Kashf Journal of Multidisciplinary Research
Vol:03 - Issue02(2026)
P-ISSN: 3007-1992 E-ISSN: 3007-200X
https://kjmr.com.pk

BACTERIAL THERAPY FOR CANCER: A REVIEW OF MECHANISMS, APPLICATIONS, AND FUTURE PROSPECTS

***Marwana Magaji[1], Ashiru Magaji[2]**

[1] Sultan Abdulrahman College of Health Technology Gwadabawa, Nigeria.

[2]Sokoto State University, Nigeria.

[*]***Corresponding Author:***(magajimarwana123@gmail.com)

DOI:(*https://doi.org/10.71146/kjmr824*)

Article Info

Abstract

Cancer remains one of the leading causes of morbidity and mortality worldwide, despite major advances in surgery, chemotherapy, radiotherapy, and immunotherapy. However, many conventional treatments are associated with serious side effects, drug resistance, and limited specificity for tumor cells. In recent years, bacterial therapy has re-emerged as a promising alternative or complementary strategy for cancer treatment. Certain bacteria have the natural ability to selectively target tumors, stimulate anti-tumor immune responses, and deliver therapeutic molecules directly to cancer cells. This review discusses the historical background, mechanisms of action, types of bacteria used in cancer therapy, genetic engineering approaches, clinical applications, challenges, and future directions of bacterial-based cancer therapy.

Keywords:

Cancer; Bacteria; Therapy; Salmonella; Tumor; Anti-tumor

1. Introduction

Cancer is characterized by uncontrolled cell growth resulting from genetic and epigenetic alterations. Although current treatment modalities have improved survival rates for many cancers, they often lack specificity and may damage healthy tissues. These limitations have driven the search for novel therapeutic strategies that are more targeted and less toxic (Hanahan and Weinberg, 2011).

Bacterial therapy for cancer is not a new concept. Its roots can be traced back to the late 19th century when William Coley observed tumor regression in cancer patients following bacterial infections. Although this approach was largely abandoned with the development of modern cancer therapies, renewed interest has emerged due to advances in microbiology, molecular biology, and genetic engineering (McCarthy, 2006). Today, bacteria are being explored as tumor-targeting agents, immune system modulators, and delivery vehicles for anti-cancer drugs.

2. Historical Background of Bacterial Cancer Therapy

The earliest documented use of bacteria in cancer treatment dates back to the 1890s, when William Coley developed "Coley's toxins," a mixture of heat-killed *Streptococcus pyogenes* and *Serratia marcescens*. Some patients showed significant tumor regression, suggesting that bacterial infections could stimulate anti-tumor immunity (Hoption Cann *et al*., 2003).

Despite these early successes, bacterial therapy fell out of favor due to inconsistent results and the rise of radiotherapy and chemotherapy. However, modern scientific tools have revived interest in this approach, allowing for better control, safety, and understanding of bacterial behavior in tumors.

3. Mechanisms of Bacterial Therapy in Cancer

Bacteria exert anti-cancer effects through multiple mechanisms, which often work synergistically.

3.1 Tumor Targeting and Colonization

Solid tumors often contain hypoxic, necrotic, and immunosuppressed regions that are difficult for conventional therapies to penetrate. Many bacteria, particularly anaerobic and facultative anaerobic species, preferentially grow in these environments (Forbes, 2010). This selective colonization allows bacteria to accumulate within tumors while sparing normal tissues.

3.1 Immune System Activation

Bacterial presence in tumors stimulates both innate and adaptive immune responses. Components such as lipopolysaccharides, flagellin, and bacterial DNA activate immune cells, leading to the production of cytokines and recruitment of cytotoxic T cells that attack cancer cells (Zitvogel *et al*., 2017).

3.3 Direct Tumor Cell Killing

Some bacteria produce toxins, enzymes, or metabolites that directly induce cancer cell death through apoptosis or necrosis. Others compete with tumor cells for nutrients, thereby inhibiting tumor growth (Zhou *et al.,* 2018).

3.4 Delivery of Therapeutic Agents

Genetically engineered bacteria can be designed to deliver anti-cancer molecules such as cytokines, pro-drug-converting enzymes, or apoptotic factors directly to tumor sites, increasing treatment precision and reducing systemic toxicity (Chowdhury *et al.,* 2019).

4. Types of Bacteria Used in Cancer Therapy

4.1 *Salmonella* Species

Attenuated strains of Salmonella typhimurium are among the most extensively studied bacteria in cancer therapy. These bacteria preferentially accumulate in tumors and can be genetically modified to express therapeutic genes (Toso *et al.*, 2002).

4.2 *Clostridium Species*

Clostridium species are obligate anaerobes that thrive in hypoxic tumor cores. Clostridium novyi-NT, a non-toxic strain, has demonstrated strong tumor-lytic activity in preclinical and clinical studies (Dang *et al.,* 2001).

4.3 *Listeria monocytogenes*

Listeria monocytogenes is particularly useful as a cancer vaccine vector. It induces strong cellular immune responses and has been explored in immunotherapy for cancers such as cervical and pancreatic cancer (Wood and Paterson, 2014).

