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Primary and Secondary Bacterial Infection

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Abstract

The principal modes of transmission of bacterial infection are contact, airborne, droplet, vectors, and vehicular. Preventive measures have a dramatic impact on morbidity and mortality. Such measures include water treatment, immunization of animals and humans, personal hygiene measures, and safer sex practices. Bacterial resistance to antibiotics is a growing concern mandating their prudent use.

Bacteria are unique among the prokaryotes in that so many of them are normal flora that colonizes the host without causing infection. Once a person is infected, clinically apparent disease may or may not be seen, and only in a small subset of infections do we see clinically significant disease. Bacterial infections can be transmitted by a variety of mechanisms. In order to be spread, a sufficient number of organisms must survive in the environment and reach a susceptible host. Many bacteria have adapted to survive in water, soil, food, and elsewhere. Some infect vectors such as animals or insects before being transmitted to another human.

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Introduction

Bacteria are microscopic, single-celled organisms [1]. They are among the earliest known life forms on earth. There are thousands of different kinds of bacteria, and they live in every conceivable environment all over the world. Some are airborne and others are most prevalent in water, soil, plants, animals, and even people. Many strains of bacteria are harmless and some are even beneficial, such as those found in the human gastrointestinal tract to aid digestion and produce vitamins. There are few (less than 1% of all bacteria types) that cause illness in humans. Some bacteria can be quite dangerous, resulting in salmonella, pneumonia, or meningitis.

New species and new variants of familiar species continue to be discovered, particularly as we intrude into new ecosystems. Both Lyme disease and Legionnaire's disease, now well-known to health-care professionals, were discovered as recently as the 1970s. The recent increased prevalence of highly immunosuppressed individuals, both due to AIDS and the increasing use of immunosuppressive drugs as chemotherapy and for transplantation of organs, tissues, and cells, has led to a population of patients highly susceptible to types of bacterial infections that were comparatively rare before [2].

First, the infectivity of an organism determines the number of individuals that will be infected compared to the number who are susceptible and exposed. Second, the pathogenicity is a measure of the potential for an infectious organism to cause disease. Pathogenic bacteria possess characteristics that allow them to evade the body's protective mechanisms and use its resources, causing disease. Finally, virulence describes the organism's propensity to cause disease, through properties such as invasiveness and the production of toxins. Host factors are critical in determining whether disease will develop following transmission of a bacterial agent. These factors include genetic makeup, nutritional status, age, duration of exposure to the organism, and coexisting illnesses [3]. The environment also plays a role in host susceptibility.

Structure of Bacteria

Binary Fission

Bacteria are prokaryotic organisms that carry their genetic information in a double-stranded circular molecule of DNA. Some species also contain small circular plasmids of additional DNA. The cell cytoplasm contains ribosomes and there is both a cell membrane and, in all species except Mycoplasma, a complex cell wall. External to the cell wall, some bacteria have capsules, flagella, or pili. Bacteria normally reproduce by binary fission. Under the proper conditions, some bacteria can divide and multiply rapidly. Consequently, some infections require only a small number of organisms to cause potentially overwhelming infection [4].

Need for oxygen: Aerobic or Anaerobic, based on their growth responses in the presence and absence of oxygen [5].

Scientific names: Bacteria, like other living things, are classified by genus (based on having one or several similar characteristics) and, within the genus, by species. Their scientific name is genus followed by species (for example, Clostridium botulinum). Within a species, there may be different types, called strains. Strains differ in genetic makeup and chemical components [6]. Sometimes certain drugs and vaccines are effective only against certain strains.

Shapes: All bacteria may be classified as one of three basic shapes: spheres (cocci), rods (bacilli), and spirals or helixes (spirochetes).

Non-bacterial Primary Infections

To reduce the risk of superinfections, cases of pneumonia caused by respiratory viruses including SARS-CoV-2 are often prophylactically treated with antibiotics that target a broad-spectrum of bacteria. The alternative, i.e., no prophylactic treatment, often results in bacterial infections, in principle, demonstrating the effectiveness of this strategy. Prophylactic use of antibiotics, however, contributes to the AMR crisis and is ineffective when patients acquire antibiotic-resistant strains-nosocomial hospital-acquired infections are commonly observed for ICU patients infected with a respiratory virus [7]. Nosocomial infections are becoming more common due to the rise of resistant bacterial pathogens. Alternative antibacterial therapeutic strategies are needed; such as phage therapy or phage-derived therapeutic proteins.

