The role of MicroRNA in regulating gene expression and its impact on the genetic diseases

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Abstract

MicroRNA (miRNA) is a key player in regulating gene expression, It plays a vital role in a wide range of biological processes, Including growth, cell differentiation, and programmed cell death. This research focuses on studying the mechanism of action of MicroRNA in controlling gene expression and its effect on genetic diseases.

The study included a comprehensive review of the scientific literature on the effect of MicroRNA on gene expression and its role in causing genetic diseases such as cancer. Heart disease, neurological disorders, and others.

The results showed that changes in MicroRNA regulation may lead to dysfunctions that contribute to the development of many diseases. The potential therapeutic applications of MicroRNA were also highlighted, including its potential use as a therapeutic target in personalized medicine.

The study recommends the necessity of enhance research into the role of MicroRNA in genetic diseases and develop new technologies targeting its regulation as a future therapeutic strategy.

Keywords: MicroRNA , Gene Expression, Genetic Diseases, Cancer, Gene Therapy

Chapter one

Introduction

The MiroRNA (miRNA) are small biological molecules, lack any codons and can be highly handy in the control of the expression of the genes within the cells. These are very short sequences of RNA and the size of such strings is 20-22 nucleotide. It substitutes the role of the regulation of the expression of the genes by stranding to the messenger RNA (mRNA) molecules.

This is accomplished by attaching onto the mRNA molecules thus preventing or preventing the translation of the proteins of the genes. This is one of the pillars of the control of the various biological processes that occurs in the cells and this is regulated by a genetic control. The latter are cell growth, cell differentiation and cell proliferation (Bartel, 2009).

This is imperative as MicroRNA has an incredible number of biological processes that it regulates It is because of these that the cells are also in a position to respond to the foreign stimuli. Otherwise, it is important in the homeostasis regulation of cells and other important cellular functions such in the metabolism of nucleic acids, in the regulation of cell cycle and in response to the various environmental signals (Hannon, 2002). It has been a complicated procedure that has taken place and caused MicroRNA s to be an important part of the genetic system control, which defines health and sickness.

The recent years were marked by the pointing to the fact that the research has revealed that a majority of the genetic diseases could be caused by the defects in the activity of MicroRNA . These are cancer, neurological diseases and cardiovascular diseases. Some of them include the fact that alteration in the expression of particular classes of MicroRNA have been observed to be linked to the development of certain types of cancers including breast and lung cancer (Croce, 2009). The other element of the study also demonstrated that dysfunction of the MicroRNA is closely linked to

the prevalence of the neurological disorder that entails not only the Alzheimer but also the Parkinson disease (Wang and Wang, 2017.)

Besides, MicroRNA may be utilized in therapy and diagnosis. These variations of concentrations of MicroRNA can be identified in the body fluids like urine or blood that provides an opportunity to use them as biomarkers of the early diagnosis of the hereditary disease (Chen *et al.,* 2008). The other reason that leads to the development of new avenues to the treatment of most of the diseases that were not available to the conventional treatment is the potential of manipulation of the MicroRNA or the targeting with the help of the gene therapy.

It is based on this that the activation of the genes by the MicroRNA s and its role in regulating genetic diseases is one of the most important fields of research in the molecular biology and medicine. Besides this information, the enhanced deciphering of the MicroRNA act can be likewise utilized in shaping the new paradigm of treating the existing incalculable genetic disorders.

Importance of research

1. The conclusion drawn by the article is significant in as far as the implication of MicroRNA is concerned to the regulation of the genes which is questionable in the context of molecular pathogenesis of genetic disease.

2. It may help in finding the components of the molecules that can be traced further to identify new treatment of hereditary illnesses.

3. Gives additional data regarding the role of the MicroRNA ratios of the cellular life on another plane of the molecular medicine and gene therapies.

4. Helps to disseminate the knowledge on the importance of future research on the relevance of MicroRNA as a biomarker in the early diagnosis of genetic illnesses.

