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DISINFECTION AND STERILIZATION IN DENTISTRY

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МИНИСТЕРСТВО ЗДРАВООХРАНЕНИЯ РЕСПУБЛИКИ БЕЛАРУСЬ
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КАФЕДРА ЭПИДЕМИОЛОГИИ

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ДЕЗИНФЕКЦИЯ И СТЕРИЛИЗАЦИЯ В СТОМАТОЛОГИИ

DISINFECTION AND STERILIZATION IN DENTISTRY

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Содержится информация о видах, методах и средствах дезинфекции объектов внешней среды в эпидемических очагах инфекционных заболеваний, а также сведения об этапах и методах проведения и контроля качества стерилизации медицинского инструментария в лечебно-профилактических организациях. Освещены особенности проведения стерилизации инструментария, используемого в стоматологической практике.

Предназначено для студентов 4-го курса медицинского факультета иностранных учащихся, обучающихся по специальности 1-79-01 07 «Стоматология», изучающих эпидемиологию на английском языке.

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MOTIVATIONAL CHARACTERISTIC OF THE TOPIC

Total training time is 5 hours.

The development of most infectious diseases is supported by the presence of pathogens in the environment that is a prerequisite for the implementation of the infectious agents' transmission mechanism from a source of infection to susceptible people. For a number of pathogens that cause human disease, the environment serves as a natural habitat. The destruction or reduction in the number of pathogenic and opportunistic pathogens on the abiotic objects of the environment in order to prevent the emergence and spread of infectious diseases is the basis of anti-epidemic measures aimed at breaking of the transmission mechanism of the causative agent. Conducting disinfection and sterilization measures is a prerequisite for ensuring sanitary and epidemiological well-being of the population, a means of nonspecific infectious disease prevention. Improving the disinfection and sterilization effectiveness is due to the scientific and organizational level of their performance taking into account the etiology and epidemiology of specific infections developing under certain conditions.

Conducting disinfection measures in the hospital to prevent the development of purulent-septic infections is also important.

To fulfill professional duties clinicians (including military ones) must know and develop the skills in the field of prevention of infectious diseases using methods of disinfection and sterilization. Graduates of the medical faculty must understand the fundamentals of the implementation of such preventive and anti-epidemic measures as disinfection and sterilization, master the skills in assessing their quality and effectiveness, in organization of disinfection in the foci of infectious diseases.

The aim of the study: the development of scientific and organizational principles of disinfection and sterilization in accordance with the epidemiological features of infectious diseases with regard to the etiological agent that caused it.

Objectives are:

1. To study:

– basic concepts and terms used in Disinfectology; the system and organization of disinfection services;

– methods of disinfection and sterilization;

– methods of quality control of disinfection measures and sterilization;

– modes of disinfection of various objects of the environment in the foci of some infectious diseases.

2. To get acquainted with:

– theoretical foundations of disinfection and sterilization;

– instructional and training documents relating to the basic disinfection measures and quality control, as well as a list of disinfectants approved for use.

3. To learn to:

– justify the necessity for disinfection and sterilization measures depending on the type of infectious agents and specific conditions;

– organize disinfection and sterilization in healthcare organizations and at the patient`s place of residence;

– assess the quality of sterilization of the medical equipment.

Requirements to the initial level of knowledge. To master the topic the student must know:

– General Chemistry*:* properties of some chemicals used as disinfectants, especially their effects on the human body as well as the rules of solution preparation of different concentrations;

– Microbiology, Virology and Immunology: properties of infectious agents, their epidemiological characteristics (resistance in the environment, sensitivity to disinfectants and adverse environmental factors).

Control questions from related disciplines:

1. Name chemical substances that may have antimicrobial effect.
2. What are the solution preparation principles of chemicals of various concentrations?
3. Indicate the route of penetration of chemicals used as disinfectants into the human body.
4. Describe the pathogens' resistance in the environment.

Control questions on the theme of the session:

1. Give the definition of the term «disinfection».
2. Name the types of disinfection, define their purpose.
3. What are the indications for current and final disinfection?
4. Specify the basic sanitary and hygienic measures conducted in case of the current disinfection at home.
5. Specify the final stages of disinfection in the epidemic focus.
6. Describe disinfection methods; specify the advantages and disadvantages of each method.
7. Describe the advantages and disadvantages of the main groups of chemicals used as disinfectants.
8. Specify the content and organization of current disinfection.
9. Give the definition ща the term «sterilization».
10. What are the main stages of carrying out medical instrument sterilization? Describe each of them.
11. Specify the methods of medical instruments sterilization.
12. Describe quality control methods of sterilization.

DISINFECTION

Basic concepts and terms

Disinfection is a set of measures aimed at destroying or reducing the number of population of resting or vegetative forms of pathogenic and conditionally pathogenic (opportunistic) microorganisms within abiotic objects of external environment, the main aim of which is to prevent the spread of infectious diseases.

Disinfection is divided into two types: preventive and focal ones.

Preventive disinfection is carried out in places of probable accumulation of infectious agents without regard to the epidemic foci.

Focal disinfection is carried out within the borders of already existing epidemic focus due to a case of infectious disease or bacteria disease carrier. There are two types of focal disinfection: *current* and *final*. Current disinfection is carried out in the focus while the source of infection is still present there, and is aimed at the destruction of any pathogens produced by a patient or bacillicarrier. Final disinfection is carried out after hospitalization, recovery or the death of the patient (after removal of the source of infection from the focus to provide complete clearance of the focus from pathogenic agents).

Disinfection organization

Preventive disinfection. A high probability of microorganisms' accumulation and the risk of the spread of infection are the indications for preventive disinfection. It is carried out without any regards to the disease occurrence or formation of an epidemic focus. The main objects of preventive disinfection are:

– hospitals and outpatient healthcare organizations;
– pre-school and school institutions;
– crowded or public places (stations, ships, coaches, theatres, hostels, etc.);
– enterprises of food industry, trade and public catering, markets;
– enterprises for processing and storage of raw materials of animal origin;
– water intake and water supply facilities;
– hairdressing salons, spas, swimming pools and other sports and health organizations.

