminated or if their integrity is compromised. Wearing two pairs of gloves has been shown to reduce skin contact with blood or body fluids from the patient especially during complicated or involved procedures.



Fig. 12: Sterile surgical gloves

Putting on and removing surgical gloves

Surgical gloves are cuffed to make it easier to put them on without contamination. The outside of the glove package is not sterile and should be opened prior to performance of a surgical scrub.

Steps for putting on surgical gloves

<p>1. Prepare a large, clean, dry area for opening the package of gloves. Perform surgical antisepsis and ask someone (e.g., circulating nurse) to open the package of gloves.</p>	<p>Fig. 13: Steps for putting on surgical gloves</p>
<p>2. Open the inner glove wrapper, exposing the cuffed gloves with the palms up.</p>	


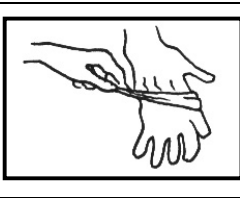

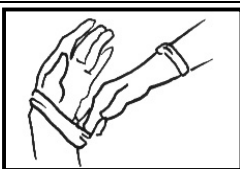
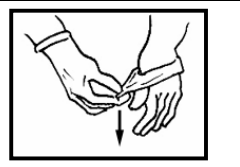
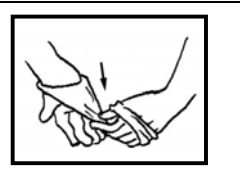
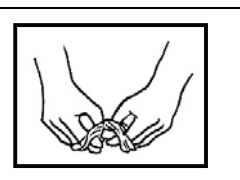
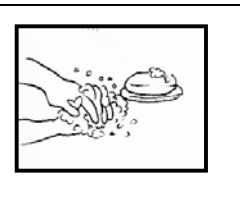
<p>3. Pick up the first glove by the cuff, touching only the inside portion of the cuff (the inside is the side that will be touching your skin when the glove is on).</p>	
<p>4. While holding the cuff in one hand, slip your other hand into the glove. (Pointing the fingers of the glove toward the floor will keep the fingers open). Be careful not to touch anything, and hold the gloves above your waist level.</p>	
<p>5. Pick up the second glove by sliding the fingers of the gloved hand under the cuff of the second glove. Be careful not to contaminate the gloved hand with the ungloved hand.</p>	
<p>6. Put the second glove on the ungloved hand by maintaining a steady pull through the cuff. Adjust the glove fingers and cuffs until the gloves fit comfortably.³¹</p>	

Fig. 14: Steps for removing surgical gloves

Steps for removing surgical gloves

<p>1. Grasp on glove near the cuff and pull it partway off. The glove will turn inside out. Keep the first glove partially on before removing the second one to protect you from touching the outside of a glove with your bare hand.</p>	
<p>2. Leaving the first glove over your fingers, grasp the second glove near the cuff and pull it partway off. Keep the second glove partially on.</p>	
<p>3. Pull off the two gloves at the same time, being careful to touch only the inside surface of the gloves with your bare hand and make sure not to result in splashes in the environment.</p>	
<p>4. Gloves are disposed immediately. Wash hands immediately after gloves are removed.³¹</p>	

Surgical glove tips

Preparation for gloving: The outside of the glove package is not sterile. Have another member of the OT team open it for you, e.g. the circulating nurse.

Change gloves:

- When gloves become contaminated;
- After touching the outside of gloves with a bare hand;
- After touching anything that is not sterile or high level disinfected;
- When gloves develop holes, tears, or punctures.²⁹

OT Personnel - Practices to Prevent SSI

Establishing and Maintaining a Sterile Field

A sterile field must be established and maintained in order to reduce the risk of contaminating the surgical/procedure site. The sterile field is created by placing sterile towels and/or surgical drapes around the surgical/procedure site. Additional sterile fields may also be established, such as on the stand that will hold instruments and other items that are needed during the procedure.²⁹

A sterile field is maintained by:

- Placing only sterile items within the sterile field;
- Opening, dispensing, or transferring sterile items without contaminating them;
- Considering items located below the level of the draped client to be unsterile;
- Not allowing sterile personnel to reach across unsterile areas or vice versa or to touch unsterile items;