Research problem

Despite the fact that the field of molecular genetics has experienced an enormous progress, the contribution of the MicroRNA s to the regulation of the gene expression remains poorly examined, and the failure mechanism of MicroRNA s results in the appearance of the genetic diseases. The questions raised in the research are as follows:

- How do the MicroRNA s regulate the functioning of the genes and their cells?
- What is the relation between the MicroRNA mal-regulation and the development of the genetic diseases?
- Can we target MicroRNA and find new ways of treatment?

Research objectives

1. Understand how the MicroRNA is capable of controlling the gene expression and its effect on several biological functions.
2. Present the relationship of MicroRNA and genetic disease with the end works.
3. Arguments as to why MicroRNA can be considered a biomarker in the diagnostics of genetic diseases.
4. Considering that, there are probability of introducing the application of a second line of therapy of MicroRNA targeting, in the process of treating certain genetic diseases.

Chapter two
Literature Review

This part will entail literature review of the functions of MicroRNA in expression and regulation of genes and implications of MicroRNA in the genetic diseases. this chapter will focus on offering the general introduction of scientific and biological context on MicroRNA and its function in genetic regulation, besides outlining the experimental evidence, which is critical to the correlation between the regulation of MicroRNA change and the incidences of different genetic diseases. The

uses of MicroRNA millions of times in diagnosis and therapy will also be mentioned and the new advances in the field.

1. controlling of gene expression by the assistance of MicroRNA .

MicroRNA is important in the gene control mechanism of living organisms not only is it a significant element of gene control at post-transcriptional level. The MicroRNA s are also associated with the messenger RNA (mRNA) molecules translation since they interact with the messenger RNA molecules, inhibiting or promoting the destruction of the said molecules in the cells. This kind of gene control may be referred to as any of the super controllers or silencer of the genes expression and enables to control the quantity of proteins produced by the cell and at the appropriate time depending on the biological need and the change in environment that takes place (Bartel, 2009).

The synthesis of MicroRNA is done on the foundation of MicroRNA cellular genes, Whereby ultimately MicroRNA is synthesized into an end product after a complicated pathway of enzyme processing which involves a tremendous number of enzymes such as Dicer. These are the first molecules that are present in pre-miRNA molecules that can be modified to mature miRNA molecules of length 20-22 nucleotides. Its MicroRNA functions in its turn on the molecules of mRNA, which leads to the destruction of the latter or the inhibition of the conversion of the mRNA into protein (Hannon, 2002). It confirms that MicroRNA may not be called by any other designation such as a biological molecule because it is one of the most important control points of processes of cellular activity which involve cellular development, cellular differentiation and reaction to external forces (Ambros, 2004).

Theoretically, it is seen that these MicroRNA s may lead to an intricate network of perturbation of the genes and that the MicroRNA -gene-interactions can be cell-specific and therefore allows the distribution of genes expression as dependent on the type of the cell type and the cell environment (Bartel, 2009). This indicates that the

MicroRNA s are important in the homeostasis of the intracellular functions in addition to the regulation of response of cells to the diseases and stressor conditions..

2. Association of MicroRNA with the genetic diseases.

The outcome of the expression change in the MicroRNA s has been reported to cause a number of genetic disorders that could be able to impact the whole body. Although the MicroRNA s can be termed as a natural regulatory process, but reduction in the expression or increase in the expression may lead to dysfunction in the same process hence the development of various diseases. The changes of the MicroRNA can be characterized as the increased or decreasing expression, It can be directly associated to the significant percentage of genetic diseases like cancer, Neurological diseases, heart diseases and autoimmune diseases.

In such a case, the best example would be cancer as it has been known that some of the MicroRNA s were tumour suppressor genes. Two of the MicroRNA tumor suppressors are the miR-15 and miR-16, Low concentration of the two MicroRNA has been detected in majority of the cancer including leukemia and breast cancer. Conversely, Some other MicroRNA s such as the miR-21 were approximated to be tumor enhancers, Its over-expression causes cancer tumors to multiply (Calin *et al.,* 2002; Mott *et al.*, 2007).

