SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING
CORRELATIVE IMAGING COUNCIL
NEWSLETTER

Winter 2014/2015

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A Message from the President

Amol M. Takalkar, MD

I have enjoyed being the President of the Correlative Imaging Council (CIC) of SNMMI since June of last year. Dr. Patrick Colletti became the new Vice-President, Dr. Lale Kostakoglu is the immediate past president and Dr. Simin Dadparvar became the Secretary/Treasurer. We had some fresh faces join us on the CIC Board of Directors, and they are Drs. Samuel Almodovar, Alan Klitzke, Louise Thomson, and Katherine Zukotynski. Drs. Alan Waxman and Carina Mari Aparici have continued to serve on the BOD and Dr. Erik Mittra as the CIC intern. So we have a great team and we are having a productive and fruitful term.

The CIC has been instrumental in providing CT education courses over the last 10 years and is the council responsible for several CE sessions related to multimodality imaging. CT education is critical in Nuclear Medicine today and MRI will likely become a necessary skill for Nuclear Medicine professionals in the near future. So we have also actively implemented MRI education in the form of case reviews and CE sessions in collaboration with the PET CoE.

Moving forward, we hope to offer similar educational activities to the technologist and are currently looking forward to discuss new initiatives with the SNMMI-TS leadership. Other initiatives that we want to provide pertain to offering an interesting case every month that is related to correlative imaging, important guidelines and/ or cardiac education (CT, MRI, EKG, cath correlation) as well as other activities along those lines. Our new and existing board members have already expressed interested and made concrete ideas to lead these new initiatives and we will be exploring various online tools like webinars and online forums to help facilitate these educational initiatives. We will continue to present the Walter Wolf Award every year at the SNMMI annual meeting.

In spite of these activities, the CIC membership at the SNMMI is dwindling (similar to most other councils). Although some of the above mentioned activities are available only to CIC members, the major and most significant offerings (like the CT and MRI case reviews as well as other CE sessions) are also available to the general SNMMI membership. So it is difficult to show specific value added by joining the council. However, we need to increase our membership on a council level. Our sessions are certainly valuable to most nuclear medicine professionals. Indeed, the consistently high attendance at the CT and MRI case reviews speaks volumes about that. Although the NM job market may be making it tough for people to retain council membership; when was the job market not difficult? I strongly believe that these sessions (especially the CT case reviews and the newly implemented MRI case reviews) make Nuclear Medicine Professionals better trained and provide them with an essential skillset that is crucial in today's era of Molecular Imaging with hybrid modalities. So we have to come up with ways to address this issue and make us more visible to the general SNMMI membership to attract and retain members at the CIC. I would also encourage existing CIC members to better engage within the CIC. Please attend the CIC business meeting at the SNMMI annual meetings and voice your suggestions, recommendations and concerns. This would be a valuable contribution.

CT training remains important

Patrick M Colletti, MD

The Correlative Imaging Council has delivered 16 high-quality CT review courses

covering over 100 hours of case presentations to nearly 4,000 physicians and technologists. This is the result of major efforts of leaders including George Segall, Lalitha Ramanna, Lale Kostakoglu and Simin Dadparvar. Such review courses require careful planning and judicious management. Expenses may challenge resources. Perhaps the meeting time scheduled for CT could be shared with other important educational topics.

This can raise the question: with the majority of SNMMI membership having had either radiology training or recent nuclear medicine training including CT, or having participated in one or more of our CT courses, should we continue to offer comprehensive CT training at our meetings? After some thought, the answer is a resounding "Yes"!

Here are the major considerations:

1. CT training within nuclear medicine residencies is idealized*:

IV.A.6.b) Residents entering the program at the NM1 level must:

IV.A.6.b).(1) participate in a minimum of six months of CT experience; and,

IV.A.6.b).(1).(a) A minimum of four months must be obtained on a diagnostic radiology CT service.

IV.A.6.b).(1).(b) The remaining two months may be continued on the diagnostic CT service and/or may be combined with a rotation that includes PET/CT or SPECT/CT.

IV.A.6.b).(1).(c) This experience must be supervised by qualified faculty members.

