Role of Nanotechnology in Medical Imaging

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ABSTRACT

Imaging methods have been used for decades for cell/tissue imaging in diagnostics. However the results of conventional imaging techniques were less distinctive and transparent because of the use of unstable organic dyes as contrast agents. These dyes offered low photo stability and quantum yield resulting in poor quality images. However with the advent of nanotechnology, field of medical imaging has revolutionized immensely. Application of different nanomaterials such as silica nanoparticles, quantum dots, gold nanoparticles, etc. have overwhelmed many of the restrictions of conventional contrast agents employed in imaging and thus enhances the performance potential of the existing diagnostic tools.

Keywords: Contrast agents; Magnetic resonance imaging; Quantum dots; Silica nanoparticles; Liposomes

INTRODUCTION

The development of fabrication methodologies for the synthesis of nano-based contrast agents aimed to improve our understanding of the biological procedures at molecular level by enhancing the performance potential of the existing diagnostic tools for better treatment [1]. Conventionally used organic dyes offered low photo stability, reduced quantum yield and inadequate in vitro/in vivo consistency [2]. Therefore use of nano-based luminous dyes such as silica nanoparticles, quantum dots and gold nanoparticles have overwhelmed many of the restrictions of conventional contrast agents employed in imaging [3,4]. These nanoparticles are currently being established for providing good absorbance and emission in the nearby ultraviolet area, which permits their application for real time and deep tissue imaging through optical methods [5,6].

NANOTECHNOLOGY IN MEDICAL IMAGING

Nanotechnology offers an important enhancement in the conventional medical imaging of tissues and cells by utilizing fluorescence microscopy to produce body images of high resolution [7]. In conventional imaging dyes such as fluorescein isocyanate and rhodamine were often bound with biomolecules that specifically binds to the cells or cell constituents from side to side ligand/receptor interactions [8]. However insufficient luminescence strength and photo bleaching were the two most common problems encountered in this type of method [9]. Photo bleaching causes the reduction in fluorescent potency of the dye thus making it non fluorescent [10]. In order to overcome these problems, Quantum dots were employed as these nanoparticles releases resilient fluorescent light underneath electromagnetic illumination [11]. Quantum dots can release light that is far more concentrated and expressively more established than conventional organic colorants [12]. In addition, Quantum dots possess numerous binding sites present on its external surface on which many solvable and bioactive molecules can be chained [13]. Another imaging technique is the Magnetic Resonance Imaging (MRI) that is employed to achieve three-dimensional, non-invasive examinations of the body [14]. MRI scans include assembly of several images based on three-dimensional position as well as on weighting based on T1 (denotes the time compulsory for re-establishment of nuclear rotations in arrangement with the stationary magnetic field) and T2 (denotes the usual time on which the corner to corner magnetization of the hydrogen nuclei become extinct) i.e. relaxation times [15,16]. Different types of body tissues can be distinguished on the basis of altered T1 and T2 [17]. As in medical imaging the naturally occurring variance in relaxation
time among the areas of interest are little that’s why use of contrast agents is necessary [18]. Usually nanoparticle based paramagnetic compounds such as iron oxide is commonly used as an active contrast agent because it alters the time of relaxation of desired tissues/ fluids that are present in the body [19]. In addition, gadolinium complexes of have been effectively used as contrast agents for numerous years but the relaxation times of super paramagnetic nanoparticles are considerably higher as compared to gadolinium-based agents [20,21].

Choice of nanoparticle to be used in imaging as contrast agent
A widespread variety of nanoparticles with different properties have been used in imaging techniques for the creation of various contrasts [22]. Examples of few nanoparticles used as a contrast agent in imaging is given below:

• Gadolinium complexes such as liposome, lipoproteins and carbon nanotubes were employed as contrast in MRI [23]. It provides positive contrast based on agent accumulation in the tissue [24]
• Super paramagnetic iron oxides have been generally utilized to encourage contrast for T2-weighted MRI [25]. Iron oxide is more sensitive so it causes loss of signal as it provides a negative contrast [26]. However there are other factors that are taken into consideration when selecting these nanomaterials such as Iron oxides are suitable to be used as contrast agents for imaging that produces identical MRI signals [27]
• Quantum dots on the other hand provides an excellent contrast for fluorescent imaging [28]. They have extensive stimulation openings, thin discharge openings, they fluoresce with high efficacy, and are not susceptible to photo bleaching [29,30]
• These nanoparticles have been used as CT contrast agents because they have a tendency to be based on electron density due to their high atomic number [31]
• Microemulsions such as decafluorobutane act as an ultrasound contrast agents [32]. However most of the time these contrast are less biocompatible with short circulating half-life and becomes toxic [33]. In order to make these materials more capable and bioactive, a diversity of different carrier molecules have been used such as phospholipids, dextran, polyvinylpyrrolidone, PEG, or silica as coatings [34,35]

Toxic potential of nanoparticles used in imaging
Nanomaterials being effectively used in medical diagnostics also display different types of toxic effects in the body thus restricting their use. Few examples are discussed below:

• The main toxicological hazard related with the use of QDs in is the exposure of its inorganic core that possess distinctive chemical properties thus can pose a toxic effect inside the body [36]
• The use of numerous metal oxide-based nanoparticles as contrast agents in clinical use is well recognized. However the chemical surface alteration of these metallic nanoparticles can, nevertheless, causes toxicity [37]

• This group of nanoparticles are undoubtedly the least challenging with admiration to toxicity because they are mostly enclosed with an uncharged polymers that are neutral [38]

CONCLUSION
Thus, nanotechnology plays a potential role in enhancing the functional capabilities of imaging techniques by utilizing different nanoparticles to produce a better result.

REFERENCES