S. A. KLIMUK, N. Y. BOVTYUK

ASEPSIS

Minsk BSMU 2015

МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ

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КАФЕДРА ОБЩЕЙ ХИРУРГИИ

С. А. Климук, Н. Я. Бовтюк

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Р е ц е н з е н т ы: канд. мед. наук, доц. каф. военно-полевой хирургии Белорусского государственного медицинского университета А. Л. Попченко; канд. мед. наук, зав. отд. общей хирургии 4-й городской клинической больницы им. Н. Е. Савченко г. Минска Н. Н. Дорох

Климук, С. А.

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Содержит учебно-методические рекомендации по хирургической асептике, включая исторические аспекты и современное состояние проблемы.

Предназначено для студентов 2–3-го курсов факультета иностранных учащихся, обучающихся по программам лечебно-профилактического и стоматологического факультетов на английском языке.

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MOTIVATIONAL CHARACTERISTIC OF THE TOPIC

Total in-class hours:

– specialty 1-79 01 01 General Medicine — 11 hours;

– specialty 1-79 01 07 Dentistry — 4 hours.

At the ancient times demons and evil spirits were thought to be the causes of disease including wound suppuration. But even at that times some healers and doctors began to understand the importance of hygiene and wound cleaning. But many people believed that wound suppuration could favor its healing. There even existed a notion of «laudable pus». This wrong belief resulted in the fact that 85% of excellently performed operations could have lethal outcome due to suppuration. Healers didn't understand the cause inflammation, and tried to fight it empirically: they cauterized wounds, and used boiling water and oil. This period in the history of asepsis is called empiric. After the empiric period one should mention: 1) period of «prelisterian» antisepsis; 2) the period of Lister's method; 3) the period of asepsis and antisepsis.

In the beginning of the XIX century Nikolay Pirogov used carbolic acid, silver nitrate, zinc sulphate, spirits, and iodine for wound treatment. He considered that wound processing may fight an infection. Also N. Pirogov suggested that patients should be triaged into purulent and «clean» (impurulent). This principle is the base of asepsis and antisepsis nowadays.

In the «prelisterian» period the notion of «antisepsis» («anti-suppurative») was introduced by English surgeon John Pringle (1750) on the basis of his observations. At 1847 Hungarian obstetrician Ignaz Zemmelweis stated that doctors should wash hands before examination of obstetric patients in order to prevent puerperal fever. Josef Lister, an English surgeon, invented a complex of measures to reduce mortality caused by wound suppuration. He used Louis Paster's data on investigation of wine fermentation. By 1865 J. Lister used pure carbolic acid for instillation into wounds and onto dressings. Ernst von

Bergmann analyzed the accumulated knowledge and demonstrated the results at the 10th Surgery Congress at Berlin in July, 1890. He was named «the Father of Asepsis». During the Congress appeals to reject antisepsis were proclaimed because of aggressive nature of first antiseptics. But later less harmful chemicals were introduced into medical practice. Since then asepsis and antisepsis became inseparable and considered the basis of surgery and medicine at whole.

In 1882 F. A. Trendelenburg constructed an apparatus for sterilization of surgical material and instruments with dry steam. E. Bergman and K. Shimelbush constructed a sterilizing machine for instrument boiling; they designed metallic drums for linen and dressing sterilization. Being asked what was new in surgery in the 1882 Ernst Bergman said: «Today we wash hands before surgery». In 1886 Bloodgood invented rubber gloves for surgeon's hand protection, but their use was not a routine practice until William Stewart Halsted invented rubber gloves — at first to protect hands of his operation nurse who became his wife later. Within couple of years gloves became obvious both for surgeons and nurses.

The discovery of penicillin was first reported by Alexander Fleming (USA) in 1928. In the 1930s a research group at Oxford University headed by Howard Florey and Ernst Chain began to investigate the properties of naturally occurring antibacterial substances including penicillin, and by 1939 they treated infections
in mice and by 1942 the product had been successfully tested on humans. In the Soviet Union antibiotics were introduced into clinical practice in the 1940s by Z. V. Ermolyeva.

The contemporary measures to prevent surgical infection consist of two main principles:

Everything that is in contact with the wound should be sterile

Patients should be triaged as purulent and «clean» (impurulent)

Purpose of the lesson**:** to study the base of asepsis.

Objectives:

1) to learn methods of surgical instruments, linen, and dressing material sterilization;

2) to learn the ways of sterilization boxes arrangement;

3) to learn the principles of the autoclave and air sterilizer acting;

4) to be able to control the quality and sterility, presterilization tool processing;

5) to know the protocol for scrubbing and medical personnel hands decontamination;

6) to detect signs of wound suppuration;

7) to collect pus for research on the flora and antibiotic sensitivity properly;

8) to perform a clean and purulent wounds dressing;

9) to learn the rules of rational antibiotic prophylaxis.

Requirements for the initial knowledge level. To learn the topics completely student must know:

 microbiology (the concept of pathogenic and opportunistic microflora; cell wall structure of Gram-positive and Gram-negative microorganisms);

 histology and physiology (structure and function of the skin);

 inorganic and organic chemistry (classification of substances, properties of acids, bases, oxidants).

Test questions:

1. What is asepsis?
2. What are the sources of exogenous and endogenous infection?
3. Describe the measures for the prevention of airborne, droplet, contact and implant surgical infection.
4. Describe the methods of surgical instruments processing.
5. Explain the principles of operation of the autoclave and drying ovens.
6. What methods for sterility control do you know?
7. Explain the concept of disinfection.
8. What is hospital infection? Name the standard cases of nosocomial surgical infection.
9. Describe the protocol of medical personnel hands decontamination.

Asepsis (from the Greek. A — prefix meaning «no sign + septikos» — putrid, saprogenous) is a set of activities including hygiene to prevent germs penetration into the wound and the body. It is achieved via destruction of bacteria and their spores through sterilization and disinfection, using chemical, biological and physical agents and factors.

The modern asepsis is based on two main principles:

Everything that is in contact with the wound should be sterile.

Patients should be triaged as purulent and «clean» (impurulent).

Surgery differs from other medicine because of necessity to violate the integrity of the skin and mucous membranes. That is why surgical procedures and operations may lead to microbes penetration into the wound.

There are two main sources of surgical infection: exogenous (external) and endogenous (internal). **Endogenous** infection originates from loci inside the body and on its surfaces (skin, gastrointestinal tract, respiratory tract, oral cavity, etc.). Sources of endogenous infection are carious teeth, foci of chronic infection in the internal organs — cholecystitis, bronchitis, pyelonephritis and other. Pathways of endogenous infection dissemination are following: *lymphogenous, hematogenous, througout (per continuentatem)*, *contact* (for example, through surgical instruments). Endogenous microphlora could be divided into: 1) *resident* that persists inside the body all the time; 2) *transient* when bacteria inoculate as patient contacts with different environmental surfaces.

The main sources of **exogenous** infection include patients with purulent inflammation or healthy microbe carriers, tools and hospital/home equipment and occasionally animals (domestic or wild). Pathways of germs transmission from exogenous sources are following: 1) *airborne* — from the air, with a spray of saliva, by sneezing; 2) *direct contact* — objects that are in contact with the wound (tools, instruments, dressings, staff hands, etc.); 3) *implantation* — items left in the wound (drains, sutures, vascular prostheses, artificial materials, etc.); 4) *infusion* — variant of implantation pathway, via injection (intraarterial, intravenous [IV], intramuscular, subcutaneous, intradermal, intraarticular, etc.).

One should remember that it is easier not to infect than disinfect. Prevention of all types of infections is carried out via number of measures regulated by legislation, and based on science and technology. Every country has its own legislation basis on the infection safety.

PREVENTION OF AIRBORNE INFECTION

Airborne infection causes **10 %** of wound infection. The main pathways of its transfer into the wound are turbulent air flows arising around hot objects (equipment, staff and patient's bodies, etc.). Contemporary specially designed operating units and rooms with sterile laminar flow of conditioned air are introduced into practice worldwide. Isolated HVAC[1] systems should be used.

Prevention of air contamination includes complex activities:

- design of surgical wards;
- separation of patient streams;
- design and layout of the operating unit;
- organization measures and regulations for surgical department and operational unit staff and visitors.

The main unit of surgical department is **ward**. Current daily cleaning in surgical wards should be carried out at least three times per day, including one cleaning using chemical disinfectants. After the daily cleaning air disinfection should be carried out (ventilation, ultraviolet radiation). Tools and instruments used for patient's care should be disposable if possible, and changed on demand. Subsidiary rooms for certain activities such as dressing, handling, bathroom, enema cabs, staffroom, dining room, pantry room, linen room, etc. should be arranged.

The main requirement for **operating unit** is its complete isolation from other units. Nowadays in modern hospitals the operating unit is located in separate block connected with surgical department through the hall. To be protected from environmental factors (urban noise, dust) operating unit should be located in the upper floors of the building (1st floor and higher).

Operating room (OR) should match following requirements:

- Should be close to emergency room/department.
- Double door entrance to the unit.
- Temperature — 19–22 °C.
- Humidity — 45–55 %.
- Ventilation — change of air 3–4 times per 1 h.
- Ultraviolet bactericide lamp air disinfection.
- Adjustable lightings.
- Easy-to-clean room design.
- Static electricity prevention (facilitate dispersal dust).

[1] HVAC — heating, ventilation and conditioning system.

 Reducing the time of contact with the air open wound.

All instruments, apparatus, equipment moved into the operating unit should be decontaminated. Storage of devices, apparatus, equipment not used during surgery in OR is prohibited.

There are special requirements for OR cleaning premises (wet cleaning using disinfectants only). The following types of cleaning procedures may be performed in OR:

 provisional — before work started;
 current — during the operation;
 cleaning — after the operation;
 final — at the end of the working day;
 general — once a week.

REQUIREMENTS FOR OPERATION UNIT PERSONNEL, STUDENTS

Before entering the operation room one should:

 Change into clean scrubs (anesthesiologists are allowed to wear their in-hospital clothes).

