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Mini Review

MicroRNAs in Cancer: Small Molecules, Big Implications

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Abstract

MicroRNAs (miRNAs) are short RNAs with crucial functions in various types of cancer. Their altered expression and function can contribute to the development and progression of the disease, affecting important molecular pathways such as cell proliferation, apoptosis, and angiogenesis. These small single-stranded molecules have the potential to be used as biomarkers for early cancer diagnosis and prognosis, and miRNAs are also utilized as small molecules for innovative cancer therapies.

Keywords: miRNAs, Cancer, Gene regulation, Biomarkers, Innovative therapies.

Abbreviations: PTEN: Phosphatase and Tensin Homolog; SOCS1: Suppressor of Cytokine Signaling 1; CDKN1B (p27): Cyclin-Dependent Kinase Inhibitor 1B (p27); p53: Tumor Protein 53; ZEB1 and ZEB2: Zinc Finger E-Box-Binding Homeobox 1 and 2; ROBO1: Roundabout Guidance Receptor 1; NF-κB: Nuclear factor kappa-light-chain-enhancer of activated B cells; TGF-β: Transforming growth factor beta; PI3K/AKT/mTOR: Phosphatidylinositol 3-kinase/protein kinase B/mammalian target of rapamycin pathway.

Introduction

MicroRNAs, also known as miRNAs, are small non-coding RNA molecules, composed of approximately 19-25 nucleotides, capable of regulating gene expression by binding to specific messenger RNA sequences, thereby affecting protein synthesis and playing a fundamental role in different cellular processes, including the development of diseases such as cancer [1,2]. Some miRNAs can act as oncogenes, meaning they promote tumor formation and growth. These miRNAs are expressed at abnormally high levels in tumor cells, and their overexpression leads to the inhibition of tumor suppressor genes. On the other hand, certain miRNAs function as tumor suppressors, acting as molecular guardians to maintain balance and prevent tumor development. These miRNAs are often decreased or absent in cancer cells compared to normal cells. Alteration in the expression and function of oncogenic and tumor suppressor miRNAs leads to various effects, including increased cell proliferation, evasion of apoptosis, promotion of angiogenesis, cellular invasion, inflammation, and drug resistance in different types of cancer, as detailed in Table 1 [2,3].

Table 1: miRNAs and their influence on cancer progression.

miARNs	Type	Types of Cancer	Function in Cancer	Protein Target	Molecular Pathways	Reference
miR-21	Oncogen	Breast, Lung, Colon, Pancreas	Promotes cell proliferation and cell invasion	PTEN (tumor suppressor)	Activates the PI3 kinase/AKT/mTOR pathway	[3,4,5]
miR-155	Oncogen	Lymphoma, Leukemia, Breast, Lung, Colon,	Promotes inflammation and cell survival	SOCS1 (inhibitor of NF-κB)	Activates the NF-κB pathway	[3,4,5]
miR-221/222	Oncogen	Glioma, Hepatocarcinoma, Prostate cancer	Increased drug resistance	CDKN1B (p27, cell cycle inhibitor)	Activates the PI3 kinase/AKT/mTOR pathway	[3,4,5]
miR-34a	Suppressor	Prostate, Breast, Lung, Colon,	Induces apoptosis and suppresses proliferation	p53 (tumor suppressor gene)	Activate the p53 pathway	[3,4,5]
miR-200	Suppressor	Breast, ovarian and pancreatic cancer	Inhibits epithelial-mesenchymal transition	ZEB1 and ZEB2 (transcription factors)	Activates the TGF-β pathway	[3,4,5]
miR-218	Suppressor	Glioma, breast cancer, prostate cancer	Suppresses angiogenesis and metastasis	ROBO1 (axonal guidance receptor)	Activates the TGF-β pathway	[3,4,5]

miRNAs as Biomarkers and Therapies in Cancer

miRNAs have emerged as key elements in the field of cancer due to their dual role as biomarkers and potential therapies. Some miRNAs have been identified as biomarkers in various types of cancer due to their altered levels in tissues and body fluids such as urine, saliva, serum, or blood plasma. Detection of these miRNAs could be crucial for early diagnosis and accurate prognosis of the disease, as mentioned in Table 1 [2,4,5]. In addition, miRNAs have also attracted interest as potential innovative therapies in cancer. These include using antagonistic miRNAs to block the function of endogenous miRNAs, replacement therapy for suppressed miRNAs to restore their function, nanoparticle therapy for more specific and efficient delivery, combined therapy miRNAs and drugs to improve treatment response and reduce drug resistance, CRISPR-Cas9 gene editing to modify dysfunctional miRNAs, and immunotherapy based on designed miRNAs to induce activity in specific immune cells that combat the tumor [2,5,6,7].

Future challenges in miRNA-based therapies for cancer include clinical validation, to improve the targeting of tumor cells, overcome resistance and relapse, ensure stability and bioavailability, identify specific targets, and investigate drug-drug interactions. Overcoming these challenges could enable more effective and personalized treatments for cancer, improving patient response rates and survival.

Conclusion

miRNAs represent a key component in understanding and treating cancer, acting as regulators of fundamental cellular processes. Their potential as biomarkers and innovative therapies opens new perspectives to enhance early detection and therapeutic approaches in the fight against various types of cancer.

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Author Contribution

Perez Mora and Cedeño Arboleda contributed equally to this work.

Conflict of Interest

None.

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