

2019 SNMMI Highlights Lecture: General Nuclear Medicine and Molecular Imaging

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From the Newsline Editor: The Highlights Lecture, presented at the closing session of each SNMMI Annual Meeting, was originated and presented for more than 30 years by Henry N. Wagner, Jr., MD. Beginning in 2010, the duties of summarizing selected significant presentations at the meeting were divided annually among 4 distinguished nuclear and molecular medicine subject matter experts. Each year Newsline publishes these lectures and selected images. The 2019 Highlights Lectures were delivered on June 25 at the SNMMI Annual Meeting in Anaheim, CA. In this issue we feature the lecture by Heather A. Jacene, MD, associate professor in the Department of Radiology at the Dana-Farber Cancer Institute, Brigham and Women's Hospital, and Harvard Medical School (Boston, MA), who spoke on highlights in general nuclear medicine and molecular imaging. Note that in the following presentation summary, numerals in brackets represent abstract numbers as published in The Journal of Nuclear Medicine (2019;60[suppl 1]).

It is a delight to present the General Nuclear Medicine Highlights for the 2019 SNMMI Annual Meeting. This year the General Clinical Specialties track included 127 abstracts in the categories of musculoskeletal, gastroenterology, renal/hypertension, pediatrics, outcomes/infection/pulmonary, and nontherapy endocrinology. I want to thank everyone who sent slides for this presentation and regret that because of time constraints I am not able to share all the excellent work presented at this meeting.

Abstracts in General Clinical Specialties once again came from around the world, with the highest number of submissions from the United States and China, followed by Japan and Korea, and then by Canada, India, and South Africa. The themes this year overlapped with those from last year, including quantitation and dose and time efficiency, but also seemed to focus a little more on hard-to-diagnose diseases and new tracers to investigate these pathologies. Outcomes and specific pediatric applications were also themes.

Diagnostic Dilemmas

Autoimmune diseases are among the most difficult to diagnose and can be very debilitating for patients. Giant-cell arteritis (also called temporal arteritis) has been investigated with ^{18}F -FDG PET/CT, but these reports have primarily concentrated on large vessels. Schembri et al. from Royal North Shore Hospital (St. Leonards, Australia) looked at "Patterns of vessel involvement in patients referred for possible giant cell arteritis" [1286]. In this prospective study, they focused on craniofacial temporal arteritis, which includes medium-sized cranial vessels and can cause irreversible vision loss.

The study enrolled 64 patients, of whom 58 underwent temporal artery biopsies for the gold standard comparison. Biopsy was positive in 12%. The researchers first described visual patterns of vessel uptake on the PET scans, including uptake in the vertebral arteries and smaller vessels (Fig. 1). Smaller vessels visualized included the maxillary, superficial temporal, and occipital arteries. The overall sensitivity of ^{18}F -FDG PET/CT for the detection of craniofacial temporal arteritis was 92%, with a specificity of 85%. No single vessel was always involved, and the aorta was never involved alone. Twenty-five percent of biopsy-positive patients had uptake only in the cranial vessels. Uptake in maxillary and occipital arteries was specific for giant cell arteritis. The authors concluded that inclusion of the cranial arteries in the assessment of patients with giant-cell arteritis is feasible and that ^{18}F -FDG PET/CT has a high accuracy in its diagnosis, with the potential to guide clinicians in early treatment decisions for this serious condition. This also reminds us of the importance of being able to recognize different patterns of uptake for nononcology, in addition to oncology, indications.

Complex regional pain syndrome (CRPS) is a chronic condition, and often the pain itself is so severe that patients are unable to undergo the invasive testing needed for diagnosis. Fifty thousand new cases are diagnosed every year in the United States. Yoon et al. from Stanford University (CA) looked at "Musculoskeletal changes on ^{18}F -FDG PET/MRI from CRPS in the foot" [94]. The study included 7 patients with CRPS diagnosed by clinical criteria and 7 healthy controls. Uptake on ^{18}F -FDG PET/MR imaging in skin, muscle, and neurovascular bundles was compared between the 2 groups. The authors found that PET detected more abnormalities than MR, and higher SUV_{max} was seen in the muscle, skin, and neurovascular bundles in the CRPS group than in the control group (Fig. 2). The authors concluded that ^{18}F -FDG PET may be more sensitive to earlier CRPS changes than MR imaging, before the onset of irreversible muscle or skin atrophy. Their findings also led to the observation that the existence of global metabolic abnormalities may suggest that multiple CRPS subtypes with different etiologies could be responsible for similar clinical manifestations and that specific imaging strategies might be able to differentiate among the subtypes. This is a potential nononcology indication for



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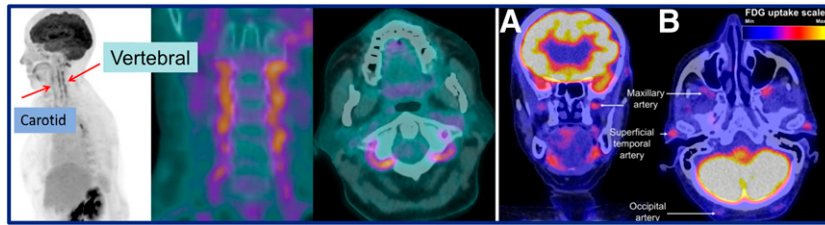


FIGURE 1. ^{18}F -FDG PET findings in craniofacial giant-cell arteritis (GCA). Uptake was seen around the posterior elements of C1 and C2 within the transverse foramina of the cervical spine in the vertebral arteries and in smaller vessels, including the maxillary, superficial temporal, and occipital arteries. ^{18}F -FDG PET/CT showed high accuracy in craniofacial GCA diagnosis, with the potential to guide clinicians in early treatment decisions.

PET/MR imaging if larger studies can validate these findings and show clinical impact.

Hariri et al. from the Health Sciences Centre (Winnipeg) and the Montreal Heart Institute (both in Canada) looked at the use of “ ^{18}F -FDG PET/CT for the assessment of sternal wound infection following sternotomy” [223]. This was a retrospective study of 40 patients who underwent median sternotomy, baseline PET/CT, and subsequent PET/CT at 32.6 ± 60.4 months after surgery. As a gold standard, imaging was compared against positive bacteria culture and/or purulent material at surgery. Overall results showed a significant difference in SUV_{max} between infected and noninfected sternal wounds but with some overlap. When participants were divided into earlier and later surgery groups (<6 mo and ≥ 6 mo, respectively, between surgery and imaging), the overlap was evident in the group who underwent imaging in the first 6 mo after sternotomy. SUV_{max} on ^{18}F -FDG PET/CT performed >6 mo after surgery could differentiate infected from noninfected wounds. Using a gestalt interpretation, ^{18}F -FDG PET/CT was more specific than CT alone for the presence of sternal wound infection (Fig. 3). This was likely because, as the authors reported, the varying patterns of uptake contributed to the correct interpretation. Patterns more specific for sternal infection were soft tissue extension, focal uptake, and sternal wire uptake. This study could provide some guidance for us to give to referring clinicians regarding the timing of ^{18}F -FDG PET/CT imaging after surgery when sternal wound infection is suspected. If the scan is performed within 6 mo of surgery, we should also be relying more on the pattern than the intensity of tracer uptake to make our interpretation.

