Antibiotic classification, mechanisms, and indications: A review

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Abstract
An antibiotic was originally a material created by one microorganism that selectively inhibits another's development. Since then, synthetic antibiotics have been developed that perform comparable tasks, typically chemically similar to natural antibiotics. There are no effects of antibiotics on viral infections. Antibiotics are used to treat bacterial infections in humans and animals. Several proposed classifications of antibiotics including chemical structure, mode of action, or organism of inhibitory activity. Most of the classification systems include two primary categories, the first categorizing based on chemical structure and the second categorizing based on the mechanism of action. Depending on their action, antibiotics are classified into bactericidal or bacteriostatic agents. Bactericidal agents kill or destroy the bacteria in the infected tissue; examples of bactericidal agents include penicillin, cephalosporins, fluoroquinolones, and aminoglycosides. Bacteriostatic agents cease bacterial multiplication, allowing other mechanisms of the immune system to kill the microbes. The antibacterial actions of antibiotics include inhibiting the bacterial cell wall, interrupting protein synthesis, plowing down the bacterial nucleic acid (DNA/RNA), inhibiting the biochemical metabolism, chelating metallic cations that are necessary for bacterial growth, and impairing the bacterial membranes by disintegrating it.

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Introduction

The classification of antibiotics is not routinely presented in all pharmacology textbooks, regardless of the intrinsic value of considering physical and chemical properties, as well as the most important activity against bacteria. classification including chemical structural and biological categorization, mechanisms of action, and some common examples for each group, together with their therapeutic use (Satoskar & Bhandarkar, 2020; Gallagher & MacDougall, 2022) [47, 19]. An antibiotic is a compound or substance synthesized by microorganisms and can inhibit or kill other microorganisms at a very low concentration. Antibiotics are used to treat bacterial infections in humans and animals. It was once thought that antibiotics may act as an absolute poison to microorganisms (m.o.) and hence these are named 'antibiotics'. But later, some antibiotics are purified and forced to gain up in accumulative concentration or prostration behave as reduced forms and accelerate the growth of many mouse crisis anemias produced a little package of amalgloylobulin oven dominant plasma cell. Antibiotics are only active against infective agents and there is no increase in virulence of them nor development of resistance to therapy. Therapy is based on the antibiotic response of the infective agent and the proper choice of appropriate antibiotic by following the way to culture and sensitivity test. Administration of a specific antibiotic is always based on proper patient, drug, and route factors. Antibiotics cannot act on viral

infections as both viral and bacterial infections have different modes of action (Urban-Chmiel *et al*., 2022 and MacInnes *et al*., 2022) [54, 36].

2. Historical Development of Antibiotics

The discovery and development of antibiotics were major steps in history that preceded major applications in the treatment and prevention of infections related to diseases and public health problems. The Nobel Prize for Medicine related to the development of the first antibiotic, that is, antigerm acid, was given in 1945 to Sir Howard W. Florey, Alexander Fleming, and Ernst B. Chain. Three factors will significantly contribute to the development of antibiotic discovery, which removes these details from other antimicrobial agents. They are highly potent, quite specific for m.o., and produce no significant host side effects. An antimicrobial agent is a natural or synthetic chemical that is selectively toxic to organisms, that is, bacteria, fungi, helminths, parasites, and rickettsiae, without having a toxic effect on the host (Graham, 2023 and Lalchhandama, 2021) [21, 33].

The treatment of infections and disease conditions, especially in intensive care units such as oncology, transplantation, transplantation of stem cells and solid organs, and endocrinology certainly requires pre-antitreatment strategies based on the patients or diseases involved. The mechanism of action of drugs in the treatment of disease and infections has been used in clinics, areas of trade, and the development of new and appropriate drugs for pre-antibiotics (pharmaceutical trade) in defense strategies. (Cook & Wright, 2022 and Uddin *et al*.2021) [13, 53].

