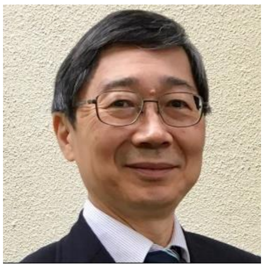
Progress of Nuclear Cardiology in Japan: 2022 Updates



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Non-invasive imaging for stable coronary artery disease

A main target of nuclear cardiac imaging has been detection of stress-induced ischemia in patients with stable coronary artery disease (CAD). While number of coronary CT angiography (CCTA) examinations has rapidly increased in Japan, the appropriate roles of nuclear imaging and CCTA have been discussed, that is, how we can effectively use these non-invasive imaging modalities for clinical practice. Recently, Initial Invasive or Conservative Strategy for Stable Coronary Disease (ISCHEMIA) trial was conducted and published, and Japanese Circulation Society (JCS) subsequently summarized 2022 Guideline Focused Update on Diagnosis and Treatment in Patients With Stable CAD [1]. Based on the recommendation, CCTA is the preferred imaging to rule out the presence of CAD, whereas stress nuclear imaging is preferred as an initial imaging test in patients with a high pre-test probability or known history of CAD for risk assessment, namely rule-in strategy. The trends of high-resolution high-sensitivity imaging with CZT camera, cardiac focused camera, and reduction of radiation dose are similar in Japan. Dynamic acquisition with CZT camera has become one of the options for CAD to overcome weakness for multi-vessel diseases and to focus more on coronary flow reserve.

123I-labelled radiopharmaceuticals in Japan:

One of the unique progresses of nuclear cardiology in Japan is wide-spread clinical utility of 123I-tracers including MIBG and BMIPP. 123I-MIBG, sympathetic innervation imaging tracer, is standard radiopharmaceutical listed in the Japanese clinical guidelines. 123I-MIBG is approved for prognostication of chronic heart failure patients by JCS guidelines (recommendation class IIa) and recognized as a powerful marker for predicting heart failure death, progression of heart failure, and lethal arrhythmic events. Lewy-body diseases are another important indication and the differential diagnosis of Parkinson’s disease and syndrome, and Alzheimer disease and dementia with Lewy bodies are typical examples [2]. 123I-BMIPP, fatty acid imaging, has indications for myocardial ischemia. The major targets in guidelines (recommendation class I and IIa) include myocardial ischemia, hibernating myocardium, vasospastic angina, myocardial ischemia in dialysis patients, and risk and prognosis assessment. The use of 123I-BMIPP for triglyceride deposit cardiomyopathy is also interesting application which utilizes washout rate from the heart.

Application of artificial intelligence (AI) and machine learning (ML) for diagnosis and treatments:

The use of AI-based applications has become a topic in nuclear imaging. As the detection of ischemia is important target of myocardial perfusion imaging, neural-network based application (cardioREPO) is clinical used in Japan. The software was created by multicenter collaboration using supervised learning of >1000 patients with CAD. The probability-based judgement of stress defect and/or ischemia has comparable diagnostic ability when compared with expert reading. Machine learning is also applied for predicting cardiac death, especially focusing on differential diagnosis of heart failure death and arrhythmic death (including sudden cardiac death). Several unique characteristics of cardiac mortality observed in multicenter studies could be simulated by the ML-based model, which seems promising and under investigation.

I have the following Conflict of Interest to disclose:
Collaborative research and funds: 1. PDRadiopharma, 2. Nihon-Medi Physics, 3. Siemens Healthcare, and 4. Spectrum Dynamics.

1. JCS guideline: 2022 Guideline Focused Update on Diagnosis and Treatment in Patients With Stable CAD (doi:10.1253/circj.CJ-21-1041)

2. Komatsu J, et al. 123I-MIBG myocardial scintigraphy for the diagnosis of DLB: a multicentre 3-year follow-up study. Neurosurg Psychiatry 2018;89:1167–1173.

3. Nakajima K, et al. Diagnostic accuracy of an artificial neural network compared with statistical quantitation of myocardial perfusion images: a Japanese multicenter study. Eur J Nucl Med Mol Imaging. 2017; 44: 2280-2289

4. Nakajima K, et al. Machine learning-based risk model using 123I-metaiodobenzylguanidine to differentially predict modes of cardiac death in heart failure. J Nucl Cardiol 2022;29:190–201

Overview and frontiers of nuclear neurology

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Since its establishment in the 1980s, quantitative positron emission tomography (PET) has served as a physiological imaging method to elucidate the pathophysiology of various brain disorders. Measurement of changes in blood flow and associated compensatory changes in oxygen metabolism, established in 80s, is still the gold standard for the diagnosis of cerebrovascular diseases. Imaging researches have been developed in various fields to generalize and to apply the physiological index established using PET to other modalities. Methods to estimate oxygen extraction fraction (OEF), which has been considered to be measured only on PET, are being attempted with MRI images. On the other hand, with the development of molecular imaging methods in recent years, diagnostic techniques using specific molecular probes have become more widespread in neurodegenerative diseases such as dementia and Parkinsonian syndromes. Furthermore, recent development of hybrid PET/MRI scanners which combines PET and MRI in a single gantry is very beneficial in the neuropsychiatric field, particularly for evaluation of neurodegenerative diseases. It provides precise fusion images of high grade anatomical MRI and functional brain PET, elucidating changes in cerebral blood flow (CBF), metabolism and receptor/ transporter densities. PET/MRI is expected to evaluate brain functions as well as deposition of abnormal protein aggregates like β-amyloid (Aβ) and tau-protein without other neuroimaging studies. PET molecular imaging would be improved by using this cutting-edge technology of the integrated multimodality scanner.

This talk will provide an overview of PET/SPECT neuroimaging studies followed by summary of our recent PET/MRI studies including molecular imaging. Quantitative evaluation is important in perfusion PET imaging to evaluate cerebral hemodynamic status before neurosurgical treatment in patients with cerebrovascular diseases (CVD). Therefore, accuracy of CBF measurement was assessed using 15O-water PET/MRI and measured regional CBF values. The time-activity curves were obtained using the image-derived input function (IDIF) method. MR attenuation correction (MRAC) methods were also evaluated using the CT atlas-based or the zero- echo time (ZTE) method to estimate individual bone attenuation for PET images. PET-CBF images were compared with arterial spin labelling (ASL) MRI images quantitatively. In the amyloid PET studies, patients with mild cognitive impairment (MCI) and the early stage of dementia including Alzheimer’s disease (AD), as well as age-matched healthy controls (CTL) were assigned. They underwent clinical and neuropsychological assessment such as the Mini-Mental State Examination (MMSE), etc., followed by 11C-PiB and 64Cu-diacetyl-bis(N4-methylthiosemicarbazone) (Cu-ATSM) PET/MRI. 64Cu-ATSM PET is expected to elucidate oxidative stress tissues in the brain. During the dynamic PET scans, they also underwent multiple MRI scans (T1WI, T2WI, FLAIR, DWI, MRA, rs-fMRI, ASL-perfusion, etc.) simultaneously. All of these molecular PET imaging, functional MRI and MR volumetry were evaluated quantitatively and compared between the CTL and patient groups. Recent advances in molecular imaging and multimodality techniques in neuroimaging have been very beneficial for the assessment of pathophysiology of neuronal degeneration.

I have no Conflict of Interest to disclose.