Preventive disinfection can be carried out by the organizations themselves, if it is required constantly and continuously, for example: constant and continuous disinfection of water in swimming pools; disinfection of tools in hairdressing salons, manicure rooms, etc. In these cases the personnel of the organizations carry out preventive disinfection.

When preventive disinfection has a one-time or periodic nature, then it is carried out on a contractual basis by the measures and means of Preventive Disinfection

Centers or by the disinfection departments of Hygiene and Epidemiology Centers, for example, periodic disinfection of markets, etc.

Current disinfection. The most common indications for current disinfection are:

– the patients who stay in the focus before hospitalization;

– treatment of an infectious patient at home until recovery;

– the presence of bacteriocarriers in the focus until their full sanation and dispensary deregistration;

– the presence of the convalescent in the focus before dispensary deregistration.

Current disinfection in flat foci includes two groups of measures: sanitation measures and disinfection of environment objects, as well as secretions of the patient. Sanitation measures include:

– isolation of the patient in a separate room or fenced part of it; avoid contacts with children; limitation of number of objects with which the patient may come into contact;

– providing a separate bed, care items, food and drink dishes — they are stored and washed separately from other family members` belongings;

– observation of the rules of personal hygiene;

– storing and washing dirty linen of the patient separately from other family members` linen;

– keeping rooms and common areas clean (airing and wet cleaning using different cleaning equipment for patient rooms and other rooms 2–3 times a day); in the aerosol infection foci — wearing cotton and gauze dressings; systematic control of flies population in summer.

In infectious and somatic hospitals current disinfection is aimed at the prevention of hospital-acquired infections and dissemination of infection outside medical institutions. After the current daily cleaning air disinfection and ventilation should be carried out.

Final disinfection is carried out after hospitalization of the infectious patient or bacilicarriers, their recovery or death, i. e. after the removal of the source of infection. Its aim is complete clearance of the focus from infectious agents. Final disinfection is carried out by Preventive Disinfection Centers or by disinfection departments of Hygiene and Epidemiology Centers.

In organizations final disinfection is carried out using chemical disinfectants in the absence of people (patients) who are not related to cleansing. The personnel involved in the final disinfection must use personal protective equipment (respirator, gloves, etc.).

Final disinfection is carried out in stages:

– preparation of the necessary concentrations of disinfectant solutions;

– extermination of flies in the summer;

– sanitary processing of the front door and floor of the patient's room;

– disinfection of the patient's underwear and bed linen by boiling or putting them in bags for subsequent chamber disinfection, which are cleaned with a disinfectant solution before removal from the outbreak;

– disinfection of the patient's excretion and containers for them;

– disinfection of sanitary equipment;

– disinfection of the patient's dishes used for food and food debris;

– disinfection of toys used by the patient;

– sanitation of paintings, figurines, polished things in the patient's room which he could contact with;

– disinfection of walls, windows, floors in the patient's room; cleaning should be started from the far corners of the room towards the exit;

– disinfection of cleaning equipment, rags;

– putting disinfectors` overalls in bags for chamber disinfection;

– washing the hands of the personnel involved in the sanitary processing.

In the final disinfection, mainly physical (boiling, burning of low-value items) and chemical (solutions of disinfectants — irrigation, rubbing, soaking, immersion) disinfection methods are used. Moreover, the choice of used disinfectants is strictly selective taking into account their advantages and disadvantages, focusing on the properties of infectious disease agents.

Methods of disinfection

There are several methods of disinfection: physical, chemical, biological and combined.

Physical method of disinfection is the destruction or reduction of microbial populations by means of:

– the mechanical way;

– the thermal way;

– the radiation way.

Mechanical method of disinfection provides elimination of pathogenic and conditionally pathogenic microorganisms from the environmental objects by wet wiping, airing, ventilation, washing, wet cleaning.

The main advantage of the method is the simplicity and accessibility of its performance, the main disadvantage is impossibility of complete disinfection of the object.

Temperature method. The most effective way of all physical methods is the impact on microorganisms by a high temperature (burning, calcination, boiling) that is available and easily applicable in any environment. The elimination of microorganisms under the influence of high temperatures is associated with the coagulation of proteins. Heat sources that can be used as disinfecting agents are fire, boiling hot water, dry or humid hot air, water vapor. At the temperature of 100°C most of vegetative forms of microorganisms die instantly or after 1–2 minutes. A

2 % sodium bicarbonate solution enhances the antimicrobial effect of boiling. It is widely used to disinfect dishes, toys, patient care items, medical instruments, etc.

Dry hot air, unlike water, has a thermal conductivity of 25 times lower. Therefore, the heating of the item with dry hot air will be very slow. Disinfection with dry hot air requires a high temperature (at least 140 °C) and a long period of time. It's used at temperatures above 100 °C in air sterilizers, chambers and other devices intended for the disinfection of dishes, tools, metal items, glass, silicone rubber. It has a bactericidal, virucidal, fungicidal, sporocidal effect.

Water vapor is the gaseous state of water. Water vapor with a temperature of 100 °C and above is one of the best disinfectants in the reliability of action as it has the ability to penetrate deep into disinfected objects. The degree of disinfecting effect of water vapor depends on its temperature, pressure and degree of saturation. Under the influence of water vapor the proteins of the microbial cell swell and coagulate as a result it dies.