3. Classification of Antibiotics

The diverse group of antibiotics has resulted in several proposed classifications, including by chemical structure, mode of action, or organism of inhibitory activity. The chemical structure is first classified as a beta-lactam or non-beta-lactam. Beta-lactam antibiotics have a four-membered β-lactam ring as a critical structure required for the antibacterial spectrum of activity. Several antibiotic classes are not present in the beta-lactam subgroup,

Classes of antibiotics

Penicillin Aminoglycoside 2- and 4-Quinolones Macrolides Tetracycline Carbapenem Cephalosporin Sulfonamide Glycopeptides Quinupristin and dalfopristin Rifamycin

Developing a systematic and practical classification system based mostly on similarities in chemical structure has been proposed, including beta-lactams, aminoglycosides, macrolides, quinolones, fosfomycin, polymyxin, sulphonamides, tetracyclines, and glycopeptides. Another informative classification is based on the specific mechanism of action, which includes the following subcategories: cell wall synthesis inhibitors, protein synthesis inhibitors, DNA replication inhibitors, RNA synthesis inhibitors, folate metabolism inhibitors, RNA polymerase inhibitors, mycobacterium tuberculosis inhibitors, antifungal, anti-malarial, and species-specific inhibitors. (Wang, 2023 and Sahoo and Banik 2020) [56, 46].

Most of the classification systems include two primary categories, the first categorizing based on chemical structure and the second categorizing based on the mechanism of action. The primary system discussed in this review will be based on the mechanism of action due to its level of detail and functionality. Thus, the mechanisms and indications sections may be accurately located under the primary category of drug action, (Klein et al., 2021 and Nguyen *et al*., 2020) [30, 38].

3.1. Classification Based on Chemical Structure

The major class is β-lactam antibiotics, which can be further classified into penicillins, cephalosporins, carbapenems, and aztreonam. Penicillins have diverse subclasses including natural, penicillinase-resistant (methicillin and oxacillin, nafcillin), aminopenicillins (amoxicillin and ampicillin), and antipseudomonal and extended-spectrum penicillins (piperacillin, ticarcillin). Tazobactam, clavulanic acid, and sulbactam are β-lactamase inhibitors that, used in combination with β-lactam antibiotics, inhibit the bacterial enzyme targeted against the drug, hence augmenting their antibacterial action. There are also other antibiotic classes, which are lincosamide, vancomycin, teicoplanin, ansamycin, macrolide, tetracycline, aminoglycoside, fluoroquinolone, and sulfonamide. (Lima et al. 2020 and Kim et al. 2023) [35, 28]. Depending on their action, antibiotics are classified into bactericidal or bacteriostatic agents. Bactericidal agents kill or destroy the bacteria in the infected tissue; examples of bactericidal agents include penicillin, cephalosporins, fluoroquinolones, and aminoglycosides. Bacteriostatic agents cease bacterial multiplication, allowing other mechanisms of the immune system to kill the microbes; examples include tetracycline, clindamycin, and metronidazole. The antibacterial actions of antibiotics include inhibiting the bacterial cell wall, interrupting protein synthesis, plowing down the bacterial nucleic acid (DNA/RNA), inhibiting the biochemical metabolism, chelating metallic cations that are necessary for bacterial growth, and impairing the bacterial membranes by disintegrating it. Each class of antibiotics is known to kill susceptible bacteria in one or more of these ways. Therefore, it is important to understand each antibiotic classification and its mechanism to use for the right clinical infection. (Baquero & Levin, 2021) [9] (Zhang & Cheng, 2022) [61].

3.2. Classification Based on Mechanism of Action

3.2.1. Inhibitors of cell wall synthesis: a) Beta-lactam antibiotics b) Glycopeptides c) Bacitracin (Bhattacharjee, 2022) [11].

3.2.2. Inhibitors of cell membrane function (Bu *et al*., 2022)

3.2.3. Inhibitors of protein synthesis: a) Aminoglycosides b) Tetracyclines c) Macrolides d) Chloramphenicol and Thiamphenicol e) Pleuromutilines f) Lincosamides g) Oxazolidinones h) Streptogramins i) Nitroimidazoles (Aguirre et al.2021) [4].