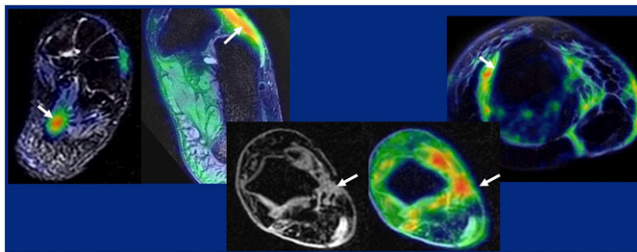


FIGURE 2. Musculoskeletal changes in complex regional pain syndrome (CRPS) of the foot on ^{18}F -FDG PET/MR imaging. Focally high uptake was seen in (left to right): foot muscle, neurovascular bundles, and skin and subcutaneous tissue. PET detected more abnormalities than MR imaging. ^{18}F -FDG PET may be more sensitive to earlier CRPS changes than MR, before the onset of irreversible muscle or skin atrophy.

Braun et al. from Siemens Healthcare GmbH (Forchheim, Germany), Siemens Medical Solutions USA, Inc. (Hoffman Estates, IL), and University Hospital Basel (Switzerland) presented “Quantitative $^{99\text{m}}\text{Tc}$ -DPD SPECT/CT for the detection of prosthetic loosening in patients with hip and knee joint replacement: An interim analysis of a prospective study” [92]. They looked at quantitative SPECT/CT with and without use of anatomic bone segmentation as well as with and without mitigation for CT metal artifact reduction in 13 patients with painful knee and hip joint prostheses (total of 22) suspected of loosening. They showed that, regardless of the reconstruction method, loose prostheses had higher periprosthetic SUV_{max} than stable prostheses or joints in which no prostheses were present. They also demonstrated by using a receiver operating characteristic analysis and applying several cutoffs that xSPECT Bone quantification with iterative metal artifact reduction reconstruction methods, for example, was more effective for detecting the presence of a loose joint than qualitative interpretation by either trainee or senior readers. This quantitative data could provide helpful objective information for interpreting these commonly performed scans and underscores the high potential of quantification as a biomarker for diagnosis of prosthetic loosening.

Development: New Tracers

The second theme I want to highlight, development of new tracers, ties into the first theme in that many of the new tracers presented were also for hard-to-diagnose diseases, particularly in pulmonary pathologies. Abou Alaiwa et al. from the University of Iowa (Iowa City) reported on “Imaging mucociliary clearance using ^{18}F -alumina PET: A proof-in-concept study” [293]. Abnormal mucociliary clearance is present in multiple pulmonary pathologies, including asthma, chronic obstructive pulmonary disease, idiopathic pulmonary fibrosis, and cystic fibrosis. CT-based mucociliary clearance imaging is not practical for clinical use. Their objective was to develop a method using aerosolized nanoparticle ^{18}F -alumina PET to visualize and quantify mucociliary clearance in a porcine model. The method achieved a diffuse and homogeneous delivery of the nanoparticles in the large airways (top row, Fig. 4), and the small distal airways could also be visualized using this method (bottom row, Fig. 4). Clearance of the radiotracer was evident over a relatively short period of a few minutes. The next step for these researchers will be evaluating this tracer and associated distribution methods in models of specific pulmonary pathologies.

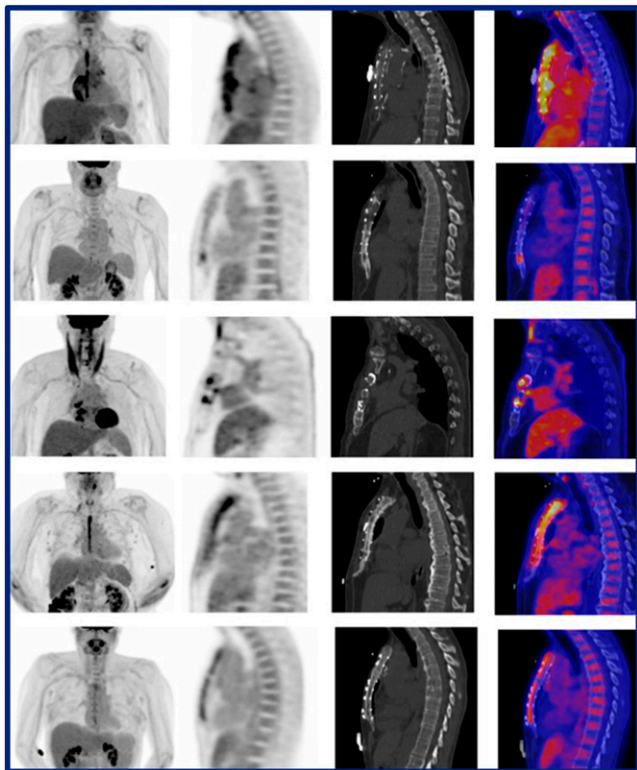


FIGURE 3. Imaging results after median sternotomy, showing (top to bottom): soft-tissue extension, focal uptake, sternal wire uptake, diffuse high-grade uptake, and diffuse low-grade uptake on (left to right): maximum-intensity projection, ^{18}F -FDG PET, CT, and ^{18}F -FDG PET/CT imaging for assessment of sternal wound infection. PET/CT was more specific than CT alone for the presence of infection, and varying patterns of uptake were identified. These patterns can affect interpretation, as can timing of imaging after surgery.

Montesi et al. from Massachusetts General Hospital and Harvard Medical School and Siemens Healthcare (both in Boston, MA) described “Collagen-targeted PET imaging in pulmonary fibrosis: Initial human experience” [297]. Pulmonary

fibrosis is a progressive and ultimately fatal disease. Current radiologic methods can detect established scar (fibrosis) but are unable to distinguish between new and old scars with any single measure. They developed a PET tracer, ^{68}Ga -CBP8, that binds type I collagen with high affinity and specificity. In previous work, they showed that this tracer can detect and stage pulmonary fibrosis in a mouse model and measure treatment response. At this meeting, they reported on first-in-human studies with ^{68}Ga -CBP8 PET in 5 healthy volunteers and 9 patients with idiopathic pulmonary fibrosis. The tracer was well tolerated and safe, with rapid renal clearance and low background uptake in the lungs of healthy volunteers. They demonstrated more heterogeneous uptake in the patient group and that the uptake of the tracer correlated with areas of fibrosis on CT scans (Fig. 5). Test-retest reproducibility studies were performed in 3 patients, with $<5\%$ average variation between tests. This is a potential new biomarker for monitoring progression and treatment of idiopathic pulmonary fibrosis that may help in new drug development.