 Remove all jewelry, watches and rings (risk of bacteria transfer is 10 times higher when nurse wears rings).

 Remove pager and cell phone.

 Put on surgical cap, mask, shoe covers (mask must be tied before entering the operation room; hair must be completely covered), waterproof apron (not necessary if waterproof gowns are used): protective clothing use reduces the risk of transmitting infection by **20–100** times!

 Surgeons and operation nurses should wash hands using international standard for hands processing (to be prepared for scrubbing in the operation room) and put on sterile gowns (fig. 1).

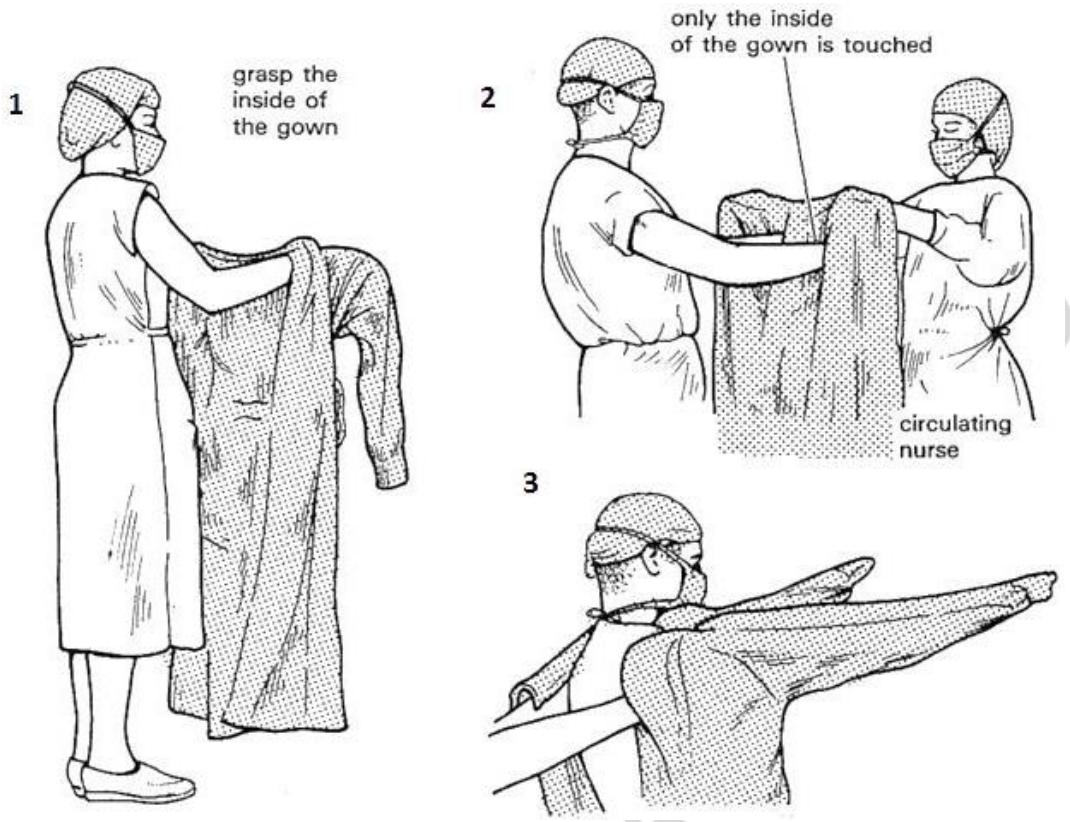


Figure 1. Technique of gowning

Medical clothes used by medical staff in the operating unit should vary in color or be easily distinguishable from clothing used in other departments of healthcare organization (fig. 2). Before entering OR students/employees who are not directly involved in operation must put on clean gown and cap, new mask, shoe covers over a changed footwear.

Figure 2. Color codes for staff

While working at the operation room:

 do not take off surgical cap, mask, shoe covers;
 use individual protection means such as surgical gloves (double gloves protect better), masks, visors; change them as required (masks are to be changed as early as 3 hrs pass, gloves — immediately when injured, after surgical hands processing, after 3 hrs of activity);

 remember about sterile areas of staff's bodies, operation table and operation room (fig. 3).

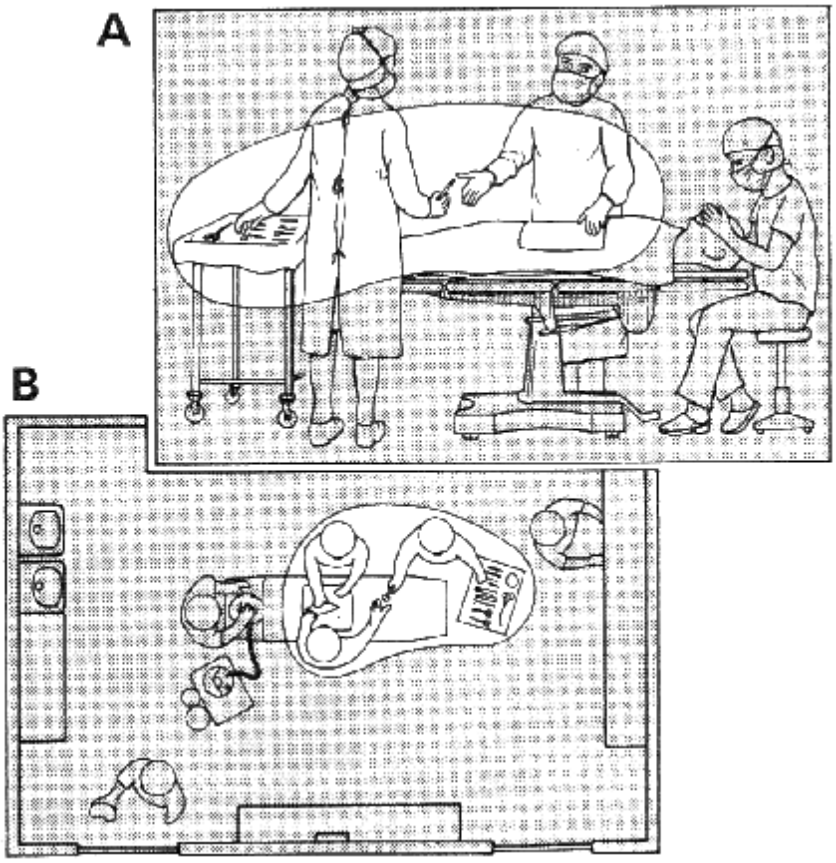


Figure 3. Sterile zones of operation table and staff bodies during operation

Measures to fight respiratory infections:

 prohibition of conversations in OR;
 obligatory wearing of masks covering mouth and nose;
 timely cleaning;
 immunization of the medical staff against respiratory infections;
 prohibition of large student groups entrance (remote training systems for watching the operation course with live video in classrooms).

After the operation/any manipulation:

 take off all the medical clothes;
 dispose all disposable tools;
 NEVER perform more than one operation using the same clothes, mask, gloves, shoe covers, linen, instruments and materials;
 collect into specially marked and labeled containers:
- individual protective tools;
- linen;

- used dressings;
- instruments;
- anatomic waste.

For medical interventions in patients with suppurative processes health care organizations should have:

 septic elective and urgent operating unit/room with a separate entrance;
 septic dressing-rooms.

If separate septic operating unit/room and septic dressing-rooms are absent, routine medical interventions in patients with suppurative processes must be carried out in the *second turn*, after all «clean» interventions have been performed. After performing urgent (emergent) medical intervention in patient with acute and/or suppurative processes in general operation room staff should perform:

 cleaning;
 final disinfection;
 decontamination of air in accordance with the internal rules and requirements of the organization.

Decontamination of waste, individual protective tools, dirty linen, dressings and medical instruments should be conducted in accordance with the local laws and regulation.

GENERAL PRINCIPLES OF CONTACT INFECTION PREVENTION

Prevention of contact infection is a number of activities consisting in the sterilization and disinfection of all items that are to be in contact with the wound.

The classification system for Medical Devices and Levels of Disinfection first proposed by Dr. E. H. Spaulding divides medical devices into categories based on the risk of infection involved with their use. This classification system is widely accepted and is used by the Food and Drug Administration (FDA), the Centers for Disease Control and Prevention (CDC), epidemiologists, microbiologists, and professional medical organizations to determine the degree of disinfection or sterilization required for various medical devices. Three categories of medical devices and their associated level of disinfection are recognized.

***Critical*:** a device that enters normally sterile tissue or the vascular system or through which blood flows should be sterile. Such devices should be sterilized, which is defined as the destruction of all microbial life.

***Semicritical*:** a device that comes into contact with intact mucous membranes and does not ordinarily penetrate sterile tissue. These devices should receive at least high-level disinfection, which is defined as the destruction of all vegetative microorganisms, mycobacterium, small or nonlipid viruses, medium or lipid viruses, fungal spores, and some bacterial spores.

***Noncritical*:** devices that do not ordinarily touch the patient or touch only intact skin. These devices should be cleaned by low-level disinfection.

Disinfection is a destruction of microorganisms potentially pathogenic for humans on objects of external environment to separate infectious agents transmission paths. Disinfection is a destruction of vegetating pathogens, that means that disinfection is a process of reducing the number of microorganisms without affecting bacterial spores. This is the difference of disinfection from sterilization that destroys all types of microorganisms, including spores. Disinfection may vary in level according to the grade of microbes destruction (table 1).

Table 1

Levels of disinfection according to the type of microorganism

Level	Bacteria			Fungi	Viruses	
	Vegetative	Tubercle bacillus	Spores		Lipid (medium)	Nonlipid (small)
High	+	+	+	+	+	+
Intermediate	+	+	±	+	+	±
Low	+	–	–	±	+	–

The term «decontamination» is used to describe the removal of microbial contamination. It includes washing/cleaning and disinfection, and in the opinion of some authors — cleaning, disinfection and sterilization as sequential processing steps.

Disinfectant is a substance or preparation for destruction of vegetative forms of bacteria and most viruses.

Antiseptic is a non-toxic disinfectant used for treatment of skin and other living tissues.

