A Review of Nanoparticles in Treatment of Myocardiac Ischemic-Reperfusion Injury

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Abstract: Myocardial ischemia-reperfusion injury is a kind of pathologic physiology, clinical refers to, when myocardial or coronary artery in patients with partial completeness of acute obstruction, and leads to ischemia after a period of time, restore blood supply, at this time although the myocardium and coronary ischemia returned to normal perfusion, but they are so tissue level by damage, seriously affecting the prognosis of patients with myocardial infarction. Studies have proved that the injury caused by reperfusion is even more serious than that caused by ischemia itself. The mechanisms leading to myocardial ischemia-reperfusion injury mainly include :(1) calcium overload due to recovery of oxygen supply; (2) cardiac ultrastructural changes; (3) lipid peroxidation; (4) leukocyte infiltration; (5) Increase of free radical reactive oxygen species. Different approaches have been used clinically to reduce ischemia-reperfusion injury, including medication, pretreatment and post-treatment. In recent years, the targeting ability of nano-agents has been used to make drugs highly concentrated at the injury site, thus improving the therapeutic effect of drugs for ischemic-reperfusion injury. This emerging medication method has gradually entered the field of vision of experimental researchers and doctors. This review summarizes the successful development of nanoparticles for the treatment of myocardial ischemia-reperfusion injury.

Keywords:Ischemia-Reperfusion Injury(Iri); Treatment; Myocardial Infarction(Mi); Nanoparticle(Nps); Pharmacodynamics; Targeting; Drug Delivery; Atherosclerosis; Reactive Oxygen Species (Ros); Drug

Introduction

Nanoparticles have been demonstrated to be safe and biocompatible in the treatment of IRI by a variety of preclinical studies. A nanoparticle drug delivery system is a new type of drug delivery system, in which particle size is between 1 and 1000 nm and is usually selected according to the size and thickness required to stay on the target organ. Drugs with nanoparticles can avoid biodegradation during drug administration, expanding drug distribution, prolong action time, and increase drug bioavailability. The outer membrane of the nanoparticle is made of natural polymer materials or polymers, and the active drug is wrapped inside the particle. Different types of nanomedicine preparations that are commonly made for use, including nano-enzyme, nanometer vesicles, nanomedicine, nanoparticle, nanocrystalline, and nanocomposite. An introduction to the m nanoparticles used in the treatment of myocardial ischemia-reperfusion injury so far, including their active components, carrier materials used, and preparation methods.

1.1 Nanocolloidal lipid carriers

This classification includes nanoliposomes, nanocrystals, and nanometer colloids. Their carriers for making nanoparticles are phospholipids or other amphipathic materials that resemble cell membranes. By using a simple stirring precipitation method that always encapsulates biological drugs such as enzymes, DNA, RNA, proteins, and colors. Ruijian L. et al. synthesized polyvinyl alcohol (PVA) coated with 4-vanilanol (VA) by microemulsion method to reduce ROS [1]. Martijn J W Evers et al. prepared modified mRNA liposomes by microfluidic approach. [2]

1.2 Colloidal nanopolymer carrier

Nanopolymer is a technique using a biodegradable macromolecule polymer as a membrane to encapsulate pharmaceuticals, such as polyethylene glycol, and polylactic acid, which are two biodegradable macromolecules. These kinds of nanoparticles are typically generated by the microemulsion method and are frequently used to encapsulate abiotic medicines.

Yabing Z. et al. created polydopamine nanoparticles modified with polyethylene glycol to regulate cellular iron death. Antioxidants are targeted at ROS excess sites in the body through the conventional stirring method. Polydopamine is a family of antioxidants that are used to neutralize excess ROS. Polyethylene glycol modification can enhance the drug's biocompatibility and stability. Fourier transform infrared spectroscopy (FTIR) and transmission electron microscopy was used to analyze the nanoparticles. The nanoparticles were found to be effective in reducing IRI caused by iron death in cardiac cells [3]. This may indicate other anti-iron medicines be acceptable for transport via polyethylene glycol (PEG). Chen-Jie L. et al. created water-soluble nanoparticles with mesoporous silica as the carrier, a high dispersity, and quercetin as the primary active ingredient. The nanoparticles were generated using the solution gel method and characterized using dynamic light scattering (DLS). The results indicated that the nanoparticles might modulate the JAK2/STAT3 pathway and protect cardiomyocytes from oxidative stress-induced damage [4]. As a result, mesoporous silica can be employed to transport water-soluble medicines. Gentaro I. et al. produced nanoparticles using polyethylene glycol/glycolic acid (PLGA) as the carrier material and cyclophilin D as the active ingredient, followed by an emulsion solvent diffusion method and suitable labeling. Experiments were conducted in vitro and in vivo. The nanoparticles decreased mitochondrial permeability conversion pore opening and monocyte-mediated inflammation, as well as reducing IRI produced by verification [5]. The author did not characterize the nanoparticles used in this experiment because they were made similarly to those described in other publications [6][7]. Ju-Rol. et al. produced nanoparticles by using a single emulsion/solvent evaporation method. Polydigestible/Glycolic acid (PLGA) as the carrier material, polyethylene glycol as the aqueous phase, and Bcl2 inhibitor (ABT263) as the active drug. Scanning electron microscopy, nanoparticle tracking analysis, and high-performance liquid chromatography (HPLC) were used to analyze the nanoparticles. The results indicated nanoparticles could minimize apoptosis in cells generated by ischemia-reperfusion injury [8]. Xiaotian S. et al. synthesized nanoparticles with PEG (PEG) and lactoferrin (LF) modified mesoporous ferric oxide as carriers, hexadiene trisulfide (DATS) as the primary active component. PEG was used to extend the activity period of nanoparticles, whereas lactoferrin was used to transform nanoparticles into typical blood-brain barriers. Characterization was carried out using scanning electron microscopy. The results indicated the nanoparticles mitigated hypoxia-induced neuronal and myocardial injury [9]. Thus, distinct modified pieces can be placed on the surface of nanoparticles to alter their properties and render them selective. Mengying Hou et al. investigated the co-delivery of VCAM-1 siRNA (SiVCAM-1) and dexamethasone (DXM) to central granulocytes using PLGA nanoparticles modified with CrGD-polyethylene glycol (PEG)crosslinked PEI (RPPT). 13 C NMR, 1 H NMR, and Fourier transform infrared spectroscopy was used to analyze it (FT-IR). The results indicated that the nanoparticles could mitigate inflammatory cell-induced cardiac injury [10].

Discussion

Nanoparticles can be prepared in many ways and materials and should be suitable carrier materials according to the quality and target of drugs. However, no articles compared the biochemical changes and long-term therapeutic effects of different vectors on the same type of drugs. In the case of the same sample size and environment, it is difficult to determine which carrier material has the best effect. That is a feature worth considering and the main research direction of future nanotechnology for the same disease or topic. The selection of suitable nanoparticle preparation technology according to the properties of drugs is also a key index for the safe and effective use of nanomaterials in clinical treatment.

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