Werner et al. from the University Hospital Würzburg (Germany) and Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences (Japan) introduced a “Novel ^{18}F -labeled renal PET imaging agent, fluoro-deoxy-sorbitol: A comprehensive investigation from bench to bedside” [25]. ^{18}F -FDS is a sorbitol derivative with renal clearance kinetics similar to those of inulin, with free filtration at the renal glomerulus and no tubular reabsorption. ^{18}F -FDS is derived through a single reduction step from ^{18}F -FDG. The authors first evaluated the tracer in a renal impairment model of unilateral obstruction in a rat. The obstructed kidney showed the typical delayed uptake and clearance pattern, whereas the healthy kidney showed a normal renogram (Fig. 6). Figure 7 represents the first images of ^{18}F -FDS in a healthy human. Again, normal uptake and excretion of the tracer through the urinary system were seen. Due to the higher resolution of the PET images, the investigators were able to draw specific regions of interest around the renal cortex and medulla. They suggested that this PET agent, if further

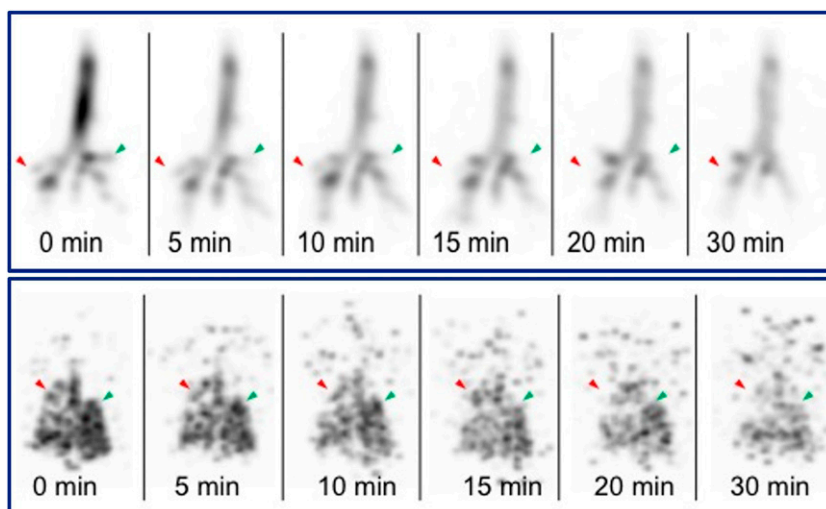


FIGURE 4. ^{18}F -alumina PET imaging of mucociliary clearance in a porcine model. Upper row: Images of clearance of ^{18}F -labeled alumina nanoparticles showing mucociliary clearance in the bronchial tree. Arrows indicate clearance from large airways at (left to right): 0, 5, 10, 15, 20, and 30 min. Lower row: Arrows indicate clearance from upper lobes at corresponding times, with visualization of distribution in small distal airways possible. Clearance of the radiotracer was rapid.

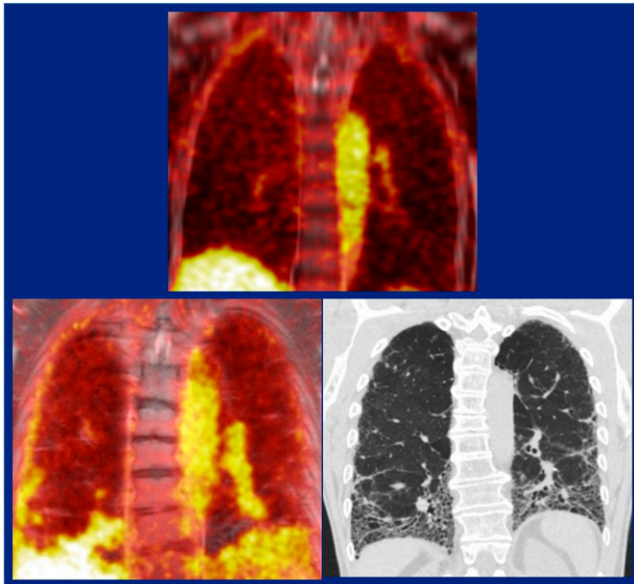


FIGURE 5. Collagen-targeted ^{68}Ga -CBP8 PET imaging in a healthy individual (top) and in an individual with idiopathic pulmonary fibrosis (bottom left), with corresponding CT scan (bottom right). The tracer binds type I collagen with high affinity and specificity and, in this first-in-human study, was well tolerated and safe with rapid renal clearance.

validated, can provide a more detailed evaluation of renal urodynamics compared to standard tracers and also could provide an opportunity for absolute quantitation that we are unable to achieve with current planar and SPECT renal agents. Its translation into clinical use could be accelerated by its simple synthesis from ^{18}F -FDG.

Outcomes

Chirindel et al. from University Hospital Basel (Switzerland), Siemens Healthcare GmbH (Forchheim, Germany), and Siemens Medical Solutions USA, Inc. (Hoffman Estates, IL) presented “3D quantitated lung perfusion $^{99\text{m}}\text{Tc}$ -MAA SPECT/CT: Impact on intended management in comparison to planar (2D) lung perfusion scan in lung cancer patients” [299]. This is part of the PERF-ECT study. At last year’s meeting the authors showed that 3D quantification was more accurate than a gold standard phantom and 2D quantification for predicting forced expiratory volume 1/lobar perfusion after surgery. This year they went a step further

and looked at the impact on intended patient management. The study included 50 individuals with suspected or known lung cancer who underwent preoperative evaluation with $^{99\text{m}}\text{Tc}$ -MAA planar and SPECT/CT lung perfusion scans. The lobar contribution to total lung perfusion was assessed using a 2D planar method and a 3D method. Using the anterior and oblique posterior 2D methods, the patient in Figure 8 would have been considered high risk for surgery and nonoperable. However, with the 3D quantitative method the patient was considered operable. The 3D quantification had a major impact on intended surgical management in 7 (14%) patients in the study.

Brown adipose tissue (BAT) activity remains an area of interest, with a particular focus on the ways in which BAT relates to development of metabolic syndromes and lipoprotein metabolism. Park et al. from the Catholic University of Korea and Seoul St. Mary’s Hospital (both in Seoul, South Korea) reported that “BAT activity on FDG PET/CT is associated with favorable change in lipid profile and reduced risk of diabetes” [438]. The authors compared metabolic outcomes (lipid profiles and diabetes) in patients with and without BAT. The study data were drawn from a database of 1,834 patients with breast cancer. Twenty patients (1.1%) showed BAT activation on ^{18}F -FDG PET/CT, and a comparable age-matched group of 119 patients without BAT was analyzed. Patients with BAT activity were younger, leaner, and had lower baseline glucose and lower cholesterol levels than the no-BAT group. Over 5-y follow-up, the presence of BAT activity was the only statistically significant negative predictor for development of diabetes, with a hazard ratio of -9.007 . These results support current interest in the role of brown fat in lipoprotein metabolism and in potential applications of BAT-related therapies in diabetes.

Pediatrics

Many interesting abstracts on nuclear medicine in pediatric populations were presented at this year’s meeting. Nadel et al. from Lucile Packard Children’s Hospital (Stanford, CA) and British Columbia Children’s Hospital (Vancouver, Canada) looked at “The use of optimized post-contrast enhanced PET/CT to improve diagnostic accuracy, staging, and follow-up of children with cancer” [1169]. This presentation won this year’s General Clinical Specialties first-place poster

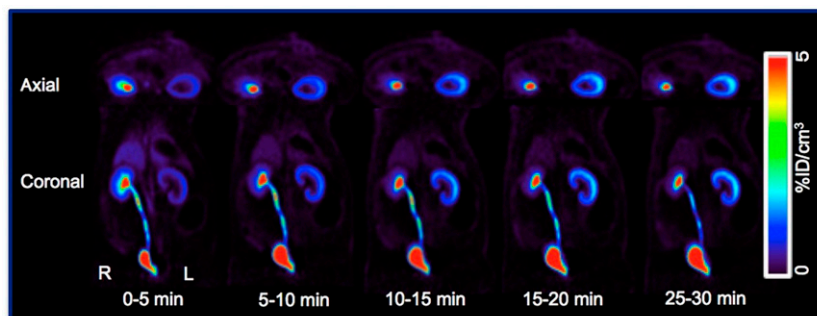


FIGURE 6. Novel ^{18}F -fluorodeoxyisobutyl PET imaging in a rat model of unilateral renal obstruction at (left to right) 0–5, 5–10, 10–15, 15–20, and 25–30 min after injection. The obstructed left kidney showed typical delayed uptake and clearance, whereas the healthy right kidney showed a normal renogram.