Secondary Bacterial Infections

Secondary bacterial infections develop in patients during or after initial infection with an infective pathogen, often a virus and are associated with high morbidity and mortality rates. Co-infections, secondary infections, or "superinfections" occur during viral epidemics; around 50 million deaths were ascribed to bacterial co-infections during the 1918–1919 Spanish Flu pandemic; although clinical records often do now record such infection complications. While secondary infections occur in succession to the primary infection, co-infections are caused by multiple pathogens of viral, bacterial, or fungal origin and occur simultaneously at the same time [8]. There tends to be a strong focus on a single pathogen rather than a combination of pathogens, especially for the viral–bacterial infections most commonly observed in patients. Staphylococcus aureus, Streptococcus pneumoniae, Neisseria meningitides, Haemophilus influenzae, Klebsiella pneumoniae, and members of the genus Proteus, Enterobacter, and Citrobacter spp., are some of the most commonly isolated bacteria during secondary infections. Hospitals are a common source of the pathogens that cause secondary infections, these so-called nosocomial pathogen infections are acquired from an environment in which antibiotics are commonplace, and as such; many have acquired resistance to a broad range of antibiotics [9].

MDR is a global health challenge as in many cases no (chemical) antibiotics exist to treat such infections, including secondary infections. Secondary bacterial infections are facilitated by the exposure to a pathogen together with an immune system that is inapt to appropriately react to both pathogen types, as a consequence of the primary viral infection. For such patients, the only option is to support their immune system and prevent progression of the infection that could lead to the death of the patient such as septic shock. Antibiotics therapies deployed as a "last resort" or the use of exceptionally high doses of antibiotics often have negative consequences. Many key human pathogens are showing resistance to antibiotics including Methicillin-resistant *S. aureus* (MRSA), multidrug-resistant Streptococcus, Vancomycin-resistant Enterococci (VRE), resistant Mycobacterium, Carbapenem-resistant Enterobacteriaceae (CRE), Colistin-resistant Klebsiella, Carbapenem-resistant Pseudomonas aeruginosa, and Carbapenem-resistant Acinetobacter baumannii [10]. The problem is exacerbated by the discontinuation by big pharma of chemical antibiotics discovery programs in the search for chemical antibiotics.

Conclusion

A Basic microbiology laboratory is generally able to culture bacteria from blood, sputum, and urine, but with the right materials any body fluid or tissue can be processed for culture. Specimens suspected of being infected with bacteria are plated on solid nutrient-rich media or inoculated into broth. On solid media, bacteria grow and produce colonies composed of thousands of cells. Colonies of different species have characteristic appearances and smells that help in their identification. In broth, growth is detected by the presence of turbidity and then the broth is subcultured onto solid media for identification. Some parasitic bacteria, such as Chlamydia and rickettsia, cannot be grown on artificial media and require the presence of host cells (cell culture) for growth. Others, such as Mycobacterium leprae (the agent of leprosy) and Treponema pallidum (the agent of syphilis) cannot be grown at all except in live animals.

Secondary bacterial infections play a critical role in the morbidity and mortality rates of patients initially falling ill with pulmonary viral diseases. Evidence from the current SARS-CoV-2 pandemic shows that the antibiotic-resistant bacterial infections are a significant threat to hospitalized COVID-19 patients. Nosocomial infections including ventilator-associated infections are often unavoidable and especially so during a pandemic, and the use of broad-spectrum antibiotics is often a routine preventative measure. Phage therapy is one of the most promising options for treating secondary bacterial infections. Phage therapy either as a stand-alone treatment or in combination with antibiotics may offer a valuable alternative for treating secondary bacterial infections. Clinical studies should evaluate the efficacy of phage therapy in virus infected patients.

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