Low-Dose Cardiac Myocardial Perfusion Imaging

As one of the premier academic medical centers in Europe, University Hospital Zurich (UHZ) delivers cutting-edge patient care across a wide range of health issues by utilizing the latest advancements in technology and knowledge from clinical research. The hospital has a long tradition in cardiac imaging using SPECT, PET, CT and MR.

In December 2016 and March 2017, UHZ replaced its two Discovery™ VCT PET/CT systems with GE Healthcare's latest-generation, all-digital PET/CT system—Discovery MI. Discovery MI provides outstanding spatial and volumetric resolution through the combination of time-of-flight (TOF) imaging and Q.Clear, GE's exclusive full convergence PET reconstruction technology.

According to Ronny Buechel, MD, a cardiologist and nuclear medicine physician at UHZ, the replacement process was conducted in two steps so that at least one scanner was fully operational in the department. While PET/CT is most often utilized for oncology exams at UHZ, the use of cardiac PET is growing.

PET enables an accurate measurement of myocardial perfusion, absolute myocardial blood flow and function at both stress and rest in a single study session. While PET myocardial perfusion imaging

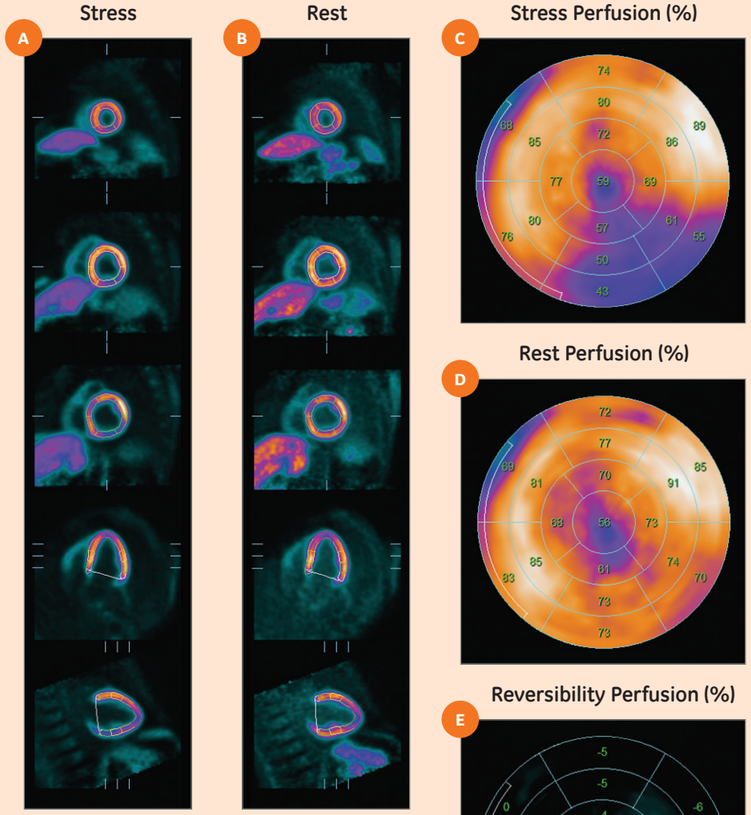

Figure 1. A 68-year-old woman with known three-vessel coronary artery disease and a history of PCI/stenting of the LCX and LAD. Referred to PET due to increasing dyspnea. PET MPI shows a large inferolateral perfusion defect during regadenoson stress.

(MPI) is the primary cardiac application for the new scanner, there has been heightened interest from colleagues to use PET in cases of endocarditis and sarcoidosis.

Dr. Buechel adds that PET perfusion imaging is the gold standard for the assessment of quantitation of myocardial perfusion. The most common PET tracers utilized for PET MPI are rubidium-82 (^{82}Rb) and nitrogen-13-ammonia ([^{13}N] ammonia). PET MPI provides a highly accurate evaluation for the detection of obstructive coronary artery disease (CAD) with an average specificity of 89% and an average sensitivity for detecting stenosis greater than or equal to 50% in at least one coronary artery also at 89%.[1,2]

"In our facility, we see a shift to PET for myocardial perfusion imaging due to its high diagnostic accuracy," Dr. Buechel says.