The radiant energy. Ultraviolet radiation is electromagnetic waves whose lengths are in the interval from 205 to 315 nm. UV-radiation at a wavelength of 265 nm has the most expressed bactericidal effect, causing a greater extent of photochemical damage to the DNA of microbial cells. After ultraviolet irradiation of air (it should be more than 30 minutes) the amount of microflora sharply decreases. They are used for air disinfection of the premises of medical institutions in order to prevent the occurrence of nosocomial infections in bacteriological and virological laboratories. Wall, ceiling, portable and mobile bactericidal lamps are used for this purpose.

In some cases ionizing radiation is used. Ultrasound is also widely used in world practice for pre-sterilization cleaning (PSC) of healthcare products.

Physical method of disinfection is safe, environmentally friendly, safe for the personnel. However, it is not universal, its application requires special equipment, sometimes it shouldn't be used because it damages the treated object.

Chemical method of disinfection is the use of various chemicals (disinfectants) causing the death of microorganisms on the surface and inside of objects and items of the environment, as well as in the air and various substrates (pus, sputum, stool, etc.) (Fig. 1).

Fig. 1. Disinfectants

Chemicals are easily available in daily practice and can be used for things that do not have high-temperature capability, however, their action is superficial. The abundance of chemicals that have antimicrobial effect allows a wide variation selecting the most optimal mode of disinfection without damage to the treated object.

Selected disinfectants must meet the following requirements:

– a wide range of antimicrobial activity, i. e. the ability to destroy bacteria, viruses, fungi and spores effectively, regardless of the duration and frequency of their use, which suggests the presence of properties that prevent microorganisms from developing resistance;

– low toxicity, the possibility of use in the presence of patients and medical staff; a disinfectant must be safe for humans and animals both during its preparation and use, and after the end of the intended use;

– aggressiveness low degree in relation to disinfected items (lack of corrosive activity on metal products, damaging effects on other materials used in the manufacture of high-tech medical equipment);

– multifunctionality and convenience in use; simplicity in preparation and disposal;

– long shelf life of concentrates and working solutions, as well as the possibility of their repeated use;

– good solubility in water;

– possibility of combining disinfection and PSO in medical institutions;

– lack of protein fixation;

– short exposure (not more than 60 minutes);

– easy washing of the treated object from the disinfectant;

– accessibility for healthcare institutions and the population at cost (economic expediency);

– the presence of rapid control methods of active substances in the working solutions;

– environmental safety.

To achieve a reliable effect of the destruction of microorganisms it is necessary to comply with the basic requirements which are set forth in the methodological instructions for each disinfectant (consumption rates, concentration, exposure time, processing ratio, drug form).

Factors affecting the efficiency of chemical disinfection:

– biological resistance of microorganisms to disinfectants;

– massiveness of microbial contamination of the treated object;

– material features of treated objects;

– physical and chemical properties of disinfectants, their concentration;

– method of disinfection;

– the degree of contamination of the object with organic substances;

– the exposure time of the disinfectant on treated objects;

– physical and chemical environmental factors.

It is advisable to use disinfectants in the form of aqueous solutions as liquid elements containing disinfectants are easily and quickly adsorbed by the microbial cell membrane and penetrate through it.

In the presence of organic substances (feces, sputum, pus, blood, mucus), the speed of the disinfection process slows down as active substances partially interact with organic substances and are spent on the formation of water-insoluble albuminates with them. Only the remaining free amount of active substances interacts with microbial cells that is often insufficient to kill microorganisms. In addition, organic substances provide mechanical protection for microorganisms. In urine where there are no protein impurities the disinfection process is faster than in sputum, feces, vomit.

Among bacteria gram-positive ones such as staphylococci are most easily destroyed, while gram-negative bacteria are more resistant to disinfectants. Mycobacterium tuberculosis, other acid-resistant bacteria and especially bacterial spores are resistant to most disinfectants.

Not only the type of bacteria but also their number has the influence on the effectiveness of disinfectants. The more massive the contamination by microorganisms is, the greater the concentration of the disinfectant and the disinfection time must be.

Mechanisms of antimicrobial action of disinfectants and antiseptics.

Microbiostatic and microbiocidal action of antiseptics and disinfectants is associated with their ability to:

– cause destruction of microbial cell structures,

– increase the permeability of the cytoplasmic membrane,

– oxidize organic compounds included in the composition of the microbial cell,

– be involved in metabolic reactions with enzymes and metabolites.

When disinfecting objects potentially contaminated with pathogens, certain rules must be followed.

1. Used items are first placed in a disinfectant solution.

2. Adding detergents to disinfectants facilitates the penetration of the disinfectant into the organic material.

3. Hollow tools should be immersed in a disinfectant solution vertically to displace air bubbles and ensure that the solution contacts with the entire surface of the treated objects.

4. Disinfectants are more active at higher temperatures of solutions (when washing, hot water is almost always used).

5. The use of the necessary concentration is very important. If the concentration is lower than recommended, the result may be zero.

6. For a successful disinfecting effect on microorganisms, a certain exposure is necessary, since no modern preparation gives an instant disinfecting effect. The activity of most disinfectants ceases after they dry.

7. You can't use two disinfectants at the same time or immediately one after another. The only exception to this rule is alcohol, which can be effectively used with other disinfectants. It is known that one disinfectant can inactivate another.

Disinfectants are divided into main groups (depending on the main active substances):

– Halogenated drugs;
– Aldehydebased drugs;
– Peroxides;
– Alcohols;
– Surface-active substances;
– Guanidines;
– Phenols;
– Tertiary amines;
– Quaternary ammonium compounds;
– Compositional products.

Halogenated drugs are chlorines, bromines, iodine.

Mechanism of their action: they are oxidizing agents and have a marked bactericidal effect due to the released chlorine and oxygen.

Advantages of chlorine-containing disinfectants:

– broad-spectrum of antimicrobial activity (bactericidal, sporicidal, virucidal, fungicidal, tuberculocidal);
– multipurpose;
– dissolve well in water (preparations of the first and second generations);
– quick action;
– relatively low cost.