Sterilant is a substance that can destroy vegetative and spore forms of bacteria, viruses, fungi, etc under certain conditions.

There are two types of disinfection: preventive and focal. **Preventive** disinfection is carried out regardless of infection presence in order to prevent it; **systematic** disinfection means disinfection of items used for patient care in health care organizations. **Focal** disinfection is carried out in the outbreak of infection.

It can be current and final. *Current* disinfection is performed for killing pathogens after their extraction from source of infection. Disinfection covers everything that surrounds the patient. *Final* disinfection is carried out after the patient's recovery or death in order to release the source of infection from pathogen within first 6–12 hours after patient's outcome occurrence.

There are several methods of disinfection:

1. **Mechanical** (removal of microorganisms with shaking, wet cleaning, ventilation, ventilation, washing, bathing, cleaning).

2. **Physical** (disinfection with physical agents exposure: ultraviolet radiation, dry heat, steam boiling).

3. **Chemical** (disinfection with disinfectants: halogen derivates, oxygen-containing, surfactants, guanidine derivates, aldehyde alcohols, phenol, acids, mixed, etc.).

Effectiveness of these disinfectants depends on the following factors:

 quality of the pre-clearance;
 concentration of disinfectant;
 type and concentration of microbial contamination;
 time of contact of surface to be disinfected and disinfectant;
 physical and chemical environmental factors (presence of soluble calcium or magnesium salts improves water rigidity and neutralizes disinfectant, heat accelerates the action of disinfectant);
 presence of biofilms on the treated object.

Sterilization is complete elimination or destruction of all forms of microbial life and in health care facilities it is accomplished by either physical or chemical processes. If any reusable instrument or equipment is classified as *critical*

(i. e. comes in contact with the blood stream or body tissues) it should be cleaned and sterilized before each use. Also disposable instruments and

materials are to be sterilized before packaging or inside of the protective package at the manufacturing site. Sterilization is performed using steam under pressure, dry heat, or chemical sterilants (in healthcare organization), by ionizing radiation or by chemical sterilants (at the manufacturing site). The choice of sterilization method depends on a number of factors including the type of material that the object to be sterilized is made of, the number and type of microorganisms involved, classification of object, and availability of sterilization methods.

Instrument and medical device sterilization in any health care facility traditionally takes place at specialized units, and pretreatment (cleaning, disinfection, inspection and packaging) is carried out at certain services (endoscopy units, preoperation rooms etc.). Effective decontamination requires the attainment of acceptable standards at all stages of the instrument cycle. The aim of decontamination is to make re-usable medical devices safe for patient and staff to handle without infection hazard. Failure to perform any of these stages will result in inadequate decontamination. At all stages of reprocessing,
the following issues need to be taken into account:

1. Location and activities where decontamination takes place.
2. Instrument reprocessing facilities and equipment at each location.
3. Ensuring that used equipment is validated, maintained, and tested in accordance with manufacturer's guidelines and legislation.
4. Existence of effective management arrangements.
5. Existence of policies and procedures for all aspects of decontamination.

STEPS OF INSTRUMENTS PROCESSING (fig. 4)

STEP 1: CLEANING

Dirty instrument cannot be effectively sterilized. This is because the soil shields bacteria and viruses from the sterilizing agent. As a result, bacteria and viruses may survive the sterilization process and can cross infect the next patient.

*The common method of cleaning instruments is manual cleaning (cleaning by hand). Manual cleaning has the advantage of flexibility, e.g. any type of instrument can be cleaned manually. Dis*advantages *of manual cleaning are that the cleanliness of the instruments can vary between workers as well as that employees are at risk of infection as they are in contact with contaminated instruments. For these reasons, it is important for health care facilities to establish protocols for instrument cleaning and require staff to wear personal protection devices when working with contaminated instruments.*

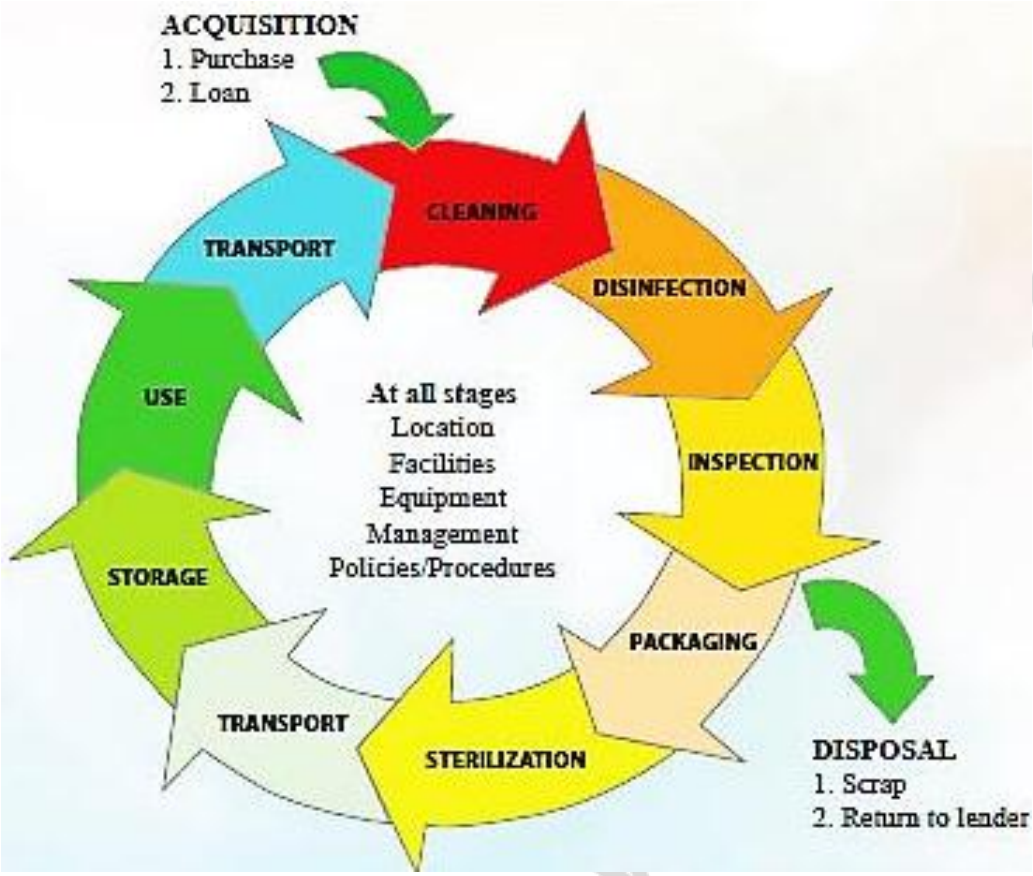


Figure 4. Instrument «life cycle»

Recommended procedures for manual cleaning are to soak the instrument first in a tepid or lukewarm water or detergent bath for at least 10 min. This step softens and loosens the soil that may have dried on the instrument between usage and cleaning. The soak duration depends on soil amount and duration of drying. Note: enzyme detergents are preferred as they help to break up organic soil more readily and rapidly than conventional detergents do.

The next step is complete brushing of instrument with a medium-soft bristle brush while it is in the soak bath. In case of tubular devices (dental handpieces, suction tubes etc.), the insides (lumens, channels, etc.) should be brushed out as well. Only brushes recommended by the manufacturer should be used to prevent instrument damage. Note: brushing should be done under the surface of the water to minimize aerosols and with brush strokes away from the body to avoid exposure to spray from the brush. Then instrument should be rinsed with clean water and, if difficult-to-remove soil remains, another enzyme soak followed by brushing and rinsing should be done.

Ultrasonic cleaning is used in contemporary operation units because manual cleaning that removes most or all of the visible soil from instruments may not remove small or microscopic particles that are protected by the surface texture or design features like hinges. Ultrasonic cleaners create microscopic bubbles in liquid phase that collapse when in contact with instrument and release energy. This energy «kicks» any soil on the instrument surfaces. This process is called cavitation. The detergent in ultrasonic bath suspends the soil particles and keeps them from attaching back to instrument. Ultrasonic cleaning should be done in accordance with specification of instrument, detergent, or ultrasonic bath manufacturer, whichever is longer. Following ultrasonic cleaning instruments are to be

rinsed with clean water and dried. Distilled water is preferred to ensure removal of detergent, but is only essential if the tap water has a high mineral content that could cause spotting.

Automatic washers are used in the healthcare organizations when there is a need to clean a large quantity of instruments and/or cassettes. These devices resemble home dishwashers or may be specialized for specific needs of cleaning complex instruments, e. g., endoscopic instruments. Being validated to meet needs of specific instrument cleaning, automatic washers offer a wide range of temperature settings that allow to process instruments at maximum safe temperature. Higher temperatures speed cleaning and provide some disinfection. Regardless of automatic washer type used, instruments must be prepared for processing before being placed into a washer, with the extent of preparation depending upon the capabilities of washer. Preparation must be carried out in accordance with washer manufacturer's instructions. For simplest washers, manual presoaking and sonication remain necessary reprocessing steps. More sophisticated washers include presoaking as part of automatic process.

After cleaning all the instruments are to be dried on air or using dry heat (80 °C, 20 min). After drying, the instruments may be packaged for sterilization

STEP 2: INSPECTION

Each and every instrument should be inspected for function and cleanliness after cleaning. Any damaged instrument should be replaced and any instrument with visible soil or residual debris should be re-cleaned. It is prohibited to clean dirty instrument in a clean area: cleaning action can cross contaminate other instruments and work surfaces.

According to the local belarussian rules 1 % of every instrument batch should be tested for residues of blood and detergents. If a batch contains less than 100 items, at least 3 instruments are to be tested. Test for blood residue is performed using benzidine assay, test for detergents residue is performed using phenolphthalein assay, or other conventional tests. In case of positive testing the batch is to be reprocessed totally (cleaned in case of blood residue, rinsed with clean water in case of detergent residue).

STEP 3: PACKAGING

Package, i.e. pouches, wrap, or rigid containers, serve to maintain sterility of processed instruments and ensure aseptic opening at point of use. Packaging should be done in clean area.

