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EDITORIAL

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Short Essay on 60 Years' Challenges and Achievements of KSNM

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According to the *Book of Changes* (周易), a traditional philosophy book of ancient China, it takes 60 years for space and time to return to their original site in the cosmos, so-called sexagenary cycle. The 60th birthday is considered the turning point of rebirth. The next life should not be a simple repetition, but a better one based on the experiences and wisdom of the past 60 years. The Korean Society of Nuclear Medicine (KSNM) was founded in 1961, and we would like to have an opportunity to celebrate the 60th birthday and to review the achievements for future development. The *Nuclear Medicine and Molecular Imaging* (*NMMI*) has a plan to publish a series of articles in this year on the history and current status of academic activity in each subspecialty of KSNM. We expect that the information would be of help to promote nuclear medicine especially in developing countries.

Summarized History of Nuclear Medicine in Korea

Prof. Munho Lee of Seoul National University Hospital (SNUH) initiated nuclear medicine in Korea [1, 2]. He studied the medical application of radionuclide at Freiburg University of Germany under the supervision of Prof. Ludwig Heilmeyer from 1954 to 1957. Dr. George Hevesy, a Nobel Prize laureate who invented the "radiotracer principle," had worked at Freiburg University as a chemistry professor, and there was a great tradition of research on radioisotope tracers. Thus, it can be said that KSNM follows the academic mainstream of nuclear medicine. Young pioneers including Munho Lee, Jang-Kyu Lee, Ki-Seok Hwang, Byung-Seok Min, and Chang-Soon Koh founded KSNM on December 28, 1961. Prof. Munho Lee was elected the first president of KSNM. The *Korean Journal of Nuclear Medicine*, the former title of *NMMI*, was first published in March 1967.

In the late 1960s, static and dynamic nuclear imaging became available by installing gamma cameras in pioneering hospitals in Korea. Thyroid scan, liver scan, hepatobiliary scan, brain scan, and serial renal scan were major imaging studies in nuclear medicine. In the late 1970s, quantification of static and dynamic images became available after installing a computer system to gamma cameras. SPECT cameras were introduced after the mid-1980s, which were mainly practical for blood flow analyses of the brain and myocardium. In the mid-1990s, positron emission tomography (PET) and medical cyclotron were first introduced in Korea [1, 2].

With these new methodologies, nuclear medicine physicians have focused on functional and metabolic images of various organs. Anatomical images such as X-ray, ultrasound, CT, and MRI have been used widely in patient management. However, morphologic changes usually appear lately following functional and metabolic changes in many disorders. Thus, molecular and genetic imaging using radionuclide technology is investigated to prepare future molecular medicine. Genetic imaging seeks out the fundamental cause of a disease and the truths on the disease or even life. As the belief of Mahatma Gandhi, "Truth is god", molecular and genetic imaging enables us to broaden our knowledge and hopefully to explore inventor of the cosmos.

With the expansion of nuclear medicine–based imaging and therapy in clinic, the Korean Specialty Board of Nuclear Medicine was established in 1995 [1]. After the separation of nuclear medicine as an independent medical specialty, many young physicians and scientists assembled in the field. In addition to board members from the regular training course of nuclear medicine, specialists in internal medicine or radiology had been trained to be nuclear medicine specialists, through

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fellowship courses. These "dual specialty" board members contributed greatly to the initial settlement of nuclear medicine specialty by using their expertise in both fields. Consequently, scientists from the related fields have joined to develop and manufacture drugs, instruments, and machines for nuclear medicine. These groups were well organized to produce synergies under the harmonized leadership of KSNM. The establishment of an independent specialty board was a turning point for explosive growth of nuclear medicine in Korea, because nuclear medicine physicians can independently participate in making policies on medical practice and researches.

Statistical Data

Medical Facilities, Equipment, and Human Resources

There was a rapid increase in medical facilities practicing nuclear medicine in the 1980s. The number of medical facilities practicing nuclear medicine was approximately 100 in the 1990s and increased further up to 150 in the 2000s. Today, there are 237 gamma cameras, 59 SPECT/CT, and 157 PET machines (3 PET, 149 PET/CT, 4 PET/MRI, and 1 PEM) in 153 hospitals. The number of board-certified nuclear medicine physicians is 214, and 73 more physicians including residents are working in clinics. In addition, there are 139 nuclear scientists including biomedical engineering scientists and radiopharmacists [3].