Disadvantages of chlorine-containing disinfectants:

– high aggressiveness in relation to metals and tissues (corrosive action on metals);
– high toxicity;
– pungent smell;
– irritant effect on mucous membranes of the respiratory system and eyes;
– fabric bleaching effect;
– the ability to form more environmentally dangerous compounds;
– reduced activity in the presence of inorganic and organic substances;
– sensitivity to changes in temperature, light, pH, etc.;
– insufficient stability during long-term storage (for preparations of the first generation) that leads to loss of the drug activity.

Bromine-containing disinfectants are used for water disinfection of swimming pools, for disinfection of household premises, baths, archives.

Iodine-containing drugs used in the alcohol and aqueous solutions for the treatment of purulent wounds, hands, injection and operative field. Complex preparations of iodine and surface-active compounds are called ***iodophors***. They have bactericidal, fungicidal, sporicidal and virucidal action, but they paint treated surfaces, may cause burns of tissues, the corrosion of metals.

Aldehydebased drugs is one of the most reactive classes of organic compounds. The microbicidal action of aldehydes is mainly associated with their ability to form strong compounds with the amino groups of proteins and nucleins. Active substances are glutaraldehyde, orthophthalic aldehyde, formaldehyde.

Advantages:

– broad-spectrum of antimicrobial activity (bactericidal, sporicidal, virucidal, fungicidal effect and at a concentration of 2 % or more can be sporicidal one);

– multipurpose;

– dissolve well in water;

– no (or low) corrosion of metals;

– effective in the presence of organic substances;

– quick action;

– can be used for optical instruments;

– long-lasting activity of working solutions (14 days);

– working solutions can be used repeatedly.

Disadvantages:

– increased volatility;

– the ability in some cases to fix organic contamination (blood, mucus, pus), which requires pre-cleaning of medical items;

– irritant effect on the skin and mucous membranes;

– when disinfecting, fabrics/tissues can be painted in yellow color;

– formaldehyde has potential carcinogenic properties.

Peroxides. Hydrogen peroxide works by producing destructive hydroxyl free radicals that can attack membrane lipids, DNA, and other essential cell components. Catalase produced by aerobic organisms and facultative anaerobes with cytochrome systems can protect cells from metabolically produced hydrogen peroxide by decomposing hydrogen peroxide to water and oxygen. This protection is overcome by the concentrations used for disinfection.

Advantages:

– high antimicrobial activity (bactericidal, sporicidal, virucidal and sporicidal);

– suitable for sterilization;

– their use does not lead to the formation of microorganism strains resistant to disinfectants;

– environmentally friendly (decompose into oxygen, carbon dioxide and water).

Disadvantages:

– have a relatively low stability (working solutions lose their activity within 12–24 hours);

– show the corrosivity;

– have an irritant effect on the respiratory system.

Alcohols: ethyl, propyl, isopropyl. Alcohols penetrate the microbial cell and cause irreversible protein denaturation. This mechanism is confirmed by the observation that absolute ethyl alcohol as a dehydrating agent is less bactericidal than mixtures of alcohol and water because proteins denature more quickly in the presence of water. The bacteriostatic action was believed to be caused by inhibition of the production of metabolites essential for rapid cell division.

The advantages of disinfectants based on alcohols:

– broad-spectrum of antimicrobial activity (bactericidal, sporicidal, virucidal, including those which are active against hepatitis B, viruses, HIV, fungicidal);

– environmentally safe;

– quick action;

– lack of residual chemical effect, does not leave spots;

– do not leave any residue after evaporation;

– microorganisms do not developed resistance.

Disadvantages:

– fixation of organic contaminants;

– easy flammability;

– no sporicidal effect;

– prolonged contact leads to swelling and increase of the plastics hardness, rubber and further deterioration of these materials;

– can be inactivated by organic materials;

– evaporates quickly resulting in reduction of concentration (prolonged contact of objects with the disinfectant if they are not immersed in alcohol solutions is impossible).

Surface-active substances. Surface-active substances contain in one molecule a hydrophilic and hydrophobic group. During the adsorption on the microbial cell membrane the hydrophilic part of the surfactant is absorbed on proteins; hydrophobic one interacts with membrane lipids. The mechanism of the damaging action is associated with the fact that surfactant molecules enter the bilayer system and disrupt the packing of phospholipids, it leads to a violation of the permeability of the cell membrane.

Surfactants are classified into cationic (+), anionic (–), amphoteric (+ –), nonionic (in accordance with the ionization of the hydrophilic group of the molecule). Cationic and amphoteric surfactants are used as independent disinfectants. Among the cationic surfactants Quaternary ammonium compounds are widely used in disinfection practice.

Quaternary ammonium compounds (QAC) have a high surface activity that provides them with detergents, solvent and some disinfection properties. They have good potentiating properties and are used as additives in the composition of disinfectants. The QAC have some good bacteriostatic and bactericidal properties.

Advantages:

– does not cause the metal corrosion;
– does not discolor the fabric;
– have a low toxicity level (can be used in hospitals in the presence of patients and staff);
– have no strong odor;
– have good cleaning properties.

Disadvantages:

– a relatively narrow spectrum of antiviral action (only some of the preparations have a virucidal effect on lipophilic viruses);
– the lack of sporicidal and tuberculocidal action;
– reduction of antimicrobial activity in the presence of organic substrates;
– microorganisms develops resistance with prolonged use;
– easily adsorbed and neutralized by many materials (cotton, wool, etc.).

Guanidines. Complex organic substances are the active ingredients of the disinfectants based on guanidine. Chemicals of this group are active against bacteria (possess weak activity against Mycobacterium tuberculosis, viruses and fungi). Expanding the range of antimicrobial activity occurs when guanidino are combined with Quaternary ammonium compounds.