Sterilization pouches are commonly used for small, lightweight instruments and should be placed on edge facing the same direction in sterilizer. This best practice of loading technique assists sterilant penetration and facilitates drying. Before sealing a sterilization pouch it is important to put inside a multiparameter chemical indicator (intended for certain sterilization method) and remove excess air. With self-sealing pouches it is necessary to fold the adhesive flap on the perforation line and ensure contact with both paper and plastic film (ideally 50 % each). Some sterilization pouches come printed with both external and internal chemical indicators. This complies with CDC[2] guidelines, if the supplier has validated internal indicator as multiparameter.

Sterilization wrap is commonly used for instrument trays or cassettes. There are many different types and sizes of wraps available. Typically, two layers are needed to provide

[2] Center for Disease Control.

effective barrier, and specific technique is recommended to ensure aseptic opening. Wrapped instruments should be secured with sterilization tape that also serves as an external indicator. Before closing, multiparameter chemical indicator should be put inside along with instruments. Recently, wrap manufacturers have stated not to stack wrapped items during storage as this can compromise sterility.

Rigid sterilization containers are commonly used for heavy, mostly layered instrument trays, i.e., orthopedic sets. There are many different types and sizes of rigid containers, all of them provide protection during storage and can be stacked during storage without compromising sterility. For quality assurance, multiparameter chemical indicator should be included on each layer of multilayered sets and in opposite corners of rigid containers.

STEP 4: STERILIZATION

Steam sterilization is the most commonly used process for sterilizing instruments, trays, and cassettes. Steam under pressure is the process of choice whenever possible as it is considered safe, fast, and the most cost-effective for health care facilities. Steam sterilizers come in many different sizes and sterilizer cycles can vary among manufacturers. The cycle a sterilizer runs can typically be found in the sterilizer manual. There are examples of standard cycle parameters for packaged instruments.

Gravity — 121 °C/250 °F for 30 minutes exposure and 15–30 minutes drying time.
Gravity — 132 °C/270 °F for 15 minutes exposure and 15–30 minutes drying time.
Gravity — 135 °C/275 °F for 10 minutes exposure and 30 minutes drying time.
Dynamic Air Removal — 132 °C/270 °F for 4 minutes exposure and 20–30 minutes drying time.
Dynamic Air Removal — 135 °C/275 °F for 3 minutes exposure and 16 minutes drying time.

Other sterilization processes include: chemical vapor, dry heat, ethylene oxide, vaporized hydrogen peroxide (low-temperature plasma), and ozone. Although each of these processes offer advantages and disadvantages, choice of sterilization process depends on instrument specification and validated from *instructions for use. Chosen process must not damage goods and must be efficacious to ensure sterility.*

As methods of sterilization depend on type of instrument, conventionally all the surgical instruments are divided into 4 groups:

- **Metallic cutting** (scalpels, scissors, needles, sutures, etc.) — steam under pressure (rarely), chemical, dry heat, ionizing radiation.
- **Metallic non-cutting** — clamps, needle holders, retractors etc. — steam under pressure, chemical, dry heat, ionizing radiation.
- **Rubber and plastic:** catheters, drains, etc. — chemical, incl. ethylene oxide, hydrogen peroxide, and ozone, ionizing radiation.
- **Optical:** laparoscopes, gastroscopes, cystoscopes, etc. — chemical (liquid — except lenses and oculars), incl. ethylene oxide, hydrogen peroxide, and ozone, ionizing radiation.

STEP 5: STERILE STORAGE

Sterilized packages should be stored in a manner that reduces potential for contamination, i. e., clean, dry, and temperature- and traffic-controlled areas. Sterility is event-related, and items are considered sterile until packages are damaged or open. Therefore, it is important for sterilized packages to be handled with care: avoid dragging, crushing, bending, compressing, or puncturing. During transport, they should be protected

from environmental contaminants. Prior to use, each sterilized package should be inspected for integrity. If a package damage is suspected, it should not be used and the item should be reprocessed. Sterile packages should not be opened until point of use.

STEP 6: QUALITY ASSURANCE

Sterility assurance of processed instruments should be routinely verified using three (3) types of indicators; physical, chemical, and biological.

Physical indicators consist of the time, temperature, and pressure indicators built into sterilizers. For each sterilization cycle, these readings should be observed and verified prior to sterilizer unloading. Large freestanding sterilizers, which are often found in surgery centers and hospitals, are required to have a chart or printout that is initialed after each cycle. This physical indicator is then maintained as part of their overall infection-control records. This is indirect method of sterility control.

*Chemical Indicators (**CIs)*** (fig. 5, left) *change color during the sterilizer cycle to verify that some or all sterilization parameters were met. As stated earlier, CIs should be used on the outside and inside of all sterilized packages. CIs vary in performance characteristics, and health care facilities should select the CI that fits their monitoring needs best. Indicator tape is an example of an external CI and it indicates that a package was in sterilizer run. Internal CIs are used to ensure the sterilant penetrated the packaging system and integrating indicator demonstrates that ALL of parameters necessary for sterilization were met for that specific cycle.* This is **indirect** method of sterility control.

Figure 5. Chemical Indicators and Biological Indicators

Biological Indicator (BI) (fig. 5, right) *monitoring is the gold standard for sterility assurance as BIs contain bacterial spores that test the lethality of sterilizers. If sterilizer can effectively kill the highly resistant spores in the BI, then it is capable to kill less resistant organisms found on instruments. BIs should be run at least weekly. Weekly BI monitoring is completed by running a BI in the sterilizer with a load.* This is **indirect** method of sterility control.

Direct method of sterility control includes planting from hands of surgeons, operating nurses, surgical field, air of operation room, nasopharynx of staff members. It should be performed according to epidemiological situation and on demand of clinical epidemiologist.

STERILIZATION OF SURGICAL LINEN AND DRESSING

*Dressing materials made from gauze (napkins, narrow cotton swabs, gauze sponges), surgical drapes, gowns, caps, sheets, towels, made of cotton textile (after washing and disinfection) are to be sterilized using sterilizing boxes. Material should be packed to allow taking out any item without touching the rest. S*terilizing boxes can be arranged in three ways:

1) universal (for the same type of surgery — particular items);

2) targeted (for a particular operation);

3) specialized (napkins only, gowns only, draping only etc.).

After placing into an autoclave the holes of sterilizing boxes *should be opened. Sterilization is performed in an autoclave under a pressure of 2 atm, temperature of 132 °C with an exposure of 20 min, at 1.5 atm — 120 °C/45 min. After sterilizing and drying the holes* sterilizing box should be closed*, and labeled with date and time of sterilization. Closed s*terilizing boxes keep sterility for 72 hrs. Once *opened s*terilizing boxes are sterile *for 12 hrs.*

Dressing materials *(*napkins, narrow cotton swabs, gauze sponges*) can be sterilized in the packaging material (paper) in a dry steam at 180 °C/1 hour.*

Disposable sets of surgical linen, draping *and dressings are sterilized at manufacturing site using ionizing radiation.*

Syringes and **gloves** are sterilized at manufacturing site with ionizing radiation. To prevent transmission of infection health care facility should use disposable single use syringes and gloves only. Injection of blood-borne viruses is the major hazard of needle stick injuries, especially the viruses that cause AIDS (the HIV virus), hepatitis B and hepatitis C. To prevent professional occupational infection of the medical staff and eliminate the risk of needle stick injuries the rules of syringes handle should be followed strictly:

- Putting caps on used needles is prohibited.
- After medical intervention medical syringes with needles and sharp objects should be collected in puncture-proof containers followed by disinfection and destruction (fig. 6).

Figure 6. Reusable containers for sharp items collection

THE MICROFLORA OF THE SKIN OF HANDS AND SKIN

Transmission of microorganisms on hands depends on various factors, such as type of microorganisms; ability of microorganisms to survive on skin surface; number of micro-organisms; skin's moisture.

The total number of microorganisms on the hands of staff depends on duration of operation, grows in a linear manner, and increases in average by 16 microorganisms per minute on ungloved hands. Higher microorganisms density on the staff hands could be revealed after direct contact with patient after manipulation on respiratory organs, contact with body fluids and after patient care activity.

American surgeon P. B. Price proposed to distinguish microbes that are able to live and breed on (in) the skin — **resident** flora, and those that only contaminate the skin, — **transient** flora.

Resident microflora The number of resident microbes is about 10^2–10^3 per
1 cm^2. Microorganisms representing resident (normal, permanent, colonizing) flora permanently live and multiply on the skin. About 20 % of them may live in deep skin layers, including grease and sweat glands, hair follicles. The greatest number of resident hand bacteria is found around and under

fingernails, at lesser extent — between fingers. Resident flora is primarily coagulase-negative cocci (primarily *Staphylococcus epidermidis*) and diphtheroids (*Corinebacterium* spp.). Gram-negative bacteria (excluding *Acinetobacter* spp.) are rarely resident, but some enterobacteria, mainly *Klebsiella*, can survive and even multiply on skin for several days. In such cases they are called a «temporary resident» microorganisms. *S. aureus* is detected in nasal cavity of approximately 20 % of healthy people and less frequently in other habitats. *S. aureus* rarely colonizes undamaged hand skin, but in hospital environment it can be detected on medical personnel hands with frequency equal to nasal cavity.

It is almost impossible to remove resident microorganisms completely with conventional hand washing, or even antiseptic procedures, although number of microbes may be significantly reduced. Skin sterilization is neither impossible nor undesirable: normal skin microflora prevents colonization by other, sometimes much more dangerous microbial strains, especially Gram-negative bacteria.

Transient microflora could be obtained during contact with infected (colonized) patients or contaminated objects of environment; it has the greatest epidemiological importance. Transient microorganisms are retained on hands for

a short time (rarely more than 24 hours), and can be easily removed with routine hand washing or destroyed using antiseptics. Transient flora may include much more epidemiologically dangerous microorganisms (*E. coli*, *Klebsiella spp.*, *Pseudomonas spp.*, *C. albicans*, rotaviruses, etc.), including nosocomial strains. The rate of opportunistic pathogen planting from medical staff hands can be very high. In most cases pathogens causing infections in patients could not be found anywhere except hands of staff; as these germs persist on the skin, they can be transferred to patients and contaminate various objects — further pathogen transmission could occur. When skin is damaged (including application of inadequate methods of washing and hand antisepsis), transient microorganisms begin to colonize and infect skin creating a new and much more dangerous resident (but not normal) flora.

