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Meaningful Innovation and the Human Factor in Healthcare

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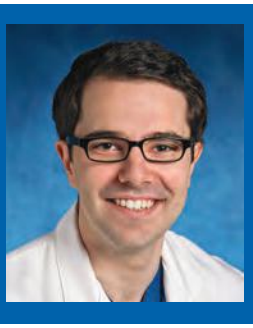

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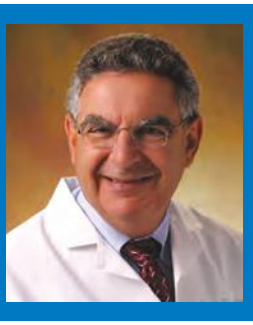

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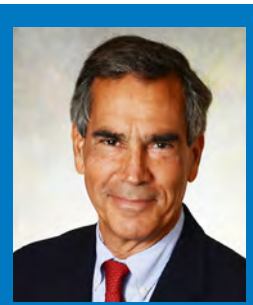

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Empowering the people behind the image

At Philips we're committing our time and resources to conducting groundbreaking research to more completely understand the needs of the people behind the image.

Kees Wesdorp
Business Group Leader, Diagnostic Imaging

From overcoming the challenges faced by our customers in health care today, to continuing the battle to drive down costs while improving quality and outcomes, Philips continues to advance our strategy of patient-centric innovation. We're focusing considerable resources on combining smart technology with clinical expertise to generate better outcomes for patients.

In this evolving era of value-based, patient-centered care, we're using this approach to enhance the patient and staff experience while driving imaging appropriateness, simplifying data and insight gathering, and reducing the overall cost of care. We believe these four major goals can be achieved by supporting the people across the entire imaging value chain with innovation that helps get the right scan the first time.

Our deep understanding of the people behind the image — from the patient to the technologist, radiologist, and referring physician — offers a unique perspective that drives our innovation and enables a simpler, faster and smarter path to a confident diagnoses. By concentrating our efforts in this way, we enhance value for the imaging suite, for the healthcare system, and most critically, for patients.

At Philips we're committing our time and resources to conducting groundbreaking research to more completely understand the needs of the people behind the image, and we're partnering with our clinical customers to work on new solutions that deliver on these commitments.

In the following pages, clinicians from a range of specialties will share their perspectives on how Philips' innovations are helping them to deliver better care and achieve better outcomes for their patients. Our hope is that these insights will inspire you with the realization of just how powerful meaningful innovation in health care can be.

We will continue to build on our strong legacy of imaging innovations with interoperable clinical solutions to bring the additional value, simplified and intuitive workflows, and reproducible, high-quality results that radiology leaders are looking for to provide better value for their patients.

We would like to extend our thanks for their collaboration and insights to all the clinicians included in this special supplement as we work together to improve health outcomes.

Meaningful Innovation and the Human Factor in Healthcare

Claudette Lew

Healthcare consumers have certainly benefitted from the clinical progress made possible through imaging innovations, but they have also more recently felt the effects of high-cost care. As consumerism gains traction, the healthcare industry is shifting from quantity to quality, tying reimbursement to outcomes and forcing the entire healthcare ecosystem to be more vigilant about patient-centered care, reducing costs, and improving efficiencies.

As health care transforms, imaging can drive significant change. Most imaging technology manufacturers have begun to make changes in some areas, but truly meaningful innovation focuses on optimizing the experience of every user, from the patient, to the technologist, to the radiologist, to the healthcare administrator.

Indeed, Philips' focus on the 'human factor' in imaging is based on the idea that a deeper understanding of each user's experience can provide important insights to deliver more meaningful innovation that helps patients, clinicians and administrators fulfill their respective roles with less stress and more confidence. Approaching imaging as an integrated system in which technology and data are seamlessly connected to enable the people who depend on them, Philips is streamlining the path toward more confident diagnoses — a win-win scenario that benefits patients, providers and health systems.