Advantages:

– have a prolonged effect;
– recommended for surface treatment of various materials (toys, tableware);
– do not spoil the textile, carpet;
– easy to use;
– application in the presence of staff and patients;
– relatively environmentally friendly.

Disadvantages:

– narrow spectrum of antimicrobial action;
– possibility of formation of a resistant film on the treated surfaces.

Phenols. They have an effect on:

– gram-positive and gram-negative bacteria;
– fungi;
– complex viruses;
– protozoa.

The mechanism of antimicrobial action is associated with the denaturation of proteins and surface-active properties of the solutions.

Currently, the pure form of phenol-containing disinfectants are not used (because of toxicity). Analogues of phenol are used as additives in the compositions of disinfectants, which expands the spectrum of antimicrobial action.

Disadvantages of phenols:

– mild sporicidal effect;
– inactivation by organic material;
– attacks rubber and some plastics;
– have a local irritant and cauterizing effect;
– easily absorbed through the skin and mucous membranes, and in large doses they cause toxic effects.

Tertiary amines are characterized by a wide range of antimicrobial activity, they are active against bacteria (including mycobacteria), fungi and viruses. They have a low toxicity and good cleaning properties. Tertiary amines form an alkaline environment that enhances their antimicrobial activity, especially in combination with other substances.

Quaternary ammonium compounds. The bactericidal action of the quaternary ammonium compounds has been attributed to the inactivation of energy-producing enzymes, denaturation of essential cell proteins and disruption of the cell membrane. There is evidence to confirm these and other possibilities.

The results from manufacturers' instructions and from published scientific literature show that QAC sold as hospital disinfectants are generally fungicidal, bactericidal, and virucidal against lipophilic (coated) viruses; they are not sporicidal and generally not tuberculocidal or virucidal against hydrophilic (nonenveloped) viruses.

Composite products. Composite products include:

– active substance;
– stabilizers;
– various additives (detergent, deodorant and other components).

The combination of disinfectants of two or more groups extends the range of antimicrobial action and provides cleaning, anti-corrosion and other positive properties that increases the quality and effectiveness of disinfection measures.

Resistance of microorganisms to disinfectants. It is known that microorganisms of different groups, families and even different strains of the same species have unequal, often significantly different resistance to certain external influences.

Differences in resistance to disinfectants of various microorganisms are established. So, viruses (they differ in their structure, size and chemical composition) also have different resistance to the effects of physico-chemical factors. Before using various disinfectants we need to take it into account.

Biological method of disinfection is the destruction of infectious agents in the environment with the help of microbes-antagonists. It can be used for:

– destruction of waste water in the fields of irrigation and filtering;

– disinfection of garbage and waste in composts and bio-thermal chambers;

– destruction of Staphylococci and Pseudomonas aeroginosa on objects of the environment in hospitals with the help of bacteriophages.

Chamber method of disinfection. The most reliable and appropriate method of disinfection of mattresses, pillows, outerwear, fur and leather, books is the chamber decontamination. It provides a reliable disinfection of the things infected by vegetative spore forms of pathogens, and provides pest control. As active agents necessary for warming things up to a certain temperature, dry hot air, saturated water steam, humidified hot air are used herewith the desired temperature and humidity are created in the chamber and in things. In some types of chambers the action of the temperature factor is combined with the action of chemicals, with formaldehyde in vapor or gaseous state in particular.

The chamber method of disinfection is used in plague, cholera, relapsing fever, epidemic typhus fever, Brill's disease, Q-fever (pulmonary form), anthrax, a highly contagious hemorrhagic viral fevers, typhoid, paratyphoid, tuberculosis, leprosy, diphtheria, fungal diseases of hair, skin and nails (microsporia, trichophytosis, rubrofitii, favus), and the chamber method of disinsection is used incase of wardrobe lice and scabies.

Types of disinfection chambers. The chambers are divided into several types depending on the disinfecting agent:

– steam-saturated water vapor is used;

– steam-formalin, in which the steam-formaldehyde mixture and humidified heated air are used;

– air, where heated air is used;

– gas, in which gases or mixtures are used (sulfur dioxide, ethylene oxide, methyl bromide, chloropicrin, etc.);

– combined, which are adapted for disinfection by several agents (water vapor, steam-air mixture, formaldehyde).

Disinfection chambers of the indicated types are divided into stationary and mobile according to their design. Shower units can be mounted in combination with mobile disinfection chambers.

The principles of the disinfection chamber structure. Disinfection chambers include:

– a working chamber in which things are loaded;

– heat source (steam boiler, firebox, electric heater);

– instrumentation (thermometers, manometers, safety valves);

– equipment for introducing chemicals (nozzles, evaporators);

– ventilation devices (ventilators, steam sectors, etc.).

Control over the work of disinfection chamber. In order to ensure the reliable disinfection of things, disinfection chambers are systematically subject to technical, thermal and bacteriological controls.

Disinfection quality control is performed by visual, bacteriological and chemical methods.

Bacteriological quality control of disinfection in the foci of intestinal infections is carried out in order to find out E. coli; in the foci of airborne infection – staphylococcus; in the medical institutions – pathogenic bacteria.

The quality control of disinfectant solutions is carried out using chemical methods (laboratory method and short-term tests).

STERILIZATION

Basic concepts and terms

Sterilization is the complex of measures aimed at complete elimination of the environmental objects from vegetative and resting forms of microorganisms using physical or chemical factors.

Antisepsis is a complex of preventive measures aimed at the destruction of microorganisms in a wound, another pathological formation or body as a whole.

Asepsis is a complex of therapeutic and preventive measures aimed at the prevention of infectious agent penetration into the wound, tissues, organs, body cavities of the patient at any medical (diagnostic including) procedures.

Sterilization is carried out to:

– prevent introduction of microorganisms into the human body during medical interventions;

– exclude microbial contamination of drugs and diagnostic materials, culture media and cell cultures used in microbiological and immunological research.