* Page 21:
https://www.acgme.org/acgmeweb/Portals/0/PFAssets/ProgramRequirements/200_nuclear_medicine_07012014.pdf

Often nuclear medicine resident participation in these rotations is limited. There is typically no comprehensive general "CT" rotation (that would include brain, head and neck, spine, chest, cardiac, abdomen, pelvis and musculoskeletal CT) existing in current radiology residencies. Thus, most commonly there is no more efficient manner than our CT review courses for residents to learn all of the CT knowledge that typically applies to nuclear medicine.

2. Driven by hybrid imaging, nuclear medicine technologists are increasingly desiring and requiring initial and ongoing CT training.

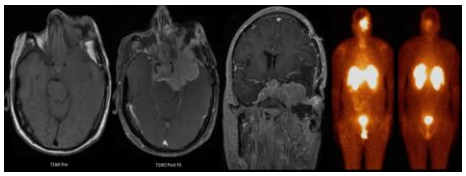
3. Regulatory organizations and payers are increasingly scrutinizing physician initial training and MOC. It must be of concern to all of us when "The Joint Commission" enters this arena with "Standards and Survey Methods Diagnostic Imaging Standards Changes for Radiologists' Qualifications and Competency Field Review." This document does not appear to recognize nuclear medicine practitioners as qualified interpreters of CT. It will be challenging to negotiate the specific language to allow for such participation. This must be supported by ongoing documented and credible CT training.

Given these considerations, we must continue to offer case-based CT training and MOC regularly at our meetings.

Correlative Imaging Case 2014

What is the most likely diagnosis?

A. Carcinoid
B. Neuroblastoma
C. Macroadenoma
D. Meningioma



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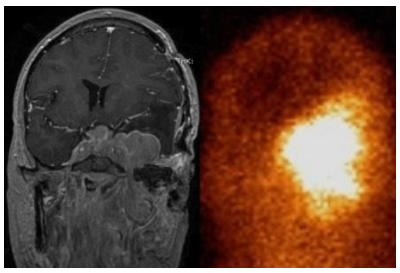
Answer:

D. Meningioma

This 38-year-old man has a history of progressive recurrent atypical meningioma after three resections and external beam radiotherapy. The patient was evaluated with an OctreoScan to evaluate for expression of somatostatin receptors that are present on most meningiomas. There have been reports that octreotide therapy can inhibit the growth of meningiomas[1, 2].

Note that this is a massive recurrent tumor that crosses the midline through the cavernous sinuses with right and left cavernous carotid encasement. There is left inferior penetration of the skull base into the left pterygoid fossa noted on the coronal enhanced MR. These fingerlike tumor projections are suggested on the anterior pentetreotide image.



Previous right and left enucleations noted on axial MR images demonstrate the initial anterior extracranial extension of this tumor.

References:

1. Reubi, JC. Peptide receptors as molecular targets for cancer diagnosis and

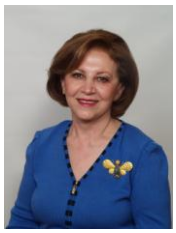
therapy. *Endocrine reviews* 2003; 24: 389-427.
2. Bartolomei M, Bodei L, De Cicco C., et al. (2009). Peptide receptor radionuclide therapy with 90Y-DOTATOC in recurrent meningioma. *European journal of nuclear medicine and molecular imaging* 2009; 3: 1407-1416.

Case courtesy of
http://scipose.com/groups/group-discussions/nuclear-medicine-teaching-files-keck-medical-center-of-usc/forum/topic/octreoscan-and-meningioma/

Patrick M Colletti, MD

Correlative Imaging Council Membership Report

Simin Dadparvar, MD



The Correlative Imaging Council (CIC) has 133 members, including 118 physicians and scientists and 15 technologists. The physicians and scientists category comprises 110 full members and 8 emeritus members.

There has been a steady decline in membership since 2009, when the council had 235 members. However, in the past two years, the membership stabilized. The memberships in the other SNMMI councils and the PET Center of Excellence show similar trends in membership decline.
The CIC has provided several courses to train nuclear medicine physicians, technologists and scientists for several years. The most popular is the CT course for nuclear medicine physicians, offered since 2006, but CIC has also offered new MR training and additional categorical and CE courses offering CME credits and SAM credits at SNMMI annual meetings and mid-winter meetings.