«Infectious» hand microflora. R. P. Wenzel proposed to add another type to the classification of P. B. Price — so called **«infectious»** flora, i. e. flora that causes bacterial skin infections (e. g. felon). It is important to bear in mind that

the micro-organisms (most commonly *S. aureus* and beta-hemolytic *streptococci*) are retained on hand skin: use of antiseptics in treatment of cutaneous infections do not provide safety in the framework of infection transmission.

HAND-HYGIENE TECHNIQUES

HYGIENE HAND WASHING

When washing hands with soap and water (table 2), wet hands first with water, apply the amount of soap recommended by the manufacturer to hands, and rub hands together vigorously for at least 15 seconds, covering all surfaces of the hands and fingers. Rinse hands with water and dry thoroughly with a disposable towel. Use towel to turn off the faucet.

 Before direct contact with patients and after contact with a patient's intact skin (such as when taking a pulse or blood pressure or lifting a patient).

 After contact with inanimate objects (including medical equipment) in the immediate vicinity of the patient.

 Before meals and after restroom.

Table 2

Properties of commonly used cleansers and antiseptics

Cleanser/Antiseptic	Comments
Plain non-antimicrobial soap	Very little antimicrobial activity; it mainly removes dirt and transient bacterial flora
Antimicrobial soap	Eliminates transient flora, and has the additional advantage of sustained activity against resident hand flora
Waterless alcohol-based hand antiseptics	Excellent spectrum of antimicrobial activity and rapid onset of action, dry rapidly, and do not require the use of water or towels; emollients are often added to prevent an excessive dryness of the skin caused by antiseptics

HYGIENE HAND ANTISEPSIS

When decontaminating hands with an alcohol-based hand rub, apply product to the palm of one hand and rub hands together, covering all surfaces of hands and fingers, until hands are dry. Follow the manufacturer's recommendations regarding the volume of product to use.

 After occasional direct contact with patient's intact skin contaminated with body fluids or excretions.

 After occasional contact with body fluids or excretions, mucous membranes, damaged skin, and wound dressings, even if hands are visually clean.

 If moving from a contaminated body site to a clean body site during patient care.

 After gloves removal.

SURGICAL HAND ANTISEPSIS

Surgical hand preparation is a critical element of safe surgical care; it reduces skin bacteria release from hands of surgical team in case of unnoted puncture of surgical glove and potential bacteria penetration into the wound. In contrast to hygienic handwashing, surgical hand preparation must eliminate transient and reduce resident flora content. It should also inhibit bacterial growth on the gloved hand**.** Surgical hand preparation should be performed **before any interventional manipulation/operation**. Surgeon, assistants, and scrub nurse perform a surgical hand preparation before gloving for a surgical procedure. An effective antisepsis implies use of antiseptic detergent solutions, preferably waterless and alcohol-based (table 2, 3).

Table 3

Cleanser/Antiseptic active ingredients properties

Cleanser/Antiseptic	Comments
Chlorhexidine	Mode of action: cell wall disruption Antifungal activity: fair Poor activity against Mycobacteria Adverse effects: ototoxicity, eye irritation
Iodine/iodophors	Mode of action: oxidation and substitution by free iodine Antifungal activity: good Broad antibacterial spectrum; minimal skin residual activity Adverse effects: possible absorption toxicity, skin irritation
Alcohols	Mode of action: protein denaturation

	Antifungal activity: good Rapid action; little residual activity Volatile and flammable (!) Adverse effects: skin dryness

These solutions should:

- substantially reduce microorganisms on intact skin;
- possess broad-spectrum activity;
- contain a non-irritating antimicrobial preparation;
- be fast-acting and persistent.

Thus, antiseptic preparations intended for use in surgical hand preparation are chosen for their ability to reduce number of bacteria: a) **immediately** after washing; b) after surgical gloves wearing within six hours (**persistent** activity); c) after multiple applications over five days (**cumulative** activity). Immediate and persistent activities are considered the most important.

Waterless, alcohol-based hand hygiene products are highly recommended for routine decontamination of hands as they are both safe and effective antiseptics. They can be used as long as hands are not visibly soiled. If hands are visibly soiled, soap and water must be used first. Solutions containing either **chlorhexidine gluconate** (4 %) or one of the **iodophors** (e. g. 7.5 % povidone-iodine) are the most effective surgical scrub preparations. There also the fewest problems with their stability, contamination and toxicity. Studies showed that chlorhexidine gluconate allows significant, immediate reduction of microorganisms, and has persistent and residual efficacy (an important property during long-lasting operations).

Alcohols are among the safest known skin antiseptics, ensuring the greatest and most rapid reduction in bacterial counts on clean skin. A vigorous **1-min scrubing** with enough alcohol to wet hands completely has been shown to be most effective method for hand hygiene. Antiseptics for hand hygiene should be readily available in operation room or scrub room in wall-mounted dispensers (e. g. with an elbow-operated mixer tap), foot pump-operated containers, or automated dispensers (e.g. activated by light sensor).

Steps for surgical hand preparation

Steps before starting surgical hand preparation (fig. 7):

1. Keep nails short and pay them attention when washing your hands — most microbes on hands come from beneath the fingernails. Artificial nails or nail polish are forbidden for operation unit staff.

2. Remove all jewellery (rings, watches, bracelets) before entering OR.

3. Wash hands and arms up to elbows with a non-medicated soap before entering OR area or if hands are visibly soiled.

4. Clean subungual areas with a nail file. Nailbrushes should not be used as they may damage the skin and encourage shedding of cells. Nailbrushes, if used, must be sterile and used only once. Reusable autoclavable nail brushes are available commercially.

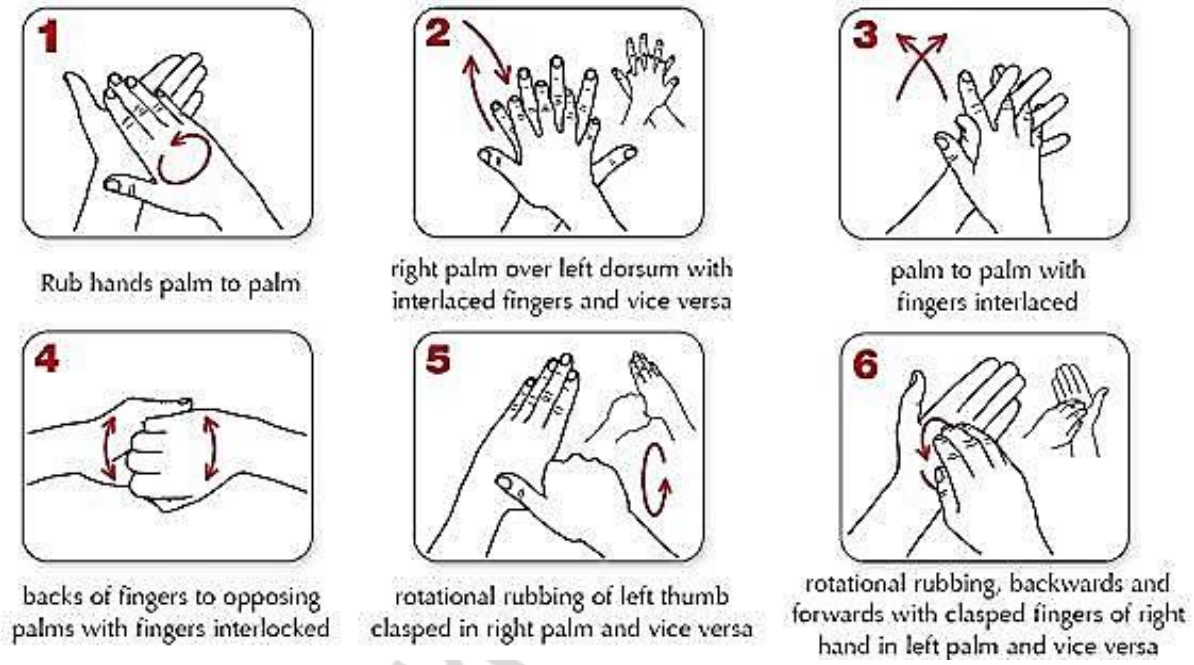


Figure 7. Standard of surgical hand scrub

Protocol for surgical scrub with a medicated soap:

1. Start timing. Scrub each side of each finger, between fingers, and back and front of hand for two minutes totally.

2. Proceed to scrub arms, keeping the hand higher than the arm at all times. This helps to avoid recontamination of the hands by water from the elbows and prevents bacteria-laden soap and water from contaminating the hands. Wash each side of arm from wrist to elbow for one minute.

3. Repeat the process on the other hand and arm, keeping hands above elbows at all times. If the hand touches anything except the brush at any time,

the scrub must be lengthened by one minute for the area that has been contaminated.

4. Rinse hands and arms by passing them through the water in one direction only, from fingertips to elbow. Do not move the arm back and forth through water.

5. Proceed to OR holding hands above elbows.

6. During the scrub procedure, care should be taken not to splash water onto surgical attire.

7. Once in OR, hands and arms should be dried using a sterile towel and aseptic technique before putting on gown and gloves.

Protocol for surgical scrub with an alcohol-based preparation:

1. Start timing. Use sufficient product to keep hands and forearms wet with the handrub throughout the procedure.

2. After application of the alcohol-based product, allow hands and forearms to dry thoroughly before donning sterile gloves.

3. Proceed to OR holding hands above elbows.

Wearing two pairs of surgical gloves rather than a single pair is considered to provide an additional barrier and to further reduce the risk of contamination.