Fig. 15: Sterile field (a)

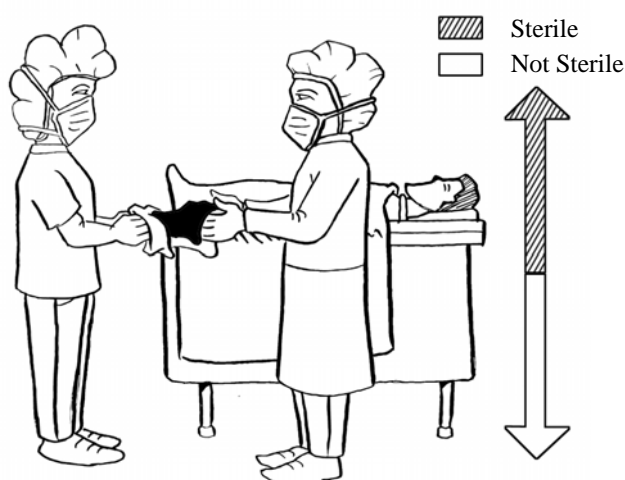
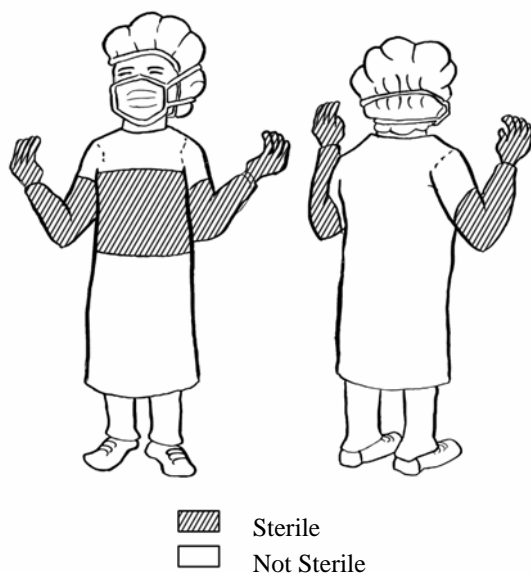


Fig. 16: Sterile field (b)



- Recognizing and maintaining the service provider's sterile area. When gowned this area extends from chest to the level of the sterile field; sleeves are sterile from 5 cm above the elbow to the cuff. The neckline, shoulders, and back are considered to be unsterile areas of the gown.
- Recognizing that the edges of a package containing a sterile item are considered unsterile;
- Recognizing that a sterile barrier that has been penetrated (wet, cut, or torn) is considered contaminated;
- Being conscious of where your body is at all times and moving within or around the sterile field in a way that maintains sterility;
- Not placing sterile items near open windows or doors.²⁹

Note!

When in doubt about the sterility or high-level disinfection of an item or an area, consider it contaminated.

Some recommendations are:

- Sterile drapes should be used to establish a sterile field.
- Items used within a sterile field should be sterile.
- All items introduced into a sterile field should be opened, dispensed, and transferred by methods that maintain sterility and integrity.
- A sterile field should be constantly monitored and maintained.
- Moisture in the sterile field should be avoided. If a solution soaks through a drape, then it should be covered with another sterile drape.
- All personnel moving within or around a sterile field should do so in a manner to maintain the integrity of the sterile field.
- Policies and procedures for basic aseptic technique should be written, reviewed annually, and readily available within the practice setting.³²

Using Good Surgical Technique

Post-procedure infections are more likely to occur:

- In tissue that has been damaged due to rough or extensive manipulation during surgery. In addition, damaged tissue heals more slowly. This increases the time that it remains more susceptible to infections.
- When excessive bleeding occurs. The tissue is more susceptible to invasion by microorganisms after excessive bleeding.

Therefore, paying meticulous attention to controlling bleeding and to gentle tissue handling during surgery can reduce the risk of infections. ²⁹

Environmental Control and Design for the Prevention of SSI

Maintaining a Safer Environment in the Surgical Procedure Area

Specific rooms should be designated for performing surgical/clinical procedures and for processing instruments and other items. It is important to control traffic and activities in these areas since the number of people and the amount of activity influence the number of microorganisms that are present and therefore influence the risk of infection.

