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Opinion Article

Clinical Applications of Immune Surveillance: Preventing Rejection and Infections

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DESCRIPTION

Immune surveillance is the body's natural mechanism of monitoring and detecting abnormal cells, including cancer cells and pathogen-infected cells, to prevent disease. This critical function of the immune system plays a important role in maintaining health and combating infections. In clinical settings, enhancing immune surveillance can have significant applications, particularly in preventing transplant rejection and managing infections. This study discusses about the mechanisms of immune surveillance, its role in clinical applications, and strategies to enhance this function to prevent rejection and infections.

pathophysiology of immune surveillance

Immune surveillance involves a complex network of immune cells, including Natural Killer (NK) cells, T cells, and Antigen-Presenting Cells (APCs), that work together to identify and eliminate abnormal cells. NK cells are important for detecting and destroying infected or transformed cells without the need for prior sensitization. They recognize stressed cells through activating and inhibitory receptors. Cytotoxic T Lymphocytes (CTLs) recognize and kill cells presenting foreign or abnormal antigens *via* Major Histocompatibility Complex (MHC) molecules. They play a significant role in targeting virus-infected cells and cancer cells. Dendritic Cells (DCs) capture antigens from pathogens or abnormal cells and present them to T cells, initiating an adaptive immune response. Macrophages cells engulf and digest pathogens and dead cells, and they also present antigens to T cells, linking innate and adaptive immunity.

Clinical applications in preventing rejection

Organ transplantation is a life-saving procedure for patients with end-stage organ failure. However, the immune system often recognizes the transplanted organ as foreign and mounts an immune response against it, leading to rejection. Enhancing immune surveillance can help in preventing rejection in several ways. Immunosuppressive therapy while traditionally used to dampen the immune response, modern immunosuppressive drugs can be customized to balance the prevention of rejection with the preservation of immune surveillance against infections. Drugs like tacrolimus and cyclosporine inhibit T cell activation, reducing the likelihood of rejection. T cell depletion strategies like using Anti-Thymocyte Globulin (ATG) can deplete T cells, reducing their ability to mount a response against the transplanted organ while maintaining the capacity to combat infections. T regulatory cells (tregs) are critical in maintaining immune tolerance. Enhancing the function or numbers of Tregs through therapies like low-dose *IL-2* can help in preventing transplant rejection by promoting tolerance to the transplanted organ. chimerism inducing mixed chimerism, where both donor and recipient hematopoietic cells coexist, can promote immune tolerance and reduce the need for long-term immunosuppression. In bone marrow transplantation, particularly in cases of allogeneic transplants, the risk of Graft-Versus-Host Disease (GVHD) is a significant concern. Enhancing immune surveillance can mitigate risk donor selection using matched donors can reduce the incidence of GVHD while ensuring effective immune surveillance against infections. Post-transplant cyclophosphamide strategy selectively eliminates alloreactive T cells, reducing GVHD risk while preserving the graft-versus-leukemia effect and immune surveillance. Adoptive T cell transfer infusing donor-derived Tregs can help in modulating the immune response, reducing GVHD and enhancing immune surveillance against infections.

Clinical applications in preventing infections

Cancer treatment in cancer, immune surveillance is often impaired, allowing tumor cells to evade detection and proliferate. Enhancing immune surveillance can boost the body's ability to recognize and destroy cancer cells are checkpoint inhibitors drugs like pembrolizumab and nivolumab inhibit checkpoint proteins (PD-1, CTLA-4) that cancer cells exploit to avoid immune detection. By blocking these proteins, these drugs enhance T cell activity against cancer cells. CAR T cell therapy involves engineering patients' T cells to express Chimeric Antigen Receptors (CARs) that recognize specific antigens on cancer cells, enhancing immune surveillance and targeting of tumors. Cancer

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vaccines therapeutic vaccines that present tumor antigens to the immune system can boost immune surveillance and promote an immune response against cancer cells. Infectious diseases enhancing immune surveillance is important in managing infections, particularly in immunocompromised patient's antiviral therapies drugs like interferons can enhance immune surveillance by boosting the antiviral response, helping in the control of viral infections like hepatitis B and C. Immunomodulators agents like *IL-7* and Granulocyte Macrophage Colony Stimulating Factor (GM-CSF) can stimulate immune cell production and function, enhancing immune surveillance in patients with immunodeficiencies or undergoing chemotherapy. Probiotics and prebiotics modulating the gut microbiota with probiotics and prebiotics can enhance mucosal immunity and immune surveillance against gastrointestinal pathogens.

Challenges and future directions

While enhancing immune surveillance holds great potential, several challenges need to be addressed:

Balancing efficacy and safety: Enhancing immune surveillance must be balanced with the risk of excessive immune activation, which can lead to autoimmunity or inflammatory damage.

Individual variability: Differences in genetic makeup, underlying health conditions, and microbiome composition can affect the efficacy of immune-enhancing therapies, necessitating personalized approaches.

Long-term effects: Long-term effects of enhancing immune surveillance, particularly in terms of immune aging and potential for chronic inflammation, need further study. Enhancing immune surveillance offers a promising strategy for preventing transplant rejection and managing infections, with significant implications for clinical practice. By leveraging advances in immunotherapy and understanding the mechanisms of immune surveillance and develop targeted therapies that enhance the body's natural defenses while minimizing risks. Continued research and clinical innovation will be important in optimizing these approaches, ultimately improving outcomes for patients undergoing transplantation or facing infectious diseases.