

ACTION OF ANTIMICROBIAL AGENTS ON THE BACTERIAL CELL WALL

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The use of antimicrobials must be sufficient enough to achieve a therapeutic effect against the invading organisms. Knowledge of the biochemistry and mechanism of action of the specific antimicrobial is necessary when dealing with the surgical patient. By combining knowledge of antimicrobials with the structural function of the bacterial cell wall, cell lysis or destruction of the pathogen can be achieved effectively.

The purpose of this article is to help the surgical technologist understand the mechanisms of antimicrobial agents upon pathogenic organisms. The operating suite requires meticulous use of disinfectants while the staff employs use of antiseptics to prevent skin flora from entering the surgical site. Often patients may require antibiotic therapy to prevent (prophylaxis) or treat invading pathogens.

The action of antiseptics, disinfectants, and other antimicrobial agents on microorganisms is more easily understood by analyzing the cellular components of microorganisms and the specific effects on the microbe by the agent of choice. Antiseptics are defined as chemical agents used on tissue that either kill pathogenic organisms or inhibit their growth while there is contact between the agent and the organism. Examples of antiseptics include hexachlorophene, iodophor, and benzalkonium (Zephiran chloride). Disinfectants, such as glutaraldehyde (Soricide or Cidex), are germicidal, chemical substances used on inanimate objects to kill pathogenic organisms. Other antimicrobial agents include pharmaceutical agents that act to destroy the microbe and not the patient. Typical examples of pharmaceutical agents are penicillins and aminoglycosides.

Classification of Microorganisms

Microbial cells can best be understood by categorizing their cellular organization into specific biologic forms. These cells are divided into internal compartments by membrane systems. The compartments have specific activities for the maintenance of the functions of the cell. The nuclear compartment (nucleus) contains the cell's hereditary material (DNA). Outside the nuclear membrane the organelles of the cell, within the cytoplasm (eg, ribosomes, golgi, lysosomes), are encased by the cell wall of the organism.

There are three classifications of pathogenic microorganisms:

Type I, *Acellular*, consist of prions, viroids, and viruses. These are the smallest of organisms able to demonstrate pathogenic potential. Viruses are obligate intracellular

parasites that depend entirely upon the host cells' synthetic machinery for reproduction. They contain either DNA or RNA.

Type II, *Unicellular*, are divided into prokaryotic cells (chlamydiae, mycoplasmas, bacteria) and eukaryotic cells (fungi, protozoa). Prokaryotes lack a true cell nucleus (Figure 1). The genetic material of the cell lies within the cytoplasm. Unlike viruses, bacteria contain DNA and RNA and reproduce through binary fusion.

Eukaryotes are larger than bacteria and their genetic material is separated from the cell cytoplasm by a nuclear membrane. They reproduce by budding (yeasts) or growing colonies of attached organisms (mold).

Type III, *Multicellular*, consist of helminths (adult worms, larvae, and ova) and arthropods. Infections within this category depend on species, total number of helminths supported within the body of the host, and the host's defenses. The damage to the host varies from species to species. An example is the hookworm, which attaches directly to the intestinal mucosa and feeds on blood often causing anemia within the host.

Arthropods are important medically because they infest the human skin or serve as vectors in transmission of other pathogens.

Capsule

A few bacterial types, including a number of disease producing bacteria, are able to manufacture a capsule that surrounds the entire cell exterior to the cell wall. The role of the capsule in the life of bacteria has yet to be discovered, but it does serve as a protective structure from phagocytosis.

Bacterial Cell Wall

The bacterial cell wall is rigid, provides protection, and gives shape to the cell. The most abundant substance of the cell wall is peptidoglycan, a complex of short peptides and sugars.

Bacteria are divided into Gram-negative and Gram-positive groups based upon their reaction to a staining procedure, which is due to differences in their cell wall structures. (Figure 2). Gram-negative bacteria have a very thin peptidoglycan layer next to the cytoplasmic membrane. The outer layer of these bacterial membranes is thicker and is composed of lipoprotein and lipopolysaccharide attached to the peptidoglycan layer. This outer membrane contains the somatic O antigens and the endotoxin characteristic of Gram-negative bacteria.

Gram-positive bacteria have a heavy, rigid layer of peptidoglycan and teichoic acid that is thicker than that of Gram-negative cells. Gram-positive cells are more sensitive

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to the enzyme lysozyme, found in tears, saliva, and other body fluids, which hydrolyzes peptidoglycan.

Cytoplasm and Cytoplasmic Membrane

The cytoplasm contains ribosomes. Although the ribosomes function in a similar manner, it is possible to distinguish the ribosomes of prokaryotic cells from those of eukaryotic cells by their different sedimentation velocity in the ultra centrifuge. Bacterial ribosomes have a sedimentation value of 70s (Svedberg units), whereas eukaryotic ribosomes are larger and heavier with a sedimentation value of 80s.

Removal of the cytoplasmic membrane surrounding the entire cell will lead to bacterial lysis because the cell is unable to withstand the osmotic pressures found in nature.