3.2.4. Inhibitors of nucleic acid synthesis: a) Inhibitors of DNA gyrase enzyme b) Inhibitors of DNA-dependent RNA polymerase enzyme c) Inhibitors of DNA-dependent DNA polymerase enzyme (Kirsch *et al*., 2022) [29].

3.2.5. Antimetabolites: a) Sulphonamides b) Trimethoprim (Acharya & Kurosu, 2023) [2].

3.2.6. Inhibitors of RNA synthesis

Based on the mechanism of action, the following are the categories of antibiotics. The main function of beta-lactam antibiotics and glycopeptides is to inhibit cell wall synthesis. Beta-lactam antibiotics exert their actions by inhibiting enzymes that form the structure of the cell wall due to the

inhibition of the synthesis of peptidoglycans during the replication of bacteria. Glycopeptides are recorded in interprim and vancomycin. They inhibit the synthesis of the peptidoglycan layer in cell walls through a mechanism different in peptidoglycan precursor formation. The most important characteristic of the inhibitors of cell wall synthesis is their bactericidal effect. Agents that IIR concentrated in macrophages and neutrophils show a concentration-dependent decrease in the number of bacteria in an inoculum with a time and concentration-dependent post-antibiotic effect (PAE) in mutants that change their behavior iv. Inhibitors of cell wall synthesis such as beta-lactam antibiotics and glycopeptides are affected at the time of processing, whereas pre-fasting decreases the effect of aminoglycosides. (Bhattacharjee, 2022 and Riu *et al.*,2022) [11, 44].

4. Mechanisms of Action of Antibiotics

The variety of antibiotics entering our medical practice is due to the great number of different cellular targets that the antibiotics attack. The main strategies of antibiotic action are related to the following key cellular functions (listed in order of importance): (Wilson *et al.*, 2020) [58].

1. Inhibition of Cell Wall Synthesis: The chemical structure of peptidoglycan in bacterial organisms is known in considerable detail because this structure is distinct from the cell walls of higher animal and plant cells. The success of the beta-lactam group of antibiotics in conserving peptidoglycan synthesis demonstrates the importance of its irreducibility. The larger numbers of agents used to treat gram-positive organisms than to treat gram-negative rods are due to the lesser permeability of this subgroup of microorganisms. Acids and lysozyme in nature constitute a line of defense in higher animals with significant control over bacterial infections (Frei *et al.*, 2023) [18].

2. Inhibition of Protein Synthesis: The bacterial cell has the largest number of protein-synthesizing ribosomes per unit of dry mass. The penicillins, chloramphenicol, tetracyclines, erythromycin, lincomycin, viomycin, puromycin, and streptomycin can all inhibit bacterial protein synthesis. Mitochondria possess a protein synthesis/photosynthesizing system analogous to that of the rickettsial and chloroplasts of the blue-green algae. Vanadomycin was active against *E. coli* and also blocked the chloramphenicol-resistant protein synthesis of everted-cell preparations of these organisms. Penicillin exerted no influence in the same preparations. Similarly, tetracyclines and erythromycins exert no influence when combined with each other in regard to blocking protein synthesis. Synergism between chloramphenicol and tetracyclines has not been studied in this context, but either chloramphenicol or tetracyclines combined with streptomycin seem to increase the total inhibition. Understanding why such agents should rescue penicillin-killed staphylococci and bring about a typical stimulating antagonism commonly seen with penicillin and neomycin. Activation of mitochondrial respiration to near-normal levels and reversal of the glycogen depletion induced by penicillin implicate these agents in a special way and would be relevant pathogenically (Anandabaskar, 2021 and Singhal *et al.*,2023) [7].

