

Chronic Lymphocytic Leukemia and Psychoneuroimmunology

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Abstract

This research paper discusses the pathology and causes of chronic lymphatic leukemia and the relationship that psychoneuroimmunology has with the progression and treatment of this chronic, incurable blood cancer. Discussions surround current data, demographics of those suffering from the disease, phases of the disease, and general biological information about the disease. Potential drug therapies, clinical trials, and stem cell transplantation are discussed as well as the role that behavioral modification and nutrition have in delaying the onset of the set of the latter phases of the disease as well as supporting the immune system in preventing secondary infections that could become life threatening. Additionally the roles that stress, coping, and social support have for a person suffering from CLL from a psychoneuroimmunological standpoint is investigated as well as recommendations for future research.

Chronic Lymphocytic Leukemia and Psychoneuroimmunology

Psychoneuroimmunology is a field of study that demonstrates the connection between the mind and the body through the management of the homeostasis of the body. There are many pathologies that are related to a deviation from homeostasis and often occur through the disruption of the normal healthy functions of the immune system (Walling, 2006). Chronic lymphocytic leukemia is one such illness that can benefit from the perspective of psychoneuroimmunology.

Leukemia is a well known cancer of the blood which can present itself in one of four forms (O'Conner & Boneva, 2007). The major types are acute myelogenous leukemia (AML), chronic myelogenous leukemia (CML), acute lymphocytic leukemia (ALL) and chronic lymphocytic leukemia (CLL). An acute leukemia has a more rapid progression whereas a chronic leukemia progresses more slowly. Chronic lymphocytic leukemia is a cancer of the white blood cells and it originates in bone marrow (O'Conner & Boneva, 2007).

Currently this blood disease has no known cause and no known cure. CLL is the generation of too many non-functioning white bloods cells in the bone marrow resulting in an overabundance injected into the blood stream. CLL can be aggressive or it can be passive depending on a variety of individualized factors (Shanafelt, Kay, Lee, Call, Grzegorz, Dingli, & Zent, 2005). However, the average person diagnosed with CLL in the United States is most often a male in his sixties.

Bone marrow is responsible for the formation of both red and white blood cells as well as stem cells which can develop into either red or white cells. CLL results in an accumulation of nonfunctioning white blood cells in bone marrow and the blood stream which eventually results in a negative impact upon the immune system (Zent, 2006). Specifically, those diagnosed with CLL have an impaired immune system and are not able to fight off illnesses and often succumb to secondary infections (Zent, 2006).

Psychoneuroimmunology's Influence

The study of psychoneuroimmunology focuses upon the role that psychological processes have upon the physical illness as well as the incorporation of stress and coping mechanisms which have an influence on overall health and wellness (Cohen & Herbert, 1996). Psychoneuroimmunology is related to CLL because the immune system is an integral part of how the body functions, survives, and maintains homeostasis which, in part, is accomplished when the immune systems reacts to destroy infected cells. With CLL the immune system is not functioning optimally and infections and diseases may overtake normally functioning cells.

The adrenal axis plays an important role in immune related diseases in a complex systemic manner. Specifically, the relationship between the hypothalamic-pituitary-adrenal axis and the sympathetic-adrenal-medullary axes when presented with chronic stress impair the immune system's ability to respond to physiological and environmental events. This can cause disruption at

the cellular level and can result in a reduction of T-cells (Reiche, Maria, Kaminami, Morimoto, & Nunes, 2005).

The autonomic nervous system has an important role with immunity in that the system can be altered and influenced by a variety of factors. One example is how the autonomic nervous system can increase white blood cell counts as well as increasing lymphocytes and neutrophils (Reiche et al., 2005). A variety of research is currently being conducted to assess the relationships between stress, the immune system, and the relationship between the production of B and T cells that will be of interest to CLL researchers.

It is estimated that over 11% of patients that have CLL will develop a second type of cancer such as Kaposi's sarcoma, myelodysplastic syndromes, acute myelogenous leukemia, brain cancer, bladder cancer, stomach cancer, or malignant melanoma (Shahid, Shahid, Rimawi, Siddiqui, Rossoff, Sison, Steinberg, & Rai, 2005). Therefore, monitoring the health of the immune system in those diagnosed with CLL is critical.