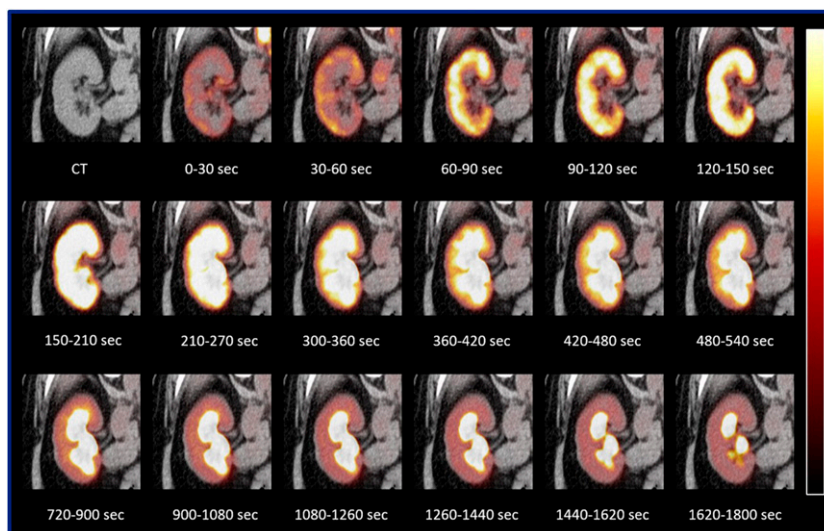


FIGURE 7. First-in-human ^{18}F -fluorodeoxy-sorbitol PET imaging, showing normal uptake and excretion of the tracer through the urinary system over a time period of 0–30 min after injection. This tracer may provide a more detailed evaluation of renal urodynamics than standard tracers and could facilitate absolute quantitation that is currently not achievable with planar and SPECT renal agents.

award. This was a retrospective study of 1,758 PET/CT scans of various tumor types, 83% of which were performed with intravenous contrast-enhanced CT as part of the PET/CT scan as the only diagnostic CT performed. The researchers sent out 1,140 scan evaluation surveys to referring pediatric oncologists, with 759 (67%) completed and returned. The survey asked about changes in management and decision making, along with other information. The results indicated that ^{18}F -FDG PET/CT with enhanced contrast changed management, both for local and systemic disease, in 68% of patients and improved decision making in 92% of cases. Changes in patient management included alterations in plans for systemic therapy (38%), surgery or biopsy (28%), radiotherapy (21%), and/or intention to treat (21%). The authors concluded that optimized low-dose post-contrast enhanced ^{18}F -FDG PET/CT with attenuation correction in all solid tumors for diagnosing, staging, and follow-up may suffice without an additional scan in this patient population, reducing the number of scans needed and decreasing radiation exposure.

Li et al. from Peking University People's Hospital (Beijing, China) reported on "Prediction value of $^{99\text{m}}\text{Tc}$ -MDP

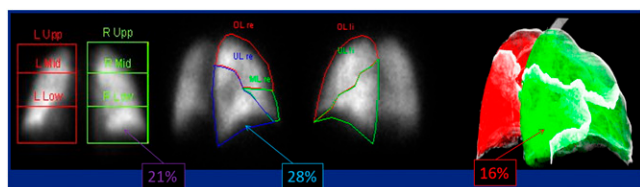


FIGURE 8. 3D-quantitated lung perfusion $^{99\text{m}}\text{Tc}$ -MAA SPECT/CT and intended patient management in lung cancer. The authors compared the 2D projection method and their 3D quantitative method in assessing the lobar contribution to total lung perfusion and resulting management decisions. In this patient, the planar anterior/posterior (2D) method (left) resulted in 21% lobar perfusion, indicating high risk status and pointing to non-operable status. With the 3D quantitative method (right), lobar perfusion was 16%, and the patient was considered to be operable. 3D quantification had a major impact on intended surgical management in 14% of patients in the study.

epiphyseal uptake in bone scintigraphy for growth potential of the tibia: An observational study from pediatric limb salvage for malignant bone tumors" [97]. It was not until quite recently that expandable prostheses for children became available in China. These authors looked at the ways in which tibial epiphyseal plates, as visualized on bone scan, differed depending on endoprosthesis type. The study included 24 skeletally immature patients diagnosed with osteosarcoma or Ewing sarcoma who received endoprosthetic reconstruction after tumor removal (6 with hemiarthroplasty prostheses and 18 with epiphysis-minimal invasive prostheses). Eleven patients with adult-type rotation-hinged prostheses were enrolled as a control group. In addition to $^{99\text{m}}\text{Tc}$ -MDP whole-body bone scintigraphy at 3–8 mo after limb salvage surgery, tibia length was measured by conventional X-ray, and growth velocity was calculated. Sixty-six percent of patients with hemiarthroplasty maintained normal epiphyseal plate uptake on bone scan postoperatively, compared to 5.6% of patients with epiphysis-minimal invasive endoprostheses, and 0% in children with adult-type rotation-hinged prosthesis plates placed (Fig. 9). The authors identified a positive correlation between tibial epiphyseal $^{99\text{m}}\text{Tc}$ -MDP uptake and growth velocity in the tibia. Figure 10 shows 2 contrasting examples. The patient on the top (left) had a hemiarthroplasty with normal uptake in the tibial growth plate on the post-op bone scan. On 2-y follow-up, growth rates of the 2 tibiae in this child were equal (right). In the patient with the adult-type prosthesis (bottom row), decreased uptake on bone scan was seen postoperatively in the tibial growth plate, with limb length discrepancy at 2-y follow-up. The authors concluded that evaluation of proximal tibial growth plate on $^{99\text{m}}\text{Tc}$ -MDP bone scintigraphy early on after endoprosthetic reconstruction surgery could both predict long-term limb length discrepancy and enable interventions. These results may also suggest that hemiarthroplasties are perhaps a better prosthesis type for growing children.

The final 2 abstracts that I will highlight from this meeting are the results of an ongoing and productive collaboration

between researchers at Boston Children's Hospital (MA), Brigham and Women's Hospital (Boston, MA), Johns Hopkins University (Baltimore, MD), and the University of Florida (Gainesville). These studies include complex physics, pharmacodynamic, dosimetric, and modeling work, with results that may directly impact pediatric practice in nuclear medicine. In particular, the consortium sought to provide evidence that can harmonize European Association of Nuclear Medicine/North American Pediatric Dosing guidelines to ensure consistency—meaning that a pediatric patient undergoing a nuclear medicine scan in Anaheim will get the same administered activity as a child undergoing the same scan in Barcelona. Conventional practice guidelines offer consistency but are based on expert opinion and may not be optimal. Optimal dosing is, of course, the lowest administered activity to achieve good image quality so that we can make a reliable diagnosis.

