WINTER 2021–2022

Johns Hopkins Medicine

Radiology Update

THE RUSSELL H. MORGAN DEPARTMENT OF RADIOLOGY AND RADIOLOGICAL SCIENCE

Moving *Forward*

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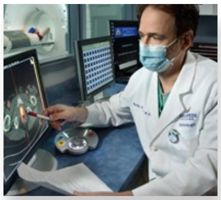

The Inaugural Bearman and Zerhouni Professorships

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CHAIR'S MESSAGE

Karen Horton, M.D.

The Johns Hopkins Department of Radiology and Radiological Science continued to progress forward in 2021 with our tripartite mission while maintaining COVID-19 response measures. Additional priorities for the representation of our diverse staff were recognized and led to the establishment of the Radiology Black Caucus. The goal of One Radiology was furthered with the welcome of a new Johns Hopkins Bayview Medical Center leadership team, comprising Dr. Harjit Singh as the interim chair of Johns Hopkins Bayview's Department of Radiology and Radiological Science, Danielle Karavedas as administrator, and Dena Dempster as clinical operations manager

CLINICAL

Our clinical staff and faculty members have truly shown their dedication and commitment to providing full imaging services across Johns Hopkins hospitals and outpatient imaging centers. With a second site confirmed for Columbia and a brand-new site anticipated in Rockville, we look forward to expanding access to high-quality, value-driven imaging within communities.

RESEARCH

We have had several exciting developments in research, ranging from establishment of the Radiology Physician-Scientist Incubator program, entering clinical trials for immunotherapy imaging and the FDA approval of PyL for prostate cancer imaging. The development of PyL has been a 25-year journey for Martin Pomper and his team, and we congratulate him on this remarkable milestone.

EDUCATION

For the third year in a row, our radiology department was ranked #1 in U.S. News & World Report's Best Radiology Programs.

The experience and collaboration we emphasize for our residents and trainees have remained priorities, with a new online dashboard dedicated to helping residents track progress for the Accreditation Council for Graduate Medical Education.

As the pandemic continued, stories of collaboration, achievement and clinical excellence emerged across our clinical teams, researchers and administrators. We share a few of those stories in this newsletter. I hope you enjoy them. As always, alumni and donors are welcome to reach out to me with any questions.

Sincerely,

Karen M. Horton
Martin W. Donner Professor of Radiology
Director, Department of Radiology and Radiological Science

Innovation in Outpatient Imaging

The Johns Hopkins Medical Imaging outpatient centers continue to innovate, with new online scheduling options, the acquisition of equipment and reduced scan times.

The online patient portal, MyChart, offers direct online scheduling by patients for multiple imaging exams, including mammograms and CT scans. To better leverage this resource, exams available for online scheduling were expanded, and Johns Hopkins Medical Imaging led marketing efforts to push MyChart utilization by patients. This also assisted the scheduling center volume and increased response time.

Johns Hopkins Medical Imaging at Green Spring Station will be acquiring a third MRI scanner at Pavilion III, with an anticipated fall 2021 opening. This will significantly increase availability for patients.

A dedicated MRI Taskforce was formed to reduce MRI exam times. Comprising faculty radiologists and technologist leaders, the taskforce selected multiple protocols across divisions for optimization and coordinated with equipment vendors for rigorous testing and review. Their work culminated in achieving a quicker MRI experience while maintaining or improving image quality, with all 60-minute scans now able to be completed in 30-minute time slots. ■

Radiology Continues to Pivot and Adapt to Everchanging COVID Protocols

In early spring 2020, as the COVID-19 pandemic descended, it seemed as if the entire world was consumed by questions. In radiology at The Johns Hopkins Hospital, the department's frontline technologists and nurses faced many challenges, both expected and unforeseen.

"There was just a lot of anxiety for patients, faculty and staff," says **Pamela Johnson**, vice chair of quality and safety, vice president of care transformation, and a professor in the Department of Radiology and Radiological Science.

Starting from the earliest days of the crisis, Johnson led a team of technologists, nurses and scheduling staff members charged with navigating ambulatory, Emergency Department and hospital imaging, with no historical precedent to guide them. She was later joined by faculty members **Jenny Hoang**, **Linda Chu**, **Aylin Tekes** and **Haris Sair**.

The need for care redesign quickly become apparent. Imaging was a mandatory service. The department could not put its work on hold, but neither could it downplay the pandemic's severity. In those early days of COVID-19, as telemedicine became commonplace for other specializations, radiology remained an in-person endeavor, and chest X-rays became a critical tool for diagnosis in patients with respiratory symptoms. In the ambulatory setting, this required rapid implementation of dedicated imaging suites where radiology technologists could safely image an outpatient who had any of the symptoms of COVID-19 infection.

All the while, radiology's numerous other patients, many with serious non-COVID-19-related conditions — cancers, high-risk pregnancies, strokes — all continued to flow through. Every one of those patients was like an incoming flight circling in the skies above a busy airport and in need of guidance on where, when and how to land safely. In fact, air traffic control is the analogy the team members used to refer to the ad hoc system of protocols and procedures they would develop over the ensuing weeks and months. Instead of air traffic control, however, they dubbed their system Care Traffic Control.

In the beginning, there were many open, fraught questions to grapple with, recalls Hoang. Hoang and Johnson immediately began an imaging decision tree — a flowchart of relevant questions and responses, though the tree of today bears little resemblance to the one sketched out in those early days.

