



Review

Gadolinium loaded nanoparticles in theranostic magnetic resonance imaging

Yongjun Liu, Na Zhang*

School of Pharmaceutical Science, Shandong University, Ji'nan, People's Republic of China

ARTICLE INFO

Article history:

Received 8 March 2012

Accepted 25 March 2012

Available online 21 April 2012

Keywords:

Gadolinium

Theranostic

MRI

Cancer

Nanoparticles

ABSTRACT

Theranostic magnetic resonance imaging (MRI) is now receiving a growing interest in imaging-guided drug delivery, monitoring the treatment and personalized administration etc. Theranostic agents are essential for the usage of theranostic MRI. Among different kinds of theranostic agents, gadolinium loaded nanoparticles (GdNPs) are one of the most promising theranostic agents which are very promising in combination of diagnostics (molecular imaging) and therapeutics (molecular therapy) functions in a single platform. In this review, we provided fully discussion on the design considerations of GdNPs as a platform for theranostic MRI. The mainly factors that affect the preparation process, such as GdNP materials, the loading of Gd/drugs in GdNPs, and the passive and active targeting strategies were discussed. Major classes of GdNPs including lipid-based nanoparticles, polymeric nanoparticles, micelles, dendrimers and Gd-silica nanoparticles were described in detail. The use of GdNPs as theranostic agents offers potential advantages that change the usual cancer therapy from separating diagnosis and treatment to theranostic approach.

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1. Introduction

For the past few decades, nanoparticles (NPs) have been widely used as carriers in both research and clinical areas of drug delivery and disease diagnosis [1]. As drug carriers, NPs could increase the drug stability, protect drug against degradation, target deliver to site of action and reduce undesirable toxicity or side effects [2]. A nanoparticlar cremophor-free albumin-bound paclitaxel (PTX) formulation (Abraxane™) which has already been used in clinic is the best example of the successful use of NPs as drug carriers. Compared to traditional PTX formulation, Abraxane™ could change the non-specific biodistribution of PTX, increase the treatment efficiency, reduce the unwanted toxicity and especially be administered conveniently [3,4]. As diagnostic agents, NPs could be modified with different kinds of bioactive molecules to detect human diseases, meanwhile, some NPs possess unique optical, electronic and magnetic properties depending on their core materials [5]. For example, superparamagnetic iron oxide (SPIO) NPs, such as Feridex®, have widely been used as contrast agents in magnetic resonance imaging (MRI) for cancer diagnosis especially for liver tumor [6]. Both these two applications of NPs have great prospects in the field of clinical medicine and pharmacy. Recently, at the intersection between treatment and diagnosis, a new

approach, named as theranostics, which combined molecular diagnosis and therapy was born and have attracted more and more interests in the individual treatment of diseases [7].

The birth of theranostics came from an anti-breast cancer medicine trastuzumab which is a humanized monoclonal antibody to HER2. Because not all the stage IV breast cancer cells over-express HER2, the HER2 test must be done before the administration of trastuzumab to determine the suitability of trastuzumab for each specific patient in order to reach the best treatment [8]. In this initial application, theranostics defined as a treatment strategy that combines therapeutics with diagnostics. It associated both a diagnostic test that identifies patients most likely to be helped or harmed by a new medication, and targeted drug therapy based on the test results [9]. While in the recent researches, theranostics mostly defined as the strategy that combined therapeutics and diagnosis on a single platform. It required a multifunctional carrier which could load therapeutic drugs and diagnostic agents simultaneously [10]. These theranostic formulations offered several advantages including the assessment of the biodistribution and accumulation of drugs at target sites noninvasively, the visualization of drug distribution and drug release at the target site, the optimization of formulation which relied on triggered drug release, and the real-time monitoring the therapeutic responses with the help of different kinds of imaging modalities [11]. These theranostic imaging modalities included MRI, computed tomography (CT), ultrasound (US), positron emission tomography (PET), optical imaging and single photon emission computed tomography

* Corresponding author. Tel.: +86 531 88382015; fax: +86 531 88382548.

E-mail address: zhangnancy9@sdu.edu.cn (N. Zhang).