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Immunomodulatory Effects of Anticancer Drugs: A Comprehensive Review

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Introduction

Anticancer drugs have long been recognized for their primary role in targeting cancer cells and inhibiting tumor growth. However, emerging evidence suggests that these drugs can also exert significant immunomodulatory effects, influencing the immune system's response to cancer. Understanding the immunomodulatory properties of anticancer drugs is essential for developing effective combination therapies and improving patient outcomes. In this comprehensive review, we explore the diverse mechanisms by which anticancer drugs modulate the immune system and discuss their potential implications for cancer treatment. The field of cancer treatment has witnessed remarkable advancements in recent years, with a growing focus on immunotherapy as a promising approach. While traditional anticancer drugs primarily target cancer cells, emerging evidence suggests that many of these agents possess immunomodulatory effects as well. This comprehensive review aims to explore the immunomodulatory properties of various anticancer drugs, shedding light on their potential to enhance immune responses against tumors [1].

Description

Chemotherapeutic agents

Drugs such as cisplatin and doxorubicin induce Immunogenic Cell Death (ICD), promoting the release of danger signals and stimulating antitumor immune responses. Paclitaxel and vincristine can enhance antigen presentation and activate T cells, leading to an improved antitumor immune response. Cyclophosphamide and gemcitabine can selectively deplete regulatory T cells (Tregs), thereby relieving immunosuppression and promoting antitumor immunity [2].

Targeted therapies

TKIs, such as imatinib and sorafenib, can inhibit tumor cell growth and also affect the tumor microenvironment, leading to decreased immunosuppression and enhanced immune surveillance. ICIs, including anti-PD-1/PD-L1 and anti-CTLA-4 antibodies, block inhibitory signaling pathways, reinvigorating exhausted T cells and boosting antitumor immune responses. CAR-T cell therapy and TCR-engineered T cells can enhance immune responses by genetically modifying T cells to specifically recognize and attack cancer cells. Vaccines, such as peptide-based or dendritic cell-based vaccines, can activate tumor-specific T cells and prime the immune system against cancer cells [3].

Metronomic chemotherapy

Low-dose, frequent administration of chemotherapeutic drugs can have immunomodulatory effects. Metronomic chemotherapy can inhibit angiogenesis, promote the expansion of effector immune cells, and suppress immunosuppressive cells, leading to enhanced antitumor immunity. The integration of immunomodulatory agents with conventional anticancer drugs has shown promising results. Synergistic effects can be achieved by combining chemotherapy, targeted therapies, and immunotherapies to maximize tumor cell killing while augmenting immune-mediated tumor clearance. Chemotherapy, a cornerstone of cancer treatment, primarily acts by killing rapidly dividing cancer cells. However, growing evidence suggests that certain chemotherapeutic agents possess immunomodulatory effects as well. For example, some agents, such as cyclophosphamide, can deplete regulatory T cells (Tregs), which suppress immune responses. Other chemotherapeutic drugs, including doxorubicin and paclitaxel, can enhance the presentation of tumor antigens to immune cells, promoting an antitumor immune response. Targeted therapies, such as monoclonal antibodies and small molecule inhibitors, have revolutionized cancer treatment. Beyond their intended targets, these therapies can modulate the immune system. For instance, immune checkpoint inhibitors, such as pembrolizumab and nivolumab, block inhibitory signals on T cells, reinvigorating the immune response against cancer. Additionally, tyrosine kinase inhibitors, like imatinib and dasatinib, have been shown to influence immune cell activity and cytokine production Immunotherapies harness the power of the immune system to recognize and eliminate cancer cells. Cytokines, such as interleukin-2 (IL-2) and interferons, can boost immune cell activity and promote tumor cell death. Adoptive cell therapies, such as Chimeric Antigen Receptor (CAR) T-cell therapy, genetically engineer T cells to recognize specific tumor antigens, leading to tumor destruction. These approaches not only directly kill cancer cells but also enhance immune responses by activating and expanding immune cells [4,5].

Conclusion

The immunomodulatory effects of anticancer drugs have emerged as a critical factor in cancer treatment. Understanding these effects provides opportunities for developing novel combination strategies that harness the immune system's potential to eradicate cancer. Further research is warranted to optimize drug combinations, dosing schedules, and patient selection to maximize the therapeutic benefits of immunomodulatory anticancer regimens. Ultimately, harnessing the power of the immune system in conjunction with anticancer drugs holds great promise for improving patient outcomes and ushering in a new era of cancer treatment. Anticancer drugs not only directly target malignant cells but also exhibit immunomodulatory effects, highlighting their potential to harness the immune system in fighting cancer. Understanding and utilizing these immunomodulatory properties can lead to the development of novel treatment strategies, combination therapies, and improved patient outcomes. Further research and clinical trials are warranted to fully explore the immunomodulatory potential of anticancer drugs and optimize their integration into cancer treatment protocols.

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Conflict of Interest

None.

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