Nuclear Medicine in the Era of Precision Medicine

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Precision medicine is an emerging approach for disease prevention and treatment that takes into account variations in genes, environment, and lifestyle among individuals. It integrates research disciplines and clinical practice to build a knowledge base that can better guide individualized patient care [1].

Genetic information on human diseases is being rapidly gathered with improvements in biotechnology and is being used to stratify patients according to their likely response to a certain therapeutic approach. Tailored treatment based on genetic information improves success rates and reduces costs by providing the right therapy at the right time to each patient [1, 2]. Innovative clinical trials of targeted drugs for cancerous diseases are being actively conducted based on the understanding of molecular pathology of the disease gained from genomic studies. Such trials facilitate the development of effective treatments that target subclasses of tumors that have certain discrete molecular profiles [3].

Genomic, proteomic, and metabolomic features of diseases must be gathered to develop optimal individualized therapeutic strategies. Large international consortia are trying to map the molecular features of thousands of diseases to identify new opportunities for their prevention, early detection, and treatment [3]. The right drug can be matched to the right patient through the processes of precision medicine by recognizing the molecular features of the disease, and appropriate matching can offer greater

potential for durable clinical benefits [3]. Detection of the molecular features of diseases is one of the key steps to developing the best tailored therapeutic strategy for individual patients, and it is usually achieved by analyzing pathological samples from each patient. Although pathological samples have been classically used to detect biological features of diseases for a long time, innate invasive nature is a significant drawback of techniques using tissue samples. Heterogeneity of cancer lesions in a single patient is one of the biggest challenges for therapeutic success, and biopsy of every metastatic lesion is impossible in practice [4]. Imaging technologies, which are able to visualize biological features in a disease, might be a noninvasive solution, removing the issue of heterogeneity.

Molecular imaging, one of the fastest growing biomedical fields, is able to visualize biological characteristics of diseases within intact living organisms; therefore, the molecular features of a disease can be noninvasively assessed using an imaging technology [5]. Molecular imaging can be performed with various imaging technologies such as optical imaging, nuclear medicine imaging, computed tomography, magnetic resonance imaging, ultrasonography, Raman spectroscopic imaging, and photoacoustic imaging. Molecular imaging technologies have their own unique strengths and are actively applied to preclinical studies to answer specific questions raised by researchers; however, they are seldom used in clinical applications, except nuclear medicine, owing to their inherent weaknesses such as poor tissue penetration of imaging signals, low sensitivity, and toxicity of imaging probes [6].

Nuclear medicine imaging has been used to visualize pathophysiological features in thyroid disease for more than 70 years and is still the only molecular imaging modality used practically regularly in the clinic owing to its advantages of high sensitivity and proven safety.

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Radioiodine nuclear imaging can visualize sodium iodide symporter expression in thyroid cancers, whereas nuclear imaging with radiolabeled estrogen can demonstrate estrogen receptor in breast cancers. Based on the information obtained by nuclear imaging, radioiodine treatment or hormonal therapy can be successfully used in certain subgroups of patients with thyroid cancer or breast cancer, respectively [7–9].

Rapid advances in radiochemistry and electrical engineering of nuclear imaging instruments have broadened the application of nuclear molecular imaging as an imaging tool that is now able to show the molecular characteristics of various diseases in the clinical setting. Although their clinical availability is still quite limited, nuclear molecular imaging technologies using radionuclide probes will potentially be able to visualize various genomic, proteomic, and metabolomic features of diseases in the near future. It is obvious that nuclear molecular imaging will play a crucial role in precision medicine and will tremendously contribute to various clinical fields, particularly oncology.

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Compliance with Ethical Standards

Conflict of Interest The author Byeong-Cheol Ahn declares that he has no conflict of interest.

Ethical Approval This work does not contain any studies with human participants or animals performed by the author.

Informed Consent Under Ethical Approval None.

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