Out of the various nervous disorders, the breakdown of the MicroRNA has not been thoroughly investigated to state that it is a factor in the incidence of Alzheimer and in the instance of Parkinson disease; it has been assumed that the MicroRNA has a role in regulating the misfolded proteins that may eventually cause the diseases (Wang and Wang, 2017).

3. The discovery of MicroRNA .

One can mention the process of MicroRNA as one of the new findings that led to its application in medicine. Another emerging and new diagnostic and curative device is the MicroRNA . Such micro RNA are diagnosable in the body fluids like blood and urine and are an excellent method of early diagnosis of the genetic

ailments. Gestally, it is identified that part of the MicroRNA s miR-21 and miR-155 are biomarkers in an endeavor to make an early diagnosis of colon cancer and breast cancer (Chen *et al.,* 2008). This gives the level of significance needed to the MicroRNA screening prevention and early diagnosis.

Following the research experiment, it has been stressed that MicroRNA can have the power of being used as a treatment agent during the therapeutic process by either modifying or regulating the target mRNA. One of the methods that would enable production or inhibition of expression of several MicroRNA s is the gene therapy of the genetic diseases. In order to introduce the point, a Clinical trials targeting MicroRNA miR -21 has led to the discovery that reduction in tumors growing and the propensity of cancerous cells to grow and propagate into metastasis is possible (Weidhaas *et al.,* 2007).

Conversely using of the micro RNA is also being disputed as a tool to provide the answer to the twisted forms of the genetic anomalies like the cystic fibrosis which with the help of Gene therapy the procedure of repairing the damaged genes and the subsequent expression of the MicroRNA s that restores the genetic balance in the cells .(Weidhaas *et al.,* 2007).

The great importance is the fact that MicroRNA is a gene expression control feature and is a key factor in the natural occurrence of the genetic diseases in the scientific fraternity. This illustrates that the user will be more attentive of the mechanics of the MicroRNA activity as it can make significant contributions as far as the delivery of the new approaches to curing and analysing the genetic ailments. It will appreciate such molecules and this will enable it to come up with new diagnostic and treatment equipments that will help in enhancing the well being of an individual and minimise the effects of hereditary illnesses (Chen *et al.,* 2008).

Chapter three

The Exogenous role of the MicroRNA on the Genetic Diseases.

The mechanism of action in this case will be used to address the influence of MicroRNA on the case of hereditary disease. Scientifically it is known to be manifested in various forms depending on development of multiple genetic diseases. The particular focus will be made on the particular genetic diseases, which are the most common ones, and the development or intensification of the identified diseases will be related to the modification of the activity of MicroRNA , as well, the prospects of its application in the specified treatment will be discussed.

1. The process that is attained by MicroRNA on genetic diseases is the biological process.

The MicroRNA manages to control the processes that exist within the cells and it inhibits or eliminates the messenger RNA (mRNA) molecules before the latter transforms into proteins. It is a very crucial process in cell functions stabilization and any malfunction in MicroRNA can lead to the development of a genetically oriented disease that culminates in the emergence of multiple genetic diseases.

Study indicates that some groups of MicroRNA are significant as regulators of the cell related gene that are linked to cell growth and differentiation as well as cellular response to stress. They lead to the dysfunction of the primitive life functions in the case where the activity of these molecules suffers. What makes people susceptible to get infected by genomic diseases such as cancer, neurological diseases and hereditary heart diseases (Bartel, 2009).

The incidences show that MicroRNA s do not nonexist that fulfill the functions of regulating the expression of cell proliferation genes and apoptotic genes. This way, This is

relates to cancerous tumours development or neurodegenerative disease directly (Croce, 2009).