Location of the Operating Theatre Suites

Operating theatres may be located in either purpose-built units or in converted hospital accommodation. They are busy units and therefore they require considerable planning and discussion before they are built in order to prevent expensive mistakes. They should be:

- Separated from the main flow of hospital traffic and from the main corridors; however, it should be easily accessible from surgical wards and emergency rooms.
- Ideally, the floor should be covered with antistatic material, and the walls should be painted with impervious, antistatic paint. This reduces the dust levels and allows for frequent cleaning. The surfaces must withstand frequent cleaning and decontamination with disinfectant.

Layout of the Operating Theatre

The operating theatre should be zoned and access to these zones should be under control of OT personnel. Aseptic and clean areas should be separated

from the outer areas. This is easier to achieve in purpose-built units. Physical barriers may be needed in order to restrict access and to maintain unidirectional movement of air in converted theatre units.

Note:

No one should enter the theatre complex without changing into a fresh theatre suit, shoes and cap.

The outer zone

This zone should contain:

- A main access door;
- An accessible area for the removal of waste;
- A sluice;
- Storage for medical and surgical supplies;
- An entrance to the changing facilities.

The clean or semi-restricted zone

This zone contains:

- The sterile supplies store;
- An anesthetic room;
- A recovery area;
- A scrub-up area;
- A clean corridor;
- Rest rooms for the staff.

Staff must change into theatre clothes and shoes before entering this area, but there is no need for a mask, gloves, or a gown. There should be unidirectional access from this area to the aseptic area (operating theater), preferably via the scrub-up area. The operating theatre should be restricted to just the personnel involved in the actual operation. In principle the clean zone should require exiting through the outer zone.

Aseptic or restricted area

This area should be restricted to the working team. It includes:

- The operating theatre;

- The sterile preparation room (preparation of sterile surgical instruments and equipment)

Staff working in this area should change into theatre clothes, should wear masks and gowns, and, where necessary, should wear sterile gloves.

Table 12: A Suggested Layout for an Operating Theatre Complex

Zone	Barrier	Areas included
Dirty/outside	Physical	Sluice, storage, waste disposal, outside corridor, changing rooms
Clean	Partial	Supply store, scrub area, anesthetic room, recovery room
Aseptic	Operating theatre	Sterile preparation, autoclave access

Remember:

- Clean and sterile supplies should be taken to the operating room from a reprocessing or supply area outside of the suite on a covered cart. The dust cover over the cart is removed when the cart enters the surgical suite.
- Supplies entering the suite should be removed from their shipping or transport containers prior to transport to the OT.
- Soiled items should travel in covered containers from the operating room through the clean zone to a decontamination area where soiled items are stored until they are transported to the reprocessing area.
- All soiled items should be contained and not stored in the same area with clean or sterile items.

Temperature and Humidity

The temperature and the humidity (not less than 55%) play a very important role in maintaining staff and patient comfort. They must be carefully regulated and monitored. In low humidity there is a danger of the production of electrostatic sparks.

Ideally, the operating room should be 1°C cooler than the outer area. This aids in the outward movement of air because the warmer air in the outer area rises and the cooler air from within the operating theatre moves to replace it.

Ideal Air Ventilation System: Air Supply and Exhaust

Positive pressure ventilation with respect to the corridors and adjacent areas in the operating theatre where surgical procedures are performed should be maintained. The number of operating theatres supplied by air handling units (AHUs) should be consistent with the number specified by the AHU

manufacturer. Also, there should be routine maintenance of the AHUs and these units *should not be turned off* unless being serviced.

