Microbiology

◉ Sheet ○ Slides

Number: 6

Done by: Sondous Al-khateeb

Corrected by: Alma Jarkas

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Subject: Disinfection and Antimicrobial drugs

Doctor: Dr. Asem Shehabi

We have mentioned before that when we use chemical agents, disinfectant agents or antiseptic agents (in relation to our body, mucosal, oral cavity, skin) we need an agent that is not harmful and does not have a side effect on our bodies.
Before using of any agent on our skin or on the surface of instruments or with any device or equipment in our homes or in the hospitals, we must take in consideration that we have to get rid of all available organic materials which considered as contamination such as the presence of blood, saliva, fatty acids and carbohydrates, all of these materials have to be washed out by water and a detergent before using any antiseptic agent or disinfectant agent.

EXAMPLE: in preparation of the skin to a surgery the first thing to do is washing the skin with water and any detergent , then you can start using the disinfectant agents (the most common disinfectant agents used in hospitals are alcohol & iodine).Therefore, the presence of organic materials (like blood or saliva for example) will interfere with the disinfectant or antiseptic agent and as a result of this reaction the agent won't reach the concentration level which is required to affect the presence of microorganisms and reduce the number of the organisms to a safe level .

The **concentration** of the chemical agent is so important, so we must always be sure that the concentration is according to recommendation, because sometimes there is an available concentration solution that cannot be applied.

EXAMPLE: the **H_2O_2** (hydrogen peroxide), the available concentration of hydrogen peroxide in hospitals is 30 % concentration, but this concentration is high and might harm our skin or mucosa, if we have injuries in the oral cavity or in the skin it will affect them producing burning sensation, so 30% of H_2O_2 is damaging to the skin therefore it must be diluted to approximately (3-5%) before it can be used safely on skin.

Sometimes, if we have a large amount of fluids (like water), we must control the **PH**, for example we can't use chlorine as disinfectant agent in an acidic water (or in acidic medium generally) because it won't affect the microorganisms at all, it needs a neutral or slightly alkaline medium to make an effect on microorganisms.

If there is a living tissue (like the skin, the oral mucosa or any part of our body), we have to use an antiseptic agent and the mostly used antiseptic agents are either alcohol with different solutions or the iodine solutions.

1- **Alcohol** :

When we use alcohol as antiseptic agent , we do not use absolute alcohol because we need alcohol to contact about 2 minutes with the targeted surface (skin for example) and the absolute alcohol is quickly evaporated (in less than 1 minute) and it will be not effective , so the best alcohol to use as antiseptic is **diluted alcohol** (70-90%) of alcohol ,and keep in mind that diluted alcohol must be stored in transparent bottles because certain organisms can survive in such diluted alcohol ,and if this happens it may be associated with infections later .
" we must store diluted alcohol in a transparent bottles in order to notice any organisms that may survive In it ,which would be difficult if it was stored in a dark bottles" .

2- **Iodine**:

There are 3 types for iodine solutions available for the processes of preparing the skin to operation or injection of materials and also preparing it to simple procedures like removing small part out of the skin for example.
- First type: aqueous iodine which is (3-5%) of iodine with sterile water.
- Second type: Tincture iodine, tincture means that we have alcohol iodine solution, 70% of alcohol with 2 -3 grams of (2-3%) iodine.
- Third type : complex iodine main **Betadine** or **Povidone-iodine** is available , all these usually should be applied under certain conditions in hospitals , and there are usually guide lines how to prepare the skin first with alcohol , you have to use alcohol by applying it to the skin for at least 2 minutes , you have to wait and later to apply the iodine with a tincture iodine or Betadine again for 2-3 minutes and to wait then there will be an interaction between the available microorganism on the surface of skin to be killed or at least inhibited and removed.

There are other compounds that are mainly used as disinfectant agents which mean that they are used with devices –all type of devices, articles and services which can be used in hospitals- which are :

1- group of chemicals called **Chlorohexidine** :

This compound is composed of chlorine ions as well as phenol , the combination between chlorine and phenol usually produce a variety of chemical compounds that can be used as disinfectants (such as savlon ,dettol , Cetrimide, Lysol, etc) all these are belonging to group of chlorine with phenol (sometimes companies add another component such as H_2O_2 (2-3%)or isopropanol (2-3%) and so on) , but the basic structure composed of phenol (not more than 1% because it is very dangerous chemical compound which cannot be used as pure substance , it can produce side effects and burning sensation on the skin or the oral cavity).