> "Rules from the hospital epidemiology team were changing by the week. We kept adapting through it all."
>
> — JENNY HOANG

"Rules from the hospital epidemiology team were changing by the week," Hoang recalls. "We kept adapting through it all."

With an airborne infectious disease, there was no room for error. Every question had to be asked of every patient. Every rule had to be followed. Every step in the process had to be taken. The protocols did not govern just patient flow but also the donning and doffing procedures for personal protective equipment, as well as equipment cleaning and disinfection measures.

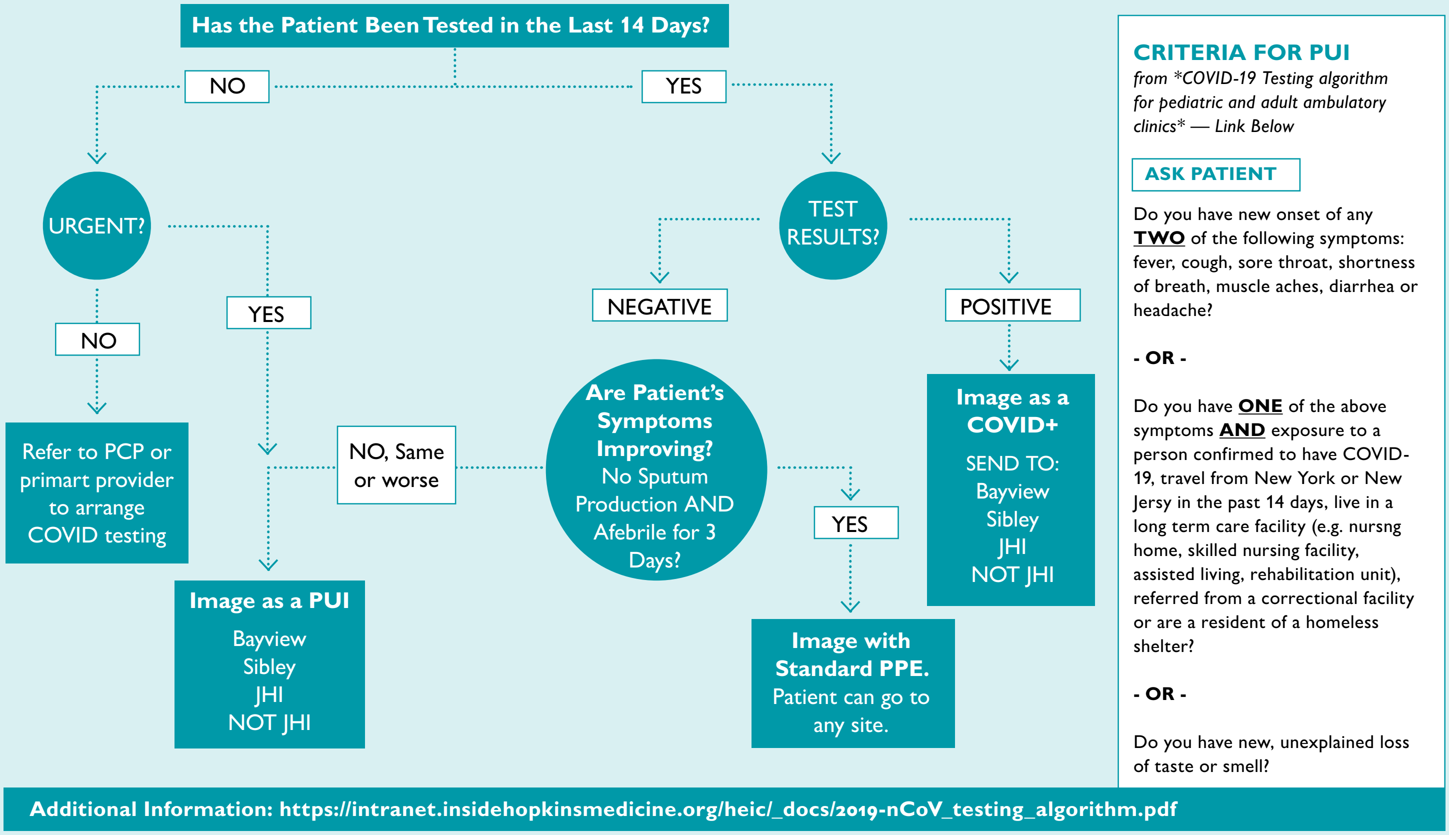
Radiology Care Traffic Control even remade physical spaces. Johnson says the fluoroscopy suite had to be redesigned to accommodate the personal protective equipment requirements involved with treating COVID-19-recovering patients in the ICU who needed swallowing studies after a protracted period on a ventilator. Frontline staff members had to have access to the necessary equipment, which demanded storage, distribution and disposal areas, but this also begot designated areas for staff members to don and doff new gear for every patient.

Over the subsequent months, as the world's understanding of the disease evolved, COVID Care Traffic Control evolved throughout the health system as well. Early on, the roundabout in front of The Johns Hopkins Hospital's iconic dome became a drive-through COVID-19 testing center for ambulatory patients, complete with tents and temporary facilities that would make a mobile Army surgical hospital proud.

"No one has used that circle for years, but the hospital turned it into a testing center. We even put an X-ray unit in one of those tents for Emergency Department patients," Johnson says.

