CHAPTER 3

STIMULI-RESPONSIVE NANOCARRIERS FOR TARGETED CANCER THERAPY

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INTRODUCTION

Cancer, a complex disease characterized by uncontrolled cell proliferation and a tendency to metastasize, is a public health problem that remains of global importance, causing approximately 10 million deaths in 2022 (1, 2). While a small ratio of cancers have an inherited genetic basis, most result from acquired risk factors such as carcinogen exposure, lifestyle, and environmental pollutants (2, 3). Conventional therapies such as surgery, chemotherapy, and radiotherapy have been the main approaches of cancer treatment for decades. While surgery is appropriate for early-stage solid tumors, chemotherapy and radiotherapy are more commonly applied due to their ability to target rapidly proliferating cells (2, 4). However, these conventional methods have significant drawbacks. For example, because chemotherapeutics are nonspecific, they target all rapidly proliferating cells, which can lead to collateral damage in healthy tissues such as bone marrow, hair follicles, and intestinal epithelium, leading to serious side effects such as myelosuppression, alopecia, and mucositis (5).

These dose-limiting toxicities, which include neutropenia, cardiomyopathy, and nephrotoxicity, often determine the maximum tolerated dose and may negatively impact treatment success (6).

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DOI: 10.37609/akya.3840.c1154

in cancer treatment, offering advantages such as controlled/targeted release, extended therapeutic window, and reduced systemic toxicity.

CONCLUSION

In conclusion, this review highlights the critical role of targeted nanocarriers in cancer therapy, emphasizing their ability to exploit tumor-specific internal stimuli such as pH, redox imbalance, enzymatic activity, and hypoxia for precise and selective drug release. In addition, external stimuli including light, ultrasound, magnetic fields, temperature, and electric fields provide spatiotemporal control, enabling on-demand and non-invasive modulation of drug delivery. These smart delivery systems not only enhance drug solubility, stability, and tumor accumulation but also minimize systemic toxicity by concentrating therapeutic action within the tumor microenvironment. By integrating the principles of nanotechnology with stimuli-responsive strategies, targeted nanocarriers present a promising solution to the limitations of conventional chemotherapy. While significant progress has been made in preclinical studies, further research is needed to ensure clinical translation, large-scale reproducibility, and regulatory approval, paving the way for their incorporation into personalized cancer treatment.

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