The courses have been open to the general SNMMI membership as well as both non-members, both domestic and international. Our hope is to provide teaching courses online for CIC members to promote the membership in 2014.

Cross-Sectional Imaging of Liver lesions

Neel Patel, MD

Focal liver lesions are a common finding on cross-sectional imaging. They can represent a wide spectrum of diseases processes from benign, indolent conditions to aggressive malignancy. Being able to characterize lesions accurately and knowing which lesions require further investigation or intervention is important in the further management of patients. This article gives a brief review of imaging characteristics of common liver lesions.

Phases of Contrast

Characterization of liver lesions is primarily achieved by using contrast agents. These take advantage of the fact that the liver has a dual blood supply. Seventy to eighty percent of blood is provided via the hepatic portal vein, and the remainder is from the hepatic artery, which means that normal liver enhances in the portal venous phase. In the arterial phase, hypervascular masses that derive their blood supply primarily from the hepatic artery will enhance greater than the normal liver. In contrast, hypovascular masses will enhance less than liver when in the portal venous phase and will be hypodense. Delayed phases of imaging help characterize lesions based on differential washout of contrast in comparison to the normal liver.

Imaging Characteristics

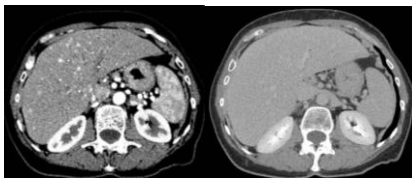


Figure 1: Hypervascular neuroendocrine tumor metastases which are visible on arterial phase imaging (A) and are isodense on delayed imaging (B)

Hypervascularity is a characteristic mainly of benign lesions within the liver, such as focal nodular hyperplasia (FNH), adenomas and small hemangiomas. Malignant hypervascular tumors are primary hepatocellular cancer (HCC) and metastases from tumors such as melanoma, neuroendocrine tumors (**Figure 1**), renal cell carcinoma, thyroid cancer and choriocarcinoma. Hypovascular lesions in the liver are most likely to be malignant with metastases being the most common.

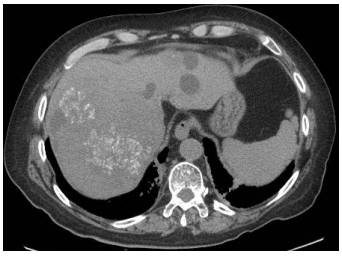


Figure 2: Unenhanced CT demonstrating calcification in colorectal adenocarcinoma metastases within the right lobe and simple cysts in the left lobe.

Calcification is found in a variety of types of lesion. The most common are inflammatory lesions such as granulomas, where the calcification involves the entire lesion. If the calcification is more central, then it may indicate malignancy such as metastases (**Figure 2**), fibrolamellar carcinoma (FLC) or cholangiocarcinoma. Calcification is also seen in hemangiomas and hydatid cysts—seen as curvilinear or ring calcification around a hypodense cyst.

Hemorrhage can be seen in vascular lesions such as adenomas and HCC. It is demonstrated as a region of hyperdensity on CT scans and can be of varying signal on MR depending on the age of the blood.

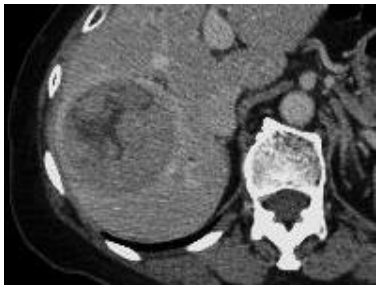


Figure 3: HCC demonstrating delayed enhancement of a fibrotic capsule.

Capsules are most commonly seen in HCC (**Figure 3**); however, other lesions, such as adenomas, cystadenoma and cystadenocarcinoma, may also have capsules. Capsules are composed of fibrous tissue that does not enhance well on arterial and portal venous phase imaging but may on delayed imaging.

Fat is sometimes seen within liver lesions and is associated with adenomas, HCC, angiomyolipomas, lipomas, teratomas, adrenal rest tumors and liposarcomas. Scars can be found centrally within lesions such as FNH, cholangiocarcinoma, FLC, HCC and hemangiomas. They are often hypodense on CT and enhance on delayed imaging. On MR images they are hypointense on T1 and T2 weighted imaging. FNH is the exception, where the scar is high signal on T2 weighted imaging, helping to differentiate it from malignant lesions.