While the precision safety protocols and high-stakes consequences are fitting of real air traffic control centers, there is one key area where the radiology experience diverges from the analogy. While air traffic controllers rely on radar,

Imaging Decision Tree for Patients with Symptoms Consistent with COVID-19



GPS, closed-circuit radio and any number of sophisticated operational systems to guide each plane home, there were no such tools for radiology. The Care Traffic Control team updated its ever-evolving flowchart on a laptop. Patient orders were communicated and tracked by a simple email form that populated a spreadsheet to make sure that all cases were resolved expeditiously, Johnson says.

The department's quality lead, **Vince Blasko**, a former technologist, set up the email forms. Nurses from each Johns Hopkins imaging site would email the CT, MRI or ultrasound team, and enabled the radiologist on the service to review the patient's electronic record, contact their physician, and report disposition to the nurse and technologist on the front line and the scheduling team. Johnson personally handled countless such cases for the first month. After months in operation, Johnson says, it became a well-oiled machine.

"If they didn't hear back right away, they'd call my cell," she remembers of the urgency of the most difficult of days. To date, the team has navigated more than 700 potentially infected outpatients who needed a radiology test, with same-day imaging in many cases.

Early in the process, the COVID Care Traffic Control proved itself up to the ultimate challenge. A patient with no apparent COVID-19 symptoms would come in for imaging for another condition — cancer surveillance, perhaps — and the radiologist would spy the distinctive appearance of COVID-19 in the scans. The disease is unmistakable to the trained eye.

"They would have full-blown COVID-19 in the lungs — asymptomatic outpatients," Johnson remembers. "The first time we saw it, we were at a loss for how to navigate this new twist." The asymptomatic challenge led to a whole new set of protocols.

"Those were crazy days. Everybody was learning and teaching and sharing together," Johnson says. "I can tell you I think COVID Care Traffic Control was a critical resource to protect our frontline staff and patients from this deadly disease. It was a real testament to the importance of a strong interdisciplinary team." ■

All-New Resident Dashboard **Streamlines Certification**

environmental photo looking at Dashboard

When it comes to professional certification, all radiology residents know the drill. They must successfully complete a prescribed number of exams across a range of specializations — brain, spine, mammography, etc. — and demonstrate proficiency using all the various technologies available today: MRI, CT, PET, etc. The entire training program must be completed within a given period and under the close supervision of a senior physician. The Accreditation Council for Graduate Medical Education (ACGME) sets the standards nationally through its Common Program Requirements.

The stakes couldn't be higher. Not only does the resident's professional future ride on reaching ACGME milestones, but the images reviewed are drawn from real patients with real health concerns. The results of the scans become part of patients' electronic medical record.

For decades, tracking resident progress against these standards was a cumbersome task, consuming valuable time and resources tabulating, cataloging and transferring data to ACGME, resident by resident, rotation by rotation, exam by exam.

"It was not easy, but it had to be done. Now, with our new resident dashboard, I think we've improved on that workflow considerably," says **Lilja Solnes**, associate professor of radiology and radiological science, and program director of the Diagnostic Radiology Residency Program at Johns Hopkins, whose job it was to do the tracking. The electronic dashboard that she and a team of developers created provides an online resource that streamlines the ACGME certification process for residents in the Johns Hopkins radiology department.

The Resident Scorecard Dashboard provides an easy, central, highly visual way through which radiology residents can track progress toward the ACGME standards and against the high bar set by Johns Hopkins itself. Not only does it lay out all the exams a resident is required to complete, but it also charts progress over time and displays the resident's performance in specific areas relative to their peers, in quantitative and qualitative terms.

ACGME might require, for instance, that a resident complete 300 MRI body exams during a residency. The dashboard shows the exact number completed to date, flags which exams need follow-up as determined by the attending physician and graphically illustrates with color-coded arrows how well the resident did compared to others in the peer group. If a resident needs to make up ground in certain area or revisit certain exams, that information is laid out in clear, graphical detail.

For Solnes, the dashboard is an easier and more convenient way to grapple with a profound amount of data, but, more importantly, it is a way to provide immediate feedback.

"We're teaching in real time," Solnes says. "And that is a critical step in developing the best radiologists."

The Resident Scorecard Dashboard replaces an aging and inefficient patchwork of third-party applications, handwritten notes and ad hoc

> "It was not easy, but it had to be done. Now, with our new resident dashboard, I think we've improved on that workflow considerably."
> — LILJA SOLNES

spreadsheets used in prior years to track the certification information.

"Necessity is the mother of invention, right?" says **Daniele Bananto**, a business intelligence manager with The Johns Hopkins Hospital, of the decision to bring development in-house and create a custom solution. She helped design and create the back-end data source that drives the dashboard.

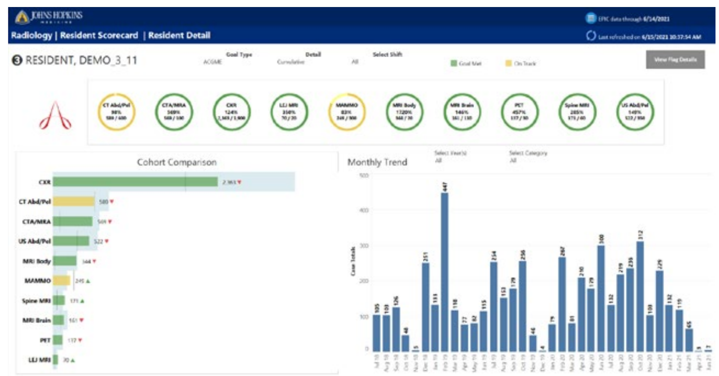
The development of the dashboard took Solnes, Bananto and team about six months, from start to finish.

