Innovative drug delivery technologies in myocardial infarction therapy

Kuat Sultan¹, Lenzatova Aruzhan², Uristembek Mahdi³, Suraganova Dina⁴, Zinorova Nuraiym⁵

¹ Master of Science in Molecular Biology and Genetics; Instinye University; Republic of Turkey
² School of Medicine, Faculty of General practitioner, the 6th course; NJSC «Astana Medical University»; Republic of Kazakhstan
³ School of Medicine, Faculty of General practitioner, the 6th course; NJSC «Astana Medical University»; Republic of Kazakhstan
⁴ School of Medicine, Faculty of General medicine, the 5th course; NJSC «Astana Medical University»; Republic of Kazakhstan
⁵ School of Medicine, Faculty of General medicine, the 4th course; NJSC «Astana Medical University»; Republic of Kazakhstan

Abstract.
Research in the treatment of myocardial infarction is focused on exploring various drug delivery methods and molecular agents to improve cardiac function and reduce scar formation. MicroRNAs miR-19a/19b, members of the miR-17-92 cluster, show potential as therapeutic targets by stimulating cardiomyocyte proliferation and inhibiting inflammatory responses in the heart. Liposomes, as potent drug carriers, provide controlled and targeted drug delivery, improving treatment efficacy. Polymers, including PLGA, and biological polysaccharides such as chitosan and alginate provide versatile carriers for drug delivery, including inhibitors and growth factors, helping to suppress inflammation. Gold nanoparticles have anti-inflammatory and regenerative properties, helping to reduce myocardial infarction and suppress fibrosis. These approaches present new perspectives for the treatment of myocardial infarction and improvement of cardiac function.

Keywords:
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Introduction:
Myocardial infarction (MI) remains one of the most common and serious cardiac diseases worldwide, causing high mortality rates and leading to serious cardiovascular complications. Despite significant advances in the treatment and prevention of this disease, the search for new and more effective therapies remains an urgent task of medical science. In recent decades, considerable attention has been paid to research into drug delivery and molecular agents aimed at improving cardiac function and reducing scar formation after myocardial infarction. These studies seek to optimise delivery methods and increase specificity of action on cardiac tissue, while minimising side effects and systemic toxicity.

In this article, we review several promising approaches to the therapy of myocardial infarction, including the use of miR-19a/19b microRNAs, liposomes, biological polymers, and gold nanoparticles. Each of these methods represents a unique tool in combating the consequences of IM and has the potential to improve cardiac function and reduce pathological changes in the myocardium.

Our article summarises recent scientific studies and details the principles and mechanisms of action of each of these drug delivery methods. We also discuss their potential as promising therapeutic strategies in treating myocardial infarction and improving outcomes of this serious disease.

Materials and Methods:
To conduct this literature review and systematize the gathered data, a search for scientific articles, reviews, and meta-analyses was performed in medical databases, including PubMed, Lancet, and other relevant sources. The studies included in the review covered the period from 2010 to 2023 and were limited to publications in the English language. Keywords and phrases such as "Myocardial Infarction", "Nanomedicine", "Drug delivery" were used for the search and selection of suitable studies.

Results:
1. Therapeutic Impact of miR-19a/19b in the Treatment of Myocardial Infarction miR-19a/19b (also known as miR-19a and miR-19b) are molecular microRNAs that play an important role in the regulation of genetic processes in cells. These miRNAs
are members of the miR-17-92 cluster of microRNAs. The miR-17-92 cluster comprises several miRNAs, including miR-19a and miR-19b, and serves as an important regulator of cell proliferation and survival.

miR-19a and miR-19b are molecular microRNAs that play an important role in cardiac protection after myocardial infarction. Researchers have found [1-4] that injecting miR-19a and miR-19b into the heart after infarction promotes recovery of cardiac function and reduces scar formation. This is due to stimulation of cardiomyocyte (heart muscle cell) proliferation and suppression of the inflammatory response in the heart. miR-19a and miR-19b can be delivered to the heart using specialised molecular delivery methods such as intravenous injections [5].

These miRNAs could be potential therapeutic targets for the treatment of myocardial infarction and heart failure. They are able to protect the heart in two phases: the first phase is stimulation of cardiomyocyte proliferation and the second phase is suppression of the inflammatory response. This opens new perspectives for the treatment of heart disease and improvement of cardiac function [2-3].