Lowering dose

A key reason UHZ was very interested in Discovery MI is its improved sensitivity. It has the highest NEMA sensitivity of any TOF PET/CT system. An additional reason was the inclusion of Revolution™ EVO, which delivers up to a 2x increase in spatial resolution[3] and a reduction in CT dose by up to 82% at the same image quality in routine imaging with ASiR-V™ iterative reconstruction.[4]

"One of the most striking features of Discovery MI is the improved sensitivity," says Dr. Buechel. "We didn't know how low we could go with the injected activity and radiation dose, so we began to cautiously lower the dose. Now, we are around 50% of the injected dose for PET scans compared to the prior system—around 1 mSv for a complete rest/stress study."

Alternatively, with the improved sensitivity of the Discovery MI, clinicians can opt to reduce scan time rather than dose. This is particularly important when scanning elderly patients who may not be able to lay still for a 30-minute PET/CT exam. According to Dr. Buechel, this flexibility translates into an increase in the patient population that he can now scan.

"What remains important for cardiac imagers is the reduced activity of ammonia without any deterioration in image quality," explains Dr. Buechel. "With the very low radiation dose exposure that we can achieve with Discovery MI, we are promoting more the use of cardiac PET."

Increased throughput

The department previously performed 4-6 PET MPI studies weekly on the prior scanners; today the volume has grown to 20-22 studies each week. Part of this increased growth is clinical demand due to the low-dose imaging capabilities, anticipated by the department. Additionally, the new scanner is capable of accommodating more patients than the current volume at UHZ. In fact, the limiting factor is the availability of the radiopharmaceutical tracer. Dr. Buechel says sites using ^{82}Rb, which doesn't require an on-site cyclotron, may not be faced with this issue.

UHZ has two cyclotrons: one onsite and another 10 km away in a separate facility that houses a third PET/CT and the SIGNA™ PET/MR. UHZ uses [^{13}N] ammonia because it provides high-resolution imaging and exhibits favorable extraction characteristics.[1]

Prognostic value of PET

A significant value that PET MPI provides is its diagnostic and prognostic value, especially when other imaging exams fail. Dr. Buechel explains the situation of a 40- to 50-year-old female patient who presents with chest pain. A coronary CT angiography (CCTA) does not detect any high-grade lesion in the coronary arteries, yet the patient complains of continued chest pain. This situation suggests the possibility of microvascular disease, which affects the walls and inner lining of tiny coronary artery blood vessels that branch off from the larger coronary artery, or dysfunction within the microcirculation. This type of heart disease more commonly afflicts women and particularly younger women.

"To examine the microcirculation, PET is preferred and has an important diagnostic role," explains Dr. Buechel. "Other non-invasive imaging techniques, and even invasive angiography, often cannot provide the information we need to assess microvascular blood flow."

CCTA, for example, is excellent for diagnosing coronary artery calcification and stenosis, but is limited when it comes to smaller vessels. Yet, in patients with a negative CTA and continued ischemia, it is important to have a tool that can enable examination of the microcirculation.

"If we just use CCTA or invasive coronary angiography and don't see any stenosis, we can assume there is a problem at