Wearing two pairs of latex gloves significantly reduces the number of perforations of the innermost gloves. There is no clear evidence that additional glove reduces surgical site infection rates in patients. Triple gloving, knitted outer gloves and glove liners significantly reduce perforations to innermost (next to skin) glove.

Evidence-based recommendations for surgical scrub:

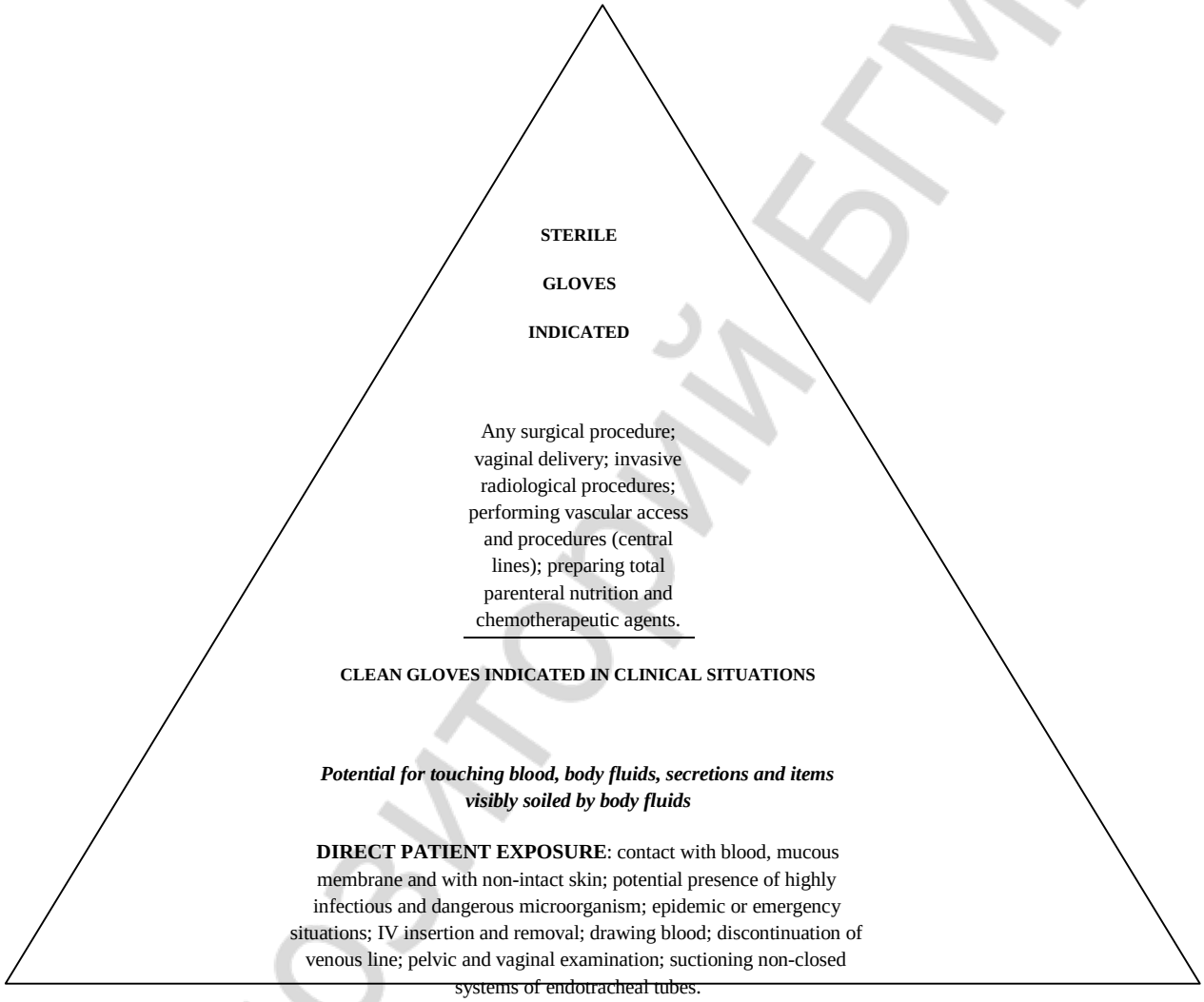
 The recommended scrub should include hands and forearms up to the elbows for 2–5 minutes (Evidence level Ib).

 Keep hands away from the body and dry with a sterile towel (Evidence level Ib).

 Keep fingernails short (Evidence level Ib), and clean under each nail at the beginning of each day (Evidence level II).

Glove use is recommended for two main reasons: a) to prevent microorganisms (which may be infecting, commensally carried, or transiently present on surgical team hands) from being transmitted to patients and from one patient to another; b) to reduce the risk for surgical team to acquire infections from patients (fig. 8).

Gloves used by healthcare workers are usually made of **natural rubber latex** or synthetic non-latex materials such as **vinyl**, **nitrile** and **neoprene** (polymers and copolymers of chloroprene). Several new technologies are emerging, e. g. impregnated glove materials with chlorine dioxide release when activated by light or moisture to produce a disinfecting microatmosphere.



GLOVES NOT INDICATED (except for CONTACT precautions)

No potential for exposure to blood, body fluids and contaminated environment

DIRECT PATIENT EXPOSURE: taking blood pressure, temperature and pulse; performing subcutaneous and intramuscular injections; bathing and dressing the patient; transporting the patient; caring for eyes and ears (without secretions); any vascular line manipulation in absence of blood leakage.

INDIRECT PATIENT EXPOSURE: using the telephone; writing in the patient's chart; giving oral medications; distributing or collecting patient dietary trays; removing and replacing linen for patient's bed; placing non-invasive ventilation equipment and oxygen cannula; moving patient's fumiture.

Figure 8. Key recommendations on glove use

Gloves does not provide complete protection against the acquisition of infections caused by the hepatitis B virus and herpes simplex virus. That is why gloves must be removed after care of a single patient and during the care of a patient, when moving from a contaminated to a clean body site or procedure within the same patient, and that hand cleansing must be performed after glove removal.

Risks and problems associated with of gloves wearing:

 Donning gloves while hands are still wet from either washing or applying alcohol increases the risk of skin irritation.

 Frequent wearing of gloves can increase the risk of skin problems.

 Allergic reactions to latex are possible.

 Use of petroleum-based hand lotions or creams may adversely affect the integrity of latex gloves.

 Following the use of powdered gloves, some alcohol-based handrubs may interact with residual powder on staff hands, resulting in a gritty feeling on hands.

Although no recommendation exists concerning washing and reuse of gloves nor washing or decontamination of gloved hands followed by reuse on another patient, these are common practices in many health-care settings in developing countries where glove supply is limited. Cleansing gloved hands to allow for prolonged use on the same patient can result in considerable savings of disposable examination gloves in resource-poor settings. This practice depends on the type of gloves and the agent used. Some evidence exists that cleansing latex-gloved hands using an alcohol-based handrub solution is effective in removing microorganisms, and shows increasing contamination rates of hands only after 9–10 cycles of cleansing. However, cleansing plastic-gloved hands with an alcohol-based formulation leads to early dissolving of the plastic material. In general, one of the major risks of reprocessing gloves is that they could show a higher rate of non-apparent holes and tears after the reprocessing cycle than new ones. The

opinion of international experts consulted by WHO is that ***glove reprocessing must be strongly discouraged and should be avoided***, mainly because currently there is no standardized, validated and affordable procedure for safe glove reprocessing. Every possible effort should be made to prevent glove reuse in health-care settings and financial constraints in developing countries leading to such practices should be assessed and addressed.

Decontamination and cleaning of good quality surgical gloves before sterilization or high-level disinfection:

1. Before removing soiled surgical gloves, hands should be briefly immersed in a container filled with 0.5 % chlorine solution.
2. Gloves should then be removed by turning inside out and should be soaked in the chlorine solution for 10 minutes. Now both glove surfaces are decontaminated.
3. Gloves should be washed in soapy water, cleaning inside and out.
4. Gloves should then be cleaned until no soap or detergent remains, which could interfere with the sterilization or high-level disinfection procedure.
5. To test for holes, gloves should be inflated and held under water. Air bubbles indicate holes.
6. The inside and outside should be gently dried. Gloves that remain wet for long periods of time will absorb water and become tacky.

Sterilization of good quality surgical gloves for reuse as examination gloves or as surgical gloves, when double gloving is performed.

1. After decontamination, cleaning and drying, gloves must be packaged before sterilization by autoclaving. The cuffs of the gloves must be folded out towards the palm. This allows putting them on after sterilization and placed in a wire basket on their side to allow optimal steam penetration.
2. Gloves need to be autoclaved at 121 °C for 30 minutes at a pressure of 106kPa. Higher temperature and pressure can destroy the gloves. Immediately after autoclaving, gloves are very friable and tear easily.
3. Gloves should not be used for 24–48 hours to allow them to regain their elasticity and to prevent stickiness.

High-level disinfection of good quality surgical gloves for reuse as examination gloves or as surgical gloves, when double gloving is performed.

1. After decontamination and washing, gloves are ready for high-level disinfection by steaming.
2. Cuffs of gloves need to be folded to avoid recontamination after high-level disinfection.

3. Gloves should be steamed for 20 minutes. Sufficient water is needed in the bottom pan for the entire 20 minutes of steaming.

4. Gloves should be allowed to air dry in the steamer pans for 4–6 hours before using.

5. Using high-level disinfected forceps, gloves can be transferred to a high-level disinfected container with a tight fitting top. Gloves can also be stored in the stacked and covered steamer pans as long as a bottom pan without holes is used. Pans containing gloves should not be placed on a tabletop, counter or other surface, as the gloves will be contaminated.

6. Alternatively, gloves can be used «wet». For this, they should cool down for 5–10 minutes before wearing. Gloves should be used within 30 minutes. After this time, the fingers of the gloves stick together and the gloves are difficult to put on despite being damp. Gloves that have been removed from the steamer pans to be worn wet but were not used during the clinic session should be reprocessed again before actually using.