Plyku et al. went beyond consensus guidelines in their presentation “Determination of renal ^{99m}Tc -DMSA pharmacokinetics in pediatric patients: Implications for current dosing guidelines in pediatric imaging” [153]. They gathered longitudinal data on pediatric renal uptake of ^{99m}Tc -DMSA by supplementing the clinically acquired planar + SPECT imaging data with images acquired earlier or later, so that each patient was imaged no more than twice. This valuable preliminary pharmacokinetic data set was extended at the University of Florida, where Li et al. made phantoms and performed pharmacokinetic modeling. In “Patient girth is better than weight for selecting administered activity in renal pediatric imaging” [154], it was found that girth-based

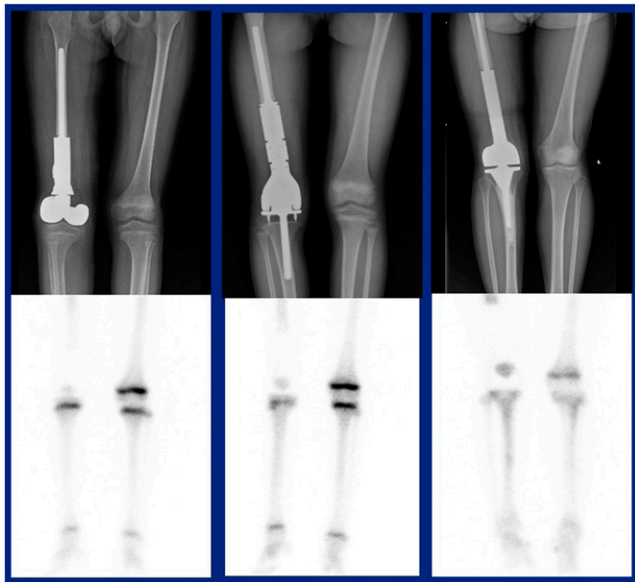


FIGURE 9. ^{99m}Tc -MDP bone scintigraphy and epiphyseal uptake for tibial growth potential in endoprostheses after malignant bone tumors. Images were acquired in (left to right) hemiarthroplasty, simple-hinged endoprostheses, and adult-type rotation-hinged prostheses, with normal ^{99m}Tc -MDP uptake maintained in 66%, 5.6%, and 0%, respectively.

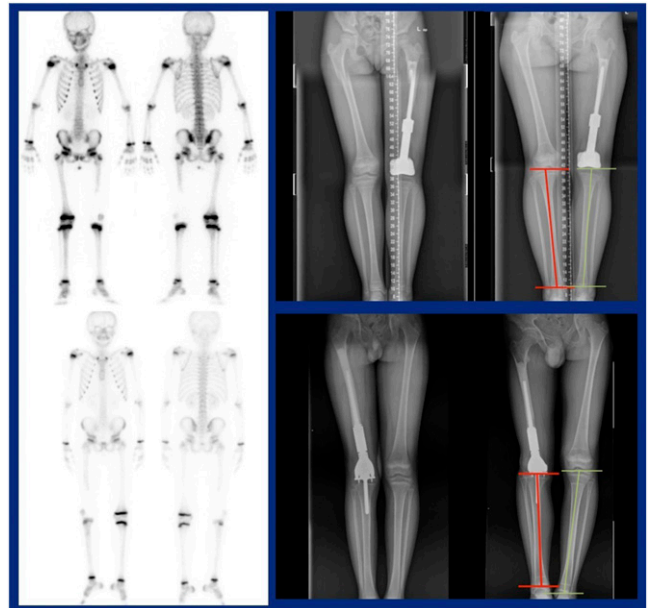


FIGURE 10. ^{99m}Tc -MDP bone scintigraphy and epiphyseal uptake for tibial growth potential in endoprostheses after malignant bone tumors. A positive correlation was noted between tibial epiphyseal ^{99m}Tc -MDP uptake and growth velocity in the tibia. Upper row (left to right): ^{99m}Tc -MDP bone imaging acquired postoperatively, radiograph acquired postoperatively, and radiograph acquired at 2-y follow-up in a patient with hemiarthroplasty. Tibial growth rates were equal. Bottom row: Corresponding images in a child with an adult-type rotation-hinged prosthesis. Decreased uptake was seen postoperatively in the tibial growth plate, with limb length discrepancy at 2-y follow-up. Evaluation of proximal tibial growth plate on ^{99m}Tc -MDP bone scintigraphy early on after endoprosthetic reconstruction surgery may both predict long-term limb length discrepancy and enable interventions.

adjustments to the administered activity yielded more consistent image quality across pediatric patients than weight-based adjustments. A tall and thin patient might need a different administered activity from that required in a short and stout patient. These authors concluded that simulated activities enabled them to acquire previously unavailable pediatric pharmacokinetic data with accurate dosimetry to yield techniques that could lead to truly optimal dosing for children and that could inform future guidelines.

Conclusions

The themes covered in this lecture were diagnostic dilemmas, development, outcomes, and pediatrics in general nuclear medicine. We have seen only a few examples of the outstanding and informative work presented at this meeting. On a personal note, the past 2 years of the Highlight Lectures have been the first of these sessions that I have attended in person—and I have really enjoyed them. For several years, I had the honor at Johns Hopkins of seeing the annual preview of these highlights lectures as presented by Henry N. Wagner, Jr., MD. So, it is a genuine privilege and honor to carry on this tradition with this highlight lecture.

Di Carli Receives de Hevesy Nuclear Pioneer Award

Marcelo F. Di Carli, MD, executive director of the Cardiovascular Imaging Program and the Joint Program in Nuclear Medicine, Founders' Chair of Nuclear Medicine and Molecular Imaging at Brigham and Women's Hospital, and a professor of radiology and medicine at Harvard Medical School (Boston, MA), was the 2019 recipient of the Georg Charles de Hevesy Nuclear Pioneer Award for his contributions to cardiovascular radionuclide imaging and services. "From Dr. Di Carli we have learned how we can practice nuclear cardiology, how we can use new instrumentation, and how we can elucidate the pathophysiology of cardiac diseases using new tracers," said Satoshi Minoshima, MD, PhD, 2018–2019 president of SNMMI. "He relentlessly advances the value of nuclear cardiology for better patient care." The award was presented on June 23 at the SNMMI Annual Meeting in Anaheim, CA.

After receiving his MD degree from the University of Buenos Aires (Argentina), DiCarli completed clinical training in internal medicine and cardiology at the Favaloro Institute of Cardiology and Cardiovascular Surgery (Buenos Aires) and in nuclear medicine at the University of California at Los Angeles. He joined the faculty at Wayne State University in Detroit (MI) in 1994, where he served as a staff physician in the Cardiovascular Division and the Department of Radiology and associate director of the university's PET center. In 2001 he moved to Brigham and Women's Hospital as director of nuclear cardiology.

Di Carli is recognized as an outstanding clinician/scientist, teacher, and mentor and noted for his research interests in the study of cardiovascular pathophysiology, with an emphasis on coronary heart disease, heart failure, myocardial ischemia, and cardiac function. His work has contributed to understanding of the pathophysiology of ischemic cardiac dysfunction and the use of PET for guiding management of patients with end-stage heart failure. He pioneered the application of quantitative PET for assessing risk and guiding management of patients with ischemic heart disease. His work demonstrated that the presence of coronary vascular dysfunction is a key marker of risk, independent of clinical and other traditional risk markers, and provided a link between coronary epicardial and microcirculatory dysfunction and increased clinical risk. This work continues to open new opportunities for improved diagnosis and targeted management of patients with coronary artery disease. His most recent research centers on the use of PET to improve diagnosis and management of patients with cardiac inflammation.

