molecular pharmaceutics

editorial

Nanotheranostics: Integration of Imaging and Targeted Drug Delivery

Nanoparticles have been evaluated in both imaging and drug delivery. Recently, more effort has been focused on integrating imaging probes and therapeutic agents into one nanoparticle for simultaneous disease imaging/detection and targeted drug delivery or imaging-guided drug delivery. A new term "nanotheranostics" has been proposed to describe these nanoparticles. The "nanotheranostics" can be used in various imaging modalities, such as optical imaging, nuclear imaging, magnetic resonance imaging (MRI), computer tomography (CT), and ultrasound imaging (US). The "nanotheranostics" can also deliver small molecules or biologics (such as proteins and siRNA) to disease targets to achieve targeted therapy. This theme issue of *Molecular Pharmaceutics* presents the most recent advances in nanotheranostics.

In the past few decades, various nanoparticles (or nanocarriers) have been studied for targeted delivery of small chemical molecules and macromolecules in preclinical and clinical settings. These nanocarriers are made of different materials, such as lipids (liposomes or micelles), organic polymers, carbon, semiconductor, gold, and iron oxide. These nanocarriers are designed to deliver therapeutic agents to disease areas (such as tumors) by passive targeting (EPR effect) or active targeting with different ligands. Despite extensive efforts for these targeted drug delivery techniques, only very few products have achieved success in the clinic and reached the marketplace. Successful examples include liposomal formulation of doxorubicin (Doxil and Myocet) and paclitaxel nanoparticle formulation (Abraxane and Xyotax). Although antibody−drug conjugates (or protein ligand−toxin conjugates) can achieve targeted drug delivery (such as Zevalin and Ontak) in clinical use, active targeting using antibodies or other ligands for nanocarriers still has great challenges for their successful clinical application. In addition, indirect measurements (such as from tissues homogenates) are usually used to determine the drug accumulation in the disease site for targeted drug delivery with nanoparticles. There were no direct approaches to visualization of drug release and accumulation before these imaging modalities were developed.

Benefiting from development of the imaging equipment and software, various imaging modalities have rapidly advanced, such as optical imaging, positron emission tomography (PET), single photon emission computed tomography (SPECT), magnetic resonance imaging (MRI), computer tomography (CT), and ultrasound (US) imaging. Both individual and combined imaging modalities (such as PET/CT) have been widely used for detection and diagnosis of diseases. Many of these imaging modalities use contrast agents, such as iodine and barium as used for CT, gadolinium (Gd) or iron oxide nanoparticles for MRI, ^{18}F-fluorodeoxyglucose (FDG) for PET, and In-111 and Tc-99m for SPECT. Although these contrast agents do not have targeting moieties to disease areas (except FDG for cancer), they usually enhance the imaging resolution and disease detection sensitivity. However, these contrast agents usually do not offer therapeutic effects.

Nanotheranostics integrates both imaging and targeted drug delivery into one nanoparticle for both disease diagnosis and therapy. Nanotheranostics can also be used for imaging-guided drug delivery. This theme issue (Nanotheranostics) of Molecular Pharmaceutics has four review articles. Lammers et al. reviewed various applications of nanotheranostics in noninvasive visualization of drug distribution, drug release kinetics, drug accumulation at target sites, drug therapeutic effect, and disease diagnosis. Bhojani et al. described the nanotheranostics in brain MRI imaging and therapy. Gao et al. summarized pH-responsive nanoparticles for drug delivery. Manthe et al. reviewed the application of different nanoparticles in tumor ablation.

This theme issue (Nanotheranostics) of *Molecular Pharmaceutics* also has nine original research articles. Lobatto et al. studied the multimodality imaging (MRI and PET) and treatment of atherosclerosis using nanotheranostics. Research articles (Mohan and Rapoport, Kheirolomoom et al., and Grainger et al.) studied imaging-guided drug delivery using ultrasound and nanotheranostics in cancer models and cancer cells. Zou et al. described nanotheranostics for intracellular pH-dependent drug release, as well as MRI and fluorescent imaging in cancer cells. Mok et al. studied a pH-sensitive nanovector for pH-dependent siRNA release for gene slicing. Research articles (Zhan et al., Liu et al., and Pang et al.) described various nanocarriers with different peptides and targeting mechanisms in tumor models.

The research results presented in this issue of *Molecular Pharmaceutics* provide a broad overview of this exciting new field combining diagnostic imaging and therapy.

Duxin Sun

Guest Editor
Department of Pharmaceutical Sciences, College of Pharmacy, The University of Michigan, Ann Arbor, Michigan 48109, United States
E-mail: duxins@umich.edu

MP1003652

10.1021/mp1003652
Published on Web 12/06/2010