***** To summarize:***

The most common disinfectant / antiseptic agents:

1- Alcohol.

2- Iodine which has 3 types.

3- Chlorohexidine.

Water - disinfection

We have one item of importance whether in our country and other countries in the world mainly related to tap water, which we use it in our homes to wash and drink , this water has certain specification , it must be free of any type of organisms which might produce any type of diarrheal disease in intestines or any type of infections , and this is not an easy task , especially in a country like Jordan ,where we have shortness in supply of water , therefore the resources of water in our country are limited to underground water , water we take from Jordan river and what collected from rain water , etc .

" I know that this look like geography lecture , but I have no choice, I have to write everything the Dr. has mentioned in the lecture " so, ***<u>sorry</u>*** :p

All these sources of water may be contaminated with feces of humans or animals , so water can be easily contaminated with a wide range of microorganisms , therefore we have to be sure that our drinking water is safe for drinking , for washing and for preparing our food , in order to be sure that our water is safe we have to chlorinate the water .

** **chlorination** of water is the cheapest method that available in country like Jordan by using chlorine , NA-hypochlorite can be easily dissociated into active chlorine and this active chlorine will interact with the cell membrane of any type of microorganisms like bacteria .Despite of this fact ,chlorine is a very effective oxidizing agent and cannot be used in a high concentration , because high concentration of chlorine might produce damage in our hair , eyes , skin, stomach , intestine , etc . there is a limitation for chlorine concentration which should not exceeded (2-3) PPM (part per million)which means the following :
For one cubic meter of water we can use 2-3 grams of sodium hypochlorite which end with free chlorine atoms ,but even with this low concentration; the odor of chlorine can be noticed it the water , therefore on the source of water we can add this concentration , because the water will be distributed to our homes by water distribution nets , and it will slowly evaporate , so it will decrease slowly , at the end the concentration of chlorine in the water shouldn't be above 0.05 PPM ,otherwise we will taste chlorine in the preparation of tea / coffee / etc .
in addition that chlorine is a toxic material , and high concentrations of it might change the colour of the hair .

It is so difficult to culture specimens of water for all possible potentials positive agents of disease (viruses, bacteria) .We have at least 50 types of microorganisms (viruses, bacteria , etc) which might produce **GI infections***, therefore we should have simple methods to know if the water is free of what we called **fecal contamination** **, the only way to know that is the **indicator organism** , the indicator organism in relation to water is **E.coli** , they select the E.coli because it found in the intestine of all humans and animals , so if the water contain even a single E.coli we have to expect the presence of other pathogenic organism like salmonella , shiglla , viruses , etc .
Drinking water must be free of E.coli (1liter of drinking water mustn't

contain a single cell of E.coli) , and this is what we usually do in laboratories to control the safety of water .

*GI tract infection starts with diarrhea and might be complicated with other type of disease .
** fecal contamination in relation to feces of humans and animals which may carry huge number of pathogenic organisms .

Oxidizing agents :

1- **Ozone**
In certain countries, they use ozone (O3) instead of chlorine in the water disinfection process , Ozone is a very strong oxidizing agent , and it is more effective than chlorine associated with the side effect , the mechanism of ozone is to release an active oxygen , which react with the cell walls and cell membranes of all microorganisms (viruses, fungi, bacteria , etc) , so it is very effective but it costs more than the chlorine .

2- **H2O2**
-Using hydrogen peroxide (H2O2):
*It can be used in low concentration to clean wounds.
*To clean any contamination of microorganism with injuries of oral cavity or skin.
*But also it can be dangerous if repeated, so H2O2 shouldn't use many times in the same period, it can be used once or twice per day but not more.

Other chemical agents used for disinfection of innate objects

1- Phenol **compounds:**
The Chlorohexidine compounds that we talked about previously are just for external uses, and they often can kill all microorganism including even some spore-producing bacteria and spore fungi.

2- **Organic acid**
Such as Sorbic acid and Benzoic Acid, these are used mainly to inhibit the presence of certain organism, mainly in:

1- **Food industry**, because they are not harmful.
2- **Cosmetics** , because cosmetics can be easily contaminated with certain microorganisms and might be a source of developing of skin infections , therefore ,all these can be avoided by using organic acids .