Di Carli established and directs the first integrated multidisciplinary cardiovascular imaging program in the United States. He also directs one of only a few National

Institutes of Health–funded T32 training programs in cardiovascular imaging. This program has been instrumental in training academic cardiovascular imaging clinician/scientists who have gone on to develop their own independent successful careers as investigators and academic leaders.

Di Carli was the founding editor-in-chief of *Circulation: Cardiovascular Imaging* and serves on the editorial boards of multiple journals, including the *Journal of the American College of Cardiology*, *JACC Imaging*, *The Journal of Nuclear Medicine*, and the *Journal of Nuclear Cardiology*. He served as a member and chair of the American Board of Nuclear Medicine, is past president of the SNMMI Cardiovascular Council, and is chair-elect of the American College of Cardiology Cardiovascular Imaging Leadership Council. He received the Laverna Titus Award from the American Heart Association and the Hermann Blumgart Award from SNMMI. He has been named a Distinguished Investigator of the Academy of Radiology Research and has authored or coauthored more than 300 scientific peer-reviewed and other publications and edited 2 books on advanced cardiovascular imaging.

SNMMI presents the Georg Charles de Hevesy Nuclear Medicine Pioneer Award to an individual for outstanding contributions to the field of nuclear medicine. de Hevesy received the 1943 Nobel Prize in chemistry for his work in determining the absorption, distribution, metabolism, and elimination of radioactive compounds in the human body. SNMMI has presented the de Hevesy Award every year since 1960 to honor groundbreaking discoveries and inventions. The list of previous recipients of this award features numerous Nobel laureates—including Ernest Lawrence, PhD, who introduced the world's first cyclotron for production of radionuclides, and Glenn Seaborg, PhD, who discovered or codiscovered 10 new elements. "I am deeply honored and humbled by this important distinction from the SNMMI," Di Carli said. "I would like to share this award with my great teachers and mentors, colleagues and collaborators, my talented trainees throughout the last 25 years, and my family for their unconditional support and encouragement. I believe that this is also a tribute to the innovation and research efforts from the broad cardiovascular nuclear medicine community that have and continue to play such an important role in advancing imaging science to improve our understanding of mechanisms underlying cardiovascular diseases, patient care, and clinical outcomes."



Marcelo F. Di Carli, MD

Moving in the Right Direction: Why Diversity Matters to the ABNM

Leonie Gordon, MBChB, Associate Executive Director, American Board of Nuclear Medicine

Over the past 3 years, the American Board of Nuclear Medicine (ABNM) has embraced change, much of it designed to improve diplomates' experience and strengthen the board's value. ABNM strives to have the examinations, longitudinal assessment programs, and evaluation of testing processes meet the highest standards. Diversity in board members assists in achieving these goals. The ABNM recognizes that diversity extends beyond issues of age, gender, language, and race. The board realizes that members should reflect the demographics of diplomates who make up the nuclear medicine workforce. The ABNM appreciates that these demographics can change over time and is familiar with compelling evidence that diversity yields immense benefit for the professional boards and their diplomates. The American Medical Association reported that, over the past 10 years, the number of women physicians (including residents) has grown more than 43%, and radiology is among the top 10 specialties for women. A study of women in radiology presented at the American College of Radiology 2015 annual meeting showed that women in leadership positions rose slightly from 2004 to 2014, with the percentage of women in the chair role at 9.6% in 2014, barely over the 8% figure from 2004. It is difficult to separate out accurate data for women physicians in nuclear medicine, but we remain underrepresented in the United States and Canada—specifically in academic and leadership positions, according to a recent study published in the *American Journal of Roentgenology* (1). Among nuclear medicine specialists, women were underrepresented in leadership roles, with 7.8% being identified as leaders. The ABNM regards membership on our 12-member board as a leadership position.

The ABNM believes that broader representation on the board would lead to overall improvement in board activities, examinations, and assessments. The board believes that diversity has value for diplomates in supporting learning, identifying with board members, and overall improvement of patient care. The ABNM recently analyzed the characteristics of board-certified physicians (diplomates) and wanted to make sure that those characteristics thought to be valuable and important for board operations were reflected in the board membership. The characteristics examined were gender, age, practice settings, dual certification, and geography. Nineteen percent of ABNM diplomates are women, and 42% of board members are women. The Accreditation Council for Graduate Medical Education's Data Resource (2016–2017) reports that 38% of residents in nuclear medicine are women; this is reflected in the ABNM board composition. The associate executive director of the ABNM is a woman. When age was analyzed, ABNM diplomates were divided into 2 groups: young professionals who were initially certified less than

10 years ago and senior professionals who were initially certified more than 10 years ago. Fifteen percent of ABNM diplomates are young professionals, and 17% of board members are young professionals. Fifty percent of ABNM diplomates are also certified by the American Board of Radiology (ABR), with the same percentage of board members being dual certified. Eighteen percent of diplomates are certified by another American Board of Medical Specialties board other than the ABR, and 8% of board members are also certified by another non-ABR board. Minority representation (African Americans, American Indians and Alaska Natives, Asians and Pacific Islanders, and Hispanics) on the ABNM board was not addressed, because those data are not readily available. This is, however, recognized as an important part of diversity.

Clear evidence indicates that women are underrepresented in academic and leadership positions and that this underrepresentation is not attributable to academic performance or level of interest (1). For the first time this year, the ABNM had an open call for nominations for new board members that was sent to all actively practicing diplomates. The board received 7 applications for each available position, with 5 male applications for every female application. Although the number of women nominees may not be as high as the board would have liked, ABNM hopes to inspire more diplomates to volunteer their time and serve on the board once they realize that the board values gender diversity. In the past 6 years, 4 board chairs (66%) were women. It is hoped that women who have been ABNM chairs and board members will serve as mentors and role models to encourage more women diplomates to become involved in ABNM activities.

The ABNM recognizes that the demographics of ABNM-certified physicians are changing and continues to strive to reflect this diversity in board composition. It is an exciting time for the practice of nuclear medicine, with the evolution of theranostics and new PET tracers. The ABNM believes that diversity on the board will ensure that the ABNM sets the highest professional practice standards that are relevant and valuable for all diplomates.



Leonie Gordon,
MBChB

REFERENCE

1. Moghimi S, Khurshid K, Jalal S, et al. Gender differences in leadership positions among academic nuclear medicine specialists in Canada and the United States. *AJR Am J Roentgenol*. 2019;212:146–150.

SNMMI Mid-Winter and ACNM Annual Meeting in Tampa, FL: Spotlight on Brain Imaging

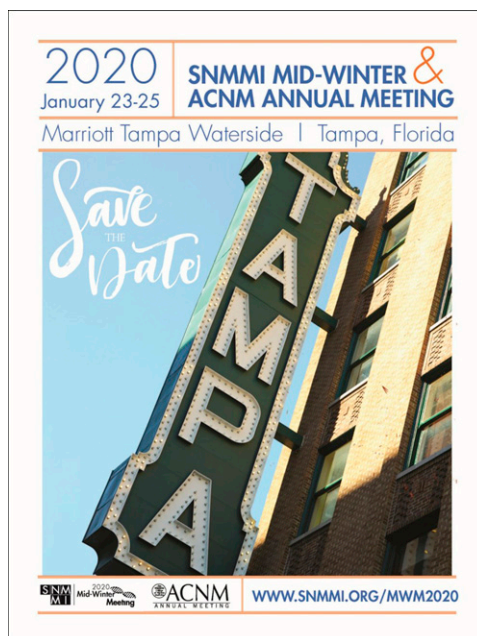
Virginia Pappas, CAE, SNMMI CEO

The SNMMI Mid-Winter Meeting and American College of Nuclear Medicine (ACNM) Annual Meeting head to Tampa, FL, in 2020 for 3 days of learning, exhibitions, and collaboration. Held January 23–25, the program includes a wide variety of education opportunities on current topics of interest within the nuclear medicine and molecular imaging community. The meeting will also host an exciting exhibit hall showcasing the latest products and technology in nuclear medicine and molecular imaging.

