Nanomedicine

Nanomedicine is the field of nanotechnology which seeks to deliver a valuable set of research tools and clinically useful devices in the near future with new applications that may include advanced drug delivery systems, therapeutics, and *in vivo* imaging. As the nanomedicine industry continues to grow; it is expected to have a significant impact on the economy. Nanomedicine is one of the largest industries, with the global nanomedicine market valued at ~$50 billion in 2009 and is forecasted to peak $100 billion by 2014. Among this, cancer imaging and therapeutics is one of the largest market segments, expected to reach $33 billion in 2014 followed by their application for CNS indications which is expected to reach $18 billion by 2014.

In general, targeted drug delivery and *in vivo* imaging are basically two areas of medicine which can be benefited enormously from current nanomedical practices. The current nanomedical approaches to drug delivery focuses on developing nanoscale particles that maximize the bioavailability of the therapeutics, whereas the *in vivo* imaging uses the nanocontrast agents that allow us to see the diseased organ. Once a disease has been imaged, it can be followed by treatment, thus allowing to cure on control even a fatal disease. As a result, both *in vivo* imaging and targeted drug delivery can potentially be achieved by nanoengineered devices. Most commonly, the effective imaging techniques may include magnetic resonance imaging (MRI), positron emission tomography (PET), single photon emission computed tomography (SPECT), x-ray computed tomography (CT), ultrasound imaging (US), and optical imaging. These imaging modalities have been widely applied and have established outstanding accomplishment in the clinical settings. However, they differ in advantages and limitations, but even with these differences when used in tandem they will offer a great potential for diagnosis. For example, MRI can provide highest spatial resolution, whereas PET or SPECT provide high target sensitivity but poor spatial resolution. Similarly, CT, like MRI, an X-ray imaging in 3D can provide a good spatial resolution while sacrificing target sensitivity. Thus, when MRI/PET or CT/PET used in concert they can provide boundless information in both functional and anatomical details. Last but not the least, US still remains cheapest imaging modality coupled with low resolution and sensitivity. Thus, it is clear that no single modality could provide information on all aspects of structures and functions. Conversely, multimodal imaging has been exploited to compensate for the loss, which provides more precise and complete information for decisive diagnosis.

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Various nanoparticulated contrast agents have been used to serve as imaging probes. Normally, superparamagnetic nanoparticles such as Fe_3O_4 and Gd_2O_3 are the most common contrast agents used for MRI or the radioisotopes such as ^{18}F, ^{124}I, ^{64}Cu, ^{99}mTc or ^{111}In has been used for radioimaging modalities. Correspondingly, the heavy atoms such as iodine, gadolinium, gold, and acoustically active micro/nanobubbles have been used as imaging agents for CT and US, respectively. Such nanotechnology-enhanced imaging systems have great advantages over the traditional agents due to the higher surface to volume ratio. Besides, nanotechnology has addressed these challenges by formulating the contrast agent which is encapsulated within or as a part of various nanocarriers, such as polymer conjugates, micelles, liposomes, solid lipid nanoparticles, nanoparticles of biodegradable polymers, dendrimer nanoparticles, and other nanostructured complexes which can increase the specificity and selectivity of these probes. For instance, the specificity of these imaging agents can be improved by tagging the surface of these nanocarriers with a selective ligand or a monoclonal antibody for a targeted delivery or can be covered with stealth layer of polymers such as polyethylene glycol (PEG) to escape recognition by the reticuloendothelial system. These formulations can greatly reduce the side effects of the imaging agents by avoiding direct exposure to the other sites of the body. Also, the smaller size of nanoparticles increases the loading capacity of the surface ligands, which can enable the visualization of the defects or abnormality in various organs even at very low concentration of the contrast agent. Furthermore, the physicochemical properties of such nanocarriers can be tailored especially for its surface chemistry which can be made resonance with a dual imaging modality. Countless, studies have explored the feasibility of

making an effective imaging agents for dual modal imaging. For example, radioactively labeled iron oxide nanocrystals can provide an excellent contrast agent for PET/MRI. Such dual responsive complexes are usually encapsulated or are doped hybrid structure. Of course, toxicity of these nanomaterials has been a matter of concern. Hence, effort has been made to alter the toxicities of these systems via surface protection by polymers such as PEG or encapsulation of imaging agent into biodegradable nanocarriers such as liposomes or nanoshells.

Likewise, the therapeutic delivery systems such as lipid- or polymer-based nanoparticles can be designed to improve the pharmacological and therapeutic properties of drugs. A brief review on the application of nanotechnology in medicine and nanodevices has been presented by Ms. Shalinee Rao in her article "Nanotechnology based devices and application in medicine: an overview," in this thematic issue on nanomedicine. Additionally, application of nanoparticles in the field of nanomedicines has also been reviewed by Mr. Yogesh Chaudari in his "Nanomedicine: 'Nanoparticles-A paradigm for topical drug delivery," and by Ms. Smita Zinjarde in her article "Nanomedicine: Bio-inspired Nanomaterials and their applications as antimicrobial agents." All these articles have reviewed a path for development of an effective, clinically adaptable targeted therapy and their advancement with frequent snags in formulation and toxicity. Moreover, each of these obstacles poses a hurdle which can be offset by the properly trained multidisciplinary team-oriented approach. Fortunately, efforts are been taken at the leading research institutes to compile a mass of multidisciplinary researchers to address the challenges that still lie ahead in the field of nanomedicine.

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