Supporting the patient to minimize discomfort and stress

Focusing on patient experience is not new to the healthcare industry, nor is that focus limited to the executive suite, which has seen the emergence of such leadership positions as the "Patient Experience Officer." According to a 2017 study published by The Beryl Institute,[1] employee engagement in providers' efforts to improve patient experience is on the rise. Employee engagement in these efforts not only increased in U.S. hospitals by 14 percent between 2015 and 2017, but it also jumped over cost management as a priority and moved from number four to the number two priority ranking among surveyed employees. It's easy to see why. From the experience of booking an appointment online, to navigating through a large, maze-like building, to having a conversation with a healthcare provider, or trying to remain still for a lengthy MR imaging exam, health care presents nearly endless opportunities to improve patient experience.

Philips Ambient Experience multimedia room solutions are designed to provide a calming distraction to patients facing various types of imaging studies. The interactive element of these design interventions provides patients a sense of control and the opportunity to actively participate in their care environment.

Radiology personnel understand the vital role of a positive experience in producing an accurate

With the Philips Ambient Experience patient in-bore solution for MR, engaging visuals are displayed on the back wall and can be seen via a mirror on the head coil, while patients can listen to music/sound through the headphones.

clinical image. Patients who feel comfortable and secure are less likely to behave in ways that compromise the quality of their imaging study — and staff play an important role in creating this calming environment. Managing complex protocols and patient throughput, balancing workloads, and completing unending administrative duties and reporting tasks can take a toll on even the most experienced technologists.

Tremendous opportunity awaits manufacturers who can address those challenges and alleviate the attendant stresses that weigh on both imaging providers and patients. Recognizing that reality, Philips targets its imaging innovations squarely at every stakeholder in the provider-patient continuum.

"Our innovation efforts focus on the needs of the people behind the images – the patients, technologists, radiologists, administrators, and executives that need to function at their individual best in order to realize imaging's potential to improve care. By understanding their daily challenges, we can deliver more meaningful innovation that helps patients, clinicians and administrators fulfill their respective role with less stress and more confidence. This whole notion of being patient-centered is really in our DNA at Philips," said Kees Wesdorp, Business Group Leader, Diagnostic Imaging at Philips. "With our history as a consumer product company, we've always been dedicated to the user experience and to experience design. In health care, we recognize the direct relationship between the patient experience and imaging outcomes, and so patient-centric design is something we care about very deeply."

Modality-specific patient support innovations, such as the Philips Ambient Experience In-bore solution for MRI, have been shown to help reduce the number of rescans due to patient motion.[2] From the moment a patient is moved into the scanner (the point at which people report the most stress) through completion of the scan, this solution helps patients to relax, follow directions, and minimize motion. The latest iteration of this in-bore patient solution, Philips Ambient Experience In-bore Connect, supports patients during an MRI examination by visually counting down how long they need to hold their breath and displaying a progress bar.

Studies have shown that simply displaying a countdown of the length of time patients are required to hold their breath makes it significantly easier for them to do so. Additionally, with the progress bar in Philips Ambient Experience In-bore Connect technology, 84 percent of patients said they felt calmer during their MRI examination, and patients were overall more likely to recommend the examination to a friend.

"One of the bigger challenges in MR, because they affect so many aspects of the diagnostic process, is due to motion artifacts that are created from a patient's inability to hold still for a 20- to 30-minute exam, for instance," explained Nandor Pinter, MD, Director of Neuro Imaging Research at Dent Neurologic Institute. "If the patient is in pain or cannot tolerate the noise, they might move or stop the study, resulting in a partial or inconclusive study, or no study at all. If it's a longer scan and the patient moves, you may have to repeat it. While this is

basically a hardware issue, if you can solve this problem or parts of this problem, you'd see a big improvement in the quality of the studies themselves, which can lead to fewer repeat exams, and potentially reduced costs as a result of that," said Dr. Pinter.

Supporting the technologist with intuitive technology for better images

Traditionally, the science of user experience has mainly been applied in consumer product industries. More recently, it has gained a foothold in health care, from improving staff experience in using electronic health records (EHRs), to optimizing operational workflows and the user interface designs for healthcare equipment and applications. In imaging, successful user design for technologists depends on deeply understanding the challenges they face. With an accomplished consumer product background, Philips has demonstrated effective user experience and design principles and has applied them for years. Philips' goal in innovating the technologist experience begins with helping them find a simpler path and greater confidence in helping their patients.