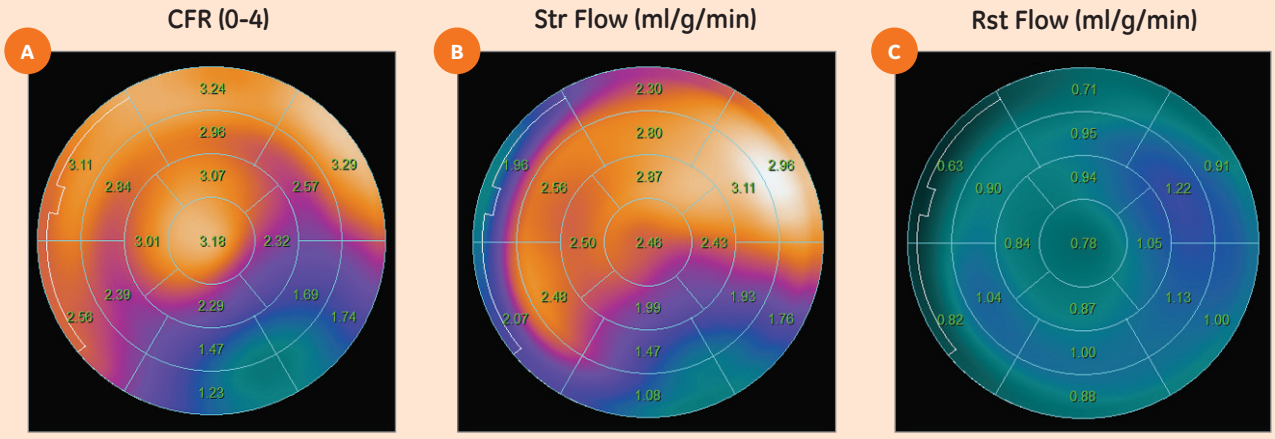

Figure 2. Quantitative PET findings match the semi-quantitative findings very nicely with decreased hyperemic flow and CFR in the inferolateral wall. Findings: a large inferolateral ischemia comprising about 20% of the left ventricular myocardium; no scar and normal LVEF.

the microvascular level but can't definitively diagnose it," Dr. Buechel adds. "In the past, we have been concerned with the radiation dose exposure in this patient population." Now with the significantly reduced dose made possible with Discovery MI, he plans to utilize PET more often in these types of patient cases.

There's one other significant advantage Discovery MI delivers—advanced CT imaging with the integrated 64-slice Revolution EVO. While UHZ has a dedicated system for cardiac CT, Revolution CT, other facilities may not have an advanced CT and could greatly benefit from this capability. Dr. Buechel says there have been a few instances when Discovery MI's CT capability was needed. "We either didn't have slots available on Revolution CT or the patient was already on the scanner, and we decided we needed a contrast-enhanced cardiac scan. With very good image quality, the CT on Discovery MI worked flawlessly."

In general, Dr. Buechel recommends that other cardiac centers take a closer look at PET MPI with the newer generation of PET/CT systems such as Discovery MI. The diagnostic and prognostic value of PET is very important today for patient management, he says, particularly with the increased financial pressure in health systems worldwide.

"It is important to have systems such as Discovery MI that can provide the information we need for diagnosis and as a therapeutic planning tool," he adds. "With PET, we can better stratify a patient and optimize preventive therapies that can help a patient avoid a cardiac event in the future.

	Str Flow	Rst Flow	CFR
APX	2.47	0.80	3.10
LAT	2.45	1.07	2.30
INF	1.53	0.92	1.66
SEP	2.36	0.84	2.84
ANT	2.65	0.87	3.09
TOT	2.28	0.91	2.55

PET delivers that evidence-based information necessary for patient management, which can have a direct impact on outcomes." ■

References

1. Nakazato R, Berman DS, Alesanderson E, Slomka P. Myocardial perfusion imaging with PET. Imaging Med. 2013 February 1; 5(1): 35–46.
2. Beanlands RS, Chow BJ, Dick A, et al. CCS/CAR/CANM/CNCS/CanSCMR joint position statement on advanced noninvasive cardiac imaging using positron emission tomography, magnetic resonance imaging and multidetector computed tomographic angiography in the diagnosis and evaluation of ischemic heart disease – executive summary. Can. J. Cardiol. 2007;23(2):107–119.
3. In clinical practice, the use of ASiR-V may reduce CT patient dose depending on the clinical task, patient size, anatomical location, and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose to obtain diagnostic image quality for the particular clinical task. Low Contrast Detectability (LCD), Image Noise, Spatial Resolution and Artifact were assessed using reference factory protocols comparing ASiR-V and FBP. The LCD measured in 0.625 mm slices and tested for both head and body modes using the MITA CT IQ Phantom (CCT183, The Phantom Laboratory), using model observer method.
4. Image quality as defined by low contrast detectability.