Gamma Camera Image

The number of conventional nuclear imaging studies using gamma cameras has continuously increased over the last two decades (Fig. 1). Among 841,662 conventional nuclear imaging studies performed in 2019, musculoskeletal imaging was the most commonly performed (68.0%) followed by cardiovascular imaging (12.5%), principally myocardial perfusion SPECT. Additionally, endocrine (6.4%), renal (4.7%), gastrointestinal (2.5%), and neurological (2.7%) imaging studies were performed [3]. The increase of bone scans was the major cause of the expansion of conventional nuclear imaging studies. Endocrine imaging which mainly includes ^{99m}Tc thyroid scan and ^{123}I or ^{131}I whole-body scans has continuously decreased over the last 10 years. The change in the trend of thyroid cancer management from radical surgical treatment to conservative surgery or active surveillance has led to a decrease in radioiodine therapy and whole-body scans. In addition, ultrasonography having high resolution replaced thyroid scintigraphy.

PET

There was a rapid increase in FDG PET studies as FDG PET was covered by the Korean National Health Insurance Service (NHIS) from 2006. The number of PET studies increased up to 410,006 in 2014. After then, nuclear medicine faced a serious challenge as the Korean government decided to reduce NHIS coverage on FDG PET scan for financial reason. The change of reimbursement guideline severely affected the PET practice, and the number of FDG PET scan sharply decreased. FDG PET is now showing a slow but steady recovery trend. The number of PET studies in 2019 increased by 8.1% compared to the previous year (Fig. 2) [3]. Recently, there is an increased demand for other PET studies including ^{68}Ga-DOTATOC, ^{18}F-choline, ^{18}F-florbetaben, and ^{18}F-FP-CIT for various clinical purposes.

Academic Activity

The scientific activity in nuclear medicine in Korea has gradually increased and accelerated after NHIS coverage of FDG PET from 2006. KSNM academic activity peaked in the early 2010s shown by the number of abstracts presented at the