Pathology of Chronic Lymphocytic Leukemia

The roles and anatomy of the immune system are important to understand when studying the relationship between CLL and psychoneuroimmunology. The immune system consists of the primary lymphoid tissues, cells, secondary lymphoid tissues, antibodies, interacting serum proteins, cytokines, and chemokines (Rabin, 2005, p. 201-203). The primary lymphoid tissues consist of bone marrow and the thymus and these are the areas in which lymphocytes mature to become functional (Rabin, 2005). Bone marrow is the source of stem

cells, which can create a variety of cells, such as white blood cells and platelets and is also the region where non-functioning white blood cells form with CLL. The thymus further matures lymphocytes that have left the bone marrow and upon maturation they are released into the blood stream. This tissue begins to decrease with age, usually around age 60, and autoimmunity deficiencies associated with dysfunctions in the thymus have also been associated with Chronic Lymphocytic Leukemia (Miyakis, 2000).

The aging process is quite complicated and often results in weaknesses in the human body being exposed to a variety of illnesses or diseases. Adults are more likely to experience chronic illnesses in the later part of life rather than when they were younger (Penedo & Dahn, 2005, p. 81). The aging process impairs neuropsychosocial functioning as well as decreasing everyday problem solving skills; therefore psychologists and physicians should take an active role in educating their patients about preventative health strategies so that neuropsychosocial functioning can be maintained for as long as possible (Thorton, Deria, Gelb, Shapiro, & Hill, 2007).

As patients age they experience what is called immunosenescence which is the aging of the immune system (Penedo & Dahn, 2005, p. 83). During this process lymphocyte activities change resulting in decreased or impaired activity in the overall immune system. Therefore, Penedo and Dahn (2005, p. 87) note that over 40% of elderly patients who receive the flu shot do not develop proficient antibodies to fight the illness so preventative steps, such as

handwashing and proper nutrition, should be incorporated into a person's lifestyle as well.

With this understanding of the immune system a further understanding of chronic lymphocytic leukemia may be explored. CLL is not associated with an exposure to chemicals, drugs, or radiation which has been suggested to be associated with the other three forms of leukemia (Miller, 1980). Rather, the cause of CLL which is still being researched suggests that mutations in the deoxyribonucleic acid (DNA) in bone marrow occurs and is caused by of a loss or deletion of a chromosome (Athanasiadou, Stamatopoulos, Tzeou, Vadikolia, Asteriou, Fassas, & Anagnostopoulos, 2006).

Initially most patients diagnosed with CLL do not demonstrate any symptoms and the illness is often discovered because of a routine blood test (Zent, 2007). If there is a suspicion of CLL a physician will most likely order a bone marrow biopsy, immunophenotyping, cytogenetic analysis, and or a blood test to check for lymphocytosis. Upon testing physicians often are able to find abnormalities and they may offer patients the option to send their lab results to alternate research facilities that conduct unconventional research studies such as cytogenetic analyses to help further CLL research (Athanasiadou et al., 2006).

Symptoms of progressed CLL include frequent infections, loss of appetite, weight loss, an enlarged lymph nodes as well as hepatomegaly or splenomegaly (American Cancer Society, 2007). However, the Rai staging system of diagnosis and the Binet staging system are preferred mechanisms of diagnosing the prognosis and stages of CLL. The Rai Stage varies from stage 0, which is low

risk or minimal symptomology, to stages 1 and 2 which are intermediate risk, to stages 3 and 4 which are high risk CLL stages. The Binet Staging System supports this by assessing the number of inflamed lymph nodes and blood platelet levels in three stages with Stage A being asymptomatic to Stage C being more severe.

The prognosis markers for chronic lymphocytic leukemia currently revolve around measurements such as the increase of the number of lymphocytes present in the blood stream and the measurement of the precise chromosomal abnormalities present in the patient's blood stream. Current research hypothesizes that patients with a high level of zeta-associated protein 70 (ZAP-70) or high levels of a CD38 antigen are markers that may signal a more rapid progression of CLL and a lower long-term survival rate (Kim, 2004).

Regular monitoring of CLL includes a battery of blood analyses. A complete blood count is a regular test that include measurements of general white blood cells which should normally range from 3.8-10.8, red blood cells which should normally range from 4.4-5.8, and hemoglobin levels which should range from 13.8-17.2 and, if low, may indicate that the red blood cells cannot efficiently carry out the vital oxygen transport functions. Additionally, low hemoglobin levels result in anemia, and therefore, fatigue which is a side effect of CLL. Further, CBC measurements include hematocrit levels which on average range from 41-50%, red to white blood cell ratios, and platelet counts (Tefferi, 2005).

