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HIV and Tuberculosis: Bacteria and Viruses

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Abstract

Summary: A syndemic is defined as the convergence of two or more diseases that act synergistically to magnify the burden of disease. The intersection and syndemic interaction between the human immunodeficiency virus (HIV) and tuberculosis (TB) epidemics have had deadly consequences around the world. Without adequate control of the TB-HIV syndemic, the long-term TB elimination target set for 2050 will not be reached. There is an urgent need for additional resources and novel approaches for the diagnosis, treatment, and prevention of both HIV and TB. Moreover, multidisciplinary approaches that consider HIV and TB together, rather than as separate problems and diseases, will be necessary to prevent further worsening of the HIV-TB syndemic. This review examines current knowledge of the state and impact of the HIV-TB syndemic and reviews the epidemiological, clinical, cellular, and molecular interactions between HIV and TB.

Keywords: HIV; Viruses; Tuberculosis; Bacteria; Infectious disease

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Introduction

A syndemic is defined as the convergence of two or more diseases that act synergistically to magnify the burden of disease. The syndemic interaction between the human immunodeficiency virus (HIV) and tuberculosis (TB) epidemics has had deadly consequences around the world [1]. This review examines current knowledge of the state and impact of the HIV-TB syndemic and reviews epidemiological, clinical, cellular, and molecular interactions between HIV and TB. For example, a virus such as that which causes measles may be attenuated (weakened) and used as an immunizing agent. The immunization is designed to produce a measles infection in the recipient but generally causes no discernible alteration in the state of health. It produces immunity to measles without producing a clinical illness (an infectious disease) [2]. The most important barriers to invasion of the human host by infectious agents are the skin and mucous membranes (the tissues that line the nose, mouth, and upper respiratory tract). When these tissues have been broken or affected by earlier disease, invasion by infectious agents may occur. These infectious agents may produce a local infectious disease, such as boils, or may invade the bloodstream and be carried throughout the body, producing generalized bloodstream infection (septicaemia) or localized infection at a distant site, such as meningitis (an infection of the coverings of the brain and spinal Cord) [3]. Infectious agents swallowed in food and drink can attack the wall of the intestinal tract and cause local or general disease. The conjunctiva, which covers the front of the eye, may be penetrated by viruses that cause a local inflammation of the eye or that pass into the bloodstream and cause a severe general disease, such as smallpox. Infectious agents can enter the body through the genital tract, causing the acute inflammatory reaction of gonorrhoea in the genital and pelvic organs or spreading out to attack almost any organ of the body with the more chronic and destructive lesions of syphilis.

HIV Is a Driver of the TB Epidemic

Evidence that HIV serves as a driver of TB at the population level has been noted by multiple epidemiological studies (15, 20). In the United States, numbers of observed TB cases had been declining from 1980 to 1985 but increased by 20% from 1985 to 1992, with an estimated 51,700 excess TB cases attributed to the growing HIV epidemic. The largest increases in rates of TB occurred in areas and populations heavily affected by the HIV epidemic at the time: New York (84%), California (54%), urban areas (29%), and the 25- to 44-year age group (55%). In San Francisco, the HIV epidemic contributed an additional 14% of TB cases from 1991 to 2002. Most of these cases were due to a reactivation of latent TB, although 41% were attributed to recent transmission. In England and Wales, nearly one-third of the increase in numbers of cases of TB from 1999 to 2003 occurred in HIV-infected patients [4]. In South Africa, the burgeoning HIV epidemic was associated temporally with a worsening of the TB epidemic in a per urban community. As the HIV prevalence rate increased from 6.3% in 1996 to 22% in 2004, annual TB notification rates increased 2.5-fold, culminating in a staggering 1,468 TB cases per 100,000 persons in 2004. For each 1% increase in HIV prevalence, TB

notification rates increased by 55 cases per 100,000 persons in 1998 to 1999 and increased by 81 cases per 100,000 persons in 2004. Biologically, this association makes sense: increasing numbers of individuals immunocompromised by HIV infection lead to a larger reservoir of individuals susceptible to reactivation TB and result in more TB cases [5].

Bacteria

Bacteria can survive within the body but outside individual cells. Some bacteria, classified as aerobes, require oxygen for growth, while others, such as those normally found in the small intestine of healthy persons, grow only in the absence of oxygen and, therefore, are called anaerobes [6]. Most bacteria are surrounded by a capsule that appears to play an important role in their ability to produce disease. Also, a number of bacterial species give off toxins that in turn may damage tissues. Bacteria are generally large enough to be seen under a light microscope. Streptococci, the bacteria that cause scarlet fever, are about 0.75 micrometre (0.00003 inch) in diameter. The spirochetes, which cause syphilis, leptospirosis, and rat-bite fever, are 5 to 15 micrometres long. Bacterial infections can be treated with antibiotics.