3- lastly , we have a lot of **detergents** that we use for washing in our homes , all these detergents are based on one chemical compound that called Surface-Active Agents , which can be either positively charged (cation) or negatively charge (anion), now these only interact with the presence of organic material including microorganisms and produce clumps , these clumps can be later washed by water and hand rapping , so the detergent cannot be effective without using of running water , this process by the presence of detergent (anion or cation) and the mechanical rubbing of your hand with running water will result in removing of what we called organic contamination as well as microorganisms.

<u>Note</u>:

Washing your hands is the first step in any hospital to keep the high standard of hygiene to control infections in the hospital. So each doctor, nurse and other medical team members shouldn't deal with any patient without washing their hands first, also they mustn't move from one patient to another without washing their hands in order to reduce the possibility to transfer certain organisms from one patient to another.

<u>keep in mind</u> ☺

- that the patient in hospitals might be infected with one or more microorganism and often they are treated with variety of antibiotics and this may associated with the presence what we called multi drug resistant organism which usually produce infection (insusceptible one), especially in patients with **Immunocompromised** condition and patients who are suffering from **malignancy**, and this might end with the death of the patient.

-**hospital acquired infections** can be controlled by using of hand-washing and by using disinfectant as well as antiseptic agents according to guide lines which usually prepared by each hospital .

Antimicrobial drugs:

despite the fact that antibiotics are excellent type of drugs which can cure any patient (infected patient with one or more microorganism), but they are not 100% safe and it can sometimes produce side effects as well as it might be associated with more serious infections later. We'll be concentrating on the relation between these antimicrobial drug and the bacteria.

Microorganisms, especially bacteria, are highly intelligent and they have a molecular genetics which allow them to resist these types of drugs. so the relation between the bacteria and the drug in this case is very important to be understood in order to appreciate if this drug can be effective under certain limitation , and in order to understand it we have to begin with a short history about the development of antimicrobial drugs .

The first chemical compound which has produced to kill types of bacteria was **sulfonamide** , sulfonamide is a synthetic chemical drug which has produced in the laboratory , it was produced in 1934 to control and treat some infections that caused by a gram positive bacteria (staphylo coccus and strepto cocci) but later they produced the first antibiotic which is penicillin, in relation that this kind of drugs had originated from a type of living cells which **is Penicillium notatum** and other kinds of penicillium which are widely distributed in the nature as **fungus** , and can be observed easily in our homes on the surfaces of bread ,cheese and fruits that might be affected by penicillium , the colour of penicillin can be yellow , green or blue.

the discovery of **penicillin G** that produced by penicillium was an accident that happened in 1941 by Alexander Fleming in Oxford university , and in this accident he noticed that the penicillium notatum that coming in contamination with culture of staff (bacteria) has killed certain colonies surrounded the colony of fungus and so he came to the idea that here there is a substance that can kill other organism and then tried to isolate the penicillin and he succeeded but they spent about 12 years to get a **pure penicillin** which can be used in treatment of infection .

at the beginning this penicillin has been used as **injectable drug** not orally due to the fact that penicillin is susceptible or sensitive to the acidity of stomach and it will be inactivated .
however , following penicillin G we had **penicillin V** which is **acid stable penicillin** (It can tolerate the acidity of stomach) and many other drugs including the group of **aminoglycosides** which Obtained from soil bacteria called Actinomycetes group, they have done a research and selected a lot types of aminoglycosides which are complex in their structure , these started by streptomycin actinomycetes and later they have introduced other more potent types of aminoglycosides like (Streptomycin, Kanamycin) .

Now, at about 100 types of drug are available for clinical medicine which means available for using in treatment of infections in humans and even animals , but we are sorry to say that these drugs will not be affective for the next generation according to what we say in practical terms in laboratories and in clinical medicine that bacteria **manage to resist** the action of many of these drugs .

Generally, any type of drug to be useful for treatment of any type of bacterial infection, it must have a specific selective toxicity on one target of the bacterial cells, in other words it must be manage to:

1- Produce damage in the cell wall.
2- Produce damage in the basement membrane.
3- Affect the arrangement of ribosomes.
4- Affect the attachment of amino acids to the ribosome.
5- Produce break down in DNA or RNA.