Stages of sterilization

Sterilization of medical devices involves three steps:

1) disinfection;

2) pre-sterilization cleaning (PSC);

3) proper sterilization.

Disinfection is required for all things after their use in patients. Disinfection of these things is carried out with the aim of destroying pathogenic and opportunistic pathogenic microorganisms including causative agents of viral hepatitis and HIV infection, Mycobacterium tuberculosis and fungi including the genus Candida. After disinfection things are washed with water, dried and used for the purpose intended or subjected to pre-sterilization cleaning and sterilization.

Pre-sterilization cleaning is carried out to remove protein, fat and mechanical impurities and drug residues.

Sterilization of products is carried out to destroy microorganisms of all kinds, including spore forms.

The following medical devices must be sterilized:

– those which come into contact with the wound surface, blood, internal sterile cavities in the body or injection drugs;

– those which come into contact with the mucous membranes when there is a risk to cause their damage.

1. ***Disinfection of medical equipment.*** Disinfection of medical equipment and instruments is carried out by physical and chemical methods.

Physical method of disinfection includes boiling, treatment with saturated water steam or dry hot air.

The instruments are boiled in distilled water for 30 minutes from the moment of boiling or in the water with a 2 % solution of baking soda (sodium bicarbonate) for 15 minutes from the moment of boiling. This type of disinfection is subjected to glassware, metals, heat-resistant polymer materials and rubbers.

Glass, metal, rubber, latex, and heat-resistant polymer materials are disinfected with the steam method using saturated water steam under excessive pressure. They are packed into sterilization boxes and placed in a steam sterilizer (autoclave). Autoclaving takes place at 110 °C for 20 minutes. Preliminary cleaning of things from organic substances is not required.

Glassware, metals, silicone rubber are disinfected with the air method in the open form on the shelves of an air sterilizer (dry heat oven) at the temperature of 120 °C for 45 minutes. In this case, obligatory preliminary cleaning of things from organic substances is required.

Physical method of disinfection of medical devices is simple, environmentally friendly and safe for personnel.

Chemical method of disinfection involves the use of chemical solutions-disinfectants, into which the medical device is immersed immediately after their use. Detachable items should be disinfected in a disassembled form, the channels and cavities of the items must be filled with a disinfectant solution.

Things that are not in direct contact with the patient can be disinfected by double wiping with a cloth moistened with a disinfectant solution.

In healthcare organizations the change of the used chemical disinfectants should be carried out taking into account the results of monitoring the resistance to chemical agents of the disinfection of microorganisms circulating in hospitals as well as in accordance with epidemic indications.

2. ***Pre-sterilization cleaning (PSC).*** PSC of medical things is carried out after their disinfection and subsequent rinsing with running water to get rid of the remains of disinfectants. New tools are treated by PSC to remove industrial grease and dirt.

In PSC special industrial chemicals or prepared cleaning solutions containing hydrogen peroxide and washingt powder based on soda ash are used. To reduce their corrosive effect 0,14 % solution of sodium Oleate (corrosion inhibitor) is added.

The PSC is carried out manually or mechanized.

PSC at the stage of soaking can be combined with their disinfection providing the application of solutions of disinfectants with virocidal, tuberculocidal and cleaning effect.

In this case the soaking time should correspond to the exposure regimen for viral infections and in tuberculosis institutions — the exposure regimen for tuberculosis.

Detergent solutions for PSC are usually used repeatedly until the appearance of visible signs of contamination (discoloration, cloudiness, the appearance of sediment, flakes). Detergent solutions prepared on the basis of hydrogen peroxide and washing powders are used up to 6 times during a work shift.

The quality of the PSC is estimated by setting azopiram samples for the presence of residual quantities of blood. For setting azopiram samples a solution of azopiram containing 10 % aminopyrine, 0.1 to 0.15 % of aniline and hydrochloric acid is used and the volume was adjusted to 100 % with ethyl alcohol-rectified. Before setting up the reaction equal volumes of azopiram solution and 3 % solution of hydrogen peroxide are mixed. The solution can be used within 2 hours. A few drops of the solution are put with a help of the medicine dropper on the tested object or it is wiped with a gauze pad moistened with a reagent, or the reagent is drawn up into a syringe and passed through a handled needle. The reagent is left on (in) the tested object for not more than 1 min, then it is released on the gauze napkin. In the presence of blood traces a purple color appears immediately or within 1 min and then it turns into pink-purple. When setting the azopiram sample, staining occurs later than 1 minute after applying drops of reagent, it's shouldn't be taken into account. The product that gives a positive reaction in the azopiram sample is subject to repeated pre-sterilization cleaning.

All products inspected with the azopiram reagent, regardless of the results, should be washed with water or wiped with a swab with alcohol and re-subject to PSC.

3. ***Proper sterilization.*** The sterilization is carried out after disinfection and pre-sterilization cleaning. Its aim is the complete destruction of all pathogenic and non-pathogenic microorganisms including spore forms.

Nowadays physical and chemical methods of sterilization are used most commonly.

The *physical method* involves thermal treatment of medical devices and the use of various types of radiation.

In the *chemical method* of sterilization chemical substances are used in a gaseous state (gas method) or in the form of solutions.

In practice thermal method of sterilization is widely used — it is the use of steam and air sterilizers.

The radiation method is used to a limited extent, mainly for industrial sterilization of disposable medical instruments. In this case, various kinds of ionizing radiation are used — gamma rays, beta rays, etc. Treatment of medical instruments is possible with the help of infrared, ultraviolet radiation and pulsed currents of ultra-high frequency (microwave, UHF), however, these methods are rarely applied.

When using steam, air and gas method, items to be sterilized are packed in special packaging materials (paper bags and other sterilization packaging materials) or in a special sterilization boxes with filters or without them.