With CLL, the quantities of lymphocytes are monitored in the CBC report (Tefferi, 2005). Typically, for an average adult there will be more neutrophils than lymphocytes (B-cells plus T-cells). However, as CLL progresses, the absolute numbers of neutrophils may stay the same or even decrease, but the absolute numbers of lymphocytes (B-cells) increase rapidly (Khoury, 2003). The percentage of lymphocytes in the white blood cells increases with the progression of CLL and in advanced stages can reach absolute lymphocyte counts as high as 500K or more which implies that most of the white blood cells are lymphocytes. CLL is also associated with a decrease in neutrophil counts (Zent, 2006). Neutrophils are important for preventing and fighting infections. If this level is seen to be much lower than normal the risk for an infection increases due to the inability to fight off illnesses causing the person with CLL to be considered neutropenic.

Blood electrolytes are an additional measurement that is carefully monitored with CLL. These metrics include sodium (Na) which should normally range from 135-147, potassium (K) which ranges from 3.5-5.5, chloride levels, bicarbonate levels, calcium (Ca) which should range from 8.5-10.3, liver enzymes such as Serum Glutamic Pyruvic Transaminase (SGPT), and Lactic Acid Dehydrogenase (LAD) which is an additional liver enzyme with average healthy ranges varying from 313-618 (Blood Book, 2007). Additionally bilirubin levels are desired to fall within 0.0 to 1.0 which are reflective of liver processes, creatine levels should be within 0.8-1.5, blood urea nitrogen (BUN) which measures nitrogen in the blood as a waste product that is normally removed by

the kidneys in the urine should fall within levels of 8-20, and albumin levels of 3.5-4.7 with globulin levels of 2.2-4.2 are desired (Byrd, Peterson, Piro, Saven, Vardiman, Larson, & Schiffer, 2003).

Antibodies are also monitored for individuals diagnosed with CLL. Antibodies play an important role in the immune functions and although there are five major classes of antibodies, microbiologists believe that there are upwards of billions of variations of antibodies (Paustian & Roberts, 2005). Antibodies are created by the synthesization of proteins into either light chains or heavy chains and the class that an antibody falls into is determined based upon the type of chain located in the structure of the antibody.

The first type of antibody classification is Immunoglobulin A (IgA) which protects mucosal surfaces with a fluid like secretion and typically has a range detected in blood of 74-327 (Blood Book, 2007). IgA is found in serum, mucus, saliva, tears, sweat, and milk and has also been associated with being transferred to an unborn child (passive immunity) and it can also protect the child after birth for several months (Niers, Stasse-Wolthuis, Rombouts, & Rijkers, 2007).

A second type of antibody classification is Immunoglobulin E (IgE) which triggers the release of histamines by attaching to antigens, basophils, and mast cells. IgE does not make up a very large portion of antigens but it is responsible for reactions resulting in hives, asthma, and hayfever as examples (Paustian & Roberts, 2005).

A third type of antibody classification is Immunoglobulin M (IgM) which forms antibody-antigens processed by the liver which is usually measured in ranges from 29-214 (Blood Book, 2007). IgM makes up about 10% of the total antibodies and it is very important in the initial phases of an illness to stop the spreading of the pathogen (Paustian & Roberts, 2005).

A fourth type of antibody classification is Immunoglobulin G (IgG) which allows for the consumption of pathogens such as bacteria by coating them so that macrophages and neutrophils will be able to recognize them as pathogens. IgG is the largest classification of circulating antibodies and on average has ranges varying from 624-1680 (Blood Book, 2007).

The fifth type of antibody classification is Immunoglobulin D (IgD) which is lacking in enough research to clearly understand all of the functions. This antibody located on the surface of B-lymphocytes (Paustian & Roberts, 2005). Research studies are currently becoming focused on immature IgD antibodies to transfer them to becoming mature B cells in an effort to try and gain further understanding of the actual function IgD antibodies which may be of benefit for individuals with CLL (Koelsch et al., 2007).