2. This is the influence of MicroRNA on the common genetic diseases.

A. Cancer

Cancer is one of the most related MicroRNA modifications as a number of MicroRNA s have been found to either be tumor suppressors or tumor promoters (oncomiRs)

Tumor-inhibiting MicroRNA s: There are some tumor-inhibiting MicroRNA s such as the miR-34 and miR-15/16 that inhibits the growth of the size of the cancerous cells by regulating the silent genes that activate the cell growth. The reduced concentration of the molecules may lead to an abnormal cell division proliferating in that manner thus forming tumors (Calin *et al.,* 2002).

Oncogenic MicroRNA : The MicroRNA can be of any kind as miR-21 and can regulate the progression of the cancer cells by the silencing of the tumor suppressor genes that enable the multiplication and survival of the cancerous cells is one of the prominent features of the cancer cells (Mott *et al.,* 2007).

B. Genetic neurological inborn conditions.

MicroRNA diseases play a colossal role in the majority of the genetic neurological diseases, It regulates the expression of proteins which constitute the brain functions. For example:

- Alzheimer disease:

As the research alleges, the accretion of beta-amyloid protein is connected with the maladaptation of the work of MicroRNA s such as miR-29 and miR-146, which is considered to be the primary cause of the Alzheimer disease (Wang and Wang, 2017).

- Parkinson disease:

It is attributed to the existence of certain MicroRNA s such as miR-133b that has been found to participate in the control of the expression of neuron proteins that are involved in the maintenance of On motor functions and the down-regulation of the proteins results in an increase in the severity of the disease symptoms (Junn *et al.,* 2009).

C. Hereditary heart diseases

Scientific research shows that MicroRNA is rather a significant phenomenon that in turn controls the work of the heart, defines the activity of other genes connected with the structure and functioning of the heart. One of them is that the concentration of miR-1 and miR-133 has been found to be different in the circumstances of forming such hereditary heart diseases as cardiomyopathy and arrhythmias (Chen *et al.,* 2008).

3. Genetic disease treatment agent MicroRNA .

The recent advent of scientific advancement in contemporary times also contributed to the fact that the majority of genetic ailments can be addressed with the help of the attack on the MicroRNA . Selecting alternative course of treatment depending on any difference in masses of MicroRNA in the cells:

- To remove toxic MicroRNA :

This would involve the use of anti-MicroRNA molecules (AntigomiRs) that would be used to suppress the MicroRNA s that may be promoting the tumor growth, or MicroRNA s that may be promoting the deterioration of the neurological conditions. They comprise AntagomiR-21 to be utilized in cancer control (Weidhaas *et al.,* 2007).Inhibition of the pathogenic MicroRNA :

Artificial RNA molecules can be made in a certain structure to induce the expression of tumor-inhibitory MicroRNA s, e.g. miR-34 in patients with a particular type of cancer. (Mitchell *et al.,* 2008.)

4. Prospects and outlook concerning the future of the MicroRNA research.

Despite the effort in an attempt to identify the causes of relevancy in MicroRNA in genetic diseases, nevertheless, clinics of the field have challenges in their path. The most evident challenges are the following:

-Specificity of targeting: There is need to put more specific means of targeting the MicroRNA molecules which have no action on other target business of the genes.

- Efficient therapeutic delivery:

 The second challenge that is worth pursuing is the delivery of MicroRNA -based therapeutics to tissues of therapeutic quality, It must be able to increase cell selective delivery systems of side-effect free molecules.

How to treat to network of genes - This has not yet been identified and now it is even unknown how to say what implications into effect of any alteration of expression of any gene it is possible to predict as it can now be connected with a myriad of genes at the same time.

MicroRNA happens to be that significant in the regulation of the expression of gene, and its interference may lead to the manifestations of the majority of hereditary disorders. Introducing its use as a possible treatment goal, in its turn, is justified by the increasing volumes of scientific evidence of its implication in cancer, in Neurological and cardiac infections. MicroRNA may also form one of the most useful tools in the future provided that the genetic disease work is not halted. (Chen *et al*., 2008).

Chapter three

Diagnostic and therapeutic MicroRNA .