Design features

Parameters to have in place if possible based on available resources are:

- **Air changes**
Maintainance of 15-20 air changes per hour, of which at least 3 should be fresh air from outside.
- **Filtration**
Filter all air with appropriate pre filters (e.g. filtration efficiency of 30%) followed by final filter (e.g. 90%)
- **Air supply**
Air should enter at the ceiling and be exhausted near the floor (important: furniture or other portable items placed against a wall exhaust at floor level will inhibit the air changeover in a theatre and therefore should be monitored and abated).
- **Ultraviolet Germicidal Irradiation (UVGI)**
Do not use UVGI in the operating theatre to prevent SSI.
- **Doors**
Keep OT doors closed except as needed for passage of equipment, personnel and the patient.
- **Traffic**
Limit the number of personnel entering the OT to only those necessary for the surgical procedure. The microbial level in the OT is directly proportional to the number of people moving about in the theatre.
- **Laminar flow & ultraclean air**
Laminar airflow is designed to move particle free air over the aseptic operating field in one direction. It can be designed to flow vertically or horizontally and is usually combined with high efficiency particulate air (HEPA) filters. HEPA filters remove particles ≥ 0.3 micron in diameter with an efficiency of 99.97%. Ultraclean air can reduce the incidence of SSIs especially for orthopedic implant operations; however, some studies suggest that other interventions such as appropriate timing of preoperative antibiotics and good OT practices such as limiting nonessential traffic can also lower incidence. Therefore, if resources are limited, laminar flow with HEPA filtration is not required for high quality surgical care.

Types of air supply

Air is supplied to the operating theatre by:

- 1. Plenum Ventilation:** This is the most frequently used system in general-purpose operating rooms. The bacterial counts at the wound site should be no more than 50 -500 colony forming units (cfu) per cubic meter.
- 2. Laminar Flow Ventilation (Ultra Clean Ventilation):** This system is unidirectional and delivers air flow over the operating table of 300 air changes per hour. A bacterial count of 10 cfu or less per cubic meter at the wound site is achieved.³³
- 3. Wall Mounted Air Conditioners:** These are installed in some tropical countries more for comfort than for clean air delivery. They should not be used as air delivery systems. The units are usually mounted on the hot outside wall and the air is directed down and back onto the unit itself (towards the wall). The operating table does not receive any significant air changes and the bacterial counts remain unaffected.
- 4. Free-standing Air Conditioners:** These are cooling units with no filtration of air and therefore do not fulfill the criteria for air delivery systems, especially for an OT.

Remember:

- Windows should remain closed.
- The operating theatre should maintain at positive pressure.
- Air should be introduced at the ceiling and should be exhausted near the floor in order to prevent bacterial contamination in the operative field.³²
- Air changes should be at least 20 changes per hour.
- Air should first pass through a series of dust filters and then enter the room through a HEPA filter. Split-unit air conditioning is not allowed.
- Humidity should be controlled and maintained between 50-55%.
- Temperature should be controlled and maintained between 18-24 degrees Celsius.

Equipment

Equipment such as suction apparatus and ventilators must be fitted with bacterial filters in order to prevent contamination of the machines. Used instruments should be counted, handled minimally, and then sent to the Theatre Sterile Services Unit (TSSU) for sterilization.¹⁵

[For more details see Part I: "Cleaning, Disinfection and Sterilization of Medical Equipment"]

Waste and Linen

- Waste should always be disposed of with minimal handling because there is a risk of blood-borne pathogen transmission (HIV, hepatitis B and C).
- Body fluids can be disposed of in the sluice by staff with appropriate protective clothing such as gloves, aprons, and eye protection.
- Equipment should not be rinsed before sending to the TSSU. Standard precautions should be used by OT and TSSU personnel as history and diagnosis cannot reliably predict those patients with possible blood-borne pathogens.
- Used linen should be contained in hampers or in soiled laundry bags at the point of use. Linen that is saturated with body fluids should be placed in fluid proof bags.
- Other contaminated waste should be handled and disposed of according to the facility's medical waste process.

Environmental Cleaning of the OT

There should be a simple, clear, cleaning policy that can be adhered to easily. The cleaning equipment for the operating room must be dedicated and kept separate from the outer zone.

Table 14: Example of a cleaning schedule for a high risk area: Operating room^{34 15}

[For more details see Part I: "Environmental Cleaning"]

Frequency	Tasks
At the beginning of the day	<ul style="list-style-type: none"> • Clean floors and all horizontal surfaces- operating/procedure tables, examination couches, chairs, trolley tops or Mayo stands, lamps, counters, and office furniture – with a cloth dampened with water to remove dust and lint that have accumulated over night.
Between patients	<ul style="list-style-type: none"> • Clean operating/procedure tables, examination couches, trolley tops or Mayo stands, lamps, counters, and any other potentially contaminated surfaces in operating theatres and procedure rooms with a cloth dampened with a disinfectant solution. • Immediately clean spills of blood or other body fluids with a chlorine solution. • Clean visibly soiled areas of the floor, walls, or ceiling with a mop or cloth dampened with a disinfectant solution.