4.1. Inhibition of Cell Wall Synthesis

The first category of antibiotics is based on their mechanism of action, which involves the inhibition of the production of the bacterial cell wall. The bacterial cell wall is a flexible macromolecule that serves to overcome disruption by intra- and extracellular pressure, and it guarantees the shape and size of bacteria. The breaking of peptidoglycan cross-links weakens the entire cell wall, verifiably resulting in excessive autolysis in gram-positive organisms. In gram-negative bacteria, the release of additional cellular components is guaranteed, leading to potentiation of the inflammatory response. The strong autolysis is generally bactericidal when the bacteria are rapidly growing, and the inhibition of cell wall synthesis is curative. However, slowly growing cells often undergo controlled autolysis. The presence of β-lactam or vancomycin in the central compartment has a bacteriostatic action because dividing cells are killed while slowly growing cells are inhibited. (Giovannoni *et al.*,2020 and Wang *et al.*,2021) [20, 57].

This is the case of rapidly dividing mycobacteria, and it is the reason behind prolonged treatment times for tuberculosis. Because animal cells do not contain peptidoglycan, this category of drugs has several safety margins. The bactericidal activity is rarely fast as the mechanical lysis is progressive due to the continued osmotic action. Grande autolysis may lead to bacterial material. Bacteriostatic activity is generally not observed in rapidly growing cells, provided that the drug concentration meets the minimum inhibitory concentration. Bacteriostatic action is visible when a stationary phase is growing slowly. The site of inhibition can determine a greater or lesser ability to induce selective resistance. (Rohs & Bernhardt, 2021and Grishin *et al.*,2020) [45, 23].

4.2. Inhibition of Protein Synthesis

Protein synthesis – also called translation is an ordered process that involves the coordination of mRNA, tRNA, and rRNA, including the ribosome. In susceptible bacterial pathogens, protein synthesis is targeted at many molecular pathways to exert the characteristic bacteriostatic activity of antibacterial agents. Antibiotic interactions most commonly interfere with this path by blocking either the A (aminoacyl-tRNA), P (peptidyl-tRNA), or E (exit) site and the step of ribosomal mRNA decoding that is catalyzed by the 30S and/or 50S ribosomal viral subunits. For example, the bacterial translation initiation complex is composed of the 30S subunit, the mRNA, the formyl tRNA, the initiation factors (IF), and the energy-rich GTP. Next, the 50S subunit passes over the 30S initiation complex (IC), displacing the initiation factors (IF) and completing the 70S ribosome. (Varela *et al.*, 2021) [55]. Several protein synthesis inhibitors alter and block the coordinated movement of the ribosomal subunits during translocation of the tRNAs and the mRNA on the ribosome or by interacting with the elongation factors EF-G and EF-Tu involved with the movement of the ribosomal subunits and sequestration of aminoacyl-tRNA. Additionally, protein synthesis inhibitors like oxazolidinones and tetracyclines result in bacteriostatic activity due to their activity preventing the ending of translation. Bactericidal antibiotics, however, also act by inhibiting protein synthesis, unlike bacteriostatic antibiotics. Most acts with these agents are related to the block of initiation or with the initial steps of protein synthesis in comparison to the block in the step of elongation which is characteristic of bacteriostatic agents and those without action against bacterial protein synthesis. (Anandabaskar 2021and Ramachanderan & Schaefer, 2021) [7, 42].

4.3. Disruption of Cell Membrane Function

The mechanisms of action have been described below. Disruption of Cell Membrane Function resulting in Lysis of Cytoplasmic Membrane and Cell Leakage Lipids are important components of the cell membrane of both Gram-positive and Gram-negative bacteria. These lipid phospholipids include a hydrophilic head (glycerol with an attached phosphate group and either choline or ethanolamine) and two fatty acid chains that are hydrophobic and repel water. The primary differences in the phospholipids of the two cell membrane types are the presence/absence of teichoic acid and lipopolysaccharide (LPS). In Gram-positive bacteria, the cytoplasmic (inner) membrane is closely associated with a thick peptidoglycan layer. In contrast, the thick peptidoglycan layer of Gram-negative organisms appears between the cytoplasmic and lipopolysaccharide (outer) membranes, with the latter also made up of a phospholipid bilayer (Szlasa *et al.*, 2020) [50].