The latter section will entail the discourse of contemporary use of MicroRNA in treatment and diagnosis. It has been viewed as one of the most important instruments of recognizing the diseases at the earliest, Creation of the effective and reliable treatment plans. The question of whether or not MicroRNA can be used as a biomarker in the context of different diseases will be raised, Its use in targeted therapy, and problems and prospects of using it as a means at the employ of the medical treatment.

1. Micro RNA as a biomedical biomarker.

A biomarker is a biological molecule that can also be measured to determine the condition of a disease, or the response of the body to specific treatment. The new

literature proves that MicroRNA has the potential of being a good biomarker to most diseases based on a number of reasons:

- It is indeed consistent in body fluids such as blood, urine and saliva hence is best in non-invasive test (Mitchell *et al.,* 2008.)

- It is real image of the alterations of the cells and tissues that are not only pathological but also the presence of the diseases is known in advance before the emergence of the clinical signs (Chen *et al*., 2008).

- It can also easily distinguish the healthy and the diseased and this factor helps in improving the diagnosis and making the appropriate decisions regarding treatment (Kosaka *et al.,* 2010).

A. MicroRNA A as a cancer diagnostics device.

It is demonstrated that certain of the classifications of the micro RNA can be effectively used to detect cancer, Micro RNA pattern varies in normal tissue and cancer tissue. For example:

The existence of miR-21 in the blood and tissue fluid in large amounts has been linked to numerous forms of cancer including colon, lung and breast cancer therefore the reason why miR-21 is an ideal biomarker in the detection of all forms of cancer at different stages (Iorio *et al.,* 2005).

The reduced concentration of miR-126 can be one of the first indicators of lung cancer because it is integrated into the mechanism of cell and neovascularization proliferation regulation (Pfeffer *et al.,* 2005).

B. Using of MicroRNA in neurological disease diagnosis.

One can also refer to a few neurodegenerative disorders including Alzheimer and Parkinson that are connected with severe alterations in the mRNA expression. For example:

- The miR-29, and miR-146 are involved in the regulation of the beta-amyloid accretion in the case of the Alzheimer disease and this makes

them be biomarkers in the detecting of the disease at a very early stage (Cogswell *et al.,* 2008).

- MiR-133b has been previously reported as being of low level that relates to degeneration of the dopamine producing neurons in Parkinson disease and this has made it a subject of a diagnostic and treatment research (Kim *et al.,* 2007).

C. Diagnosis of heart diseases: MicroRNA .

MicroRNA has a number of molecules that have been discovered to be critical in heart disease and these are:

The damage of myocardial cells is manifested in high miR-208 in blood that is a mark of heart attacks (Wang *et al*., 2010).

miR-1, miR-133 as well are associated with the cardiac arrhythmias and with hereditary heart diseases are being extensively used in the initial diagnosis of heart diseases (Ai *et al.,* 2010).

2. Targeted therapy MicroRNA .

The fact that MicroRNA determines the order of expression of the genes would bring it to the limelight of the process of designing the new therapies that would involve the regulation of the concentration of MicroRNA in the sick cells. The strategies that can be applied to the treatment with the use of MicroRNA are:

A. MicroRNA (AntagomiRs Therapy) Inhibition of vicious MicroRNA .

The antigomiRs block of MicroRNA activity in case of the overexpression that causes disease in the presence of small molecules. Examples include:

- It is also found that AntagomiR-21 has been used in management of some types of cancer since it works against miR-21 that causes development of tumours (Trang 2011).

- A study has also included one of the research uses of antigomiR-155, which is the promotion of miR-155 silencing in leukemia through its antigomiR-155 (Rothschild 2016).

b. Increased Therapeutic miRNA (miRNA Mimics).

In other cases, low level of concentration of MicroRNA induces the disease. This is reversed by the artificial molecules also known as miRNA mimics that possess:

- miR-34 Mimic has been placed in a clinical trial as a cancer therapy and it has been found to activate tumor suppressors and restore homeostasis of cells (Wiggins ,2010).
- The miR-133 Mimic is shown to be a potential drug in the treatment of heart diseases because it helps in enhancing the performance of the heart muscle muscle (Care *et al.,* 2007).

