OPEN ACCESS Freely available online

International Journal of Advancements in Technology

Short Communication

Role of Nanotechnology in Medical Imaging

Nida Tabassum Khan*

Department of Biotechnology, Faculty of Life Sciences and Informatics, Balochistan University of Information Technology, Engineering and Management Sciences (BUITEMS), Quetta, Balochistan, Pakistan

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

Correspondence to: Nida TK, Department of Biotechnology, Faculty of Life Sciences and Informatics, Balochistan University of Information Technology, Engineering and Management Sciences, Takatu Campus, Airport Road, Quetta, Balochistan, Pakistan, Tel: +92 3368164903; Email: nidatabassumkhan@yahoo.com

Received: May 16, 2020; **Accepted:** May 27, 2020; **Published:** June 7, 2020

Citation: Khan NT (2020) Role of Nanotechnology in Medical Imaging. Int J Adv Technol 11:234. doi: 10.35248/0976-4860.20.11.234

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 suscep tible 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

1. Liu Z, Liu J, Wang R, Du Y, Ren J, et al. An efficient nano-based theranostic system for multi-modal imaging-guided photothermal sterilization in gastrointestinal tract. Biomaterials. 2015;56:206-218.
2. Licha K. Contrast agents for optical imaging. In Contrast Agents II (pp. 1-29). Springer, Berlin, Heidelberg, 2002.
3. Cho EC, Glaus C, Chen J, Welch MJ, Xia Y. Inorganic nanoparticle-based contrast agents for molecular imaging. Trends Mol Med. 2010;16:561-573.
4. Cormode DP, Jarzyna PA, Mulder WJ, Fayad ZA. Modified natural nanoparticles as contrast agents for medical imaging. Adv Drug Deliv Rev. 2010;62:329-338.
5. Jin Y, Jia C, Huang SW, O'donnell M, Gao X. Multifunctional nanoparticles as coupled contrast agents. Nat Commun. 2010;1:1-8.
6. Hahn MA, Singh AK, Sharma P, Brown SC, Moudgil BM. Nanoparticles as contrast agents for in-vivo bioimaging: current status and future perspectives. Anal Bioanal Chem. 2011;399:3-27.
7. Roszek B, De Jong WH, Geertsma RE. Nanotechnology in medical applications: state-of-the-art in materials and devices. RIVM report. 2005.
8. Shi H, He X, Wang K, Yuan Y, Deng K, et al. Rhodamine B isothiocyanate doped silica-coated fluorescent nanoparticles s(RBITC-DSFNPs)-based bioprobes conjugated to Annexin V for apoptosis detection and imaging. Nanomedicine. 2007;3(4): 266-272.
9. Wells KS, Sandison DR, Strickler J, Webb WW. Quantitative fluorescence imaging with laser scanning confocal microscopy. In Handbook of biological confocal microscopy, Springer, Boston, MA, 1990:27-39.
10. Sprague RH, Fichter JHL, Hamilton WP. U.S. Patent No. 3,104,973. Washington, DC: U.S. Patent and Trademark Office, 1963.
11. Ghasemi Y, Peymani P, Afifi S. Quantum dot: magic nanoparticle for imaging, detection and targeting. Acta Biomed. 2009;80:156-165.
12. Smith AM, Ruan G, Rhyner MN, Nie S. Engineering luminescent quantum dots for in vivo molecular and cellular imaging. Ann Biomed Eng. 2006;34:3-14.
13. Bukowski TJ, Simmons JH. Quantum dot research: current state and future prospects. Crit Rev Solid State. 2002;27:119-142.
14. Liang ZP, Lauterbur PC. Principles of magnetic resonance imaging: a signal processing perspective. SPIE Optical Engineering Press. 2000.
15. Vlaardingerbroek MT, Boer JA. Magnetic resonance imaging: theory and practice. Springer Science amd Business Media. 2013.
16. Buxton RB. Introduction to functional magnetic resonance imaging: principles and techniques. Cambridge University Press. 2009.