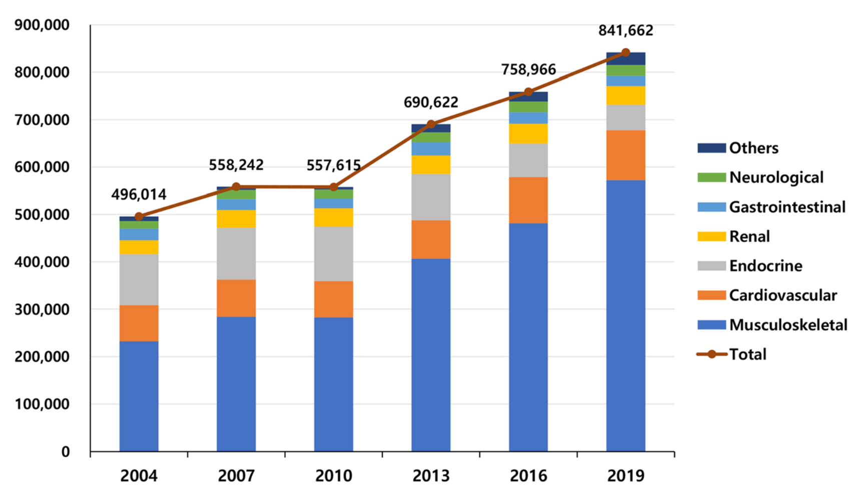

Fig. 1 The number of gamma camera imaging studies performed in Korea by year

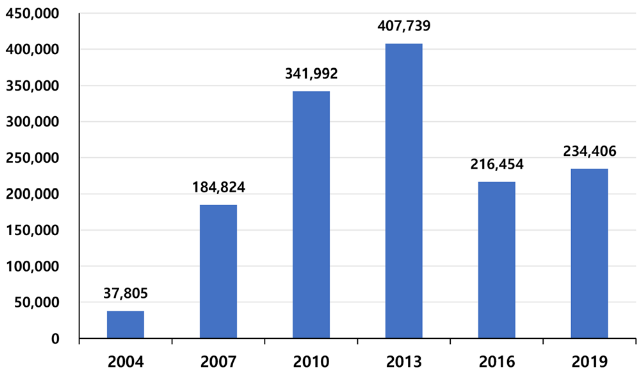

Fig. 2 The number of PET studies performed in Korea by year

Annual Meeting of the Society of Nuclear Medicine and Molecular Imaging (SNMMI). The abstract number presented at SNMMI was 163 in 2013, but it declined continuously after 2014 (Fig. 3a) [4, 5]. The decline in the number of residents after PET crisis might be the main factor. More active participation in other subspecialty meetings could be an additional factor. In spite of the diminution in quantity, the quality of KSNM research and its academic activities were still in

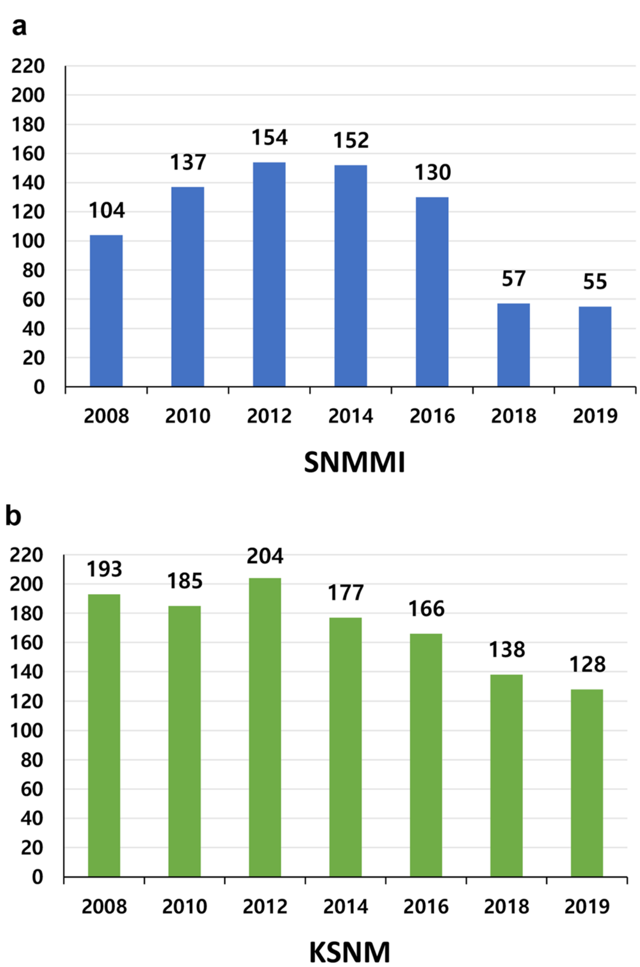

Fig. 3 The number of abstracts presented at annual meetings of the **a** Society of Nuclear Medicine and Molecular Imaging and **b** Korean Society of Nuclear Medicine

progress, which was observed in abstracts presented in domestic meetings (Fig. 3b).

Short Comments on KSNM Activity

Considering the tough situation and surrounding environment of initial nuclear medicine in Korea, our accomplishments during the past 60 years appear to be outstanding. We showed a success in both academic activities and the clinical use of nuclear medicine. In the annual meeting of SNMMI, the first abstract presentation was performed in 1985 as a poster and in 1988 as an oral presentation. Korea became one of the major contributing countries in academic activities of SNMMI. In terms of abstract number, Korea ranked the fourth in the world. The market size and volume of clinical service using nuclear medicine became the top level in the whole world (Fig. 4). More than 200 nuclear medicine procedures (number of gamma camera and PET imaging) were performed per 10,000 population per year in Korea, following the USA and Germany.