3.The potential pitfalls and threats of using MicroRNA .

Although a lot has been done so far concerning the use of micro RNA in the realm of diagnosis and treatment, it is yet to undergo several obstacles before it can be applied in the mainstream medical practice. These include:

Efficient and precise delivery: The delivery of MicroRNA molecules to the target tissue should be improved so that, the treatment is delivered to the diseased cells but does not affect the normal ones.

Response to the gene networks: Because the effect of a MicroRNA may be a sum of a number of genes being altered simultaneously, one would need to know what occurs during the interaction in order to avoid the unwanted adverse effects.

Consent and laws: MicroRNA   treatment would undergo rigorous clinical trials before it becomes acceptable as medicines that will testify the safety and effectiveness of the treatment.

MicroRNA is a novelty in the field of biomedicine since it will be applicable as an aid in early diagnosis of various diseases, such as cancer, neurological and heart diseases. The direction of treatment of genetic and chronic diseases is a new path where the treatment patterns are modelled and based on the manipulations of MicroRNA concentration manipulation. The future is also optimistic and possible that the research in MicroRNA is likely to be the branch of personal medicine and personal treatment.

Conclusion

1. Essential Controlling Factor: MicroRNA is one of the most essential factors controlling gene expression.
2. Crucial Biological Functions: This gene expression is vital for a majority of biological actions, including the blending of:

- Cell growth.
- Differentiation.
- Stress response.

3. Link to Disorders: Recent literature indicates that most genetic and chronic disorders are directly linked with a derailment in MicroRNA expression.
4. Examples include cancer, neurological, and heart diseases.
5. Future Role in Medicine: MicroRNA is also termed a genetic regulator and is a key interest for the establishment of:

- New diagnostic equipment.
- Future gene therapeutics.

6. Remaining Challenges: Despite progress, there are still technical and logistical challenges that must be met to ensure MicroRNA becomes a reliable clinical process.

Results

1. The most striking results, according to the study and the analysis, can be summarized as the following ones:

2. Important in the regulation of genes: MicroRNA has the ability to regulate the expression of genes basing on the mRNA molecules which are the determinants of protein synthesis in the cell.

3. There is a link with the case of genetic and chronic diseases: It has been found out that the alteration in the concentration of MicroRNA is related to the progression of most of the diseases including cancer and heart disease therefore it is a good biomarker to identify the disease at an early stage.

4. Its progression as a sensitive diagnostic instrument: MicroRNA is yet another imitation of a biomarker which is reproducible in body fluids that are the non-invasive and precise way of diagnosing the ailments.

Recommendations

On the above findings, it is suggested as follows:

1. Invest in science: The company ought to make investments in the additional research into the role of MicroRNA in genes expression, especially in connection with chronic diseases, and genetic diseases.

2. Enhancing methods of delivery: To create a new format of delivering the MicroRNA molecules to the target cell in an effective and precise method and mitigate the possible side effects.

3. Including it with the clinical diagnosis: It has an effort to include the use of MicroRNA tests in the clinical test to diagnose the diseases at the early stages of disease as well as in cases of cancers and neurological diseases.

4. Gene therapies research: The reasons to support the process of conducting clinical trials in order to reach the curing of the MicroRNA levels and will be helpful to provide more specific and efficient treatment.

5. Current barriers: The current barriers will be the ways of delivering MicroRNA to the target cells, and its effects on the various networks of gene whose effects are still to be explored prior to its application in larger clinical practice.

Strong regulatory practices: The institute policies and regulations that will ensure the safety and efficacy of the MicroRNA application in the medical application before it is sold out as a certified therapy.

And the last but not the least: the MicroRNA is a potential area of investigation that can potentially revolutionise the area of the diagnosing and treatment and as the sphere of research and technology advances, there is a high possibility that the MicroRNA will become an important aspect in the future in personalised medicine and tailored treatment.

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