Individuals with CLL also participate in immunophenotyping. Immunophenotyping is a way of characterizing cells by the antibodies that they display on their surface which can be of assistance in identifying specific proteins, or markers, on cellular surfaces for the purpose of accurately diagnosing how rapidly CLL may be progressing. This process, usually gathered from blood work but in some cases from bone marrow samples, can determine if

the lymphocyte samples are associated with CLL, if anemia or thrombocytopenia exists, and if gamma globulins (which fight infections) are being affected by the disease (Bayer HealthCare, 2007).

Typical immunophenotype tests for CLL include CD19/CD5/CD38, CD20, CD52, CD23, SIG Kappa, SIG Lambda, Kappa/lambda, pro-lymphocyte percentage, bone marrow cellularity, and infiltration of bone marrow (Bayer HealthCare, 2007). When these tests are reviewed it is important to assess a few more critically than the others such as the CD19/CD5/CD38. Patients with less than 30% of positive cells in the CD19/CD5/CD38 are more likely to have good CLL prognosis. CD23, which is considered to be the B-cell activation marker, should also be monitored closely as any cells with this marker may proliferate faster and is a signature of a CLL cell. Additionally, if the measurement of high bone marrow cellularity is a high percentage of the bone marrow it is considered to be an infiltration by CLL cells and a sign of advanced disease (Khoury, 2003).

Bio-Medical Treatment

CLL at this time is considered to be untreatable and therefore patients that are diagnosed with CLL in early stages often are told by their physicians that if they are asymptomatic chemotherapy or bone marrow transplant treatments should not be pursued as there is no evidence that these, or other available treatments, can prevent the onset of the advanced Rai Stages of disease progression (Giannopoulos & Schmitt, 2006). However, if there is significant growth in lymphocytes, an enlargement of the liver or spleen, or an increase in

nocturnal sweating, weakness or fatigue, or an increase in weight loss it is important to speak with physicians regarding potential treatments.

Currently potential treatments for CLL have the goal of reducing the accumulation of CLL cells while preventing infections by keeping the immune system healthy. When symptoms of advanced CLL are not present the patient continues without treatment while having regular blood tests as discussed prior. Upon the advancement of CLL to a stage in which it is symptomatic (which is usually noted by reaching Rai stages 3 or 4) there are a few options for treatment. Chemotherapy is an option; however it has not been shown to be a highly effective treatment. Medications such as Chlorambucil, Doxorubicin, Vincristine, Rituximab, and Prednisone are additionally pharmacological treatments that may be beneficial for CLL (LLS, 2006).

Stem cell replacement through bone marrow transplants in the severe stages of CLL is a potential therapy (Kim, 2004). However, this procedure is high risk and is usually only given to younger patients who have accelerated CLL who have a bone marrow donor that matches their stem cells.

Behavioral Interventions

Behavioral interventions have been extensively researched in the field of psychoneuroimmunology with the purpose of assisting mind/body healing and developing and implementing practical preventative techniques. There is evidence that group meetings and alternative therapies that change a person's lifestyle in a positive manner contribute to enhancing immune systems for those

who suffer from diseases that suppress the natural function of the immune system (Littrell, 1996).

Chronic Lymphatic Leukemia is a type of cancer that would benefit from behavioral interventions such as biofeedback techniques, massage, hypnosis, expressive writing, stress management, or exercise which may help decrease anxiety and increase states of relaxation. This can be beneficial in managing the side effects associated with this disease which includes fatigue, psychological stress, cancer-related pain, and sleep disorders (Antoni, 2005, p. 285-287). A person diagnosed with CLL should understand the basic relationship between their immune system functionality, stress management, and the progression of his or her disease. Littrell (1996) discussed studies that demonstrated that patients who actively looked for information about their disease, that arranged for their environment to be stress free, that focused on the meaning of life, and that actively sought out social support had not only lower levels of stress but they also had stronger natural killer cell activity which is very helpful to a person diagnosed with CLL.

Moderate exercise should also be incorporated into the lifestyles of individuals diagnosed with CLL. Studies have demonstrated a positive impact of exercise on the immune system as well as a decrease in behaviors such as anger, depression, and fatigue (Antoni, Schnieder, & Fletcher, 1990). Further behavioral interventions should include fatigue management, self-care, and psychological adjustment (Janice, 2004).

Nutritional Support

The field of psychoneuroimmunology recognizes that nutrition is a significant factor in the biopsychosocial model of managing overall health and preventing illness (Johnson & Kushner, 2001). As chronic lymphocytic leukemia progresses it becomes more important to incorporate a healthful diet and nutritional supplements into daily life so that the immune system can remain strong. Additionally, CLL patients often experience unintentional weight loss and a diminished ability to exercise so a nutritional program to support overall health is vital.