It should be noted that phospholipids, teichoic acid, and lipopolysaccharides are necessary for the maintenance of the integrity of the bacteria as they contribute to the selective permeability of the cell membrane. For instance, peptidoglycan incorporates d-amino acids and amino sugar polymers, is interconnected by short peptide cross-links, consists of long-chain hydrophilic glycan strands (N-acetylglucosamine and N-acetylmuramic acid, which are folded into an alternating sequence), and has repeating pentapeptide units. As essential components of the bacterial cell wall, these traits contribute to the structure of the cytoplasmic membrane by promoting curvature. Bacteria that exhibit these functions because of phospholipids, teichoic acid, and lipopolysaccharide, which create a selectively permeabilized membrane, die (Zheng *et al.*, 2024) [62].

4.4. Inhibition of Nucleic Acid Synthesis

4.4.1. Mechanisms The inhibition of bacterial DNA replication is a significant target of compounds. Quinolones are the preferred compound to be employed when the task is to target DNA gyrase, while TB antibiotics are also effective by targeting topoisomerase IV. From this stage on, moved on to present a thorough discussion of the antibiotic molecules that target bacterial ribosome (or RNA polymerase). This is excellent. The consensus is that identifying the mode of action of a novel antibacterial is a must. (Spencer & Panda, 2023 and Dighe & Collet, 2020) [49, 15].

4.4.2. Indications Tuberculosis is caused by an infection with *Mycobacterium tuberculosis.* The currently available drugs are classified into first-line therapy and second-line therapy. (Health Organization, 2021) [24]. The first-line drugs used for the treatment of TB are isoniazid (INH), rifampin (RIF), pyrazinamide, and ethambutol, Ofloxacin or levofloxacin, moxifloxacin, or gatifloxacin in addition to ethambutol can replace INH and RIF in those cases. Folate-synthesis inhibitors are used for the prevention and treatment of UTIs. Mechanisms of action include inhibition of the synthesis of tetrahydrofolic acid, which is essential for the survival of the microorganisms. The treatment of UTIs mainly targets the broad-spectrum nature. We divided the drugs based on their mechanisms of action into sulfonamides, trimethoprim, a combination thereof, and minocycline. As the first-line drugs of UTIs, bacteriostatic sulfonamides are used along with antibiotics targeting other structures of the ribosome such as rifampin (RNA polymerase) and levofloxacin (gyrase and topoisomerase). An experimental screening study was designed to maximize coverage, and thus, minocycline and doxycycline were listed. Moreover, these two drugs are broad-spectrum in terms of antifungal activity. (Peloquin and Davies 2021 and Prasad *et al*., 2021) [40, 41].

4.5. Inhibition of Metabolic Pathways

Despite much research suggesting that many different antibiotics inhibit the protein or nucleic acid synthesis of bacteria, it is also evident that a considerable number of antibiotics inhibit bacterial metabolic pathways. Some antibiotics inhibit the synthesis of metabolites and involve repression mechanisms. Inhibited processes include the biosynthesis of folic acid, isoprenoid biosynthesis, and fatty acid biosynthesis. It is important to understand the mechanisms by which antibiotics interfere with the metabolic pathways that contribute to a bacterium's ability to maintain growth, and so we have included the following general principles that could help to elucidate the mechanisms of all these classes of antibiotics that block metabolism. Although it is not always possible to specify the steps in a bacterium's metabolic pathway that are being blocked by an antibiotic, these closing points are often useful in evaluating the spectrum of antimicrobial activity of such agents (Lade & Kim, 2021 and Alavi and Hamblin 2023) [32, 6].

A detailed understanding of the mechanisms of action of antibiotics interacting with bacteria's metabolic pathways may help to determine the effectiveness of existing antibiotics against resistant organisms. As new approaches are designed to mount a defense against newly emergent resistant strains of bacteria, it might be possible, by understanding how such agents bring about the destruction of bacterial cells, to determine the spectrum of activities they might be able to do for a given agent. In three of the four classes of antibiotics outlined below, we have integrated descriptions of the synthesis of the corresponding pathways for the ease of comparing them, but we have separated the description of the related synthetic metabolic circuits in section 4.2, even though all four of them involve the synthesis of pyrimidine ribonucleotides (Abushaheen *et al*., 2020 and Uddin *et al*., 2021) [1, 53].