4.4 *Bifidobacterium* and *Escherichia coli*

Non-pathogenic strains of *Bifidobacterium* and *E. coli* have also been engineered for targeted drug delivery and immune modulation due to their safety profiles and ease of genetic manipulation (Wei *et al.,* 2021).

4 Genetic Engineering in Bacterial Cancer Therapy

Advances in synthetic biology have enabled precise genetic modification of bacteria to enhance safety and efficacy. Engineered bacteria can be programmed to self-destruct after delivering their therapeutic payload, respond to tumor-specific signals, or express anti-tumor agents only within the tumor microenvironment (Din *et al.,* 2016).

These strategies significantly reduce the risk of systemic infection while maximizing therapeutic benefits.

5 Clinical Applications and Current Status

Several bacterial therapies have entered clinical trials, particularly for melanoma, pancreatic cancer, and colorectal cancer. *Bacillus calmette–guérin* (BCG), a live attenuated strain of *Mycobacterium bovis*, is already an approved and widely used bacterial therapy for non-muscle-invasive bladder cancer (Kamat *et al*., 2015). This success has strengthened confidence in bacterial-based cancer treatments.

6 Challenges and Limitations

Despite promising results, bacterial therapy faces several challenges. These include potential toxicity, immune clearance of bacteria before they reach tumors, difficulties in dose control, and regulatory concerns regarding live microbial agents (Forbes *et al*., 2018). Addressing these challenges is essential for broader clinical adoption.

7 Future Prospects

The future of bacterial cancer therapy lies in combination treatments, where bacteria are used alongside chemotherapy, radiotherapy, or immune checkpoint inhibitors. Continued advancements in genetic engineering, microbiome research, and personalized medicine are expected to further enhance the safety and effectiveness of this approach.

8 Conclusion

Bacterial therapy represents a unique and promising strategy in the fight against cancer. By exploiting the natural tumor-targeting abilities of bacteria and enhancing them through genetic engineering, this approach offers targeted, immune-stimulating, and potentially less toxic cancer treatments. Although challenges remain, ongoing research and clinical trials suggest that bacterial therapy could become an important component of future cancer treatment strategies.

References

1. Chowdhury, S., Castro, S., Coker, C., Hinchliffe, T. E., Arpaia, N., & Danino, T. (2019). Programmable bacteria induce durable tumor regression and systemic antitumor immunity. Nature Medicine, 25(7), 1057–1063. https://doi.org/10.1038/s41591-019-0498-z
2. Dang, L. H., Bette Gowda, C., Huso, D. L., Kinzler, K. W., & Vogelstein, B. (2001). Combination bacteriolytic therapy for the treatment of experimental tumors. Proceedings of the National Academy of Sciences, 98(26), 15155–15160.
3. Din, M. O., Danino, T., Prindle, A., Skalak, M., Selimkhanov, J., Allen, K., … Collins, J. J. (2016). Synchronized cycles of bacterial lysis for in vivo delivery. Nature, 536(7614), 81–85.
4. Forbes, N. S. (2010). Engineering the perfect (bacterial) cancer therapy. Nature Reviews Cancer, 10(11), 785–794.
5. Forbes, N. S., Coffin, R. S., Deng, L., Evgin, L., Fiering, S., Giacalone, M., … Zhou, S. (2018). White paper on microbial anti-cancer therapy and prevention. Journal for Immuno Therapy of Cancer, 6(1), 78
6. Hanahan, D., & Weinberg, R. A. (2011). Hallmarks of cancer: The next generation. Cell, 144(5), 646–674.
7. Hoption Cann, S. A., van Netten, J. P., & van Netten, C. (2003). Dr. William Coley and tumor regression: A place in history or in the future. Postgraduate Medical Journal, 79(938), 672–680
8. Kamat, A. M., Li, R., O'Donnell, M. A., Black, P. C., Roupret, M., Catto, J. W., & Comperat, E. (2015). Predicting response to intravesical BCG therapy. Nature Reviews Urology, 12(7), 1–13
9. McCarthy, E. F. (2006). The toxins of William B. Coley and the treatment of bone and soft-tissue sarcomas. Iowa Orthopaedic Journal, 26, 154–158.
10. Toso, J. F., Gill, V. J., Hwu, P., Marincola, F. M., Restifo, N. P., Schwartzentruber, D. J., … Rosenberg, S. A. (2002). Phase I study of the intravenous administration of attenuated Salmonella typhimurium to patients with metastatic melanoma. Journal of Clinical Oncology, 20(1), 142–152.
11. Wei, D., Jiang, W., Zhao, H., Zhang, Y., Li, Y., Wang, G., & Zhang, Y. (2021). Bacteria-based cancer therapy: Advances, challenges, and future prospects. Cancer Letters, 505, 204–215.
12. Wood, L. M., & Paterson, Y. (2014). Attenuated Listeria monocytogenes: A powerful and versatile vector for the future of cancer immunotherapy. Frontiers in Cellular and Infection Microbiology, 4, 51.
13. Zhou, S., Gravekamp, C., Bermudes, D., & Liu, K. (2018). Tumour-targeting bacteria engineered to fight cancer. Nature Reviews Cancer, 18(12), 727–743.
14. Zitvogel, L., Ayyoub, M., Routy, B., & Kroemer, G. (2017). Microbiome and anticancer immunosurveillance. Cell, 165(2), 276–287.