Steam method of sterilization. The sterilizing agent in the steam sterilization is water saturated steam at temperatures of 110–135 °C under excess pressure.

Sterilization is performed in steam sterilizers (autoclaves) in two modes:

1) the temperature is 132 ± 2 °C, the vapor pressure is 0.2 MPa, the exposure time is 20 ± 2 min;

2) the temperature is 120 ± 2 °C, the pressure is 0.11 MPa, the exposure time is 45 ± 2 min.

The steam sterilization method is used to sterilize surgical instruments, parts of instruments made of corrosion-resistant metals, glass, syringes marked 200°C, surgical linen, surgical dressing and suture materials, rubber items (gloves, tubes, catheters, probes), items made of latex, certain types of plastics (Fig. 2, 3).

Fig. 2. Large automatic hospital autoclave

Fig. 3. Common laboratory autoclave

Air method of sterilization. Air sterilization involves the use of hot, dry air as an active agent. It reduces the number of items that can be sterilized by this method: rubber items, polymers, textiles (linen, dressings, cotton wool) are excluded. The air sterilization method is carried out in two modes:

1) at t = 160 °C, exposure time — 150 min;

2) at t = 180 °C, exposure time — 60 min.

Air method is used to sterilize surgical, gynecological, dental instruments, parts of instruments and apparatus made of corrosion-sensitive metals, syringes marked 200°C, needles, items of silicone rubber, hydrophobic materials — talc, petrolatum, oils.

Glass ball sterilizers are modern devices in which sterilization can be carried out using physical factors. The sterilizing agent in them is the environment of glass balls heated to the temperature of 190–250 °C. This method can be used for rapid sterilization of working surfaces of all-metal tools of a simple configuration used in dentistry: dental burs, diamond heads, etc. (Fig. 4).

Fig. 4. Glass ball sterilizer

The sterilization time can vary depending on the size of the instrument and ranges from 20 to 180 s. A prerequisite is that the tool must be dry. Packaging is not required for glass ball sterilizers, but instruments must be used immediately after sterilization.

Sterilization by ionizing radiation. Ionizing radiation is widely used for sterilization in industrial enterprises which produced disposable medical items: systems for blood transfusion, obstetric kits, etc. For this purpose, the method of radiation sterilization is applied (gamma rays, accelerated electrons) which is used to sterilize dressing materials, surgical instruments, some medicines, serums, etc.

There are special units created for sterilization by ionizing radiation (gamma setting, and electron accelerators), where items to be sterilized are put only in sealed plastic bags. Items sterilized by this method maintain sterility for several years.

Chemical method of sterilization. The chemical method is used in cases when it is impossible to release medical things from microorganisms with other methods. This primarily relates to instruments with mirror surfaces, optical and electronic equipment, cutting and piercing instruments with micron sharpening, catgut, a variety of items made of thermoplastics.

Chemical sterilization can be done in two ways:

1) sterilization by immersion of items in chemical solutions;

2) using chemicals in a gaseous state (gas sterilization).

Chemicals must have sporicidal activity.

Sterilization with solutions of chemicals. The sterilization with solutions is less effective than heating, and therefore is considered to be an auxiliary method when it is impossible to apply «hot» sterilization.

The disadvantages of chemical sterilization using sterilant solutions include:

– the need to create special aseptic conditions for sterilization in order to avoid secondary microbial seeding of sterilized things; all manipulations should be carried out in sterile cloths and gloves;

– a chance of side effects of used sterilizers on the staff;

– relatively high cost of drugs;

– duration of the sterilization process;

– obligatory washing of sterilized things with sterile liquid from sterilants which requires a significant supply of sterile liquid (drinking water, 0.9% sodium hypochloride solution);

– short shelf life of sterilized items due to the high probability of secondary contamination since the packaging cannot be used.

Sterilant solutions are used to sterilize thermally unstable items (some surgical instruments made of polymers, instruments for flexible endoscopes) if the other sterilization methods are not used due to the features of the material from which the item is made.

Aldehyde-containing substances, hydrogen peroxide (6 % solution) are mainly used. Sterilization is carried out with complete immersion of the item into the solution. If the item is separable, it is immersed in pieces so that all channels and cavities are filled with the solution; if it is long, it is laid in a spiral. To avoid dilution of the concentration of sterilizing solutions, all items must be dry. After appropriate exposure items are taken out from the solution with sterile instruments complying with aseptic rules and then washed with sterile water poured into sterile containers. Washed sterile items after removing residual liquid with sterile instruments are immediately transferred to sterile bixes l aid out with a sterile sheet for up to 3 days or used immediately.

Gas sterilization method. In this method volatile chemicals are used as sterilizing agents — ethylene oxide, a mixture of ethylene oxide and methyl bromide in a weight ratio of 1 : 2.5 (mixture), vapors of formaldehyde in ethanol, ozone. The advantages of the gas sterilization are: it can be carried out at low temperature (18–80 °C), it does not damage rubber and plastic, it does not cause corrosion of metals.

The gas sterilization method is carried out in a stationary or gas sterilizers in portable apparatus (microgeneration), placed in a thermostat or in a water bath

to maintain the proper temperature. Mode gas sterilization (temperature — 18°C, 35 °C, 55 °C) and exposure depend on the material of the item. After appropriate exposure, the chamber and products in it are degassed. Therefore, the rooms where gas sterilizers are installed should be well ventilated.

The need to ventilate sterilized things (as residual gases have carcinogenic and mutagenic effect) is the main drawback of the gas sterilization method.

Ozone sterilization. The ozone is generated in the ozone sterilizers and used to sterilize metal tools with simple configuration — scalpels, tweezers, mirrors, spatulas, dental burs.

Ozone is synthesized from air in gas-discharge reactor of a sterilizer. Instrument sterilization is carried out in the unpacked form, before loading into the chamber tools should be dried. The sterilization exposure time is 50 min, the time of decontamination — 10 min.