5. Common Indications for Antibiotics

It is indicated to prescribe an antibiotic for treatment.

Respiratory: The situations that employ the acronym SOUL (sinusitis, otitis, upper respiratory tract infection, and lower respiratory tract infection) are of high incidence among patients attending primary care services. Urinary tract: The urinary tract is one of the main routes of bacterial entry into the body, either from the outside or through the urethra.

Skin and soft tissues: The main causes of bacterial skin infections are Streptococcus groups A and B, especially S. aureus.

Gastrointestinal: There are numerous pathologies – of which acute diarrhea and acute infectious enteritis are the most representative – in which the causal germs are susceptible to treatment with an antibiotic.

Sexual transmission: Sexually transmitted infections are a frequent indication for empiric antibiosis because most of them often remain asymptomatic. However, if the possibility of a sexually transmitted disease is considered clinically valid, the usual empirical treatment should be administered unless there is a clear indication for microbiological confirmation.

Eye: Any infectious keratoconjunctivitis will be treated with a broad-spectrum ophthalmic antimicrobial.

Post-surgery: Antibiotics are prescribed to patients to reduce morbidity and avoid the possibility of local or systemic infection.

Childbirth, regardless of its route, particularly if vital risk factors for the newborn on the mother's side are estimated. Also peripartum emergencies, even in minor vaginal perineotomies. Sepsis, pyelonephritis, pneumonia, chorioamnionitis, meningitis peripartum, cesarean section for a vaginal emergency, the cesarean section before the start of labor, and if the time between rupture of membranes and delivery is prolonged. (Adaji *et al.*, 2020; Tietel *et al.* 2022and Mohammed et al. 2020) [3, 51, 37].

5.1. Respiratory Infections

Respiratory infections are the most common infectious conditions. This is not surprising given that the upper respiratory system is contiguous with the external environment, unlike the gastrointestinal system, for example, which is enclosed. Although respiratory infections can be mild and self-limiting, they also have the potential to become severe or be caused by pathogens that require more aggressive treatment.

Direct work with the national guidelines for Ireland indicates that the reasons for prescribing an antibiotic for respiratory (ENT, lung, and known chest infections) include acute sinusitis, acute symptoms suggesting ear infection (acute otitis media, AOM), sore throat, tonsillitis, and acute laryngitis. The lower respiratory tract encompasses the windpipe and the lungs. Known lower respiratory tract infections include (not exhaustive): colds and flu, sore throats, sinus problems and ear infections, coughs, and chest infections. The majority of these conditions are mild and will be self-limiting. However, they also have the potential to become severe and be caused by pathogens that might require an antibiotic treatment approach. (Oliveira *et al.*, 2020) [39].

In Ireland and the United Kingdom, guidance for both upper and lower respiratory tract infections is given by the National Institute for Health and Care Excellence (NICE). Bacterial pathogens play a role in respiratory tract infections. Streptococcus pneumoniae is the major cause of significant respiratory infections in almost all respiratory subsections. The underlying reasons for prescribing an antibiotic in respiratory (ENT, lung, and known chest infections) are detailed under each infection. Some management of respiratory infections aligns with the European Position Papers on Respiratory Guidelines, a collaboration from the European Respiratory Society (ERS) and the European Society for Clinical Microbiology and Infectious Diseases (ESCMID), available for respiratory clinical infections. This includes the important recent section under lung infections: Advances in treatment and diagnosis in community-acquired pneumonia in the European guidelines, which are useful. (Feldman and Anderson 2020 and Arguedas *et al.*, 2020) [17, 8].