2. Therapeutic Effect of Liposomes in Drug Delivery

Liposomes represent a powerful method of drug delivery by protecting drugs and controlling their release, which reduces systemic toxicity and allows drug delivery to specific targets. This improves treatment efficacy, especially in the case of myocardial infarction. However, liposomes can be rapidly removed by the body and their stability remains a challenge, requiring additional encapsulations and modifications to improve long-term circulation in the blood and maintain stability. Recent studies show [6-7] that modification of liposomes with various molecular targets such as antibodies, antibody fragments, and peptides can create target-specific liposomes for drug and microRNA delivery. For example, liposomes modified with peptide I-1 provide delivery of PARP-1 inhibitor to cardiomyocytes, increasing the efficiency of PARP-1 inhibition compared to free drug [8].

3. Therapeutic Effect of Biological Polymers in Drug Delivery

Polymeric structures with different hydrophobic and
hydrophilic units are widely used as drug carriers. Due to this structure, they can accommodate both water soluble and water insoluble drugs and can also be modified to deliver drugs to specific sites in the body. Polymers can be used to create various structures such as hydrogels, mesh supports, microparticles, nanospheres and nanoshells for drug delivery. They can control hydrophobic properties, degradation rate and re-susceptibility, making them versatile tools in medical applications [7, 9].

An example of such a polymer is polymer of lactic and glycolic acid (PLGA) [10], with low toxicity, biocompatibility and biodegradability, it can be used to deliver various small molecule drugs such as growth factors, bioactive peptides and receptor agonists or inhibitors [11]. PLGA allows long circulation of the drug and its accumulation in the injured myocardium, which helps in suppressing inflammation. Using PLGA it is possible to deliver the Toll-like receptor 4 protein Toll-like receptor (TLR4) inhibitor TAK242 to inhibit myocardial damage during ischaemia-reperfusion [12].

Polysaccharides such as chitosan, dextran, alginate and pectin are natural polymeric materials and have a number of advantages that make them important for the treatment of cardiovascular diseases. They have properties such as safety, degradability, uniformity and hydrophilicity. A large number of functional groups such as amino groups, hydroxyl and carboxyl groups allow researchers to synthesise various polysaccharide derivatives for different purposes. Polysaccharides including chitosan and alginate have been used to create placenta growth factor (PGF)-loaded nanoparticles designed to deliver PGF slowly and steadily to the area of myocardial infarction. This has the potential to enhance the beneficial effects of the growth factor in cases of acute myocardial ischaemia. The advantages of such polysaccharide carriers include their safety, degradability and versatility, which allows them to be used in various therapeutic scenarios. However, there are limitations such as difficulty in controlling the drug release rate and its resistance to physical and chemical stresses, which should also be considered in the design of such delivery systems.
4. Therapeutic Effect of Gold Nanoparticles in Drug Delivery

Gold nanoparticles have several advantages that make them promising carriers for the delivery of bioactive substances such as drugs, proteins and enzymes. These nanoparticles are characterised by their ease of synthesis and the ability to functionalise their surface. In addition to their conductivity, which can promote regeneration of cardiac tissue, gold nanoparticles have antioxidant and anti-inflammatory properties. They are able to bind free radicals and reduce the expression of tumour necrosis factor-α (TNF-α) [13]. Gold nanoparticles also show the ability to accumulate in the heart region in case of myocardial infarction. This reduces the infarct size and suppresses the formation of connective tissue (fibrosis)[14]. In addition, gold nanoparticles with positive charge are effectively used for gene delivery due to their effective interaction with DNA and negatively charged plasma membrane [15].

Conclusion:

In our research paper, we have provided an overview of current drug delivery methods and molecular agents in the context of treating myocardial infarction. These methods include the use of miR-19a/19b microRNAs, liposomes, biological polymers and gold nanoparticles, each with unique characteristics and potential to improve cardiac function and reduce pathological changes in the myocardium after infarction.

The miR-19a/19b microRNAs have demonstrated the ability to stimulate cardiomyocyte proliferation and suppress inflammatory responses, making them potential therapeutic targets for the treatment of myocardial infarction. Liposomes, as potent drug carriers, allow targeted drug delivery and controlled drug release, improving treatment efficacy. Biological polymers such as PLGA and polysaccharides provide versatile platforms for delivery of inhibitors and growth factors to the infarct area, helping to suppress inflammation. Gold nanoparticles have anti-inflammatory and regenerative properties, helping to reduce infarct size and suppress fibrosis.
All these methods provide reliable tools for research and development of new strategies for the treatment of myocardial infarction. However, despite the promise of these methods, further research and clinical trials are required to evaluate their efficacy and safety in real-world treatment of patients with MI.

Overall, our studies emphasise the importance of innovations in drug delivery and molecular therapies to improve myocardial infarction treatment outcomes and reduce its impact on cardiac function. These perspectives provide a sound basis for further research and the development of new strategies to combat this serious cardiovascular medical problem.

References:


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