17. Morris SA, Slesnick TC. Magnetic resonance imaging. Visual Guide to Neonatal Cardiology. John Wiley and Sons, 2018.
18. Merbach AS, Helm L, Tóth É. The chemistry of contrast agents in medical magnetic resonance imaging. John Wiley and Sons, 2013.
19. Shen Z, Wu A, Chen X. Iron oxide nanoparticle based contrast agents for magnetic resonance imaging. Mol Pharm. 2007;14:1352-1364.
20. Zhou Z, Lu ZR. Gadolinium based contrast agents for magnetic resonance cancer imaging. Wiley Interdiscip Rev Nanomed Nanobiotechnol. 2013;5:1-18.
21. Geraldes CF, Laurent S. Classification and basic properties of contrast agents for magnetic resonance imaging. Contrast Media Mol I. 2009;4:1-23.
22. Krause W. Contrast agents I: magnetic resonance imaging. Springer. 2003 Ed.
23. Raymond KN, Pierre VC. Next generation, high relaxivity gadolinium MRI agents. Bioconjugate Chem. 2005;16:3-8.
24. Chan KWY, Wong WT. Small molecular gadolinium (III) complexes as MRI contrast agents for diagnostic imaging. Coord Chem Rev. 2007;251:2428-2451.
25. Zhao X, Zhao H, Chen Z, Lan M. Ultra small superparamagnetic iron oxide nanoparticles for magnetic resonance imaging contrast agent. J Nanosci Nanotechno. 2014;14:210-220.
26. Sjøgren CE, Briley SK, Hanson M, Johansson C. Magnetic characterization of iron oxides for magnetic resonance imaging. Magn Reson Med. 1994;31:268-272.
27. Davies GL, Kramberger I, Davis JJ. Environmentally responsive MRI contrast agents. Chem Comm. 2013;49:9704-9721.
28. Jaiswal JK, Simon SM. Potentials and pitfalls of fluorescent quantum dots for biological imaging. Trends Cell Biol. 2004;14:497-504.
29. Wegner KD, Hildebrandt N. Quantum dots: bright and versatile in vitro and in vivo fluorescence imaging biosensors. Chem Soc Rev. 2015;44:4792-4834.
30. Gao X, Yang L, Petros JA, Marshall FF, Simons JW. In vivo molecular and cellular imaging with quantum dots. Curr Opin Biotech. 2005;16:63-72.
31. Kim D, Park S, Lee JH, Jeong YY, Jon S. Antibiofouling polymer-coated gold nanoparticles as a contrast agent for in vivo X-ray computed tomography imaging. J Am Chem Soc. 2007;129:7661-7665.
32. Sheeran PS, Wong VP, Luois S, McFarland RJ, Ross WD. Decafluorobutane as a phase-change contrast agent for low-energy extravascular ultrasonic imaging. Ultrasound Med Biol. 2011;37:1518-1530.
33. Quay SC. U.S. Patent No. 5,409,688. Washington, DC: U.S. Patent and Trademark Office. 1995.
34. Liu Y, Miyoshi H, Nakamura M. Encapsulated ultrasound microbubbles: therapeutic application in drug gene delivery. J Control Release. 2006;114:89-99.
35. Klibanov AL. Ligand-carrying gas-filled microbubbles: ultrasound contrast agents for targeted molecular imaging. Bioconjugate Chem. 2005;16:9-17.
36. Medintz IL, Mattoussi H, Clapp AR. Potential clinical applications of quantum dots. Inter J nanomed. 2008;3:151.
37. Tetard L, Passian A, Venmar KT, Lynch RM, Voy BH, et al. Imaging nanoparticles in cells by nanomechanical holography. Nat Nanotechnol. 2008;3:501.
38. Banik BL, Fattahi P, Brown JL. Polymeric nanoparticles: the future of nanomedicine. Wiley Interdiscip Rev Nanomed Nanobiotechnol. 2016;8:271-299.