Gloves that are cracked, peeling or have detectable holes or tears **should never** be reprocessed

PREVENTION OF IMPLANT INFECTION

Implant infection is caused by introduction of unsterile foreign objects (sutures, artificial limbs, metal plates for osteosynthesis, organs in transplantation) into the tissue. It provides the most severe complications — suppuration, sepsis, osteomyelitis, hepatitis. The most common source of infection is the suture material. Sterility of implants is the main purpose of implant infection prevention. Top reliable way of sterilizing the implants, except organs and living tissue, is sterilized with gamma rays.

PREVENTION OF INFUSION INFECTION

Mainstay for infection prevention is to ensure the infusion of sterile solutions and measures to prevent their contamination during storage and administration.

***Sterility of drugs*.** Sterile injectable solutions are prepared in a pharmacy environment or manufacturing site. Their sterility is ensured due to strict

compliance with the rules of asepsis and sterilization. In manufacturing sites dishes, auxiliary materials, raw material and final production are sterilized. Sterilization is carried out by physical, mechanical and chemical methods, depending on physicochemical properties of pharmaceutical form ingredients and components.

Medication pollution prevention. Staff should handle drugs and fluids carefully, and follow local protocols to prevent contamination. Sterile disposable syringes and needles after opening or contact with the patient should be considered contaminated and used only for certain patient. Syringes should not be used more than for one patient, even after changing the needle. Before using filled syringes and needles should be stored in a clean container and be covered to prevent contamination. After use all the used syringes with needles must be utilized using special container (fig. 4). Caution must be taken when typesetting drugs. Disposable ampoules should be destroyed after the proper amount of preparation taken out and may not be re-used for other patient. Ampoule can be stored for verification purposes and destroyed afterwards. Reusable vials are not recommended.

All infusion systems that wholly or partially contact with blood or patient's body are designed for single use. Aseptic technique should be used in the preparation for infusion; infusion breaks using stubs should be minimized. Injection ports should be used aseptically and be free from blood and closed with stub when not in use. Number of connections to injection ports should be minimized. If possible, three-way valves use should be avoided.

Standard infusion sets are to be replaced, if possible, with closed collapsing systems for IV injections. Closed system ensures safety reducing contamination risk:

- no venting is necessary during infusion;
- collapses fully without venting;
- cannulas to allow air entry are not necessary;
- always a closed system.

Requirements for aseptic technique of IV infusion therapy:

- Central venous catheter (CVC) placement should be performed aseptically. Health care professionals should work using clean dress, personal protective equipment and sterile gloves.
- Peripheral venous line (PVL) introduction via venesection should be performed in OR.

 PVL placement should be performed aseptically.

 CVC replacement should be performed once in 7 days in absence of infection signs.

 PVL replacement should be performed every 72 hours.

 After the transfusion of protein substances and blood preparations PVL should be replaced within 24 hours.

 If septic infection is suspected, or perivenous tissue infiltration occurred CVC/PVL should be removed immediately.

 Date and time of opening should be specified on the bottle (container) with infusion solution.

 The administration of a single vial should not exceed 24 hours after opening, lipid-based emulsions — 12 hours.

HOSPITAL-ACQUIRED INFECTIONS

Hospital-acquired infections (HAI) are caused by viral, bacterial, and fungal pathogens; the most common types are bloodstream infection (BSI), pneumonia (e. g. ventilator-associated pneumonia [VAP]), urinary tract infection (UTI), and surgical site infection (SSI).

HAI (or Healthcare-associated infections) are defined as infections not present and without evidence of incubation at the time of patient's admission to healthcare facility.

Within hours after admission, a patient's flora begins to acquire characteristics of the surrounding bacterial pool. Most infections that become clinically evident **after 48 hours** of hospitalization are considered hospital-acquired. Infections that occur after the patient is discharged from the hospital can be considered HAI if the organisms were acquired during the hospital stay. Laboratory investigations should be guided by the results of a detailed physical examination and review of systems. Caution should be taken when interpreting laboratory results because not all bacterial or fungal growth on a culture are pathogenic. Growth on cultures may reflect simple microbial colonization. Consider the following:

Reason for obtaining the test:

1. The process of specimen collection (e. g. a urine culture obtained through a newly placed Foley catheter is less likely to be contaminated by microbial colonization).

2. The presence of other supporting evidence of infection (e. g. significance of bacterial growth on tracheal aspirate culture is strengthened by presence of radiographic changes and clinical signs compatible with pneumonia).

By the same token, known «contaminant» skin organisms such as coagulase-negative *staphylococcus*, *Streptococcus viridans*, *Micrococcus spp.*, *Corynebacterium* spp., *Propionibacterium* spp., and *Bacillus* spp. should not easily be dismissed as contaminants if they grew on cultures of normally sterile body fluids (e.g. blood, joint fluid, cerebrospinal fluid [CSF]), especially if the patient was at high risk for severe infections (e. g. immunocompromised, neonates). Repeating cultures may help in establishing of infection presence or absence. Fungal growth on a blood culture should never be dismissed as «contamination».

Prevention. Standard precautions are to be applied to the care of all patients in all healthcare settings regardless of suspected or confirmed presence of an infectious agent. This is the primary strategy in preventing transmission of infectious agents between patients and/or healthcare personnel.

Transmission-based precautions are used in addition to standard precautions when caring for patients who are infected or colonized with pathogens transmitted by airborne, droplet, or contact routes.

Airborne precautions are used to prevent transmission of airborne droplet nuclei-containing microorganisms. These droplet nuclei remain suspended in air. Precautions include use of single-patient rooms, negative air-pressure ventilation, and respirator masks or, if not feasible, cohorting of patients separated at least 3 feet apart. Organisms transmitted by airborne route include *Mycobacterium tuberculosis*, rubeola (measles) virus, and the varicella-zoster virus. Droplet precautions are used to prevent transmission of droplets containing microorganisms propelled less than 3 feet by coughing or sneezing by an infected person.

Contact precautions are used to prevent transmission of microorganisms via direct or indirect contact with infected or colonized persons. Precautions include use of single-patient room (if not feasible, cohort patients infected with the same organism), use of gowns and gloves, and hand hygiene after glove removal.

Prevention of *intravascular catheter-associated infections* includes avoidance of unnecessary catheter placement, removal of catheter as soon as possible, aseptic technique during catheter insertion, and minimal manipulation of catheter. Over the years, increasing evidence is showing potential benefit of using *antimicrobial-impregnated catheters*, *antimicrobial-impregnated dressings*, and *antimicrobial and ethanol locks* in at-risk populations to decrease recurrences of catheter-related BSI. In addition, reduction in lumen contamination, organism density, and catheter-related blood stream infections has been shown by scrubbing the catheter hub with devices containing isopropyl alcohol.

Prevention of *healthcare-associated bacterial pneumonia* (VAP) includes education of healthcare workers about infection control procedures, thorough cleaning of devices for sterilization or disinfection, changing the visibly soiled breathing circuit, hand hygiene, and change of soiled gloves.

Prevention of *catheter-associated UTI* includes personnel education, proper techniques of catheter insertion and care, catheterizing only when necessary, emphasizing handwashing, using aseptic technique for catheter insertion, securing catheter properly, maintaining closed sterile drainage, obtaining urine samples aseptically, and maintaining unobstructed urine flow.

SURGICAL SITE INFECTION

SSI continues to be the most common complication following surgical procedures. These infections are the biological summation of several factors: the inoculum of bacteria introduced into wound during procedure, unique virulence of contaminants, microenvironment of each wound, and integrity of patient's host defense mechanisms.

Surgical site infections occur **within 30 days** after the operative procedure **or within 1 year** if an implant was placed.

Classification of SSI

*Superficial Incision SSI**

- Occurs within 30 days after the operation.
- Involves only the skin or subcutaneous tissue.
- At least 1 of the following:
  - purulent drainage (culture documentation not required);
  - organisms isolated from fluid/tissue of superficial incision;
  - at least 1 sign of inflammation (e. g. pain or tenderness, induration, erythema, local warmth of the wound);
  - wound is deliberately opened by the surgeon;
  - surgeon or attending physician declares the wound is infected.

**A wound is not considered a superficial site infection if a stitch abscess is present, the infection is at an episiotomy or circumcision site or a burn wound, or the SSI extends into the fascia or muscle.*

Deep Incisional SSI

- Occurs within 30 days of operation or within 1 year if an implant is present.
- Involves deep soft tissues (e. g. fascia and/or muscle) of the incision.
- At least 1 of the following:
  - purulent drainage from the deep incision but without organ/space involvement;
  - fascial dehiscence or fascia is deliberately separated by the surgeon due to signs of inflammation;
  - deep abscess is identified by direct examination or during reoperation, by histopathology, or by radiologic examination;
  - surgeon or attending physician declares that deep incisional infection is present.

Organ/Space SSI

- Occurs within 30 days of operation or within 1 year if an implant is present.
- Involves anatomic structures not opened or manipulated during the operation.
- At least 1 of the following:
  - purulent drainage from a drain placed by a stab wound into the organ/space;
  - organisms isolated from organ/space by aseptic culturing technique;
  - identification of abscess in the organ/space by direct examination, during reoperation, or by histopathologic or radiologic examination;
  - diagnosis of organ/space SSI by surgeon or attending physician.

Prevention of SSI can be achieved by several methods. The viable inoculum of bacteria into wound can be reduced via better preoperative preparation of surgical site, sound infection-control practice while performing operations, and adherence to principles of preventive antibiotic therapy. Modified surgical technique can reduce risk of hematoma, tissue injury, and foreign bodies within surgical site that amplify risk of infection for a given level of inoculum. Enhanced oxygen delivery, better core body temperature control, and rigorous blood glucose control in the surgical patient are new areas that have the potential to even further reduce the rate of SSI.

Prevention begins with **the skin preparation of the operative site**. Bacterial flora of patient is the principle source of surgical wound infection. Focal sources of infection should be treated prior to surgery. In patients with active infection consideration should be given to delaying surgery. Pre-operative showering with an antiseptic solution does not reduce infection rate but is necessary. **Skin shaving** is aesthetic and makes surgery, suturing and

dressing removal easier. Wound infection rate is lowest when shaving is performed *immediately* (< 1 hr) prior to surgery because abrasions can cause colonization which can lead to wound infection. Infection rate increased from 1 % to 5 % if performed more than 12 hours prior to surgery. Clippers or depilatory creams reduce infection rates to less than 1 %. For skin processing several preparations are used (table 4).