5.2. Urinary Tract Infections

This is the second most common indication for antibiotic use. In diagnosing the urinary tract infection, we must confirm the extent of the infection. Factors affecting the selection and administration of a particular antibiotic include the following: the sex of the patient, with preferences for taking into account the dysfunction of the splenic functional panel, allergies, associative diseases (diabetes), levels of intelligence, awareness, motivation, and compliance with the treatment of the infections. Besides symptomatic therapy (scale agents, physical therapy, etc.), antimicrobial treatment is the most important alongside immunomodulation for the treatment of urinary tract infections. (Czajkowski *et al.*,2021) [14]. The antibiotics most commonly implicated in the decision for the treatment of urinary tract infections in humans are nitrofurantoin, fosfomycin, cotrimoxazole, cephalosporins, fluoroquinolones, fosfomycin, β-lactams (amoxicillin-clavulanic), and imipenem. In other words, quinolones, cephems, and β-lactams show higher activity in the cause of the urinary tract for gram-negative bacilli and bronchoscopy. Moreover, the multiplicity of antibiotics that treat the systemically related, complicated part of the zero is a clinical spectrum therapy. This fact is important; the virus is being treated when the virus is minimal. In deciding on the use of an antimicrobial agent, clinicians must consider the origin, physiology, and therapeutic status of the bacterium concerned, such as the classification of bacteria, the mode of action of an antimicrobial agent, bacterial resistance and superinfection, and finally the interaction between the antibacterial agent. In general, expert citizens who are familiar with evidence-based medicine know antibiotics, how they work, clinical usefulness, and insurance principles. To effectively manage an anti-infective step, it is essential to gain an understanding of the current rationale for the use of antibiotics. (Konwar *et al.*,2022 and Tutone *et al.*,2022) [31, 52].

5.3. Skin and Soft Tissue Infections

The spectrum of microorganisms that are involved in skin and soft tissue infections is variable but includes gram-positive organisms, gram-negative organisms, and anaerobic organisms. The microbiology of skin and soft tissue infections will depend on different factors such as local etiology, life circumstances, use of previous antibiotics, and comorbidities. The empiric selection of antibiotics for these patients depends on the severity of the infection, different risk factors, and the culprit organisms that are covered by the differential antibiotics. (Yueh *et al.*,2022) [60]. In most cases, however, the most common microorganism to be involved in these infections is S. aureus. MRSA is mostly responsible for the patient's comorbidities, underlying infection or condition, or risk factors for previous contact with MRSA or hospital outbreaks. Most bacterial etiologies are susceptible to empiric antimicrobial therapy, although the number of methicillin-resistant *Staph. aureus* (MRSA) skin abscesses have been increasing. Clostridial myonecrosis, called gas gangrene, is caused by the combined effect of these anaerobic bacteria and facultative or aerobic organisms, and the resulting metabolic products. It can also result from the polymicrobial infection of damaged tissues or any wound in an anaerobic environment. The optimal surgical therapy for gas gangrene includes prompt and extensive surgical debridement with wide margins, as well as adjunct hyperbaric oxygen therapy. It may be necessary to amputate a limb if the circulation is impaired. The antibiotics of choice for treating anaerobic pathogens are high doses of penicillin together with a beta-lactamase inhibitor, such as Augmentin. Metronidazole is the drug of choice for non-Clostridium anaerobic pathogens, such as Bacteroides and Fusobacterium. The studies are conflicting, however, regarding the role of hyperbaric oxygen therapy in the treatment of gas gangrene. (Bessa, 2023) [10].

5.4. Gastrointestinal Infections

Because gastrointestinal infections are commonly caused by bacteria, physicians resort to antibiotics. An exception is gastroenteritis, most of which (about 80%) has a viral etiology. The use of antibiotics in diarrhea of viral etiology is usually contraindicated due to the possibility of increasing the host's symptoms due to the drug resistance of the non-alterative viruses. In acute watery diarrhea with the possible origin of ETEC (Enterotoxigenic Escherichia coli) and V. cholera, antimotility agents such as loperamide can be associated with antibiotics such as ciprofloxacin. Acute bloody diarrhea due to Shigella, Salmonella, Campylobacter, Brucella, and EIEC (Enteroinvasive *Escherichia coli)* requires antibiotic therapy guaranteed solely by the identification of the pathogen. The drugs used must be efficient and the time necessary for the phenotypic test result would not compromise the evolution of the disease. (Iturriza-Gómara and Cunliffe, 2020 and Rao, 2021) [27, 43].