Vamsi Nath built the front-end interface using Tableau, a leading software for data presentation. "Residents once had to get these numbers manually," Nath says. "Now, it's all right there."

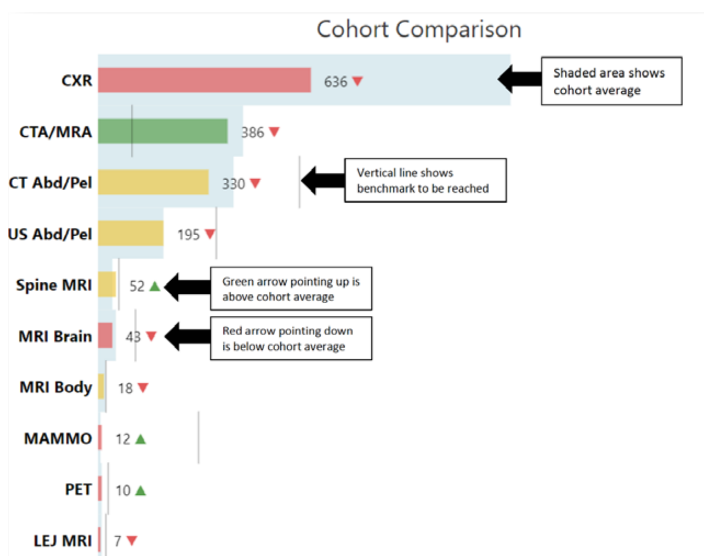
The dashboard has two view modes, one for the residents and another for the attending physician. The dashboard is helpful to both types of users, Nath points out. The interface displays a remarkable breadth of information in an intuitive, easy-to-read format; provides one-click reporting capabilities; allows senior faculty members to review, annotate and flag certain exams for follow-up; and streamlines the process of uploading of data to ACGME's master certification databases.

"We had all the data we needed in our electronic medical record system, so we built exactly what we needed for ourselves," Bananto says. "It was efficient. It was cost-effective. And, in the end, we ended up with something better for the department."

"It's really very cool," Solnes adds. ■



Icons	Description
	Click this button to clear filter box.
▲	Exceeding cohort
▼	Below cohort
Ⓒ	Critical Finding
Ⓜ	Modified Report
Ⓜ Ⓒ	Modified Report and Critical Finding reports



Caption

HISTORY

From Films to Digital: The Evolution of Imaging Records

The work to obtain higher-quality images quickly, reliably and safely is a never-ending journey, with steady progress being made by radiologists, technologists, medical physicists and supporting staff members. It can be easy to forget that the X-ray department at Johns Hopkins started with fragile emulsion-coated glass plates — strongly preferred by radiology pioneer **Frederick Baetjer** (whose hands were badly scarred due to radiation injury) — before being replaced with pliable X-ray films.

These X-ray films came with their own set of challenges, in part thanks to the rapid rise in patient volume for radiology. Wet films could take several hours to dry in the summer humidity, and completed patient films rapidly filled up the first small film room.

Patient films were collected into "jackets," with some patients collecting jackets that weighed more than 10 pounds. As additional storage locations were acquired, film clerks struggled with the unwieldy layout of film vault rows and conflicting demands from radiologists who wanted to read patient cases, house staff who wanted to show film to attending physicians, and referring physicians who wanted to take away the films.

Film clerks also had to contend with the transition process: The on-site film holding area held images up to month, then the radiology subbasement film vault held records for two to three years, then an off-site storage area met the seven-year film retention requirement. In the meantime, physical films would often be lost around clinical areas. One particular film clerk, **Theresa Dannenfelser**, gained a reputation for sleuthing out missing films under the beds, mattresses, and around various nooks and crannies of her unit.

In 1965, there was a flood in the Brady Building subbasement film vault. When the film dried, the emulsions stuck together, making it impossible to separate the films. The chief technologist at the time, John Bright, arranged for the use of a large fish tank in the pediatric area. Students from the Schools of Medical Imaging brought the film out to the fish tank, dumped them in so they could stay wet and dried film individually by processing them through the three automatic processors available.

It wasn't until 1996 that the first electronic imaging system was implemented for ultrasound. In 2000, the opening of a new Johns Hopkins Kimmel Cancer Center building (the Harry and Jeanette Weinberg Building) included a picture archive and communication system (PACS) unit that covered all modes of imaging. Over the next few years, most other sections of the department were converted to digital imaging and PACS programs.

At the turn of the century, the Johns Hopkins Department of Radiology and Radiological Science imaging workload surpassed 300,000 annual procedures. In 2020, some 1,034,174 procedures were interpreted, with 27 million images every month stored in 12.5 terabytes. The Medical Imaging Information Technology (MIIT) team, led by Ryan Fallon, director of MIIT, has become the steward of this vast electronic data. Fallon comments on the growth and future of imaging records, stating: "It is a very exciting moment in radiology where digital tools have allowed our department to expand its size and scope of increasingly specialized services. Technology continues to evolve, and we are already trying to ditch the discs used for image management today toward a future where we leverage cloud-based solutions that can support innovations, like AI, and more." ■

NEW LEADERSHIP AT THE MRI SERVICE CENTER

Founded 20 years ago as a dedicated resource for researchers who require MRI, the Johns Hopkins MRI Service Center was led by founder **Paul Bottomley** until January 2021, when he passed the baton to **Hanzhang Lu**.