Antimicrobial Agents

Chemical agents used as antiseptics and disinfectants affect pathogenic cells through disruption of the cell membrane. Many pathogenic cells possess a sulfhydryl group. Several agents such as benzalkonium, glutaraldehyde, and other disinfectants oxidize and combine with the sulfhydryl group inhibiting pathogenic virility. Other chemical agents such as iodophor and hexachlorophene concentrate on the cell surface altering the physical or chemical properties of the pathogen's cell membrane. This prevents normal cellular function and either destroys or inhibits the pathogen.

Most pharmaceutical agents can be classified on the basis of their site of action on the microbial cells:

1. Inhibition of cell wall synthesis occurs with penicillins, cephalosporins, bacitracin, and vancomycin. The mode of action is to inhibit peptidoglycan synthesis.

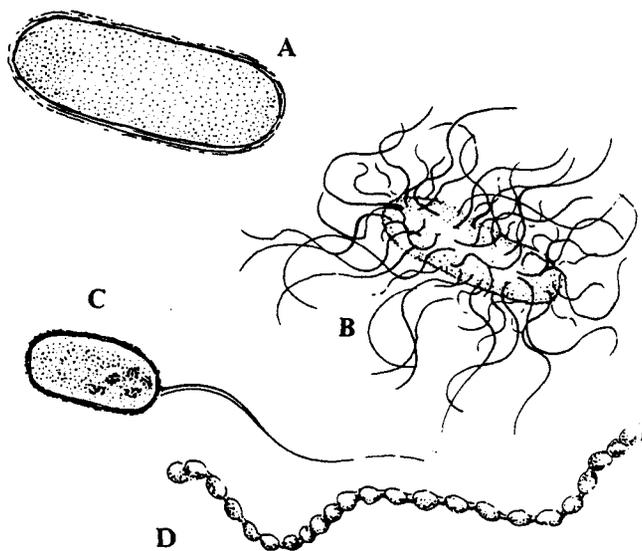


Figure 1. Examples of bacteria. **A**, *Eshcherichia coli* is a Gram-negative intestinal bacterium. Most strains are harmless, but some can cause diarrhea and urinary tract infections. **B**, *Proteus vulgaris* are Gram-negative bacteria that are a common cause of cystitis. **C**, *Pseudomonas aeruginosa* are Gram-negative bacteria that are an opportunistic pathogen in hospitals, important in causing lower respiratory and urinary tract infections. **D**, *Streptococcus* sp are Gram-positive bacteria that are one of the most common bacterial respiratory pathogens.

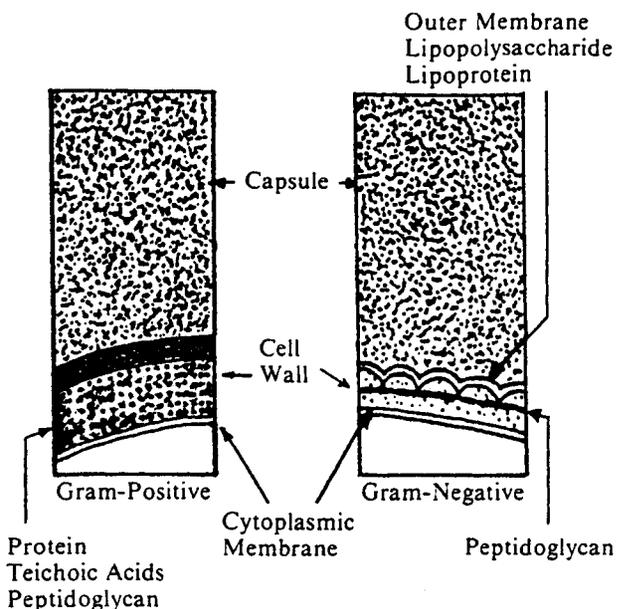


Figure 2. Cell wall structures of Gram-positive and Gram-negative bacteria.

2. Action against the cell membranes occurs with polymyxin, nystatin, amphotericin B, and imidazoles. These agents inhibit normal function of the bacterial cell membrane.

3. Inhibitors of protein synthesis include aminoglycosides, tetracycline, chloramphenicol, erythromycin, and lincomycin. These antimicrobials bind to a subunit of the bacterial ribosome causing a blockage of the initiation complex, meaning they cannot form peptide bonds, through interference with attachment of tRNA to the ribosome-mRNA complex and production of faulty proteins through distortion of the mRNA code.

4. Inhibition of transcription and nucleic acid synthesis causing potent inhibition of bacterial DNA-dependent RNA polymerase occurs with rifamycin, chloroquine, sulfonamides, and trimethoprim.

Conclusion

Knowledge of the bacterial cell wall function provides the surgical technologist with a deeper understanding of the need for aseptic techniques through use of antiseptics and disinfectants. The proper use of these agents in surgical hand scrubs and degerming the patient's skin provides the patient optimal protection against invading pathogens. Similar mechanisms of pathogenic destruction are employed by antibiotics when the patient acquires a localized or systemic infection. □

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