Operation field is to be rinsed with antiseptic solution at least **5 times** during surgery (Filonchikov–Grossykh technique):

1. **Before draping** — twice, from the place of incision towards edges of anatomical area, but not less than 5 cm around the incision line. In case of processing he area with infected wound rinsing shuld begin at the borders of the anatomical area towards the center.
2. After draping **before insicion**.
3. **Before wound closure**.
4. **After skin suturing**.

Aditionally — on demand during surgery.

Table 4

Skin preparation solutions properties

Cleanser/Antiseptic	Comments
0.5 % Chlorhexidine	Quaternary ammonium compound. Acts by disrupting the bacterial cell wall. Bactericidal but does not kill spore forming organisms. It is persistent and has a long duration of action (up to 6 hrs). More effective against gram-positive organisms
70 % Povidone iodine	Acts by oxidation / substitution of free iodine. Bactericidal and active against spore forming organisms. Effective against both gram-positive and gram-negative organisms. Rapidly inactivated by organic material such as blood. Patient skin sensitivity is occasionally a problem. Chlorhexidine may be more effective than iodine. Povidone iodine should be allowed to dry before the incision is made to allow optimum antiseptic effect

70 % Isopropyl alcohol	Acts by denaturing proteins. Is bactericidal but short acting. Effective against gram-positive and gram-negative organisms. Also fungicidal and virucidal

Drapes: after skin processing operation field is to be draped before the incision (5 sm at least from the incision site). Wet drapes on the patient may allow passage of bacteria into the operative area from other unprepared areas, so gowns and drapes that have become soaked should be replaced. Wide areas of skin preparation around the proposed surgical site will reduce the risk of microbial breakthrough into the wound area if towels and drapes become wet. Material for draping is sterilized cotton linen or disposable cellulose textile drapes. There is no evidence that *occlusive adhesive drapes* reduce infection rate, in contrary, they may actually increase skin bacterial count during surgery, especially unimpregnated (should be avoided in clean operations).

Sterilization of **instruments** after thorough cleansing of any particulate matter or usage of disposable instruments is obviously important for infection control. Adequate inventory of instruments should minimize the need for the rapid steam sterilization of dropped or contaminated instruments during the procedure.

Surgical technique is extremely important in SSI prevention. Soft tissues should be handled gently to avoid crushing that can result in tissue necrosis and increased rates of SSI. Achieving **hemostasis** at the surgical site is important, but the process of controlling bleeding may itself increase the rate of wound infection. Hemoglobin within the soft tissues or within the wound space becomes a potent stimulus to microbial multiplication and infection. Exuberant use of the electrocautery leaves necrotic tissue that is an infection control liability at the surgical site. **Suture material** in the wound can also increase rates of SSI. When braided silk is used for hemostasis or for approximation of tissue planes, the number of bacteria needed to cause an infection is reduced. Therefore, the likelihood of an infection is greater with braided silk than with an absorbable suture material. For this reason, **absorbable suture material** is preferred. Silk sutures should be avoided for skin suturing, especially on face. If permanent suture is used for wound closure, monofilament alternatives should be chosen. Although there is no clinical evidence to suggest that sutures cause infection, it is widely accepted that these devices can provide a safe harbor for colonization of bacteria. Antibacterial sutures have not been shown to reduce the rate of infection. Avoid dead space within the surgical wound,

especially in the obese patient.
The use of **closed suction drains** in the surgical wound of obese patients prevents the accumulation of tissue fluids in the dependent portion of the wound and may reduce infection rates. The drain should exit through a separate stab wound, and not through the surgical incision itself. Passive drains (e. g., Penrose drains) should be avoided.

Preventive Antibiotic Prophylaxis (AP)

The goal of AP is to achieve serum and tissue drug levels that exceed, for the duration of the operation, minimal inhibiting concentration for the organisms likely to be encountered during the operation. AP after wound closure is unnecessary, and prolonged use of prophylactic antimicrobials is associated with emergence of resistant bacterial strains. For most operations, a single antimicrobial is sufficient to prevent SSIs. However, there may be cases where an unlikely contaminant is present or suspected (e. g. in cases of coexisting infection) and for which additional coverage is necessary. Systemic preventive antibiotics should be used in certain cases. AP is warranted in all procedures in the categories of clean-contaminated, contaminated or dirty (table 5).

The optimal time for administration of preoperative doses is within 60 minutes before surgical incision. The antibiotic selected should have activity against the pathogens likely to be encountered in the procedure.

Postoperative administration of preventive systemic antibiotics beyond 24 hours has not been demonstrated to reduce the risk of SSI!!!

Table 5

Classification of operative wounds and risk of infection

Class	Criteria	Risk, %
Clean	Elective, not emergency, nontraumatic, primarily closed; no acute inflammation; no break in technique; respiratory, gastrointestinal, biliary and genitourinary tracts not entered	< 2
Clean-conta-minated	Urgent or emergency case that is otherwise clean; elective opening of respiratory, gastrointestinal, biliary or genitourinary tract with minimal spillage (e. g. appendectomy) not encountering infected urine or bile; minor technique break	< 10
Conta-minated	Nonpurulent inflammation; gross spillage from gastrointestinal tract; entry into biliary or genitourinary tract in the presence of infected bile or urine; major break in technique; penetrating trauma < 4 hours old; chronic open wounds to be grafted or covered	~ 20
Dirty	Purulent inflammation (e. g. abscess); preoperative perforation of respiratory,	~ 40

Class	Criteria	Risk, %
	gastrointestinal, biliary or genitourinary tract; penetrating trauma > 4 hours old	

Source: Cruse P. J., Foord R. The epidemiology of wound infection. A 10-year prospective study of 62, 939 wounds. Surg. Clin. North Am. 1980; 60: 27–40.

TEST

1. What is the most effective way to help prevent the spread of organisms?

A. Sterile technique.

B. Medical asepsis.

C. Use of ultraviolet properties.

D. Eliminating normal flora.

E. Hand hygiene.

2. Since iatrogenic infections result from a treatment or diagnostic procedure, all nosocomial infections are iatrogenic.

A. True.

B. False.

3. Which of the following is not true about aerosols?

A. Can be inhaled.

B. Travel short distances (about 3 feet).

C. Masks help prevent inhalation.

D. Remain suspended in the air.

E. None of the above.

4. Which of the following is true about surgical asepsis?

A. Includes practices used to render and keep objects and areas free from microorganisms.

B. Such procedures include inserting urinary catheter or IV catheter.

C. Also known as sterile technique.

D. Involves actions such as hand washing.

E. Such techniques are used continuously both within and outside health facilities.

5. When an organism becomes attached to dust particles it is considered a:

A. Direct route.

B. Droplet route.

C. Airborne route.

D. Entry route.

E. Fomite.

6. Which of the following is *not* involved in breaking the cycle of infection?

A. Cleansing.

B. Disinfection.

C. Sterilization.

D. All of the above.

E. None of the above.

7. A mask is worn only once but can be lowered around the neck and then brought back over the mouth and nose for reuse.

A. True.

B. False.

8. Transmission can be through:

A. Direct contact.

B. Blood.

C. Indirect contact.

D. Water.

E. All of the above.

9. Which of the following is the most serious of the listed microorganisms?

A. Methicillin-resistant S. aureus (MRSA).

B. Vancomycin-resistant S. aureus (VRSA).

C. Vancomycin intermediate-resistant S. aureus (VISA).

D. None of the above.

10. Alcohol-based handrubs are not as effective in reducing bacterial counts on the hands than antimicrobial soap.

A. True.

B. False.

11. Which of these is untrue about medical asepsis:

A. Also called clean technique.

B. Involves procedures and practices that reduce the number and transfer of pathogens.

C. Keeps objects and areas free of microorganisms.

D. E. g. hand hygiene.

E. E. g. wearing gloves.

12. The source of infection is always exogenous.

A. True.

B. False.

13. Which is not a disinfecting method available for use in the home?

A. Acetic acid (white vinegar).

B. Bleach.

C. Isopropyl alcohol (50 %).

D. Boiling water.

E. None of the above.

14. Gloves are a good substitute for good hand hygiene.

A. True.

B. False.

15. Which of the following is not a typical access site for HAI?

A. Surgical wounds.

B. Urinary catheters.

C. IV catheters.

D. Mechanical ventilation.

E. None of the above.

Answers: 1 — A, B; 2 — A; 3 — E; 4 — A, C, D, E; 5 — C; 6 — D; 7 — B; 8 — E; 9 — B; 10 — B; 11 — B; 12 — B; 13 — E; 14 — B; 15 — E.

LITERATURE

Basic

1. *Gostischev, V. K.* General surgery : the manual / V. K. Gostischev. M. : GEOTAR-Media, 2006.

2. *Clinical* practice guidelines for antimicrobial prophylaxis in surgery / W. Dale [et al.] // Am. J. Health-Syst. Pharm. 2013. Vol. 70. P. 195–283. [http://www.idsociety.org/uploadedFiles/IDSA/Guidelines-Patient_Care/PDF_Library/2013%20Surgical%20Prophylaxis%20ASHP,%20IDSA,%20SHEA,%20SIS(1).pdf]

3. Antibacterial therapy guidelines. 2014 [http://www.hopkinsmedicine.org/amp/guidelines/Antibiotic_guidelines.pdf]

Additional

4. *Hospital-Acquired* Infections Follow-up / H. T. Custodio [et al.] // [http://emedicine.medscape.com/article/967022-followup]

5. *Boyce, J. M.* Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/ APIC/IDSA Hand Hygiene Task Force / J. M. Boyce, D. Pittet // MMWR Recommendations and Reports. 2002. Vol. 51(RR16). P. 1–44 [http://www.cdc.gov/mmwr/preview/ mmwrhtml/rr5116a1.htm]

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Бовтюк Николай Ярославович

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