The leadership transition process was complicated by the fact that COVID-19 restrictions were fully in place, making it difficult for Lu to spend time in the physical space to view the equipment and meet the staff. Nevertheless, says Lu, "Dr. Bottomley was very supportive and incredibly helpful in guiding me through the strengths and management of the MRI Service Center."

The center houses three MRI scanners (two are 3T and one is 1.5T) for Johns Hopkins and nonaffiliated investigators. Exclusively meant for scientific research purposes, these scanners allow research activity to take place during prime work hours. With more than 50 active users, the MRI Service Center uniquely offers comprehensive, full-body imaging research for different organs, from the brain to the prostate to musculoskeletal systems to cardiology.

In his time as lead of the center, Lu has navigated several major successes, including the installation of functional MRI capabilities, migrating the scheduling to centralized software and recruiting a new technologist. This progress served to not only expand the type of research the MRI Service Center can perform but also improved the efficiency of workflow for both investigators and staff.

"Dr. Bottomley was very supportive and incredibly helpful in guiding me through the strengths and management of the MRI Service Center."
— HANZHANG LU

As the pandemic continues to wind down and research activity picks up, Lu sums up his goals: "[I aim] to develop the MRI service center into a state-of-the-art platform to facilitate cutting-edge research on and beyond the Johns Hopkins campus," he says. "In order to achieve this, we will continue to upgrade and replace equipment as needed, train staff on the latest developments in MRI, and make the MRI Service Center financially self-sustainable." ■

Photo needed (recreate existing photo of Dr. Bottomley

The **Next Step** for Immunotherapy

Caption of Dr. Nimmagadda needed

After years of work identifying imaging targets and developing imaging agents and techniques in the lab, **Sridhar Nimmagadda** is seeing his research on imaging the PD-L1 protein in cancers progress to the next step, with the launch of a clinical trial.

Trained as a chemist, Nimmagadda originally started off with an interest in tumor biology. PD-L1 is a protein commonly found in tumors, and there are several existing therapy treatments targeting PD-L1 and its receptor, PD-1. To enrich responses, patients for those therapies are often selected based on PD-L1 expression. When effective, for the few who responded to it, PD-1/PD-L1 targeted immunotherapy is a treatment that changes patients' lives.

Unfortunately, the majority of patients do not experience a positive response. Concerned by this low rate of effectiveness, Nimmagadda wanted to develop a tool or technique to better optimize these treatments.

PD-L1 detection poses several challenges. Currently, immunohistochemistry is used for detection. "PD-L1 levels are very heterogenous in nature, even within a single tumor and different tumors within a patient, which has relevance to the patient's response to that therapy. PD-L1 expression can also change rapidly during therapy," he explains. "Changes during therapy are even more difficult to assess, as biopsies can be difficult to obtain during therapy and based on the type of cancer, so I was interested in finding a noninvasive imaging technique through positron emission tomography."

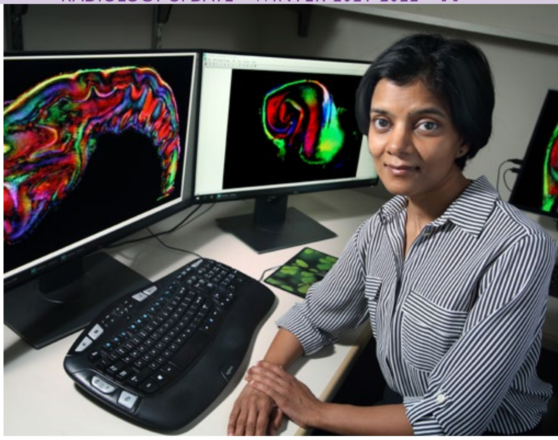
Over the course of four years, his lab members, including Dhiraj Kumar, worked closely with the Johns Hopkins University positron emission tomography chemistry colleagues **Robert Dannal**s and **Daniel Holt**. They ultimately developed a compound to better image PD-L1 protein levels comprehensively and continually throughout a patient's therapeutic journey.

The use of a specific radiotracer to serve as a biomarker in monitoring anti-tumor immune response to immunotherapy was given a go-ahead by the FDA to test in a clinical trial that is now enrolling nonsmall cell cancer patients. This clinical team is headed by **Lilja Solnes** and also includes **Steve Rowe**, **Martin Pomper**, **Patrick Forde**, **Rehab Abdalla**h and many others in the Division of Nuclear Medicine and Molecular Imaging. "We have a dedicated and collegial team that made this happen at Hopkins," says Nimmagadda.

Meanwhile, Nimmagadda continues his work with oncology and immunoimaging, applying different questions for different types of cancers. One of the many advantages of this new imaging agent is that we can evaluate any type of immunotherapy that modulates PD-L1 levels in the tumors. Many immune system targeted therapeutics that are approved or in development modulate PD-L1 levels in the tumors, so this imaging agent could find broad applicability in cancer treatment he says.

"We eagerly await the data from the clinical trial in order to begin work on guiding and optimizing PD-1/PD-L1 targeted therapies and to take the next steps," he says. "I remain very much invested in making this a success for the patients." ■

The Growing Field of Diffusion Imaging



Caption of Dr. Aggarwal needed.