The two horses that pull the further advance of nuclear medicine are imaging instruments and radiopharmaceuticals. According to the advancement of related sciences and industries in Korea, they started to manufacture imaging instruments like PET/MR and produce new radiopharmaceuticals. Nuclear medicine physicians should participate actively in the development of these instruments and radiopharmaceuticals. However, novel clinical practice can also be achieved by conventional image instruments and radiopharmaceuticals. Confucius said, “Creation of new applications can be gained by a deep understand of past knowledge and experiences (溫故知新).” In the early 1980s, Prof. Yong Whee Bahk from the Catholic University of Korea College of Medicine demonstrated the usefulness of pin-hole bone scan to differentiate various bone lesions. His group concluded that improved anatomic and spatial resolution by pin-hole collimators is very

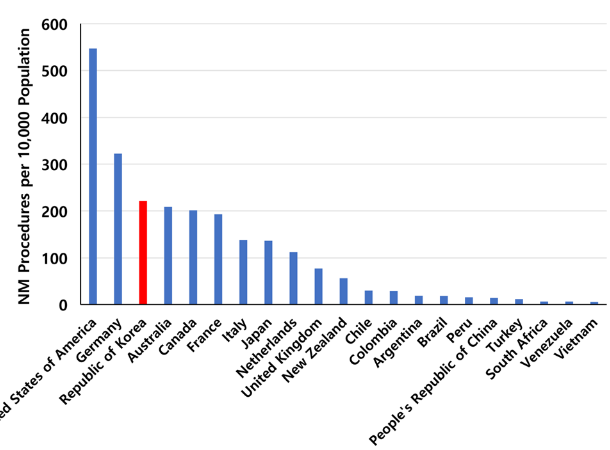

Fig. 4 Number of nuclear medicine procedures per 10,000 population per year. Data was collected from various nationwide sources

effective to detect lesions and to characterize bone pathology [6]. The notable result of pin-hole bone scan is considered as a base for the development of bone SPECT.

Nuclear medicine is a promising field connecting the past, present, and future in view of molecular medicine. For example, radioiodine has been widely used from the mid-1950s based on the characteristics of active uptake in thyroid tissue. To evaluate thyroid function and to diagnose disease, various medical examinations using radioiodine were designed: radioiodine uptake test, washout test, TSH and TRH stimulation test, and thyroid scan. Patients with hyperthyroidism and cancer have been treated with ^{131}I. In 1996, molecular biology techniques revealed that the sodium/iodide symporter (NIS) is the basic molecule responsible for iodine uptake. Using enormous previous data, NIS genes and proteins have been applied easily and greatly, contributing to the advance of thyroidology. Our laboratory at SNUH made an optimally modified NIS that is more effective than ordinary human NIS using the codon optimization technology [7].

We have made efforts to overcome the domestic PET crisis in 2014. First, we tried to expand the PET application to neuroinflammation such as dementia and Parkinson's disease. Second, we focused on adopting new radionuclide treatments. The Korean government approved transarterial radioembolization (TARE) and ^{223}Ra agents in the early 2010s, and they were adopted in clinical practice rapidly. Theranostics has emerged as a new horizon for nuclear medicine. We are developing our own theranostic agents such as ^{177}Lu-PSMA-GUL for this purpose.

We have observed that nuclear medicine in developing countries suffers from the vicious circle. The shortage of experts on nuclear medicine impairs awareness of the general public and medical specialists on nuclear medicine, which is followed by low investment to nuclear medicine facilities. This leads to clinical underuse and again the reduction of experts who participate in this field, aggravating through a feedback loop (Fig. 5a). The vicious circle has detrimental results of gradual decline of nuclear medicine. We must break this vicious circle and change it to a virtuous circle. The virtuous circle is the opposite to the vicious circle, having positive effects. In Korea, we had endeavored to give more information on recent advances not only to medical doctors but also to the public and government officers. The increase in awareness brought more investment to nuclear medicine facilities. Consequently, the volume of clinical use has been expanded, resulting in need for more experts. Many experts again contributed to increase in awareness (Fig. 5b). The virtuous circle has produced favorable results and continuous positive outcome in nuclear medicine. In fact, multi-faceted, simultaneous approaches at every point of the circle are needed.