Lesions that contain cysts have a wide differential, including cystic metastases and abscesses. If a cyst has septation or "daughter" cysts within it, then it is characteristic of hydatid disease.

Liver Lesions

Simple cysts are common and benign and arise from a few different processes. These include benign developmental cysts, biliary hamartomas (also known as von Meyenberg complex), Caroli disease and autosomal dominant polycystic disease. On CT they are well-demarcated, hypodense (<20HU) lesions without enhancement or internal structure. Cysts can be complicated by hemorrhage and infection leading to increased density. Cysts can be differentiated from cystic metastases by lack of enhancement and no restriction of diffusion on diffusion-weighted (DWI) MR.

Hemangiomas are the most common liver lesion. Their defining characteristic is an enhancement pattern that mirrors blood pool, for example, at arterial phase imaging the density of enhancing areas must be the same as density of the aorta (**Figure 4**). Typical features include hypodensity on unenhanced imaging and nodular, peripheral enhancement with progressive, centripetal fill on delayed phases. Small hemangiomas sometimes demonstrate atypical appearances with "flash-filling," where they enhance homogeneously in the arterial phase.

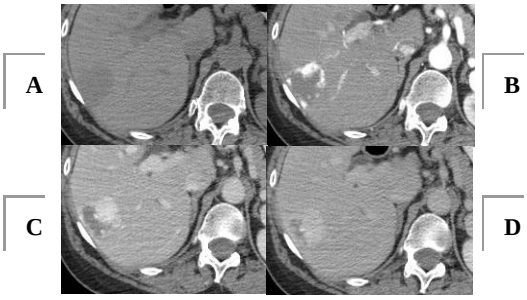


Figure 4: Hemangioma. A: On unenhanced CT it is hypodense; B: On arterial phase it has nodular peripheral enhancement; C: Portal venous phase demonstrating centripetal enhancement of the lesion; D: Delayed imaging showing almost full fill in of the lesion with contrast. Note that on all phases of imaging the regions of enhancement are as dense as the aorta.

Hepatic adenoma is an uncommon tumor that is prone to hemorrhage and related to oral contraceptive, anabolic steroids and type I glycogen storage disease. It can have varying density dependent on fat content, calcification and hemorrhage. They enhance in the arterial phase and return to near liver density on portal venous and delayed imaging. Adenomas may also have a low density capsule that slowly enhances on delayed imaging.

FNH is a common liver tumor that is most commonly found in women. Typically it forms in well-circumscribed masses with a central scar. FNH demonstrates similar enhancement characteristics to adenomas, with enhancement in the arterial phase, except for the scar. The scar demonstrates enhancement on delayed scans in about 80% of cases.

HCC is the most common primary malignancy of the liver and has a variety of appearances. It may be focal, diffuse or multifocal. Typically it enhances in the arterial phase and has rapid washout of contrast becoming iso or hypodense on portal venous phase imaging. It may have rim enhancement representing a capsule and sometimes may have a halo of focal fatty sparing adjacent to it. HCC is also associated with portal vein thrombosis, which may be due to tumor rather than thrombus and can be identified by its enhancement in the arterial phase. An uncommon variant of HCC is fibrolamellar carcinoma (FLC), which often has a central scar and has similar appearances to FNH. It can be differentiated from FNH by the fact that the scar is generally hypointense on T2-weighted imaging and does not show delayed enhancement. It is also more heterogeneous in texture than FNH.

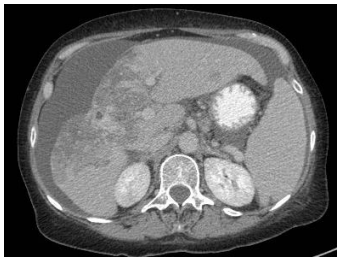


Figure 5: Cholangiocarcinoma. Note the retraction of the hepatic capsule due to fibrosis and heterogeneous enhancement pattern.