In hepatitis A, there is no specific treatment. Some steroids and azathioprine can be used in severe cases. The association of antibiotics and oral rehydration is beneficial for infection by EIEC and enteropathogenic Escherichia coli (typical symptoms of pseudomembranous enterocolitis). In all cases, the most important resource is the correct replacement of fluids and electrolytes. The suspicion of a possible etiology of Vibrio or *V. cholera* requires strict infection control procedures and the use of antibiotics such as doxycycline and ciprofloxacin. It is important to emphasize the clinical protocol, laboratory diagnosis, and vaccination against Hepatitis A, B, and C viruses. A very efficient form of control, especially in children, is the control of human feces: washing hands and long nails, the correct use of toilets, and oral vaccination or vaccination against rotavirus. Epidemiological surveillance is constantly necessary to define other etiological agents. Guidelines on the use of antibiotics for the treatment of infections of different etiologies are important. (Dutta *et al*., 2021 and Ahmadi, 2021) [16, 5].

5.5. Sexually Transmitted Infections

Sexually transmitted infections are infections that are mainly transmitted through sexual contact. Sexually transmitted infections may manifest in a variety of forms, including cervicitis, vaginitis, urethritis, orchitis, and proctitis, and may result in serious complications, including pelvic inflammatory disease, epididymitis, ectopic pregnancy, chronic pelvic pain, and infertility during long-term complications. Antibiotics for the management of sexually transmitted infections can either be prescribed empirically or after taking a genital or urine sample to confirm the diagnosis. Antibiotic choice depends on national policy, but treatment should reflect local resistance patterns to minimize the development of resistance. Sexual health services play a key role in identifying and treating people with sexually transmitted infections, both to reduce personal morbidity and to reduce the onward transmission of infection and the development of complications within the community.

Knowing which antibiotics to use in specific sexually transmitted infections, and what clinical and laboratory indications are required for a diagnosis, are important in prevention, general practice, and public health. Sexual health clinicians and microbiologists deal with a variety of infective agents causing sexually transmitted infections, such as *Neisseria gonorrhea* and Treponema pallidum. Clinicians in secondary care might also see different presentations, such as pelvic inflammatory disease and meningitis. Local policies might conflict with those issued by professional organizations. Inappropriate antibiotic use and resistance can lead to further transmission or recurrences of sexually transmitted infections, compromising herd immunity for scenario outbreaks and causing repellent genetic genome mating malformations within the community (Health Organization, 2021 and Workowski, 2021) [24, 59].

6. Conclusion

In summary, we hope that a proper foundational understanding of antibiotics is helpful for both budding clinicians and curious minds. It is our understanding that there has been greater emphasis on gross classification, which is of very clinical utility. There is some efficacy in identifying drugs by their basic structural class (i.e. penicillins, carbapenems, etc.), but the real utility lies in simply knowing what pathogens they cover and what indications they are used to battle. An early-year student may not have clinical rotations under their belt, but being able to pass STEP 1 or 2 and distinguish the big-picture drug classes will be important. However, the medical realm is moving to one of more integrated learning and away from board-specific e-learning. As such, the utility of this overview of antibiotics may be limited.

In practice, physicians are provided with updated idiosyncratic reports of "antibiograms" which tell them in their area what the most common pathogens are and what drugs are resistant to them. In effect, the number of drugs a physician may select from may be low to begin with after general physical examination and lab workup to find a focus of manifestation for infections. Moreover, the physician will generally have a general orientation to broad-spectrum agents - including coverage of pseudo-monads, which are often resistant bugs (that's what makes the widely popular "Zosyn"/piperacillin-tazobactam such a winner). Then their decision for an agent will be a combination of patient allergies, economic pressure on the patient, cost-effectiveness for payors, and general physician preference. These reasons have deterred us from discussing newer antibiotics. Furthermore, the modern pharmacologist and physician should temper these 20-plus drugs with a knowledge of each one's pharmacokinetics including absorption, distribution, metabolism, and excretion.

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