

# Exosome derived biomarkers in cancer: Targeting oncogenic RNA modifications for precision medicine.

Sira Rung\*

Department of Oncology, University of Toronto, Canada

## Introduction

Cancer remains one of the most challenging diseases to diagnose and treat effectively. In recent years, exosomes—small extracellular vesicles secreted by cells—have emerged as promising biomarkers for cancer detection and progression monitoring. Exosomes carry various biomolecules, including proteins, lipids, and nucleic acids, particularly RNA, which play a critical role in cancer biology. Among these, oncogenic RNA modifications have gained significant attention as potential therapeutic targets. Understanding the interplay between exosome-derived biomarkers and oncogenic RNA modifications could open new avenues for precision medicine and early cancer detection [1].

Exosomes are involved in intercellular communication, transferring bioactive molecules that can influence the tumor microenvironment. These vesicles facilitate tumor growth, immune evasion, and metastasis by shuttling oncogenic RNA and proteins between cancerous and normal cells. As a result, analyzing exosomal content provides critical insights into cancer progression and resistance to therapy. Unlike traditional biopsies, exosome-based liquid biopsies offer a minimally invasive approach to obtaining real-time molecular information about a tumor [2].

RNA modifications, particularly N6-methyladenosine (m6A), pseudouridylation, and 5-methylcytosine (m5C), regulate RNA stability, splicing, and translation. Aberrant RNA modifications have been implicated in oncogenesis, influencing gene expression and cellular pathways that drive malignancies. Exosome-derived RNA modifications provide a snapshot of tumor biology and could serve as early indicators of cancer onset and progression [3].

Traditional biomarkers often require tissue samples, which can be challenging to obtain, particularly for deep-seated tumors. Exosome-derived RNA biomarkers, on the other hand, can be isolated from bodily fluids such as blood, urine, and saliva, offering a non-invasive diagnostic alternative. These biomarkers exhibit high stability, making them suitable for real-time cancer monitoring and response evaluation [4].

The selective packaging of RNA into exosomes is regulated by RNA-binding proteins and post-transcriptional modifications. Studies suggest that cancer cells preferentially package oncogenic RNA into exosomes to modulate the tumor microenvironment. Understanding these packaging

mechanisms could lead to novel therapeutic strategies aimed at blocking the exosomal release of oncogenic RNA [5].

Developing therapeutic strategies to target oncogenic RNA within exosomes is an emerging area of research. Small molecule inhibitors, RNA-targeting CRISPR/Cas systems, and antisense oligonucleotides are being explored to modulate RNA modifications and disrupt cancer progression. Additionally, engineered exosomes capable of delivering therapeutic RNA to cancer cells represent a promising approach to precision oncology [6].

Despite their potential, exosome-derived RNA biomarkers face challenges related to standardization, isolation techniques, and clinical validation. Variability in exosome purification methods and the lack of universally accepted protocols hinder their widespread clinical adoption. Advances in nanotechnology and bioinformatics are expected to enhance exosomal RNA analysis and improve its reliability for cancer diagnostics and therapeutics [7].

Ongoing research is focused on integrating exosome-derived biomarkers into multi-omics approaches to enhance cancer diagnosis and treatment strategies. Combining exosomal RNA analysis with artificial intelligence and machine learning could lead to more accurate predictive models for cancer detection. Moreover, the development of exosome-based therapeutics holds promise for personalized medicine, allowing for targeted treatment strategies tailored to individual patients [8].

As exosome-based diagnostics and therapies advance toward clinical implementation, ethical and regulatory considerations must be addressed. Patient consent, data privacy, and standardization of exosome-related methodologies are crucial for ensuring safe and effective application in clinical settings. Regulatory agencies must establish guidelines for the approval and commercialization of exosome-based technologies to facilitate their integration into mainstream oncology [9, 10].

## Conclusion

Exosome-derived biomarkers, particularly those involving oncogenic RNA modifications, represent a transformative frontier in cancer research. Their ability to provide real-time, non-invasive insights into tumor biology makes them valuable tools for early diagnosis and precision medicine. However, challenges related to standardization, validation, and therapeutic application must be addressed to fully realize

\*Correspondence to: Sira Rung, Department of Cancer Biology, University of Cambridge, UK, E mail: [sira@rung.ca](mailto:sira@rung.ca)

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their potential. Continued advancements in exosome research will pave the way for innovative cancer diagnostics and therapeutics, ultimately improving patient outcomes in the fight against cancer.

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