As is shown in the vicious circle, the vital elements for promotion of nuclear medicine in developing countries are

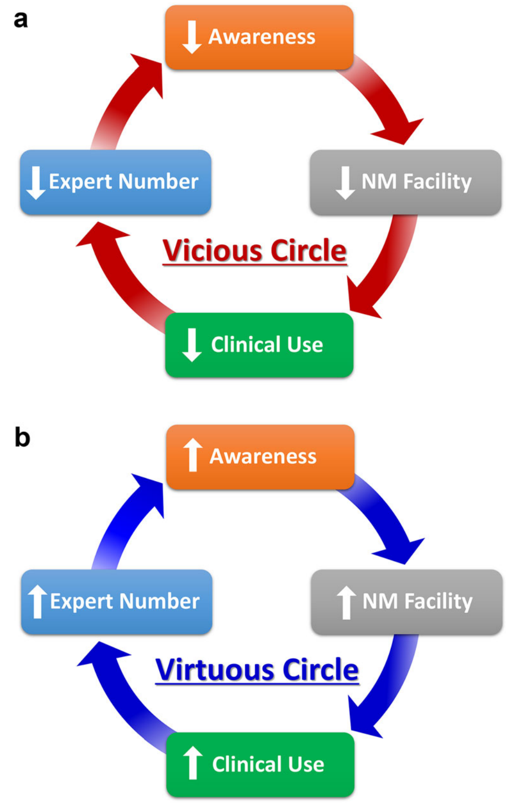

Fig. 5 Schemes of **a** the vicious circle and **b** the virtuous circle in nuclear medicine practice

education and awareness. With support from KSNM, the Asian Regional Cooperative Council for Nuclear Medicine (ARCCNM) and the Asian School of Nuclear Medicine were founded in 2001 to promote nuclear medicine in Asia. IAEA designated SNUH as the "Collaborating Center for Nuclear Medicine and Molecular Imaging" in 2005. Under the IAEA support, 38 physicians and scientists from developing countries have been trained so far. The global leadership of KSNM expanded through the congress of the World Federation of Nuclear Medicine and Biology (WFNMB) in 2006. Prof. Myung Chul Lee served as the president of WFNMB, and the congress was held successfully with a slogan of "Global Harmonization and New Horizon of Nuclear Medicine" [1, 2].

We are encouraging international cooperation on promotion of nuclear medicine. The title of the KSNM journal was changed to *Nuclear Medicine and Molecular Imaging* and is now published in English to share cutting-edge knowledge and experience internationally. Besides the IAEA funds, we have raised domestic funds from various sources to educate many fellows and trainees from developing countries.

Lastly, but not the least, we would like to emphasize the attitude of physicians and researchers. "Guide on Proper Mind of Medical Doctor (醫員正心規制)," a 550-year-old Korean recommendation corresponding to the Hippocratic oath, said "Frankness is the way of medicine" [8]. When the cause of a disease is ambiguous and the treatment is not well established, it is easy to exaggerate the experimental or clinical results and interpret them with a biased perspective. In this case, it may confuse and hinder the medical development in the next generation, because medical knowledge and arts are a collected body of historical achievements. Thus, medical scientists including nuclear medicine physicians should have the attitude of frankness with regard to research and clinical practice.

Closing Remarks

KSNM is a "small society" but an "influential society" via cooperation and competition with surrounding fields of academy and medicine. The practical key of such influence is external and international cooperation to increase awareness and education. We have 60-year experience and knowledge to change the vicious circle into the virtuous circle. KSNM has supported the promotional activity of nuclear medicine in many developing countries of the world. For further development of nuclear medicine, we must have a deep and wider perspective for the next 60 years based on the previous 60-year history. *NMMI* will highlight academic achievement and activity of Korean nuclear medicine throughout this year thanks to the contribution of experts in each subspecialty.

Author's Contribution All authors contributed to the conception, design, material preparation, data collection, draft writing, and editing. All authors read and approved the final manuscript.

Data Availability Please contact authors for data requests.

Compliance with Ethical Standards

Conflict of Interest Hyun Gee Ryoo, Minseok Suh, Jin Chul Paeng, and June-Key Chung declare that they have no conflict of interest.

Consent to Participate For this type of study, formal consent is not required.

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