Diffusion MRI has proven itself to be a rapidly evolving field for brain tissue imaging, with developments for both white matter and gray matter.

Around since the 1990s, diffusion MRI is an innovative imaging modality that utilizes the diffusive motion of water molecules to distinguish between tissues. This method can be applied to determine the orientation of brain structures such as white matter fibers and to gain information at much finer spatial scales than is possible with conventional MRI.

While the clinical and research applications of diffusion MRI are still expanding into many different areas, **Manisha Aggarwal** is particularly interested in leveraging diffusion MRI to develop techniques for microstructural imaging. With a background in electronics and instrumentation engineering, she is pursuing how different magnetic field gradients can probe different aspects of brain tissue microstructure.

"Diffusion MRI has traditionally been focused on brain white matter, but now techniques probing gray matter have been developed, and there are many areas aimed at characterization of quantitative information, such as cell sizes and additional microstructural properties," she notes. "There is also a lot of interest in how gradient shapes can be varied to look at different effects of different parameters."

An exciting use of diffusion MR techniques for probing tissue microstructure would be to enable very high-resolution imaging of the human brain. Another area Aggarwal is working on is ultrahigh-resolution imaging of the human hippocampus at high field to benefit neuroimaging and advance understanding of disorders such as Alzheimer's disease and epilepsy. However, she cautions, "The field of microstructure imaging is still a very active area of research. While the hope is that we can translate this to routine clinical use, there is still a lot of work to be done on the potential applications."

The precedent for clinical application of diffusion MRI is strong and furthered by continuing hardware advances, with a specific technique of this imaging, called diffusion tensor imaging, now routine in clinic. For now, Aggarwal continues her work developing additional techniques and staying on the forefront of the field of diffusion MRI and advances in brain microstructural imaging. ■

Radiology Physician-Scientists of the Future

The Radiology Physician-Scientist Incubator (RAD PSI) Program is an exciting new initiative launched by Radiology and Radiological Science Director Karen Horton. It aims to build a select cadre of talented junior academic clinical faculty members as physician-scientists. The program represents a major investment toward developing physician-scientist leaders who will advance and translate imaging research to address unmet needs in human health.

Vivek Yedavalli

The program was formally established this year and is led by Clinical Director **Shadpour Demehri** and Research Director **Jeff Bulte**. It includes three cli**nical faculty members — Ihab Kamel,** Robert Liddell and **Martin Pompe**r — and three research faculty members — **Manisha Aggarwal**, **Kristine Glunde** and **Hanzhang Lu**. The program has oversight from Horton and Research Vice Chair **Zaver Bhujwalla**.

The highly competitive application process requires a six-page application detailing a three-year research plan, letters of recommendation and review by the program faculty. During the selection process, applicants are requested to present their research plan. The selected candidate is provided with mentorship from the directors and program faculty members, protected research time, and funds for supplies and other costs.

The inaugural candidate selected for the RAD PSI Program is **Vivek Yedavalli**, assistant professor of radiology and radiological science, and director of stroke imaging. He is passionate about combining stroke and perfusion imaging with artificial intelligence (AI) to improve patient care through diagnosis and management. His goals during his tenure as a RAD PSI Program awardee will be to utilize AI and advanced MRI techniques to create and establish novel diagnostic and therapeutic paradigms to detect and manage stroke, stroke mimics and perfusion disorders. ■

Lynch Scholarship Affords Endless Possibilities

Over a career spanning four decades, **Edmond "Ted" Lynch** became a renowned figure in Johns Hopkins radiology. A highly skilled radiology technologist who proudly declared himself to be a "head man" (specializing in taking images of the brain, skull, jaw and teeth), Lynch graduated with the very first class from the newly formed Schools of Medical Imaging in 1941.

Just three years later, in 1944, he was a technologist on the team that assisted Johns Hopkins surgeons **Alfred Blalock** and **Helen Taussig** when they performed the famous "blue baby" surgery, which ushered in a new era of cardiac surgery. After then signing on with the World War II war effort and serving with a Johns Hopkins medical unit in the South Pacific, Lynch joined the radiology department in 1947, before it was officially a department. His achievements over the ensuing decades led to him becoming the very first inductee into the Maryland Society of Radiology Technologists' Hall of Fame.

After Lynch died in 1992, at the age of 79, his wife, Mary, curated his legacy for decades, perhaps most notably creating the Edmond and Mary Regina Lynch Scholarship in the Schools of Medical Imaging in the Russell H. Morgan Department of Radiology and Radiological Science.

The scholarship is awarded each year to a deserving student based on academic promise and financial need, and it covers the recipient's full tuition. In establishing the scholarship, Mary Lynch aimed to provide recipients with the freedom to explore their unique interests in the world of radiology and to serve the community, as Ted Lynch had done.

Sabrina Lindemon was the inaugural recipient of the Lynch Scholarship, which funded her study in the Diagnostic Medical Sonography Program at the Johns Hopkins Schools of Medical Imaging, an 18-month, full-time certification program. Lindemon, who had previously worked at Johns Hopkins as a veterinary research technician, says that the scholarship freed her to pursue her educational and professional advancement without many of the burdens other students face.

"The Lynch scholarship provided me full tuition, which allowed the financial stability to put all of my focus into my studies," she says. "Without it, the stress of a job would have made it difficult to maintain high grades. I feel very fortunate to have been selected for this scholarship." In her role as a sonographer, she works with expectant mothers in imaging, provides imaging of abdominal and superficial structures, and works with gynecology, prenatal pediatrics and neurological systems.