Proper hydration including consumption of green tea is recommended by the Mayo Clinic for those suffering from CLL (Shanafelt et al., 2005). Additionally, drinking green tea has been shown to be a beneficial supplement for the immune system's health and functionality (Shanafelt et al., 2007). Other beverages such as ACAI juice, pomegranate juice, and blueberry juice are high in antioxidants which naturally support the immune system and may be helpful for advanced stages of CLL although there are no clinical trials to support this hypothesis (Largeman-Roth, 2007).

A person with CLL should also incorporate the consumption of a multivitamin everyday as well as taking a calcium and magnesium supplement, which relaxes nerve and muscle cells, in a dosage of approximately 500mg a day. Further, consuming vitamin E is important as it is a fat-based antioxidant which protects the chain reactions of damage caused when a free-radical, such as the excessive white blood cells, enter the brain (Holford, 2004, p.270-1).

Further, a consumption of foods high in anti-oxidants may be beneficial. Beta-carotene can be found in carrots, sweet potatoes, dried apricots, squash and vitamin C can be found in broccoli, peppers, berries, tomatoes, citrus fruit all which should be consumed on a regular basis. Selenium which is found in oysters, seeds, tuna, mushrooms and lipoic acid which is found in red meat, yams, beets, spinach may also be beneficial but future clinical trials in these areas are anticipated (Murray& Pizzorno, 1998, p. 157).

Additionally, person diagnosed with CLL should supplement his or her diet with Vitamin C 500mg, B-Complex Vitamin, Beta Carotene 10,000 IU, as a fish, flax, borage, olive oil balance supplement. It is important that this regimen is approved by the medical team as each person diagnosed with CLL has a wide variety of symptomologies as well as progressive immunological related issues.

It is important to have a healthy diversified diet that does not result in excessive activation of the natural inflammatory response mechanism in individuals with CLL. For example, consuming a diet high in walnuts, spinach, salmon, onions, blueberries, and sweet potatoes as well as seasonings such as garlic, turmeric, and ginger are being studied as anti-inflammatory agents (Turner, 2007). There are also foods that have been proven to help boost the immune system's functionality which includes having two servings of fish per week, consuming oats and barley once per day in addition to alternative fibers, and eating two raw cloves of garlic per day (Rodale, 2006).

It is also beneficial to consume one 7-ounce portion of a probiotic yogurt, chicken soup (which demonstrated an ability to block the migration of

inflammatory white blood cells in a study by University of Nebraska), and natural black or green tea which is high in L-theanine and assists in maintaining the immune system (Rodale, 2006). When monitoring an individual with CLL it would also be beneficial to recommend the substitution of olive oil for butter or margarine products as olive oil has bioactive compounds that may be associated with the treatment, prevention, and progression repression of cancer (Escrich, Ramirez-Tortosa, Sanchez-Rovira, Colomer, Solanas, & Gaforia, 2006).

Stress and Coping

There is evidence that stress, and more specifically chronic stress, is associated with adverse effects on the immune system and this is further escalated with older adults (Graham, Christian, & Kiecolt-Glaser, 2006). Understanding stress and coping mechanisms is therefore even more important for a person diagnosed with CLL as they have a greater risk for a breakdown of the immune system and a subsequent infection that will proliferate in a much more aggressive manner than what may be experienced by someone without immunological stressors.

The biopsychosocial model is directly associated with stress and coping mechanisms (Ray, 2004). Walter Cannon and Hans Selye are founders of the manner in which current biopsychosocial models were developed to understand the relationship between stressors and the mental and physiological effects associated with the stressors. For example, Cannon defined the “flight or fight” mechanism that most people are all familiar with currently by assessing the

association of manner in which energy and inflammation were associated with blood flow and respiration (Brannon & Feist, 2004, p. 104).

Homeostasis is a concept that assumes that the body naturally has a place of balance and that disease, illness, and stress can remove the body from its natural homeostasis. This theory that Hans Selye supports how the human body's systems are integrated and do not act independently from each other to cause disease (Kaye & Lightman, 2005, p. 29-30). Humans are in a constant stasis in which reaction from the pituitary and hypothalamus affect the endocrine system and this results in a nervous system reaction. These up and down reactions can put strain on the immune system.