Cholangiocarcinoma is a rare tumor and has a wide range of appearances related to its variable growth pattern. Within the liver they can be mass-forming, infiltrating or intraductal. They can also be multifocal. Masses are usually hypodense to liver and enhance peripherally in the arterial phase, becoming isodense in the portal phase. The tumors may have delayed enhancement centrally and may have variable signal on MR, depending on the presence of fibrosis, mucin or edema. Fibrosis in the tumors can also cause capsular retraction of the liver (**Figure 5**). Infiltrative tumors grow along the bile ducts, are usually associated with ductal dilation and are classically found at the hilum (known as Klatskin tumors). Intraductal tumors are within the duct and can often lead to duct obstruction with or without a visible mass.

Liver metastases are much more common than primary tumors. They are most commonly hypovascular and are best appreciated on portal venous phase imaging. They may have rim enhancement and wash-out on delayed imaging. Hypervascular metastases are less common and seen best in the arterial phase. Metastases may also demonstrate other features such as calcification (e.g., mucinous adenocarcinoma and osteosarcoma) and cyst formation (e.g., ovarian cancer). Liver abscesses are generally seen as lesions with central low density and peripheral enhancement. Gas can be seen in about 20% of lesions. The distribution of abscesses depends on the route of entry to the liver. If related to abdominal sepsis the portal vein will lead to dissemination of organisms in the liver, which will be predominantly right-sided. Arterial spread usually leads to peripheral abscesses within the liver. Abscesses related to biliary intervention tend to be more central within the liver.

Peliosis is a rare vascular condition leading to dilated sinusoids and blood-filled cystic spaces within the liver. It has numerous causes leading to a wide range of appearances. Its appearances also depend on the age of blood products and the presence of thrombus within the lesions; therefore, it can range from hyper to hypodense on unenhanced CT. It enhances variably, but most typically has a a globular, central, centrifugal enhancement pattern.

Conclusion

The imaging characteristics of liver lesions are varied, with overlap between the classical presentations of different disease processes. Understanding the basic appearances of the different lesions can help accurately characterize lesions and aid further management.

CT and MRI Training for Nuclear Medicine Physicians

Simin Dadparvar, MD

The Correlative Imaging Council (CIC) pioneered computed tomography (CT) training for nuclear medicine physicians in 2006. After successfully running two short courses in CT training at Stanford University and UCLA, the CIC launched its first free-standing CT course in Philadelphia in October 2007. Since then, the CIC has held CT courses at SNMMI annual meetings and at mid-winter meetings in conjunction with the American College of Nuclear Medicine. An additional standalone CT course was offered in Seattle in August 2008. To date, we estimate that the CIC has helped train more than 3,600 physicians (who have received 100 CT case review certificates) at our meetings.

Additionally, about 450 physicians have attended at least five two-day courses (and received 500 CT case review certificates).

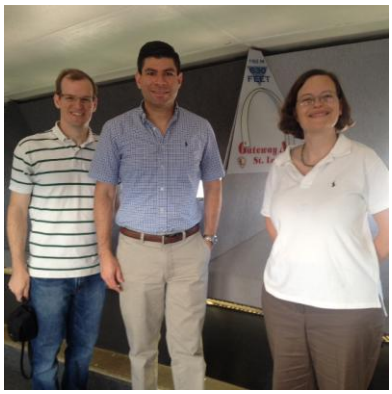
In 2012, the CIC decided to launch MR training at the SNMMI mid-winter meetings, and thus far 409 physicians and technologists have attended these sessions. Currently, the attendees learn about MR imaging case reviews, but no certificates are issued.

It is important to mention that the CIC plans to continue offering courses on CT and MR image interpretation at SNMMI meetings not only to educate the workforce in nuclear medicine but also to continue with our mandate to provide CE and SAM credits.

Correlative Imaging Council Activities

Katherine Zukotynski, MD

The SNMMI Annual Meeting in St. Louis was a great event with presentations on cutting-edge research, educational lectures and a chance to see the latest technology. The correlative imaging council 2014 Walter Wolf Young Investigator Award (YIA) winner, Jean-François Montégiani, gave his presentation on Personalized ^{177}Lu-octreotate PPRT: Cycle-to-cycle renal radiation dose prediction using quantitative SPECT/CT dosimetry. The CT and MR case reviews returned. Further educational sessions included topics such as PET/MR and multimodality imaging in bone disease, gynecologic and neuroendocrine malignancies. The meeting was also an opportunity to make new friends and reconnect with friends of old, explore a city, climb the arch and take high-level images.



From left to right: John Millstine, Samuel Almodovar and Katherine Zukotynski at the top of the Gateway Arch in St. Louis, MO

In January 2015, the CIC hosted the CT case review for the mid-winter meeting in San Antonio (January 22–25). We are planning the CT and MR case review for the annual meeting in Baltimore (June 6–10) and we will strive to bring you a vibrant CME program showcasing the synergistic aspects of anatomic and functional imaging and…we hope to see you there!

A Medical Student Perspective on Nuclear Medicine: Is there Room For Improvement in our Education?

Ms. G. Meglei, 2nd year medical student

An informal survey of medical students who had completed two years of pre-clerkship education suggests exposure to nuclear medicine is often limited and fragmented. Although students had heard of specific studies, few had been exposed to the broad spectrum of nuclear medicine practice or understood when to use nuclear medicine studies for patient care. What follows is the observations of one student, some common frustrations and suggestions for improvement.

Our foray into medicine began with an introduction to the building blocks necessary for understanding health and disease and presented a structural framework for organizing information. Nuclear medicine was omitted from this introduction and, indeed, there was little to no formal introduction to the imaging modalities, indications or limitations. Further, the importance of functional imaging, and the advantage of combining functional with anatomic imaging, was not discussed.

Subsequently, the role of imaging was not systematically covered in our systems-based curriculum. For example, although our cardiology and gastroenterology blocks had well-organized lectures dedicated to imaging that include nuclear medicine, these lectures were absent from other areas such as the respiratory, endocrine, musculoskeletal and nervous systems. Consistency and continuity could be achieved with a common framework for dedicated imaging lectures across the different body systems.
Finally, image interpretation is often taught by presenting sample cases with little additional explanation. Following this, and lacking a basic understanding, many students subsequently resort to a trial-and-error process of Googling images and finding the closest match. Rarely does someone take the time to guide us through an approach to image interpretation followed by examples and direction to good sources of reference.

Nuclear medicine fits naturally into various areas of our curriculum, and this should be exploited to develop concepts and create repeated exposure to the topic. Initially it is important to properly introduce the subject and provide students with a high level of understanding. Integration into a systems-based curriculum could then incorporate practical interpretation skills and have a greater focus on pedagogy. Sadly, without early exposure to the topic many of us never learn what nuclear medicine is all about.

CIC Intern Missive

Erik Mittra, MD
emittra@stanford.edu

I have enjoyed my first year as an intern on the Correlative Imaging Council (CIC). It has been an educational one for me as I've learned the various functions of the CIC and heard the discussions of various key topics related to our objectives, as well as important issues within the SNMMI related to our council. With the help of Dr. Amol Takalkar, I organized one of the SAM sessions at the recent annual in St. Louis on "Multimodality Imaging of Sarcoma." Although it was scheduled at 8 a.m. on the last day of the conference, it was quite well attended and the speakers all did a great job on the topic! Now, I am working with another board member, Dr. Klitzke, on organizing the SAM CT review course for the 2015 Mid-Winter SNMMI Meeting in San Antonio, Texas. I am also working with several other members, including Drs. Peeyush Bhargava and Tom Hope and one of our technologist members, Dawn Holley, to put together correlative imaging cases for both physicians and technologists on the SNMMI website. I look forward to another productive year and hope all the CIC members as well as SNMMI members at large will take advantage of all the great educational sessions the CIC puts together.

Scintillating in Puerto Rico

Bioluminescence is a phenomenon that occurs in nature as a phenotypic expression in some species. I grew up in a small beach town in the southwestern coast of Puerto Rico. The town is known, among other things, for its bioluminescent bay. For someone who has never experienced

it, a bay with scintillating waters may be hard to imagine and may even sound like something taken out of a science fiction novel.

There are very few bioluminescent bays- or biobays-in the world. Three of them are in Puerto Rico. The one in the town I grew up is near a fishermen's village called La Parguera. The bioluminesce is produced by microscopic dinoflagellates that live in the water, within a very delicate ecosystem. The bay in La Parguera is largely surrounded by interconnected mangrove trees that rise above the water and are arranged in island-like formations. I have a fond childhood memory of going at night with my father and the local fishermen into the bay. The fishermen's boats were made out of wood and built by themselves. Once in the middle of the bay, especially in a night with no moon, the water would sparkle in a neon-like blue, under a sky full of stars. I have never jumped in those waters at night. Those who did found themselves surrounded by light as they swam and moved in the water. Upon coming out of the water, they literally glowed in the dark, at least for a minute or two, once back on the boats. I remember enjoying pulling up a bucket filled with water into the boat and playing with the glowing water. After playing with it, my hands ended up covered with the water and glowing as if I was wearing gloves made out of light. Even as an adult, the memories are purely magical.

There are two other bioluminescent bays in Puerto Rico, one near the town of Fajardo and the other in the small island of Vieques. The one near Fajardo is called Laguna Grande. It is completely enclosed by mangroves and can only be accessed by kayak. The one in Vieques is known as Mosquito Bay. This one is more remote, and currently the access to it is limited.

The bioluminescent bays of Puerto Rico, with their delicate ecosystems and spectacular light phenomena, are truly extraordinary natural wonders scintillating in the Caribbean Sea.

Samuel Almodóvar, M.D.

The Correlative Imaging Council 2014 Walter Wolf Young Investigator Award

Jean-François Montégiani
Pharmacology and Pharmaceutical Sciences

YIA 2014 winner, Jean-François Montégiani, gave his presentation:

Personalized 177Lu-octreotate PPRT: Cycle-to-cycle renal radiation dose prediction using quantitative SPECT/CT dosimetry.

Jean-François Montégiani[1], Emilie Gaudin[1], Price Jackson[2], Philippe Després[1] and Jean-Mathieu Beauregard[3]

[1] Physics, Engineering Physics and Optics, Université Laval, Quebec City, QC, Canada
[2] Molecular Imaging and Targeted Therapeutics, Peter MacCallum Cancer Centre, Melbourne, VIC, Australia
[3] Radiology, Université Laval, Quebec City, QC, Canada
J Nucl Med. 2014; 55 (Supplement 1):198

Objectives: Peptide receptor radionuclide therapy (PRRT) with 177Lu-octreotate is commonly administered at fixed activity per cycle despite the known huge inter-patient variability in absorbed radiation dose to the kidney. We aimed to assess the accuracy with which renal dose is predictive of the renal dose to be delivered during the subsequent cycle, with the goal to personalize administered activities.

Methods: Eight patients underwent serial quantitative SPECT/CT (4, 24 and 72 h) after each of 4 177Lu-octreotate cycles (~7.4 GBq). Alignment of fused SPECT/CT volumes was performed through non-rigid registration of CT volumes. A GPU Monte Carlo code was used to generate a dose-rate map at each time-point. A 1-cm3 VOI was placed on the cortex of each kidney to sample the dose rates. These were fitted to a bi-exponential curve, which was integrated. The resulting renal dose was averaged between both kidneys and compared between each pair of consecutive cycles (difference expressed as % of later cycle renal dose). Positive and negative values indicated that the predicted dose overestimated or underestimated, respectively, the delivered renal dose.

Results: The mean renal dose per administered activity was 0.48 ± 0.13 Gy/GBq (range: 0.30 to 0.71 Gy/GBq), which is consistent with published data. The mean cycle-to-cycle renal dose difference was near zero at -0.7 ± 9.9 % (range: -18.5 to 14.3 %).

Conclusions: These results suggest that renal dose can be predicted from the precedent cycle with a good accuracy. This could enable prospectively personalizing administered activity at each subsequent cycle to deliver a prescribed renal dose. Personalized PRRT may improve clinical outcomes by maximizing per-cycle tumor doses, without exceeding the tolerable renal dose.

Inter-cycle renal dose differences (%)			
Patient	Predicted from cycle 1 vs. delivered at cycle 2	Predicted from cycle 2 vs. delivered at cycle 3	Predicted from cycle 3 vs. delivered at cycle 4
1	12.3	-18.5	9.2
2	-5.9	-8.1	6.8
3	-4.1	-6.2	14.2
4	10.6	-9.4	2.2
5	8.9	-6.7	-5.1
6	2.4	-7.4	-6.0
7	-3.1	0.8	4.3
8	-12.6	14.3	-10.0