Several years ago, SNMMI changed its Mid-Winter Meeting format to include a themed education track. I am pleased to share that in 2020 the track will focus on neurosciences and brain imaging. The SNMMI Brain Imaging Council has planned 2.5 days of programming on this theme, covering topics including:

- Basics in neuroimaging I: Anatomy, radiotracers, and best practices;
- Basics in neuroimaging II: Quantification and artificial intelligence;
- Bread-and-butter nuclear medicine brain scans;
- Neurodegeneration: MCI/dementia FDG;
- Amyloid and tau PET imaging;
- Movement disorders;
- Molecular imaging in traumatic brain injury, chronic traumatic encephalopathy, and disorders of consciousness;
- Brain tumors and encephalitis;
- Epilepsy; and
- Psychiatric diseases.

Many of these courses will include opportunities for participants to bring their challenging cases to be discussed by the larger group, making the sessions particularly valuable to those in the neurosciences and brain imaging field. Thank you to the SNMMI Brain Imaging Council for its work in developing a track on these hot topics in the field.



In addition to the themed track, SNMMI's Mid-Winter Meeting will feature a general education track planned by SNMMI's other councils and centers. These sessions will include topics such as oncology, therapy, cardiology, instrumentation, and general nuclear medicine. The ACNM Annual Meeting will also offer education opportunities on a variety of topics in the clinical practice of nuclear and molecular imaging. Attendees may choose to attend any of the sessions offered at the SNMMI Mid-Winter Meeting or the ACNM Annual Meeting and can earn up to 23 hours of continuing education credits during their time at the meeting.

The ACNM Annual Meeting has planned an exciting plenary session and organized a scientific program that includes both oral abstract presentations and posters. The ACNM will host its annual Awards Ceremony and Banquet on the evening of Friday, January 24.

One of the unique aspects of the SNMMI Mid-Winter and ACNM Annual Meeting is the intimate setting it provides attendees. The event allows for 1-on-1 connections with fellow nuclear medicine and molecular imaging professionals, industry partners, and exhibitors. For me, this is a valuable opportunity to which I look forward each year.

I would like to thank the SNMMI Scientific Program Committee, led by chair Umar Mahmood, MD, PhD, for its efforts in overseeing the planning of the Mid-Winter Meeting. Committee members include Donna Cross, PhD, Associate Chair for Scientific Abstracts; Heather Jacene, MD, Associate Chair for Continuing Education; Kathleen M. Krisak, BS, CNMT, Chair, Technologist Section Planning Committee; and Karina Mosci, MD, SNMMI Brain Imaging Council President. In addition, I would like to recognize the ACNM Annual Meeting Program Committee chair Gary Ulaner, MD, PhD, and committee members Erin Grady, MD, CCD; Twyla Bartel, DO, MBA; Katherine Zukotynski,

(Continued on page 24N)

Reminder: USP General Chapter <825> Effective December 1

On June 1, the U.S. Pharmacopeia (USP) published General Chapter <825> Radiopharmaceuticals—Preparation, Compounding, Dispensing, and Repackaging. This provides uniform minimum standards for designated activities for sterile and nonsterile radiopharmaceuticals for humans and animals that occur as part of state-licensed activities. Immediately following the inception of the current standards outlined in General Chapter <797>, nuclear medicine and nuclear pharmacy interests had reported that radiopharmaceuticals were underserved by the founding chapter and that specific standards based on the unique characteristics of radiopharmaceuticals were needed. This concern was addressed by the USP with inclusion of standards for compounded sterile radiopharmaceuticals in subsequent revisions of <797> and ultimately in this new General Chapter <825>. In a press release in June, SNMMI commended the USP for this effort to provide a reasonable and rational basis for protection of patients from unsafe practices.

The chapter will become official on December 1, 2019, and as of that date, affected users are expected to meet its requirements. Ensuring compliance with the requirements is the responsibility of regulators such as the U.S. Food and Drug Administration, states, and other government authorities. USP has no role in enforcement. SNMMI recommended in August that nuclear medicine community members review and compare the practices and procedures in place in their facilities against the requirements of the new USP chapter. Items such as facility design, competency of staff, and infection control practices are critical and may need attention and review.

The new chapter features sections on the importance of keeping an appropriate environment during preparation of radiopharmaceuticals, including clean

room regimes, hygiene, cleaning equipment, labeling, and air particulate matter monitoring. The chapter also details facilities and engineering controls, personnel training and qualifications, and procedural standards for processing radiopharmaceuticals in nuclear pharmacies, nuclear medicine areas in hospitals and clinics, and other health care settings that use radiopharmaceuticals. For sterile radiopharmaceuticals, these standards balance aseptic handling practices with radiation protection practices to describe appropriate strategies to maintain patient safety while also ensuring the safety of individuals performing these activities. For additional information on the new chapter, see answers to frequently asked questions at <https://www.usp.org/frequently-asked-questions/radiopharmaceuticals>.

SNMMI

NM Radiation Safety Training in Africa

The International Atomic Energy Agency (IAEA) hosted a Regional Training Course on the Prevention of Accidents and Incidents in Nuclear Medicine from July 22–26 at its headquarters in Vienna, Austria. Planned to promote adherence to the IAEA Safety Standards and to other relevant guidelines, the week-long training course was organized through an ongoing regional technical cooperation project and was attended by 21 professionals from Algeria, Kenya, Mauritius, Morocco, Namibia, Tunisia, Uganda, United Republic of Tanzania, Zambia, and Zimbabwe.

The number of nuclear medicine facilities in Africa has increased from 57 to 74 over the last decade, according to the IAEA Nuclear Medicine Database. A press release from the IAEA highlighted the fact that the increase in access to nuclear medicine services has helped many patients and at the same time emphasizes the importance of minimizing and mitigating the risks of accidental radiation exposure to patients, medical staff, or the public during such procedures.

The course was organized as an interactive learning experience and included didactic lectures, facilitated discussions, hands-on exercises, and a visit to the nuclear medicine department of Vienna's Allgemeines Krankenhaus. Information provided during the training included both theoretical and practical recommendations to reduce errors and accidents in the application of nuclear medicine. The course encouraged consideration of all possible causes and sources of accidents.

"This training will help us to put into place safety systems, by promoting awareness of the potential for accidents and by providing the necessary tools to evaluate patient safety in our medical facilities," said Skander Rahabi, MD, nuclear medicine physician from CHU de Bab El Oued Hospital (Algiers, Algeria). Among other exercises, the participants delivered presentations of errors in their facility and worked to develop action plans on the basis of the training course's material.

International Atomic Energy Agency

Brexit and Nuclear Medicine

On August 1 organizations responsible for the procurement and use of medical radioisotopes in the United Kingdom urged new Prime Minister Boris Johnson to provide assurances about supply and costs ahead of a potential no-deal Brexit. Leaders from the Royal College of Radiologists, the British Nuclear Medicine Society, and the UK Radiopharmacy Group issued a joint letter to Johnson asking him to address specific questions about supply contingencies for these vital medical products.