Looking ahead, Lindemon says she would like to help develop the skills of future technologists who will follow in her footsteps, furthering the mission of Johns Hopkins as a teaching hospital.

"In the health care field, there's always something to learn and ways to improve yourself, and I would love to help in any way I can," she says.

Lindemon, who was the first in her family to earn a college degree (she graduated from the Community College of Baltimore County in 2018), takes inspiration from the breadth of Lynch's skills and the length of his career, as well as his perseverance in pursuing his education despite challenges. Early on, after his father died unexpectedly, Lynch was forced to drop out of school in order to work to support his family.

From left, Sandy Moore, Director of the Schools of Medical Imaging; Sabrina Lindemon, Inaugural Lynch Recipient; Raj Goel, Attorney of the Lynch estate. Inset: Edmond "Ted" Lynch

Undeterred, he eventually secured a job as a hospital orderly, which led to his introduction to radiology and his eventual admission to the nascent radiology technologist program at Johns Hopkins.

"Ted Lynch had exceptional people skills and was known for putting the patient at ease during what can be an emotionally taxing and sometimes physically painful time. He was also a master of the technology," says **Bob Gayler**, a former faculty member and historian of the Department of Radiology and Radiological Science.

The radiology technologist of Ted Lynch's era had to be part photographer and part chemist, to intuit the best way to capture the needed images and the best way to process the film in the darkroom to provide the clearest images possible, Gayler explains. Accurate diagnosis often depended on the quality of the images.

"Ted Lynch was a man of many remarkable traits. I find his perseverance and adaptability over the years inspiring," Lindemon says. "If anything, his experiences show, and my own confirm, that at John Hopkins Radiology, the possibilities are endless." ■

Nagi F. Khouri

Grateful Patients Endow Khouri Fund

After more than four decades of service in the Department of Radiology and Radiological Science, Nagi F. Khouri, the former Carol Ann Flanagan Associate Professor of Breast Imaging and an esteemed colleague and mentor to hundreds of fellow radiologists, retired in December 2020. Beyond the heartfelt words of kindness and appreciation that often accompany the retirement of a beloved doctor, more than 40 of Khouri's dearest patients made the ultimate display of respect by permanently endowing the the Nagi F. Khouri, M.D. Education and Research Fund.

"We are deeply grateful to the many donors who honored Dr. Khouri in such a meaningful way. Such funding will set the stage for the type of truly pioneering research that is not typically funded by traditional sources. We could not pursue such goals without the generous support of the many contributors to the Khouri Fund," says **Karen M. Horton**, the Martin W. Donner Professor of Radiology and director of the Department of Radiology and Radiological Science at Johns Hopkins.

The Nagi F. Khouri, M.D. Fund for Education and Research will provide the necessary resources to advance the education and research of junior faculty members in breast imaging. Khouri is keen to mentor early career physician-scientists who he views as the future of the department and as the prime source of innovations in breast imaging. The fund will provide important seed research funding to get promising new radiological approaches off the ground and will support the exploration and development of innovations in patient-centered care that are not often supported through traditional sources.

For generations of residents, fellows and junior faculty members who served with and learned from him, Khouri was an exceptional role model and mentor. As a leader in breast imaging, he was a key figure in the field nationally and internationally, helping to advance the science from a subspecialty to a true specialty.

"Dr. Khouri was incredibly committed to his patients and had a remarkable bedside manner that put patients at ease during what is a very scary time for them. He was very comforting, and I learned a lot from him about the importance of putting the patient first," says **Emily Ambinder**, a Johns Hopkins radiologist who was a resident under Khouri from 2014 to 2018.

A native of Lebanon, Khouri received his medical degree from the American University of Beirut (AUB) in 1971 and completed his residency in diagnostic radiology at AUB and Johns Hopkins, where he joined the faculty in 1975. He was soon appointed to lead chest services, serving as director from 1976 to 1986. As a researcher, he led a seminal study using needle aspiration biopsy to examine pulmonary lesions for cancer, which established the accuracy of the technique and proved that invasive surgery was unnecessary.

In 1986, Khouri shifted focus to improving the care and early detection of breast cancer. During this time, Khouri introduced the concept of a dedicated breast specialization to the department and established mammography as a standard practice. He was a key figure in the creation of the Johns Hopkins Comprehensive Breast Center, among the first such centers in the nation, which quickly established a reputation for national leadership it retains to this day. Twice he was named to *Medical Imaging Magazine*'s list of Top 10 Women's Imagers.

Khouri was similarly known for his commitment to underserved people in Baltimore, extending breast screening and diagnostic services to low-income and elder populations through the East Baltimore Medical Center and the Department of Aging of Baltimore County. Building on his international reputation, he worked with governments and nongovernmental organizations across the world to improve breast cancer awareness and screening programs, and helped to design and build comprehensive multidisciplinary centers to deliver breast care. Khouri worked in Abu Dhabi, Bahrain, Jordan, Kuwait, Lebanon, Saudi Arabia and Qatar, as well as in Turkey and countries in South America, among other nations.

