molecular pharmaceutics

editorial

What Can You See with Imaging in Pharmaceutical Research?

The pharmaceutical research community has had a long-standing guideline that for experimental therapeutic preclinical studies at least six animals are required for each data point. Consequently, a large number of experimental animals are sacrificed during preclinical drug development. The methods used in conventional preclinical drug delivery are invasive and often are not predictive of the results of later clinical studies. Options for evaluating pharmaceutical and pharmacological properties of new drugs are very limited during the clinical drug development phase. Surgery- or biopsy-based tissue sampling is invasive and can result in low patient compliance. In addition, single time point measurement for drug efficacy by these methods often does not accurately reflect the true systemic efficacy of the drug.

Molecular imaging aims to provide direct and/or indirect visualization of biomarkers and biological processes in living organisms. It offers a noninvasive tool for pharmaceutical scientists to monitor how their drug behaves in vivo during both the preclinical and clinical phases of discovery and development. The pharmaceutical properties, including pharmacokinetics and pharmacodynamics, of therapeutic agents or drug delivery systems can be noninvasively and continuously evaluated in vivo after they are labeled with imaging probes or contrast agents. Their therapeutic efficacy can also be monitored by visualization of the response of biomarkers or surrogate biomarkers to the experimental treatments. For example, integrins are one class of biomarkers of tumor angiogenesis and metastasis. The therapeutic efficacy of an antiangiogenic agent can be seen by quantitative imaging of the response of the biomarkers in tumor tissues to the treatment with integrin-specific probes (Liu; Bloch et al.). Molecular imaging can be used as end points for the evaluation of the therapeutic efficacy of drug in various stages of development. Thus the number of experimental animals can be greatly reduced with noninvasive imaging during preclinical drug development, hopefully leading to better clinical trial design. The noninvasive imaging methods developed in the preclinical studies can be readily translated into clinical drug development (Chen and Schuster).

Molecular imaging offers a new opportunity for pharmaceutical scientists. Imaging probes and contrast agents are among the key elements of molecular imaging. These probes and agents are often evaluated and developed as drugs in order to proceed into clinical applications. More effective and specific imaging probes and contrast agents are needed to satisfy various applications of molecular imaging. Like therapeutic agents, in vivo pharmaceutical properties of probes and contrast agents are critical for their effectiveness and specificity in molecular imaging. Proper delivery systems, in many cases, are required for improving their specificity and efficacy. The expertise of pharmaceutical scientists in drug discovery and development is extremely valuable for the design and development of more effective and specific imaging probes and contrast agents for molecular imaging.

The articles in this special theme issue have covered the currently available modern imaging modalities that can be used in pharmaceutical research, which include X-ray computed tomography (CT), ultrasound imaging, single photon emission computed tomography (SPECT), positron emission tomography (PET), magnetic resonance imaging (MRI), and optical imaging. These contributed articles represent the interdisciplinary research of molecular imaging and pharmaceutical science. It is shown that molecular imaging is a desirable end point for noninvasive evaluation of the efficacy of a new drug in preclinical and clinical drug development (Chen and Schuster). Effective imaging probes or contrast agents are the key element for the detection of various pathological conditions, specific visualization of biomarkers or surrogate biomarkers, and noninvasive evaluation of the therapeutic response to various therapies (Bloch et al.; Erdogan et al.; Liu; Nguyen et al.; Rychak et al.; Zarabi et al.). Molecular imaging has been employed to reveal the physiological environment and metabolism in tumor tissues, which is essential for the determination of therapeutic responses (Glunde et al.). Proper labeling of therapeutics or their delivery systems allows noninvasive and continuous visualization and tracking of their delivery kinetics and biodistribution in vivo (Barnett et al. and Ye et al.).

As illustrated by the articles in this special issue, it is clear that pharmaceutical scientists can contribute to and play an essential role in the design and development of safe, effective, and specific imaging probes for molecular imaging. Molecular imaging allows pharmaceutical scientists to visualize the behavior of therapeutics in vivo. The field of molecular imaging is still in its infancy. Interdisciplinary research will certainly facilitate its maturation and have a significant impact on the accurate identification of drug candidates, and more cost-effective drug discovery and development.

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