The letter's authors estimated that ~1 million National Health Service (NHS) procedures, both diagnostic and therapeutic, use radioisotopes in the UK each year. The majority of these are made in nuclear reactors outside the UK, with much of the supply coming from nearby reactors in the European Union, including Belgium and The Netherlands. Although

the group indicated that they were encouraged by work being undertaken by officials and industry to map and test supply lines for radioisotopes, they added “we remain apprehensive about supplier readiness and the impact shipment changes and/or delays are likely to have on hospital planning and expenditure, and ultimately, on patients.” Radioisotopes currently enter the UK via road and air freight, with most coming through the Channel Tunnel. In the event of a no-deal Brexit and increased road transport delays, suppliers have been asked by the UK government to ensure that they can fly in all of their consignments. Despite some trial runs of air freight transport of radioisotopes earlier this year, nuclear medicine professionals remain concerned about whether the UK trucking industry has enough specifically licensed drivers to cover changes or delays to shipment timings from airports to hospitals. The letter writers also noted that increased transport costs for flying radioisotopes in will be passed on to hospitals. They estimate that in the event of leaving the European Union with a deal, delivery costs will go up 15% but that this figure would rise to as much as 30% in the event of no deal.

Royal College of Radiologists

Updated NRC $^{68}\text{Ge}/^{68}\text{Ga}$ Generator Guidance

On July 25 the Nuclear Regulatory Commission (NRC) released updated licensing guidance on $^{68}\text{Ge}/^{68}\text{Ga}$ pharmaceutical-grade generators. In a letter to NRC licensees accompanying the new guidance, NRC leaders noted that at the time of the last update under Title 10 Code of Federal Regulations (CFR) 35.100 in 2017, the only $^{68}\text{Ge}/^{68}\text{Ga}$ generator approved by the U.S. Food and Drug Administration and available on the market was the Eckert and Ziegler GalliaPharm generator. Licensing guidance has been revised to reflect the fact that other $^{68}\text{Ge}/^{68}\text{Ga}$ generators are becoming commercially available. The new guidance eliminates reference to any specific generator manufacturer or product.

All sections of the guidance apply to both medical licensee and commer-

cial nuclear pharmacy licensees unless otherwise specified. This guidance does not apply to licensees or applicants that will receive unit or bulk doses of ^{68}Ga radiopharmaceuticals. These licensees and applicants will be regulated under 10 CFR 35.200.

In an informational release, SNMMI reminded licensees that they must continue to provide financial assurance in amounts described in the NRC July 2016 exemption memorandum, pursuant to NRC Decommissioning Funding Plan requirements. Licensees with 1 or 2 $^{68}\text{Ge}/^{68}\text{Ga}$ generators (50–100 mCi of material) must provide for financial assurance for decommissioning in the amount of \$225,000. Licensees with more than 2 generators (>100 mCi) must provide financial assurance for decommissioning in the amount of \$1,125,000. The guidance also includes revised breakthrough reporting requirements (“multiple” failures) in addition to other licensee commitments. The guidance does not address the requirements for shipping an expired generator back to the manufacturer. To ship a generator by air, the licensee must have documented function-specific training and comply with International Air Transport Association guidelines as well as U.S. Department of Transportation regulations (10 CFR Part 71).

The full updated guidance is available on the NRC Medical Uses Licensee Toolkit at: <http://www.nrc.gov/materials/miau/med-use-toolkit.html>.

*U.S. Nuclear Regulatory Commission
SNMMI*

CMS Issues 2020 Payment Rules

The Centers for Medicare & Medicaid Services (CMS) released the calendar year (CY) 2020 Medicare Physician Fee Schedule (MPFS) and Hospital Outpatient Prospective Payment System (HOPPS) proposed rules on July 29. MPFS is used by CMS to reimburse physician services and includes resource costs associated with physician work, practice expense, and professional liability insurance. CMS uses the HOPPS to reimburse for hospital outpatient services. The HOPPS was created to

minimize beneficiary copayments in response to rapidly growing Medicare expenditures for outpatient services and large copayments being made by Medicare beneficiaries. Outpatient services covered belong to an Ambulatory Payment Classification (APC) group. Each group of procedures (i.e., codes) within an APC is presumed to be “similar clinically and with regard to resource consumption.”

In this rule, CMS described changes to payment provisions and to policies for implementation of the fourth year of the Quality Payment Program and its component participation methods: the Merit-Based Incentives Payment System and Advanced Alternative Payment Models. A press release issued by SNMMI on August 2 highlighted the following: (1) With the budget neutrality adjustment to account for changes in relative value units, as required by law, the proposed CY2020 MPFS conversion factor is \$36.09, a slight increase from the CY2019 factor of \$36.04. (2) CMS is proposing to decrease values for 41 radiology and nuclear medicine–related codes. SNMMI provided additional information about code-specific changes in the weeks after the 2020 payment rules were announced. (3) CMS did not address appropriate use criteria (AUC) or clinical decision support related to advanced diagnostic imaging services in the 2020 proposed rule. CMS published a separate AUC claims processing guidance transmittal on July 26, with additional information on the applicable Healthcare Common Procedure Coding System modifiers and G codes. The clinical decision support requirements for advanced imaging services are still scheduled to go into effect on January 1, 2020.

In the CY2020 proposed rules, CMS also included proposals that would advance its “commitment to increasing price transparency,” such as requiring that hospitals make public their “standard charges” for all items and services provided. CMS proposes to continue paying for drugs and therapeutic radiopharmaceuticals at average sales price + 6%, as set forth in the CY 2010 Medicare Hospital Outpatient

Prospective Payment System and Ambulatory Surgical Center (ASC) Payment System final rule.

In addition, the agency proposes an increased threshold payment for therapeutic radiopharmaceuticals of \$130, where CMS will package those that are priced \leq \$130 into the APC payments and pay separately for those that exceed this threshold amount. CMS proposes no new changes to the APC structure for imaging codes.

In the Physician Outpatient Office Visit Proposed Rule, CMS adopted the Common Procedural Terminology guidelines to report office visits based on either medical decision making or physician time. The agency also adopted the Relative Value Scale Update Committee (RUC) work recommendations for office visit codes. The work value increases represent \$3 billion in redistributed spending, resulting in a 3% reduction in the conversion factor. In addition, the

RUC physician time recommendations were adopted. Coupled with the work value increases and some modifications in direct practice costs, these changes will lead to an additional \$2 billion in redistributed spending, resulting in an additional 2% across-the-board reduction.

The comment period for the proposed rule expired on September 27.

SNMMI

Centers for Medicare & Medicaid Services

(Continued from page 21N)

MD; Simin Dadparvar, MD; and Justin Peacock, MD, PhD, Nuclear Medicine Residents Organization president, for their work in planning the ACNM program.

The SNMMI Mid-Winter and ACNM Annual Meeting will be held at the Marriott Tampa Waterside, newly redesigned in 2019. The hotel is located directly on Tampa Bay and

just steps from the downtown area, including the Riverwalk, Florida Aquarium, and Sparkman Wharf.

We hope that you plan to join us for the outstanding learning offerings, worthwhile networking events, and warm weather. To register or learn more about the meeting, visit www.snmmi.org/mwm.