Microreviews in Cell and Molecular Biology 2012

Antibiotic Prophylaxis and Associated Bacterial Resistance

Author: Matthew Youngwirth
Major: Biological Sciences
Department of Microbiology and Molecular Genetics, Oklahoma State University, Stillwater, OK 74078, USA

Key Words:
Antibiotic prophylaxis, agriculture, bacterial resistance

Since the accidental discovery of Penicillin in 1928, the quality of life for the human race has been substantially improved. However, there is much controversy currently surrounding the guidelines to control cavalier use of antibiotics. The use of antibiotic prophylaxis as a protective measure against infections has led to antibacterial resistance in numerous settings. Non-therapeutic use of antibiotics in agriculture and livestock is a growing epidemic and a global threat to human health. Extended-spectrum beta-lactamases (ESBLs) are enzymes that are produced by various bacteria that are responsible for the resistant to beta-lactam antibiotics. ESBLs provide a good model for bacterial resistance inside the cell.

Introduction

Let's first determine how an antibiotic works within the human body. As many know, bacteria are single-cell organisms. Our immune system works against these organisms, but if they happen to triumph over the human immune system they can begin reproducing, thus causing disease. Destruction, or lysis, of the bacteria is equivalent to eliminating the disease. An antibiotic is a sweet poison that inhibits the bacterium's cell wall building mechanism, but is safe and un-altering to the human cell. Therefore, antibiotics work against the bacterium because they are a living, reproducing life form unlike a virus that is not living. Antibiotic prophylaxis obliterates the invading disease causing bacterial organisms by leaving behind healthy cells that compromise with the human natural immunities. Antimicrobial prophylaxis is used throughout the world to prevent infection in animals and humans.

The availability of antibiotics is one of the greatest successes of science and miracles of modern life. Diseases that decimated our ancestors are now routinely controlled and cured. But we, as a society, are on the brink of throwing all this away, at least in part, because of the hunger for inexpensive meat. A recent analysis by the Union of Concerned Scientists estimates that over 84% of the antibiotics produced in the United States are given to livestock in industrial animal agriculture, and most of this is for non-therapeutic purposes (Goldman) (Figure 1). Most often these antibiotic-resistant bacteria wind up contaminating our nations meat. If resistant variants that populate our food animals, such as Salmonella, Campylobacter, Listeria, and some types of E. coli, are not controlled, the human population will become infected with these bacteria. Once infected, there will be no cure to these diseases since those bacteria have developed antibiotic resistance.

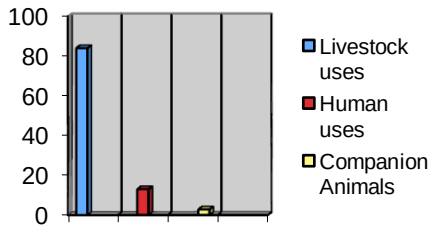

Figure 1. Percentage of antimicrobial use
The figure depicts the total percentage of antimicrobials used in the United States. Livestock usage (84%),

Recent Progress

Bacterial resistance to beta-lactam antibiotics and beta-lactamase inhibitors is an ever-increasing problem that threatens the clinical utility of drugs that form the cornerstone of the antibiotic arsenal. In recent years, there has been a major shift in the etiology of nosocomial infections, from more easily eradicated pathogens toward more resistant pathogens, with fewer options for treatment. Gram-negative pathogens resistant to beta-lactam antimicrobials have emerged as a major part of this disturbing trend (Shah). Due to the multi-resistance nature of these types of pathogens, controlling and preventing the spread of extended-spectrum beta-lactamases (ESBLs) is critical. ESBLs are beta-lactamases that hydrolyze extended-spectrum cephalosporins with an oxyimino side chain. These cephalosporins include cefotaxime, ceftriaxone, and ceftazidime, as well as the oxyimino-monobactam aztreonam (Shah). Mechanisms of resistance to these antibiotics include diminished permeability of the outer membranes of Gram-negative organisms, alteration of target penicillin-binding proteins, and production of beta-lactamases. Structurally, the lactamase enzyme breaks the beta-lactam ring open, which causes a deactivation of the molecule's antibacterial properties. Since antibiotic resistance is influenced greatly by antibiotic use, monitoring antibiotic use will help in controlling the spread of ESBLs. The expansion of structurally and mechanistically novel beta-lactamase among gram-negative pathogens is one of the most important means by which resistance occurs (Sanders). By examining the prevalence and the risk factors for development of resistance to extended-spectrum cephalosporin in beta-lactamase producing organism, we can determine prevalence of multidrug-resistant gram-negative organisms known to carry a chromosomally mediated inducible beta-lactamase (Sanders). The true prevalence of extended-spectrum beta-lactamase is not known and is probably underestimated because of difficulties encountered in their detection. However, it is clear that extended spectrum beta-lactamase producing organisms are distributed worldwide and their prevalence is increasing (Shah).

The use of a broad-spectrum antibiotic to fight infections is a widely used practice throughout the world of medicine. Many researchers believe individuals with minor infections are using antibiotics too frequently. The scare and concern with overuse of antibiotics is that bacteria can occasionally adapt to the continual use of the same antibiotic that was previously used to kill it, rendering the antibiotic ineffective. Therefore, the only way of treating and destructing this resistant organism is by using potentially toxic drugs or those that are experimental. Dosage and administration of antibacterial are also extremely important especially in postoperative prophylaxis in intensive care and in patients whose immune system are compromised. Prevention and control measures are also important due to the multi-resistant nature of these pathogens.

Discussion

Although antibiotic prophylaxis is used as a preventative, the great amount of antibiotics the United States uses in its food products, which are consumed daily, is very concerning. If the government does not regulate the use of antibiotics on food products, there will be an extrapolation in the number of antibiotic resistant bacteria. This will make many simple bacteria viruses deadly. Extended-spectrum beta-lactamases is an example of the increasing number and diversity of enzymes that inactivate beta-lactam type antibacterials. Our ability to successfully treat infections due to these increasingly resistant organisms demands a multifactorial approach combining continued research and development of novel classes of antibacterials, more prudent use of existing agents, and an increased emphasis on more effective infection control measures.

References

1. Goldman, Emanuel. "Antibiotic Abuse in Animal Agriculture: Exacerbating Drug Resistance in Human Pathogens." Human and Ecological Risk Assessment: An International Journal 10.1 (2010): 121-34. Print.
2. Sanders, Eugene W., and Christine C. Sanders. "Inducible P-Lactamases:Clinical and EpidemiologicImplicationsfor Use of Newer Cephalosporins." Review of Infectious Diseases 10.4 July (1998). Print.
3. Shah, A A., F Hansan, S Ahmed, and A Hameed. "Extended-Spectrum Beta-Lactamases (ESBLs): Characterization, Epidemiology and Detection." Critical Review in Microbiology 30.1 (2004): 25-32. Print.

