Human Immunodeficiency Virus: Cellular Interactions

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Acquired Immunodeficiency Syndrome (AIDS) is a viral disease that has assumed epidemic proportions in the last ten years. Since 1981, when the Centers for Disease Control first alerted the medical community of this then mysterious outbreak of bizarre and usually fatal infections in homosexual men, the incidence of AIDS has doubled every year. (1)

Scientists studying the phenomena identified a deficiency in the immune system (hence the name). The diagnostic features of AIDS are the appearance of one or both of two opportunistic infections in an individual who possesses antibodies to the human immunodeficiency virus (such an individual is referred to as seropositive). These infections are Kaposi’s sarcoma, and Pneumocystis carinii. The evidence of obvious HIV-induced illness in a seropositive individual without either Kaposi’s sarcoma or Pneumocystis carinii is known as AIDS-related complex, (ARC). Symptoms of ARC are weight loss, oral thrush, and lymphadenopathy (2), a disease of the lymph nodes. Around 10 percent of ARC patients eventually develop AIDS.(1)

The cause of the immunological paralysis associated with AIDS is the virtual debilitation of a specific part of the immune system. The different lymphocytes (commonly known as white blood cells) that compose the circulating portion of the immune system are divided into two groups, namely the B (or bursa-derived) lymphocytes and the T (or thymus-derived) lymphocytes. The B lymphocytes, or B cells, are responsible for humoral immune responses that are mediated by antibodies, and the T cells are responsible for cell-mediated immune responses. In a cell-mediated immune response, the T cells interact with antigens (foreign invaders into the body) on the surfaces of other cells. T cells are responsible for identifying and eliminating antigens in nearly all immune reactions. Regardless of the nature of the particular antigen—fungus, virus, bacterium or an infected host cell whose surface has been altered by a foreign substance such as a virus—the T cell must locate and destroy it.

In a cell-mediated immune response, after the T cells encounter antigens, they multiply and differentiate to become activated T cells. When the cells are involved in antigen-dependent differentiation, they activate into effector cells, such as cytotoxic (killer) T cells that are responsible for the lysis, or breakdown, of foreign cells; suppressor T cells that suppress immune response; and helper T cells, which secrete a substance called lymphokine that signals other T cells to differentiate and multiply. Because of their role of magnifying immune responses, helper T cells make up a crucial element in effective immune function. This paper deals primarily with helper T cells.

As stated above, the helper T cells are responsible for stimulating increased proliferation and
differentiation of other T cells. Therefore, after an antigen binds to a cell that possesses complementary surface receptors, the cell proliferates and differentiates into the various effector cells. After the initial immune response, the helper T cells are responsible for ensuring that the other effector cells continue to be present until the antigen is thoroughly eliminated. If the helper T cells are absent, then the immune response cannot proceed to completion, and the body is in danger of being overcome by the pathogen, or disease-causing agent.(1)

This paper examines the early interaction and infection of HIV into the helper T cells, the effects this has on the cell itself, and on some of the factors that influence this interaction. The data used here are based without exception on studies whose subjects were male individuals.

The HIV itself is enclosed in a lipid bilayer envelope that is studded with glycoproteins gp41 and gp120.(3a) This covers a matrix protein (p17) which in turn covers a cone-shaped core that houses the viral ribonucleoprotein containing the genetic information of the virus.(3b) The CD4 antigen serves as the cell surface receptor for HIV on monocytes, lymphocytes, and other cells (3c-e), which means that HIV can attach itself to the surface of the CD4 cells because of complementarity. When the virus encounters and attaches to a CD4 cell, gp41 (glycoprotein) mediates the fusion of the virus with the cell membrane. Grewe, Beck and Gelderblom reported that absorption, a second mode of entry, took place two minutes after exposing the cell to the virus at 4 degrees Celsius in vitro, and entry took place from one to three minutes later at 37 degrees Celsius. Absorption was carried out via clathrin-coated pits on the cell surface and vesicle formation. The vesicles then fused with the endosomal membranes for endocytosis. Endocytosis is not discussed further in any of the literature I found. Endocytosis takes more time than fusion, even though they both start after one to three minutes.

Fusion begins between the outer cellular membrane and the outer viral envelope at the specific attachment site. First the inner leaflet of the viral envelope and the inner lipid bilayer fuse, then either a seamless continuity between the two is established, or a rupture can occur at the fusion site. Penetration of the conical core of the virus follows formation of an opening—alogous to a silent, devastating rape. The core disintegrates and releases the viral ribonucleoprotein (RNP) into the cell. This is followed by vacuolization and cytolysis. The glycoproteins of HIV are incorporated into the cell membrane, which may be one explanation for the syncytia formation that commonly follows. At this point the CD4 cell has been taken over by the viral RNP, which has “written” its own sequences into the DNA of the cell by reverse transcriptase. The cell ceases to perform its previous function, and begins to manufacture new viruses. Eventually the cell bursts, releasing a multitude of new HIV into the system.(3)

The symptoms of AIDS usually do not appear soon after infection. As a matter of fact, the HIV-seropositive individual may be healthy for anywhere from two to five years after exposure to the virus. With such devastating effects on the helper T cells, this long incubation period is mysterious
to many scientists. It has been found that in vivo, HIV replication takes place only in activated T cells (as opposed to resting T cells) (4), and this may be associated with some of the delay. It has been suggested as well that adaptive immunity may influence the rate of virus replication and cell damage (5a) so that the actual debilitation of the immune system is achieved over a long period of time because the immune system is equipped to withstand the effects of HIV for a time, but not indefinitely. One of the adaptive responses is a rise in CD8 cells. This has been found to correspond to a lowered CD4 level in vivo. CD8 cells produce a diffusible lymphokine whose presence drastically lowers the reverse transcriptase activity, so it interferes directly with virus replication. (6) This is, of course, extremely positive for the HIV-infected individual, while this defense continues in its ability to maintain a high level of activity.

These are some proposed immune adaptations to the presence of HIV in the body. Unfortunately, after infection the virus insidiously works in the immune system, and the infected individual mounts an immune response, causing HIV antibodies to circulate in the system. At this point, the patient is considered seropositive. In men who develop HIV antigenemia (the appearance of HIV antigen that is detectable in serum or plasma) there is a highly increased chance of developing AIDS or ARC. The antigenemia is associated with lowered frequency of CD4 cells, and a lower presence of HIV antibodies. This stage precedes the development of AIDS or ARC symptoms. Patients who experience a transient or no antigenemia continue without symptoms. (2) I did not find accounts of people who were indefinitely asymptomatic, although the factors which determined the CD8 activity (6) and the presence or absence of antigenemia (2) are not known.

Because of the relative newness of HIV as an object of study, the body of information is constantly changing, and "old" theories about it are becoming obsolete as new information comes to light. Some areas that are lacking in information are the different entrance schemes (fusion and endocytosis), and what each determines in the process of infection; the relation of CD8 cells and their unique lymphokine to HIV and the reverse transcriptase activity; also any possible connections between CD8 cells and the development of antigenemia. The CD8-produced lymphokine and the CD4-produced lymphokine might be studied for their therapeutic possibilities.

As the study of AIDS progresses, so does its incidence in the human population: for every AIDS case in the United States and other epidemic areas, it is estimated that there are another fifty HIV-seropositive individuals without AIDS. (5b) The devastation that these individuals will probably endure is mirrored in a bizarre fashion in the cellular interactions of HIV. The ravages that take place in the cell parallel the disease in the whole organism as the pathogen enters and takes over.
LITERATURE CITED:


Works cited by Grewe, Beck, and Gelderblom:


Works cited by Giorgi J, et al: