SNMMI Clinical Trials Network
SOCIETY OF NUCLEAR MEDICINE & MOLECULAR IMAGING

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THE CLINICAL TRIALS NETWORK NEWSLETTER

PATHWAYS

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SPECT/CT Scanner Calibration for Quantitative Dosimetry

John Sunderland, PhD, MBA and Stephen Graves, PhD, DABR

After nearly three decades of development, the ability to perform reasonably accurate quantitative SPECT imaging has arrived. This effort has been buoyed by the addition of CT in SPECT/CT for accurate attenuation correction and by more advanced work in the scatter correction arena. Manufacturers of SPECT/CT equipment—and even third-party software developers—have been active in generating commercial implementation tools for quantitative SPECT in the clinic and for use in clinical trials. All of this background development has come in the nick of time to help support the potential implementation of image-guided dosimetry for radiopharmaceutical therapy, where accurate image-based measures are proving mission critical for the field.

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Despite this remarkable progress in quantitative SPECT/CT methods, there remains no standardized, generalizable approach to conveniently and accurately generate the necessary radionuclide-specific calibration factor that will allow conversion of the SPECT measured counts/voxel into a true radionuclide concentration measurement (Bq/mL). To fill this critical gap, the SNMMI Clinical Trials Network (CTN) has developed a prototype phantom-based calibration approach that uses a known activity of the radionuclide-of-interest in a phantom system, described below, that meets the following basic criteria.

1. An accurately calibrated, dose calibrator–measured, radionuclide-specific activity source
2. An inherent attenuation component that includes attenuation correction in the calibration chain
3. Sufficiently patient-like scatter conditions to include scatter correction in the calibration methodology

Figure 1. The prototype SPECT/CT calibration phantom system.

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MESSAGE FROM THE CO-CHAIRS

The Rising Tide of Quantitative Dosimetry in Radiopharmaceutical Therapies

Jonathan E. McConathy, MD, PhD and John Sunderland, PhD, MBA

The rapid growth of radiopharmaceutical therapies (RPT) is changing the standard of care for neuroendocrine tumors and prostate cancer, and investigational agents in clinical trials promise to expand the types of cancers treated through nuclear medicine techniques. Non-invasive imaging to predict and directly measure the radiation dose delivered to tumors and to normal organs is a unique feature of many radiopharmaceutical therapies and has great potential to increase efficacy and decrease toxicities through personalized dosimetry. Standardizing methodologies, defining scenarios where dosimetry has the greatest benefit, and dealing with the logistics of implementing dosimetry in routine clinical settings remain as challenges to widespread use. Tools and approaches to practical and accurate quantitative dosimetry exist, but they are largely in early stages of development and not yet mature technologies. This CTN Pathways Newsletter highlights practical aspects of dosimetry for radiopharmaceutical therapy from the perspective of physicists, nuclear medicine physicians, and technologists.

Clinically useful dosimetry requires attention to several key technical factors. Dose calibrators must be properly calibrated and must use the proper settings and geometries to accurately measure the amount of administered activity. Planar and SPECT/CT systems need to be calibrated using isotope-specific methodologies in order to provide accurate measurements of the concentrations of radioactivity in normal organs and tumors over time. Commercial software packages are available for dosimetry calculations but require knowledgeable staff and rely on the accuracy of imaging measurements. Although many centers perform dosimetry for radiopharmaceutical therapies, widely accepted protocols and standards have not yet been established.

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In addition to technical aspects, workflow and logistical considerations also are important for dosimetry. Repeated imaging at multiple time points requires adequate camera capacity and may be challenging for some patients and

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IN THE NEWS:

Dosimetry for Radiopharmaceutical Therapy: Currently Available Resources

Pat Zanzonico, PhD

With the ongoing growth of radiopharmaceutical therapies, there is intense interest in the development of individualized radiation dosimetry for such therapies, with the ultimate objective of optimization in terms of both safety and efficacy. The multistep paradigm for patient-specific dosimetry for radiopharmaceutical therapy is as follows:

- administration of a pretreatment tracer activity of the therapeutic radiopharmaceutical;
- measurement of its time-dependent biodistribution;
- definition of the pertinent anatomy by CT or MRI;
- integration of the measured activity-time data to derive source-region time-integrated activities;
- calculation of the tumor, organ-at-risk, and/or whole-body absorbed dose coefficients;
- and prescription of the therapeutic administered activity to deliver the maximum tolerated dose to at-risk normal organs or the prescribed tumor absorbed dose.

Important refinements of this paradigm include incorporation of voxel-level dosimetry to derive 3D dose distributions and mathematical modeling of the biological effect of the spatial and temporal nonuniformity of the doses delivered; however, such patient-specific dosimetry remains logistically and computationally challenging. An increasing number of academic as well as commercial entities are developing and distributing software packages to facilitate practical implementation of patient-specific dosimetry by performing some or all of the steps in the dosimetry paradigm, culminating in voxel-level dose maps superimposed on anatomic (i.e., CT or MRI) images as well as dose-volume histograms. In this context, traceability to national agencies of standard, or reference, sources is critical for both accurate measurement of activities administered to patients and accurate calibration of

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SPECIAL FEATURE

Personalized Dosimetry in the Era of Theranostics: When to Do Dosimetry

Hong Song, MD, PhD, Valentina Ferri, PhD, and Andrei Iagaru, MD, FACNM


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Valentina Ferri, PhD


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Despite increasing evidence supporting personalized dosimetry in radiopharmaceutical therapy (RPT) and the fact that it is routinely performed for patients receiving external radiation, dosimetry is not required for FDA-approved RPTs such as Lu-177-DOTATATE (Lutathera). Dosimetry was not included in the phase III VISION trial of Lu-177-PSMA-617 for castration resistant metastatic prostate cancer *(1,2)*. Instead, a multicycle fixed activity approach has become the accepted treatment scheme, similar to fractionated external beam radiation where normal tissue repair and recovery between cycles are possible and mild toxicity has been observed.

It is widely recognized, however, that given the patient-to-patient variation in pharmacokinetics, tumor burden, prior treatments, normal organ reserve, and DNA damage repair, patients could potentially be over- or undertreated when using fixed activity and cycles. Indeed, although dosimetry was not incorporated, the VISION trial was designed so that patients received 4-6 cycles based on evidence of response, signs of residual disease, and treatment tolerance, at the discretion of the treating physicians. In addition, the dose could be delayed by up to 4 weeks or reduced by 20 percent to lower adverse effects. In the randomized phase II TheraP trial, patients with PSMA-positive disease were selected based on SUVmax > 20 at one site of metastasis and at least 10 at all other measurable sites rather than commonly used criteria with uptake higher than liver, thereby increasing therapeutic index without performing dosimetry *(3)*. In order for dosimetry to be routinely utilized in RPT, it will require high-level evidence, from randomized control trials, demonstrating that dosimetry-based treatment planning improves overall outcome compared to planning based on a fixed dosing scheme. The additional costs and personnel required for dosimetry, as well as reimbursement, also will be important factors to consider.

Radioiodine treatment of differentiated thyroid cancer, the oldest RPT, is generally delivered using an empiric dosing scheme based on the presence of nodal or distant metastases, which limits the blood dose < 200 rads. Post-thyroidectomy bed dosimetry is feasible, but its long-term clinical benefit is undefined *(4)*. In the presence of extensive pulmonary metastases, dosimetry is performed to restrict whole-body retention to 80 mCi at 48 hours to manage lung toxicity *(5)*. Simplified dosimetry protocols are feasible for patients with extensive iodine-avid metastases or with renal function impairment. Due to the high efficacy of radioiodine treatment and the excellent long-term survival of most patients, studies so far have not been able to demonstrate survival benefit of RPT using personalized dosimetry compared to the current dosing scheme *(6)*. I-131-tositumomab for non-Hodgkin's lymphoma was one of the few RPTs approved by the U.S. Food and Drug Administration that initially required imaging-based dosimetry planning, limiting whole-body absorbed dose to 75 cGy *(7)*. Nonetheless, I-131-tositumomab was not widely adopted, despite its high response rate, in part due to the relative effectiveness of unconjugated antibody. So far, personalized dosimetry is best demonstrated in the radioembolization of hepatocellular carcinoma: based on a pretherapy Tc-99m macro-aggregated albumin scan to deliver 205 Gy to the index lesion, objective response was significantly improved compared to standard dosimetry with 120 Gy to the perfused lobe *(8)*.

Many obstacles remain to reaching the goal of incorporating dosimetry into RPT, from standardization and simplification of dosimetry calculations, to establishment of RPT-specific dose response for both normal organs and tumors, to reimbursement—which was recently reviewed in depth *(9-15)*. In current clinical practice, dosimetry may be considered in patients eligible for salvage therapy with additional cycles of RPTs or in patients with impaired normal tissue functions, for example, low marrow reserve or chronic kidney disease. Patients with extensive osseous metastases in late-stage prostate cancer may warrant dosimetry to manage marrow toxicity. In addition, a subset of prostate cancer patients treated with PARP inhibitor or checkpoint inhibitors—where combination therapies may impact marrow toxicity and outcome—may benefit from dosimetry *(16,17)*.

As with most things, a more nuanced or balanced approach is likely to prevail, such as acknowledging the benefits of dosimetry in selected patients (to be defined per disease and per RPT) and recognizing the challenges of implementing dosimetry in each patient receiving RPT. Given the numerous groups with excellent expertise who work on these topics, we remain highly optimistic that dosimetry will find its appropriate use in clinical practice, in addition to an expanded role in research protocols.

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The Dosimetry Workflow

Carlos Uribe, PhD, MCCPM

Dose is defined as the energy deposited by ionizing radiation per unit mass of tissue and is measured in units of Gray; dosimetry is the process by which the dose is calculated. In radiopharmaceutical therapies (RPTs), the patient is treated with a radiopharmaceutical that binds to cancer cells, irradiates them, and hopefully eliminates them. In contrast to chemotherapy, in RPT it is the radiation emitted and the energy deposited in tissue that causes the effect (radiobiology is the pharmacodynamics). The pharmacokinetics of RPT differentiate it from external beam radiation therapy.

The absorbed dose is the physical quantity that can determine whether a tumor will respond or whether toxicity will occur in healthy organs. How can one estimate the absorbed dose in organs and tumors? The necessary steps are quantitative imaging, time-integrated activity (TIA) determination in combination with what physicists call the "S-value," and segmentation.

Quantitative images in nuclear medicine (Fig. 1) are achieved with acquisition protocols that correct for image degrading effects (e.g., photon attenuation and scatter) and careful calibration of the equipment. Dose calibrators are calibrated with a source of the radionuclide of interest that is traceable to a standard; gamma camera and SPECT systems can be calibrated by performing either a tomographic acquisition of a phantom or a planar scan of a point source (both with a known amount of radioactivity). With corrections and calibrations applied, quantitative images provide information about the activity (or activity concentration) in each pixel of the image.

The TIA (Fig. 2) represents the total number of radionuclide decays over time in a location within the body. It combines information from the physical decay and the biological clearance of the radiopharmaceutical. It is measured by scanning the patient at different times after injection of the radiopharmaceutical and generating a time-activity curve (TAC). The TIA is the area under the TAC. New methods are being developed to allow TIA estimation with a single scan.

The S-value (Fig. 3) represents the absorbed dose in a target (organ or tumor) per decay of the radionuclide in a source region (organ or tumor). Physicists have generated precalculated tables of S-values for standard human anatomies. These values are combined with organ TIA for the estimation of organ-level absorbed doses. Similarly, voxelized S-value kernels can be used for personalized 3D dose assessments (voxel-level doses).

An important step in the dosimetry workflow is segmentation of the organ or tumor of interest (Fig. 4). Organ-level approaches require segmentation to estimate the TIA and mass of organs and tumors. Segmentation is also used to measure organ-level absorbed doses from 3D dose maps (Fig. 5). Currently, the segmentation task is the most time consuming in the dosimetry workflow; however, artificial intelligence and semiautomatic algorithms are making it much faster, easier, and potentially more reproducible than it used to be.

Continuous improvement of the dosimetry workflow through novel technologies makes this essential aspect of radiopharmaceutical therapy more feasible and accessible. Dissemination and implementation of practical and reliable dosimetry applications is a prerequisite for precision RPT. This personalization has the potential to improve patient management and therapy outcomes.

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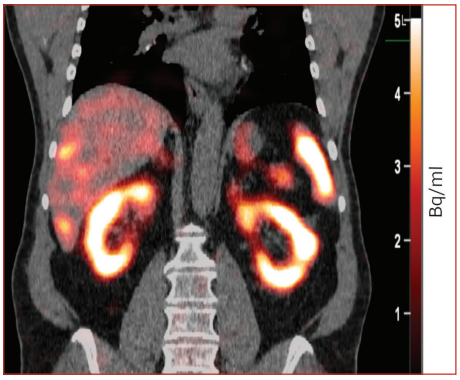

Figure 1: Quantitative fused (i.e., SPECT + CT) image with colorbar showing units of Bq/ml.

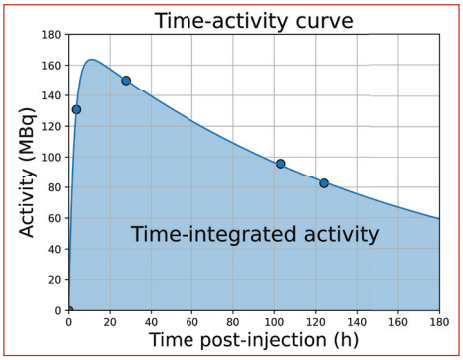

Figure 2: Example of a time-activity curve and its time-integrated activity.

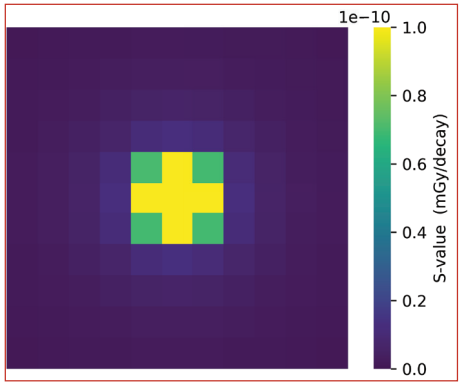

Figure 3: Example of an S-value kernel representing the absorbed dose per decay of a source located in the central pixel.

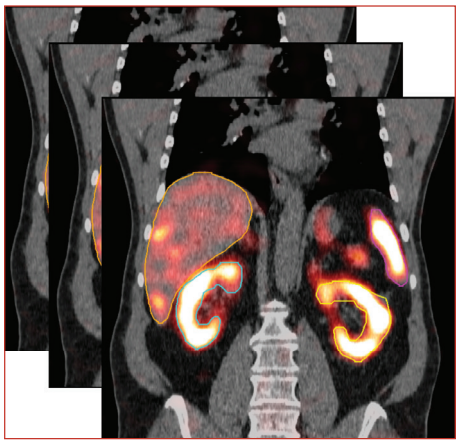

Figure 4: Segmentation of organs in 3 SPECT/CT scans acquired at different time points.

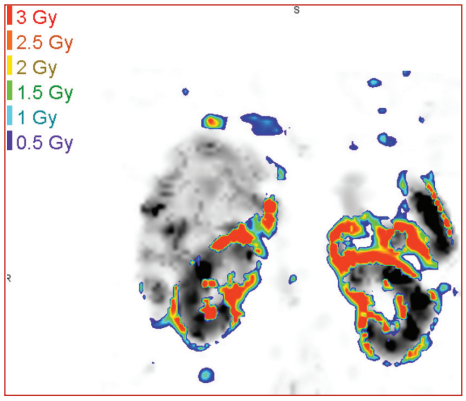

Figure 5: Dose map obtained following the dosimetry workflow.

Dosimetry for Radiopharmaceutical Therapy: A Physician's Perspective

Courtney Lawhn-Heath, MD

Without question, it's an exciting time to be a nuclear medicine physician (though really, when has it not been?). With theranostics taking the world of oncology by storm, enthusiasm for radiopharmaceutical therapy (RPT) is at a record high. This is an important time to ask ourselves as a field: should dosimetry play a role in RPT? And of most interest to me as a nuclear medicine physician: should dosimetry be used to modulate administered activities/cycles? Right now, these questions are as contentious as the evidence base is heterogenous.

It seems clear that there is room for improvement in the standard fixed activity paradigm currently used in RPT (Figure 1). Despite the tantalizing promise of personalized dosimetry in RPT, there are roadblocks between where we are as a field now and where we want to be (Figure 2), which are too numerous to discuss here. The foundational issue is the evidence base. Many RPT clinical trials make inconsistent use of dosimetry, use inconsistent dosimetry methodology, incompletely describe their dosimetry methods, have a lack of statistical power, use retrospective study designs, and/or suffer from selection bias. Perhaps due to insufficient high-quality evidence, SNMMI and peer societies including the American College of Radiology, American College of Nuclear Medicine, American Society for Radiology Oncology, and American Association of Physicists in Medicine have generally refrained from taking a firm stance on dosimetry in RPT in published guidelines. To a physician in clinical practice, this silence is deafening, and it implies a lack of consensus as to whether and how dosimetry should be used. It seems overwhelmingly likely that the evidence for dosimetry in RPT has failed to show a consistent clinical benefit, not because there is no benefit but because there are significant inconsistencies in how dosimetry is performed, used, and reported (not to mention variability introduced by different scanners, reconstruction methods, image analysis software, and segmentation methods).

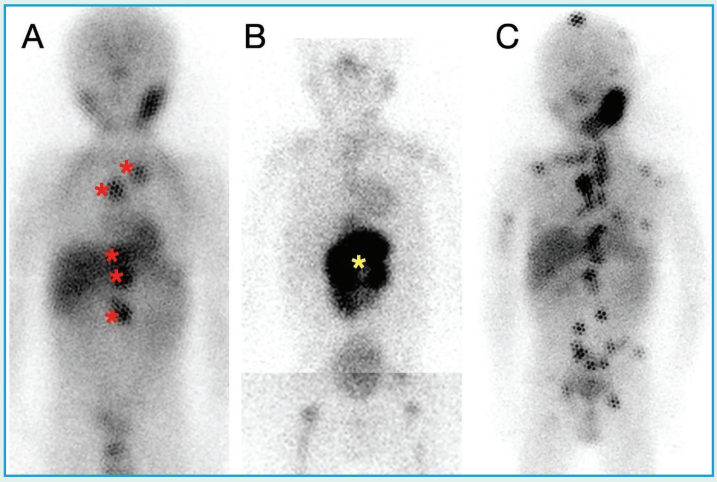

Figure 1. Fixed activity despite interpatient variations. Whole-body planar I-131 MIBG scans of three patients with metastatic neuroblastoma demonstrating (A) low to moderate disease burden in the soft tissues of the chest and abdomen (red asterisks), (B) a single large soft tissue mass in the abdomen (yellow asterisks) with low-level diffuse bone marrow metastases, and (C) extensive soft tissue and osseous metastases. All patients were treated with 16 mCi/kg I-131 MIBG.

Ultimately, the problem comes down to a vicious cycle: there is a relative lack of high-quality evidence for dosimetry-based activity modulation, so it's not routinely incorporated into clinical trials in a rigorous way. But because it's not incorporated into clinical trials, there is a persistent lack of high-quality evidence. We can break this cycle, and it starts with having a seat at the table in multidisciplinary societies and clinical trial consortia. I am excited for us to work together as a field to explore the potential of dosimetry-based activity modulation to optimize our practice of RPT and, hopefully one day, improve patient outcomes.

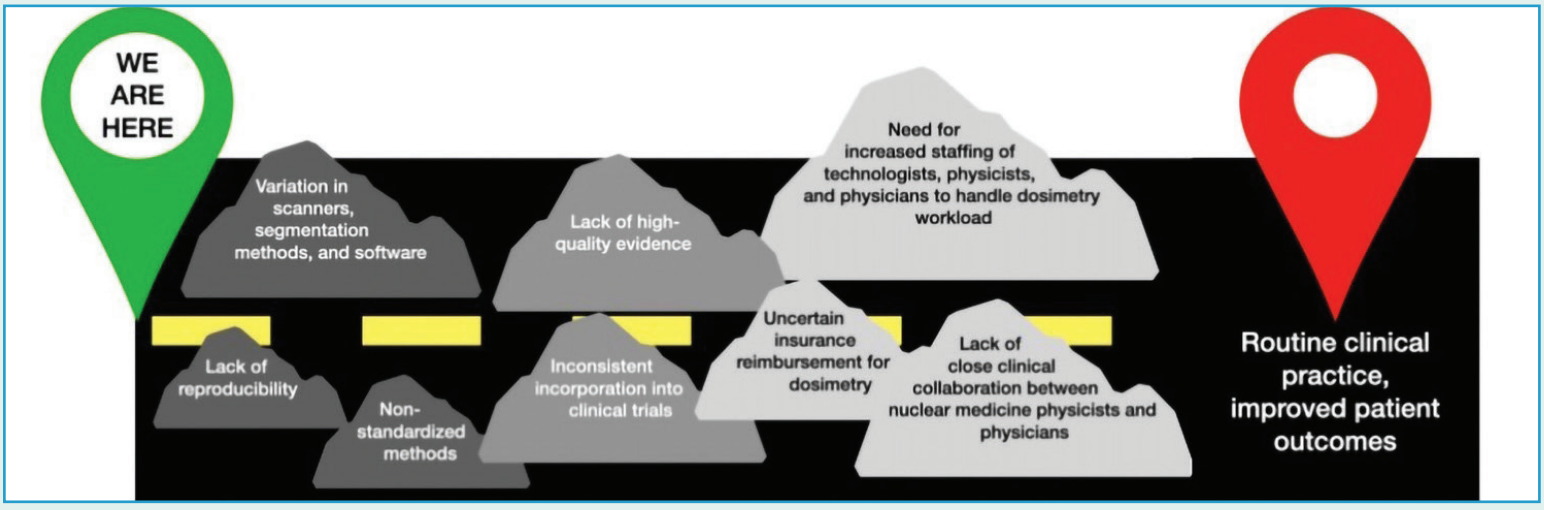

Figure 2. Roadblocks to implementation of dosimetry in clinical practice can be broken into three domains: (1) lack of standardization (dark gray), (2) lack of clinical guidelines/training (medium gray), and (3) a challenging healthcare infrastructure (light gray).

TECH ESSENTIALS

Dose Calibrator Calibration for Imaging for Dosimetry: Practical Considerations

John Sunderland, PhD, MBA and Stephen Graves, PhD, DABR

Commercial well-type ionization chamber dose calibrators have been the standard measurement devices used in nuclear medicine for nearly 50 years. Their primary use has been to measure and verify the radionuclide-specific radioactivity measurement of nuclear medicine radiopharmaceuticals and ensure that administered doses to patients are consistent with physician prescription—with typical acceptable ranges, e.g., ± 10 percent. However, advances in clinical nuclear medicine and PET practice have resulted in more and more reliable quantitative imaging techniques and analyses that have at their foundation the fundamental measurement of activity from dose calibrators. In fact, all PET/CT and SPECT/CT systems are ultimately quantitatively calibrated based on dose calibrator measures of activity.

Recently, with the explosive growth of radiopharmaceutical therapy (RPT), the stakes associated with accurate and consistent dose calibrator measurements have become even higher. In RPT we are injecting at therapeutic levels of radioactivity; overdosing can cause significant toxicity, and underdosing will result in less-effective treatments. With radioiodine therapy, which has been used for decades, the therapeutic window (the activity range for which the radiopharmaceutical effectively treats the cancer and simultaneously avoids toxicity) is so wide that accurate quantitation is less critical. However, newly approved and newly developing therapeutic radiopharmaceuticals have much narrower therapeutic windows and therefore require greater attention.

Virtually all new RPT agents under development in clinical trials are using PET- and SPECT-based quantitative imaging of organ (and tumor) uptake to measure radiation dose to critical organs. The accuracies of these image-based measurements are ultimately dependent on accurate dose calibrator measurements. With recent focus on dose calibrator measurements in these clinical trials, we are learning (and relearning) several alarming facts.

1. Dose calibrator vendor-recommended calibration settings for specific isotopes are often substantially incorrect. They frequently require adjustment (see item 4 below).
2. Even if one has multiple dose calibrators of the same make and model, they may read differently by a small amount at the same calibration settings. These should be adjusted and checked at least annually. It is most important that they individually measure accurately, not that they have the same settings.
3. Geometry and materials matter considerably. For some radionuclides, measurement of activity in a glass vial at the bottom of a dose calibrator well may read more than 20 percent different than the same activity in a plastic syringe hanging in the dipper (due to both different geometry and different self-attenuation in the water and container material). A consistent measurement approach for patient dose should be parallel to how one calibrated the dose calibrator with a best-known source calibration activity.
4. Activity measurements for shipments received from outside radiopharmacies should be measured on-site with geometries identical to those performed at the outside pharmacy. It is likely that the calibration setting on the dose calibrator will need to be adjusted to match measurements from the outside. In some cases, the radiopharmacy will send an NIST traceable activity reference, but it needs to be requested.

Renewed interest in ensuring best-practice dose calibrator utilization will result in a stronger foundation for further developments in the field of nuclear medicine, especially as therapeutic applications of radiopharmaceuticals continue to expand.

Personalized Dosimetry. Continued from page 2.

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4. Radionuclide-specific phantom filling and imaging to generate a calibration factor that will be applicable for all studies using this radionuclide
5. Inexpensive, easy to shield and store phantom, as SPECT therapeutic radionuclides have longer half-lives

The phantom method consists of a soft tissue-equivalent cylinder (20 cm diameter by 20 cm length) designed to accommodate a small plastic bottle, filled with the radionuclide solution of interest (Figure 1). The radioisotope-containing bottle was selected based on availability (low cost, commercially available), volume (~270 cm3, roughly equivalent to total renal volume), and practicality (easily stored and shielded following calibration). The tissue-equivalent cylinders, used to provide attenuation and scatter for imaging, have been obtained at reasonable cost from Computerized Imaging Reference Systems, Inc. (Norfolk, VA, USA). Scanner calibration proceeds by preparing a known quantity of radiopharmaceutical in a syringe, injecting the activity into the bottle, quantifying residual, and scanning using the relevant clinical imaging protocol. Following scan reconstruction, the number of counts within and near the bottle in the fully-corrected SPECT image are used to calculate a calibration factor.

This phantom geometry appears to provide significant advantages over simpler methods, such as using a point source for planar or SPECT sensitivity calibration, while being far more achievable than what could be considered a gold-standard calibration method (e.g., 3D-printed organ volume contained within anthropomorphic water phantom). The key advantage over simpler methods (point or line sources) is that the phantom and bottle provide realistic scatter, which is not fully corrected for using conventional SPECT imaging reconstruction techniques (dual- or triple-energy window scatter correction methods). More sophisticated scatter correction techniques are becoming available, for which the new SNMMI CTN calibration technique may provide equivalent sensitivity measures to those provided by simpler techniques; however, in general, the SNMMI CTN phantom appears to be a more robust, practical, and realistic measurement approach.

It is critical to note that, unlike PET calibration methods, the acquisition parameter details for the proposed clinical or clinical trial acquisition and reconstruction (collimator, time per detector position, number of angular samples, orbit definition, energy windows, scatter windows, reconstruction parameters) exactly match the conditions of the calibration acquisition and reconstruction.

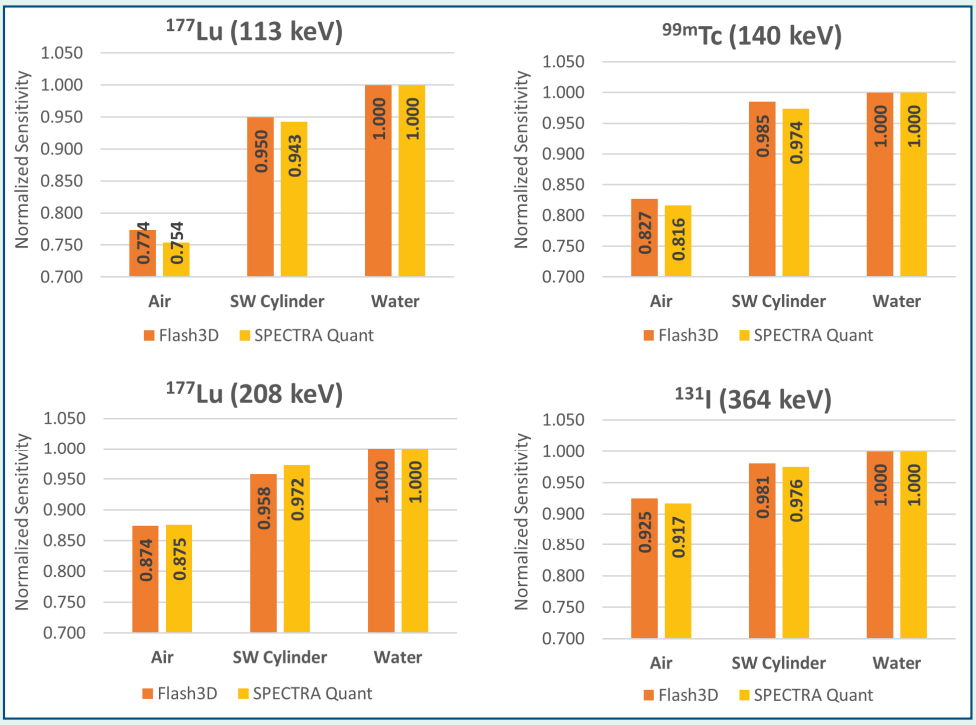

Figure 2. Normalized reconstructed sensitivity of the CTN SPECT calibration phantom ("SW Cylinder") compared to point source measured sensitivity ("Air") and a larger water-filled phantom with attenuation and scatter closer to human dimensions ("Water"). Point source sensitivities demonstrate large radionuclide-specific negative biases of 10-25% as compared to the reference standard water phantom. The CTN SPECT phantom appears to demonstrate small negative biases of 2% to 5% that, although measurable, are sufficiently close to the reference standard measurement for use as a SPECT calibration technique for clinical applications and clinical trials.

In the News: Dosimetry. Continued from page 2.

imaging systems for the measurement of activity-time data in patients. Such standards are available directly from these agencies (e.g., National Institute of Standards and Technology) or from various companies (such as Eckert & Ziegler Isotope Products and Sanders Medical Products). Dosimetry software packages are currently marketed by a number of companies:

- QDOSE (ABX-CRO, Dresden, Germany)
- Planet Dose (DOSIsoft, Cachan, France)
- GE Dosimetry Toolkit and Q.Thera AI (GE Healthcare, Chicago, IL)
- Hermes Medical Solutions (Stockholm, Sweden)
- MIM Software (Cleveland, OH)
- PMOD (PMOD Technologies, Zurich, Switzerland)
- Rapid (Baltimore, MD)
- Simplicit90Y™ (Mirada Medical, Oxford, England)
- RapidSphere Dosimetry Navigator and RapidSphere Tradeoff Explorer Navigator (Varian Medical Systems, Palo Alto, CA)
- Torch (Voximetry, Madison, WI).

With increasingly powerful computing hardware and the application of artificial intelligence (e.g., for efficient segmenting of organs and tumors), the commercial availability of such software should make patient-specific dosimetry increasingly practical and available beyond specialized academic centers.

TECH TIP

Radiopharmaceutical Therapy Dosimetry: The Technologist Perspective

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There is an undeniable surge in the utilization of existing radiopharmaceutical therapies (RPT). New and impactful treatments such as Lu-177 DOTATATE have been somewhat recently approved, and many more, such as Lu-177 PSMA, are on the horizon. The complexity and variations of these procedures is also growing, as is the need to provide the best possible outcome to the individual patient. The long-predicted era of theranostics driven by well-performed dosimetry is upon us, and the role of the nuclear medicine technologist is once again evolving.

Dosimetry itself is not necessarily new to the world of nuclear medicine technologists. Occasionally over the years a technologist may have been asked to perform radioiodine dosimetry for patients undergoing I-131 therapies with differentiated thyroid cancers. Given its historically infrequent use, the prospect of performing dosimetry has often been intimidating. If you have participated in this practice, you will know that it involves many skills that we technologists routinely draw upon. The first and probably most important step should be collaboration. Dosimetry calculations will be performed by a medical physicist. Given the current multitude of options and variables, an agreement on the needed data and procedure is tantamount to success. A brief discussion with the treating physician and physicist will help determine which steps should be performed to best assess the optimal safe dose. Standard dosimetry can include:

- imaging
- region of interest (ROI) analysis
- timed blood draws with assays
- whole-body counting with uptake probes
- preparation of standards

Each of these steps requires precision and time as they are repeated over multiple days to accurately evaluate and measure the dose to the patient.

It is imperative to address with your leadership the scope and necessity of dosimetry. Its value can be demonstrated as a multidisciplinary endeavor increasing services sought out by patients across one's Institution. It will however come as no great surprise to find that currently compensation is lagging far below actual workload. An accurate capture of the effort and time required for each patient should be presented; otherwise, the typical staffing formulas, dividing billed procedures and number of staff, will be utilized. Dosimetry's clinical and financial impact to your institution may be undervalued and under-resourced without proper explanation and evaluation.

As technologists, it is important that we support the initiative currently underway at the SNMMI to advocate for the use of dosimetry in RPT. Efforts to standardize these techniques are crucial if the practice is to be truly embraced by our community and referring base. A patient should expect the same level and accuracy of care in all clinics, and we should strive for a degree of homogeny and reproducibility throughout our specialized field. Be a participant and voice to encourage reasonable and realistic compensation. Lastly, look forward to being a critical and knowledgeable part of this translational care model as we solidly move in this new exciting direction.

The Rising Tide. ***Continued from page 2.***

clinics. Processing images for dosimetry (segmentation, conversion to activity concentration) and performing dosimetry calculations can be time consuming, and adequate reimbursement for these activities is key to sustainability.

There is growing recognition of the importance of dosimetry in realizing the best possible outcomes from radiopharmaceutical therapies. The Clinical Trials Network continues to be actively involved in the larger community working to make dosimetry more accurate and more widely available. SNMMI, the greater academic community, industry, government, and sister professional societies are collaborating to develop standard approaches and tools to accelerate this rising tide. We hope this issue of Pathways will provide a useful overview of key aspects of dosimetry and encourage your support of efforts to expand the role of dosimetry in nuclear medicine.