Plasma sterilization. The active agent in plasma sterilizers is the low temperature plasma generated by electric discharge or radio frequency electromagnetic radiation in the gas — vapor hydrogen peroxide, aldehydes, etc. Plasma is the fourth state of the substance (unlike solid, liquid and gaseous), it consists of ions, electrons, neutral atoms and molecules and is formed under the action of external energy sources. When the electromagnetic field is turned off, free radicals are converted into water molecules and oxygen, leaving no toxic waste.

The advantages of plasma sterilization include:

– short cycle (exposure is not more than 1 hour);

– the use of low temperatures (50 °C);

– sterilization of a wide range of tools and materials (including delicate instruments from corrosive metals, precious metal alloys, things made of polymers, plastics, glass, rubber, silicone, etc.);

– degassing stage after sterilization is not needed (items can be used immediately after the cycle);

– instruments can be sterilized in the packed form which allows you to store them in a sterile condition for a long period of time — up to 12 months;

– safety for the staff and patients (no harmful gases, radiation, toxic waste);

– reliability.

The significant disadvantage and obstacle to the use of the plasma sterilization method in health care institutions is its high price.

Quality control of sterilization. Sterilization parameters are checked with the use of physical, chemical and bacteriological methods. The reliability of these methods varies. Physical and chemical methods are used for operational control and to control the parameters of the sterilization effectively. The disadvantage of these methods is that they cannot serve as evidence of effective sterilization. Only the bacteriological method is reliable for determination of sterilization efficiency.

SELF-CONTROL OF THE ACHIEVEMENTS

Task 1

Formulate the definition of the term «disinfection», name the main types of disinfection with examples of their use. Which type of disinfection should be used in case when a sick patient stays at home and undergoes a treatment there?

Task 2

Name the physical methods of disinfection which can be used in epidemic foci and explain the advantages and disadvantages of these methods.

Task 3

Name the main groups of chemical disinfectants and explain the conditions when it is better to use the chemical method of disinfection.

Task 4

Formulate the definition of the term «sterilization», name the main sterilization steps. Can the first 2 steps of sterilization be combined? Under which conditions?

Task 5

Determine the quality of the second step of sterilization of medical instruments. Explain the process of preparing all the necessary solutions.

Standarts of answers

The answer to the task 1

Disinfection is a complex of measures aimed at the elimination or decrease of the population of resting or vegetative forms of pathogenic and potentially pathogenic (opportunistic) microorganisms on abiotic objects of the environment, the main aim of which is to prevent the spread of infectious diseases.

Disinfection is divided into two types: preventive, which is carried out in places of possible accumalation of infectious agents without connection with an epidemic foci, which is carried out within the borders of already existing epidemic focus due to a case of an infectious disease or bacterial carriage. Focal disinfection can be current and final. Current disinfection is carried out in the focus while the source of infection is still present there, and is aimed at the elimination of any germs produced by a patient or bacilicarrier. Final disinfection is carried out after hospitalization, recovery or death of the patient (after the removal of the source of the infection from the focus to provide complete clearance of the focus from pathogenic agents).

Thus, focal current disinfection should be used when the sick patient stays at home and undergoes the treatment there.

The answer to the task 2

The physical method of disinfection is the destruction or reduction of microbial populations by using mechanical, thermal methods or radiation.

The physical method of disinfection is safe, environmentally friendly, safe for the personnel. However, it's not universal, its application requires special equipment, sometimes it shouldn't be used because it damages the treated object.

The answer to the task 3

The chemical method of disinfection is the use of various chemicals (disinfectants) causing the death of microorganisms on the surface and inside things and objects of the environment, as well as in the air and various substrates (pus, sputum, stool, etc.). Chemicals are easily available in daily practice, can be used for items that do not withstand high temperatures, however, their action is superficial. The abundance of chemicals that have antimicrobial effect, allows you to vary them widely, choosing the most optimal mode of disinfection without damaging the treated object.

The main groups of chemical disinfectants are: halogenated and aldehydebased ones, peroxides, alcohols, surface-active substances, guanidines, phenols, tertiary amines, quaternary ammonium compounds, compositional disinfectants.

The answer to the task 4

Sterilization is the complex of measures aimed at complete clearance of objects of the external environment from vegetative and resting forms of microorganisms by using physical or chemical factors.

Sterilization of medical devices involves three steps:

1) disinfection;

2) pre-sterilization cleaning (PSC)

3) proper sterilization.

PSC products at the stage of soaking can be combined with disinfection, subject to the application of solutions of disinfectants with virocidal, tuberculocidal and cleaning effects.

The answer to the task 5

The quality of the second step of sterilization of medical instruments (PSC) is estimated by setting azopiram samples for the presence of residual quantities of blood. For setting azopiram samples a solution of azopiram containing 10% of aminopyrine, 0.1 to 0.15% of aniline and hydrochloric acid is used than the volume is brought to 100% ethyl alcohol-rectified. Before the formulation of the reaction equal volumes of the solution of azopiram and 3% of the solution of hydrogen peroxide are mixed. The solution must be used within 2 hours. On the test object a few

drops of the solution with a pipette or with a gauze pad moistened with a reagent are placed. The reagent is left on (in) the tested object for no more than 1 min, and then release it on the gauze napkin In the presence of blood traces a purple color appears immediately or within 1 min and then it turns into pink-purple. When setting the azopiram sample, staining occurs later than 1 minute after applying drops of reagent, it's shouldn't be taken into account. The product that gives a positive reaction in the azopiram sample is subject to repeated pre-sterilization cleaning.

All items controlled with the azopiram reagent, regardless of the results, should be washed with water or wiped with a swab soaked with alcohol and re-subjected to the PSC.

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CONTENT

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DISINFECTION AND STERILIZATION IN DENTISTRY

Учебно-методическое пособие

На английском языке

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