Psychopathology can be related to stress, nutrition, and external influences (Brannon & Feist, 2004, p. 440; Preston & Johnson, 2007, p. 30; & Werbach, 1999, p. 70). Stress may cause symptomologies that are at rest in the body to act up and potentially encourage psychopathologies. Selye worked to manage a concept that actually addressed the relationship between illness and stress (Brannon & Feist, 2004, p. 106-108). Additionally, Walter Canon recognized that the mind and psychological stressors can have a direct effect on a person's health and behavior (Cohen, Kessler, & Gordon, 1997, p. 12). Walter Canon believed that emotions were a part of the brain and that there was not a mind body separation; rather the mind and the body worked together (Lovallo, 2004, p. 34). Further, Cohen, Kessler, and Gordon (1997, p. 84) discussed and executed studies that assessed vulnerabilities people have with regard to how they cope with and manage stress as an indicator of the effect stress has on

each individual person's health as well as understanding the role social support systems have with helping reduce or increasing levels of stress.

Research in these areas has been advanced by the work and research often represented in the American Psychological Association by those interested in psychology and aging. Current topics of research include neuropsychological mediators of the links among age, chronic illness, and everyday problem solving skills as well as the understanding of how age and health are affected by psychosocial stressors (Thornton et al., 2007).

Depression is also an area of research that has been related to a suppression of the proliferation of lymphocytes. Older individuals who are observed having negative intrusive thoughts are observed having higher levels of the stress hormone cortisol (Graham, Christian, & Kiecolt-Glaser, 2006). Very often these behaviors are associated with the level of social support a person receives in terms of how they manage immune responses to a variety of situations.

Brannon and Feist (2004, p. 139) describe a health psychology behavioral model called the diathesis-stress model as a situation in which a person may be pre-disposed to a certain illness from a biological aspect and environmental stressors contribute to the onset, or triggering, of the illness. Now, there is further understanding of the relationship between psychological stressors and the immune system. Specifically, older adults experience stress differently from younger adults in areas such as mood and quality of life, bereavement, cognitions, coping, or personality (Thornton et al., 2007).

Psychoneuroimmunological implications with immune related diseases such as CLL include research that demonstrates there is a relationship between the health of the mind and the reaction on the body. An example of these implications include the relationship between events in life which could be either stressful or positive, perceived stress, traumatic stress, coping mechanisms, social support, personality, and anxiety and the impact these factors have upon the immune and neuroendocrine systems which can ultimately impact the progression of the disease (Antoni, Schneiderman, & Fletcher, 1990). Additionally, social support is related to better immune function which is vital for those diagnoses with CLL (Uchino, 2006).

Recommendations for Future Research

There are also exciting new fields of research that could benefit future individuals diagnosed with CLL. For example, Coghlan (2007) noted that a company named Lifeforce is now extracting blood from healthy individuals for an initial blood draw price plus a monthly storage fee with the goal of creating a copy of a person's healthy immune system so that healthy cells could be reproduced. Although this may seem to be an unproven stretch of the imagination many researchers feel there is potential for this type of work.

Further investigation into the existing understanding of the implications of a high ZAP-70 level, the unmutated $I_g V_H$ gene that high risk CLL patients carry, and CD38 levels would be recommended areas for future research as well as areas that are not clinically researched. One such area would be research in physiological and muscular therapies such as acupuncture. Walling (2006) noted

that the field of psychoneuroimmunology can benefit from furthering research in the area of acupuncture for symptomatic relief for cancer patients as well as assisting the overall homeostatic ability of the autonomic nervous system.

Further research in areas such as nutritional supplementations presents an opportunity to tie in human behavior and habits, the diathesis-stress model, and immunological responses. From a health psychology perspective additional research would be beneficial for chronic lymphocytic leukemia in areas such as mind-body relationships so that the medical community could embrace what the psychological community is already investigating with regard to the influence the brain has upon biology and the body (Ray, 2004). An example of how this research could be modeled would be to make a prediction about the occurrence of a stressful situation, monitor changes in the immune system, and track the changes in a person's overall health.

Psychoneuroimmunology assists in the understanding of how diseases can be acute, chronic, or behave in manners that are not clear but that may be influenced by a person's psychological belief system and behaviors. Understanding the relationship between the immune system and the biopsychosocial model offers great potential to assist those managing chronic lymphocytic leukemia.

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