As a researcher, he led several key studies in new radiology techniques and published extensively, including several book chapters and 49 peer-reviewed

Imaging Breakthroughs in Prostate Cancer

More than one-quarter of all cancers diagnosed in American men are of the prostate. Caught early enough, prostate cancer patients have good odds of beating the disease, but recurrence and metastasis are always lurking. Helping to improve those odds is Johns Hopkins radiologist **Martin Pomper**, who recently culminated a 25-year quest to develop better prostate cancer imaging with PET/CT.

In May 2021, the U.S. Food and Drug Administration approved the use of PyL (PYLARIFY®) — also known as 18F-DCFPyL — a positron-emitting imaging agent that Pomper and team developed. The potential impact of the work is only beginning to emerge. "Agents like this and their therapeutic derivatives promise to enhance prostate cancer therapy," Pomper says. "It's just getting traction now."

PET/CT with PyL greatly enhances the specificity and resolution of prostate cancer imaging to a degree that was unimagined just a short time ago. Using circulating tumor DNA, successful prostate cancer detection requires a tumor to reach roughly 50 million malignant cells. PyL PET/CT can detect cancers on the same order of size, as small as 15 million cells, just over 2 millimeters in width and height — about the size of a large grain of coarse salt.

> "With PyL, in one fell swoop, you prevent two largely imprecise tests with one exceptional test, and you get a definitive answer in the process."
> — MARTIN POMPER

That ability to see smaller tumors translates directly into earlier detection. Perhaps even more notable, PyL's ability to see small tumors is key to detecting the recurrence of cancer in patients who have had their prostates removed or for detecting when a cancer once confined to the prostate has metastasized to other organs or the bones. This is a key distinction as, with the prostate removed, levels of the traditional biomarker for prostate cancer, a molecule known as prostate-specific antigen, can remain low when the disease has returned or has spread. PyL spots these cases when others cannot.

In PyL, Pomper and colleagues have created a chemical that harnesses the precision targeting capabilities of a specific enzyme-inhibitor pair. The new target antigen is known as prostate-specific membrane antigen (PSMA) that is present in great numbers in the membranes of prostate cancer cells, and much less so in the prostate itself. PyL contains a positron-emitting isotope that emits tiny bits of radiation — positrons, which are converted to photons — that can be seen by PET scanners. PyL must be injected into the patient's bloodstream by a trained technician. It then circulates throughout the body and, wherever PSMA is present, it latches on.

"PyL attaches itself only to PSMA. And PSMA is nearly always present when prostate cancer is present. You marry that with the high sensitivity of detection of radioactivity, and you have the makings of a powerful diagnostic tool," Pomper says. Wherever prostate cancer is present, whether in the prostate or not, PyL will find it.

PyL worked so well that, at first, Pomper was surprised when he looked at a test scan that lit up like a Christmas tree. "The first time I looked at the images, I thought there were artifacts because they were so bright," Pomper says of his surprise. "They were so bright because there's so much PSMA in these prostate cancer cells." There are about 1 million PSMA molecules on the surface of every malignant cell.

The resolution and clarity of PET/CT with PyL are so notable that it begs

(continued from page 13)

the question of whether it might become a screening tool to find prostate cancers in people at high risk — before they have been diagnosed or show symptoms. Asked the feasibility of such a scenario, Pomper raises an eyebrow and thinks for a moment. At this point, he says, PyL is too costly, and with the involvement of radiation, routine use for screening is unlikely — but not out of the question if cost and other concerns can be addressed.

However, one promising area to be explored is whether PyL or similar chemistries can be used to detect other forms of cancer. Despite its prostate-specific name, PSMA is not specific only to prostate cancer but is found in the newly emerging bloods vessels of all solid tumors, Pomper notes. Renal carcinomas and glioblastomas, a form of brain cancer, both have particularly high levels of PSMA, he says. Furthermore, the exceptional targeting capabilities of PyL's enzyme-inhibitor chemistry is being extended to target chemotherapies directly to these tumors. Once a cancer is found, new therapeutics that instead marry drug molecules to the small molecular scaffold of PyL instead of PyL's radioactive atom can use the same targeting principles to deliver drugs right to the malignant cells.

The promise is so great and so wide open that venture capitalists are starting to take note. For now, however, Pomper is happy that PET/CT with PyL stands a good chance of supplanting traditional bone and CT scans that are the normal course of action when prostate cancer is suspected. Neither of those tests are nearly as sensitive or specific as PyL and often miss lesions that PyL can easily spot.

"With PyL, in one fell swoop, you prevent two largely imprecise tests with one exceptional test, and you get a definitive answer in the process," Pomper says. "It's the best of both worlds." ■

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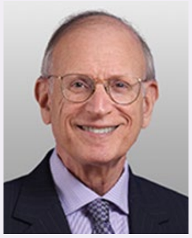

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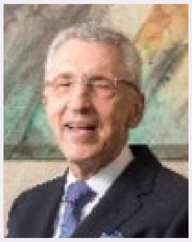

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Khouri
OVERSET = 107 words

articles. In addition to his influence in clinical care and research, Khouri was a reformer in education. He initiated and led the development of the e-Radiology Learning program, which delivered the same high-quality didactic education that Johns Hopkins residents trained, and provided to underdeveloped countries around the world.

"Through this meaningful endowed fund, Dr. Khouri will be forever linked with these promising women and men for generations to come and their contributions to the scientific community and to breast cancer patients here and around the globe," Horton says. "This endowment is a lasting and meaningful tribute to Dr. Khouri's profound lifetime influence in the field of radiology." ■