**Table 13: Example of a cleaning schedule for a high risk area: Operating room^{34 15}
(Continued)**

Frequency	Tasks
Between patients (continued)	<ul style="list-style-type: none"> • Discard waste when plastic bags of waste containers are $\frac{3}{4}$ full. • Discard safety (sharps disposal) boxes, when they are $\frac{3}{4}$ full. • Do not perform special cleaning or closing of the operating theatres after contaminated or dirty operations. Thorough, routine cleaning is sufficient to provide a safe environment for subsequent cases given the high frequency of air changes in the well designed OT.
At the end of each clinic session or day	<ul style="list-style-type: none"> • Clean all surfaces – including counters, tables, sink, lights, door handles– with detergent , water and low level disinfectant then dry. Pay particular attention to operating/procedure tables, making sure to clean the sides, base, and legs thoroughly. • . • Clean sluice with warm water and detergent. • Wipe over non-metallic surfaces and equipment. • Clean the floors with a mop soaked in a disinfectant solution. • Check safety boxes and remove and replace them if they are $\frac{3}{4}$ full. • Remove medical or hazardous chemical waste. Make sure to discard it properly and as soon as possible in order to limit contact with potentially infectious waste. • Clean non-clinical equipment, and containers.
Each week	<ul style="list-style-type: none"> • Clean all the areas inside the operating theatre complex with warm water and detergent. Dry. • Empty the storage shelves, wipe them, dry them, and then restack.

Maintenance in the OT¹⁵

- Equipment should be checked every week (or at least every fortnight).
- Ventilation (e.g. pressure relationship, air changes/hour) should be checked periodically (e.g. each quarter) and the filters should be changed as required (usually annually).
- The IC-Team should be notified whenever the air delivery system for the OT has been shut down for maintenance or malfunction. The IC-team in conjunction with facility engineers will assist with determination of need for any environmental monitoring needed once the ventilation system is re-established. At a minimum positive pressure, inspection of filters and air changes per hour should be verified prior to use of the affected OT after interruption. The theatre should be used only after clearance from the IC team.¹⁵
- It is advisable to have back-up theatre facilities so that theatre sessions are not interrupted by maintenance.

Environmental microbiologic sampling in the OT

Routine microbiologic sampling of the OT air or surfaces is not recommended because the results obtained are only valid for the time period and for the location sampled. Instead, such studies should be limited to recommendations from the IC-Team, investigations of clusters or outbreaks of infection, or to validate changes in the ventilation system (e.g. installation of new AHU). Specific methods for sampling surfaces and air have been described and input from scientists with expertise in environmental microbiology are recommended prior to use as most clinical microbiology laboratories do not have this expertise.

Verification of air flow

Air flows can be examined using an innocuous smoke-producing substance such as titanium chloride:

- A swab is held under the inlet grill and the air movements are followed around the operating theatre and out through the doors.
- The floor seals and the baffle outlets should be checked.
- The air flows are then followed to the outer zone and to the extract ventilators and grills.
- Any reversal of air flow, particularly from the outer zone inwards, should be recorded and corrected.

Air exchanges

The engineers should perform tests to check that new filters have not decreased the air changes. Any alteration should be corrected immediately.

Theatre sterile services unit (TSSU)

- The TSSU is usually under the control of the operating theatre manager, but it may be incorporated into a larger central unit. In some units all of the sterilization takes place within the theatre complex.
- The supply of surgical instruments should be sufficient to maintain an adequate supply for concurrent operations and sterilizations.
- On-site sterilization is feasible only if the TSSU possesses autoclaves and if there are proper facilities for washing and for processing contaminated instruments. In order to ensure proper quality control, it may be more sensible to centralize the service.
- If TSSU services are available, the only facilities needed in the operating theatre are those required for rapid sterilization of dropped instruments (134 °C for 3-4 minutes) and for the decontamination of fiber optics.