Some of these antibiotics might have two or three actions, but generally it is more practical to have a specific target in the bacterial cells in order to produce less toxicity in association to the used drug, so if we have a drug that can affect the plasma membrane and the DNA at the same time that means that this drug can be toxic for human body and might not be tolerated. However, in general the ideal drug must have a **selective** toxicity against the microorganism and less toxicity against our human tissue, and it’s not easy to have these two important characteristics, because according to practice there is no single drug which can be considered as a 100 % safe, especially using any type of drug in a higher concentration or lower concentration or in repeat doses might be associated with side effect.

There are many types of drugs classified according to their targets in the bacterial cells in relation to cell wall, DNA or RNA damage, etc.

All available drugs (antimicrobial drugs) are active against **growing cells**, that means that they cannot affect the resting cells, the cells must be active either during replication of the cell wall or replication of the cytoplasm or nucleic acid replication.
These drugs are divided into:

1. **Bactericidal** drugs which manage only to inhibit a step in the growth of the bacterial cells e.g.:

1- penicillin group.
2- Cephalosporin.

Which interact with the cell wall and prevent developing of cell wall.

2. Drugs with **bacteriostatic** (have inhibitory effect), e.g.:

1- Sulfonamides
2-Chloramphenicol
3-Tetracyclines

* What determines wither to use bactericidal or bacteriostatic drugs??

The type of infection, for example if the patient has serious blood infection you can't use bacteriostatic drugs; in such case you must use bactericidal drug to stop the multiplication of the bacteria in the blood stream. But if the patient has diarrhea you can use bacteriostatic drug as you can wait (you have time) so the body forms specific antibodies.

Selecting the proper drug is not easy in clinical medicine (a lot of knowledge is required).

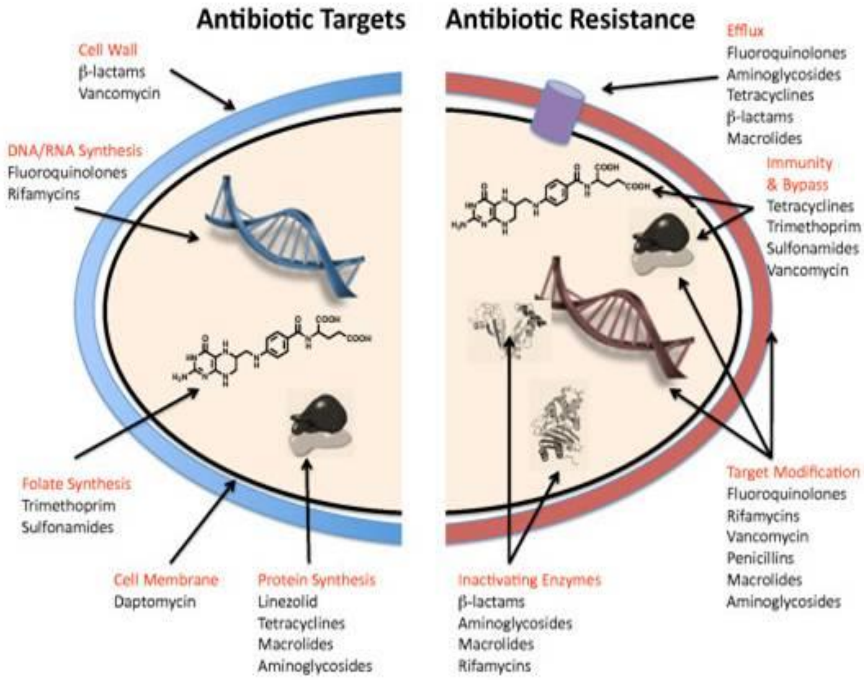
Antibiotics alone can **not** control the infection; a lot of parameters are taken in consideration to prescribe antibiotics .also, antibiotics means nothing if the patient lacks the proper immuno-**response,**

Because the immune system contributes to the cure by producing the specific antibodies, cytokines, macrophages...etc. (in these cases the acute infection will become chronic infection and the patient will die suffering from the complications associated), there is NO drug that can cure the infection (100%) without the help of the immune system.

** The following “very BEAUTIFUL" picture shows the action of drugs in relation to the specific target:

-On the right: the picture shows how the body resist the drug access and effect against the bacterial cells.

-On the left: the picture shows the drug and target structures.



There’s always a battle between the bacteria and the antimicrobial drugs. Bacterial cells always try to develop resistance against the different types of drugs.

☺ منك يبدأ كلّ عظيم ...فاااا ادرس