Bacterial infections are commonly caused by pneumococci, staphylococci, and streptococci, all of which are often commensals (that is, organisms living harmlessly on their hosts) in the upper respiratory tract but that can become virulent and cause serious conditions, such as pneumonia, septicaemia (blood poisoning), and meningitis [7]. The pneumococcus is the most common cause of lobar pneumonia, the disease in which one or more lobes, or segments, of the lung become solid and airless as a result of inflammation. Staphylococci affect the lungs either in the course of staphylococcal septicaemia when bacteria in the circulating blood cause scattered abscesses in the lungs or as a complication of a viral infection, commonly influenza when these organisms invade the damaged lung cells and cause a life-threatening form of pneumonia. Streptococcal pneumonia is the least common of the three and occurs usually as a complication of influenza or other lung disease [8].

Viruses

Viruses are not, strictly speaking, living organisms. Instead, they are nucleic acid fragments packaged within protein coats that require the machinery of living cells to replicate. Viruses are visible by electron microscopy; they vary in size from about 25 nanometres for poliovirus to 250 nanometres for smallpox virus. Vaccination has been the most successful weapon against viral infection; some infections may be treated with antiviral drugs or interferon (proteins that interfere with viral proliferation) [9].

There are two serotypes of herpes simplex virus, HSV-1 and HSV-2. HSV-1 is the common cause of cold sores. The primary infection usually occurs in childhood and is without symptoms in 50 to 80 percent of cases. Between 10 and 20 percent of infected individuals have recurrences precipitated by emotional stress or by other illness. HSV-1 can also cause infections of the eye, central nervous system, and skin. Serious infections leading to death may occur in immunocompromised persons. HSV-2 is associated most often with herpetic lesions of the genital area. The involved area includes the vagina, cervix, vulva, and, occasionally, the urethra in females and the head of the penis in males; it may also cause an infection at the site of an abrasion. The disease is usually transmitted by sexual contact. In herpetic sexually transmitted diseases, the lesions are small, red, painful spots that quickly gesticulate, become filled with fluid, and quickly rupture, leaving eroded areas that eventually become scabbed [10]. These primary lesions occur from two to eight days after exposure and may be present for up to three weeks. Viral shedding and pain usually resolve in two weeks. When infections recur, the duration of the pain, lesions, and viral shedding is approximately 10 days.

Conclusion

The HIV-TB syndetic has had a major impact on human health and disproportionately affects people in Africa. However, a high prevalence of TB anywhere in the world poses risks to the health of people elsewhere, since TB is transmitted by the aerosol route. While the scale of the HIV-TB syndemic seems daunting, the application of existing knowledge and techniques for the diagnosis, treatment, and prevention of TB can make an impact. Further progress will require advances in our understanding of the dual biology of HIV and TB confections as well as a better understanding of the interactions of M. tuberculosis with HIV-infected and -uninfected humans and their innate and adaptive immune systems. Bacterial infections are commonly caused by pneumococci, staphylococci, and streptococci, all of which are often commensals (that is, organisms living harmlessly on their hosts) in the upper respiratory tract but that can become virulent and cause serious conditions, such as pneumonia, septicaemia (blood poisoning), and meningitis. The pneumococcus is the most common cause of lobar pneumonia, the disease in which one or more lobes, or segments, of the lung become solid and airless as a result of inflammation. Staphylococci affect the lungs either in the course of staphylococcal septicaemia when bacteria in the circulating blood cause scattered abscesses in the lungs or as a complication of a viral infection, commonly influenza when these organisms invade the damaged lung cells and cause a life-threatening form of pneumonia. Streptococcal pneumonia is the least common of the three and occurs usually as a complication of influenza or other lung disease. Viruses are not, strictly speaking, living organisms. Instead, they are nucleic acid fragments packaged within protein coats that require the machinery of living cells to replicate. Viruses are visible by electron microscopy; they vary in size from about 25 nanometres for poliovirus to 250 nanometres for smallpox virus. Vaccination has been the most successful weapon against viral infection; some infections may be treated with antiviral drugs or interferon (proteins that interfere with viral proliferation).

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