Kristian Giordano, MR Imaging Manager at RWJ Barnabas Health Ambulatory Care Center in Livingston, NJ, is confident that Philips truly understands his role in the imaging ecosystem. "As technologists, we have a passion for what we do," Giordano said. "And it's exciting for me to know that we have a vendor that's really behind us. Philips has really worked to understand both the user's and the patient's experience of the [MRI] machine. How do we get the right image? How do we simplify getting that image? How can we reduce costs from not having to repeat exams? These are the things I need every day."

A complete understanding of the emotions, attitudes, and needs of an imaging technologist begins with observation, and is complemented by ongoing user feedback, to help Philips understand the entire technologist environment,

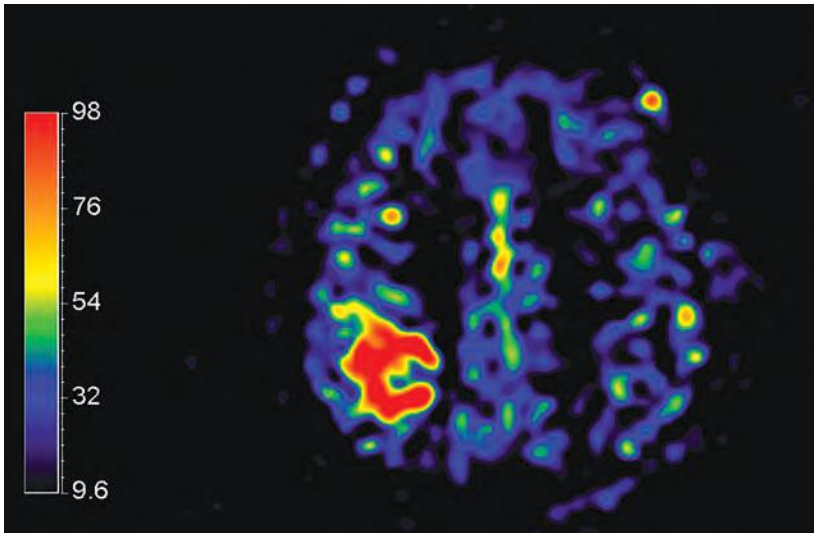
ExamCards allow exams to be customized based on specific clinical questions to save time and enable protocol sharing among colleagues for scan-to-scan consistency.

including technology constraints, business processes, the people involved, workflow, work space, challenges, and the relationships among these factors.

This has led to Philips' development of multiple imaging innovations. Some directly address patient stress factors that can cause motion artifacts, such as the Ambient Experience In-bore solution for MRI. The Ambient Experience PET/CT uptake room solution, on the other hand, uses soothing video imagery, sound, and lighting to minimize risk of unwanted FDG uptake into healthy tissue, making it difficult to differentiate normal tissue from tumor tissue in the CT images.

Some of the staff-centered technology solutions designed by Philips keep the balance intact with standard interfaces on Philips' imaging equipment, and built-in protocols so that staff are not spending the majority of the appointment time navigating the equipment, and projecting stress to the patient. Innovations such as Philips' SmartExam for MR or ExamCards for CT support scan-to-scan consistency and help imaging staff spend less time navigating machinery and more time promoting a meaningful relationship with patients.

"We had not done a pelvic floor laxity protocol in years for some reason, but a new clinician recently added it to his referring pattern,"



Axial 3D Arterial Spin Labeling (ASL). Resolution: 3.7 x 4.0 x 4.0 mm; Scan time: 5:06 min; Ingenia 1.5T. Courtesy of Winterthur Satoreti, Switzerland.

explained Giordano. "Instead of stressing and trying to reinvent the wheel, I went to the Philips Internet forum community and downloaded the protocol. All the dynamic sequences, all the bear-down protocols – it was all there for me and I didn't have to build anything from scratch," he said. "We have a slew of protocols that are built on the system to make our lives easier. We use the Philips-supplied exam cards as a base from which to work because everything is at your fingertips. Why not avail yourself of a huge database and just tweak or adjust to what your doctor or the referring doctor needs?"

Providing technologists with a supportive work environment helps to decrease stress and the potential for burnout. Improving the radiology staff's experience with simple interfaces, or pre-loaded commonly used imaging protocols can go a long way in supporting their overall efficiency and enhancing the patient experience.

Empowering the radiologist with adaptive intelligence for better insight

More and more, insights gained from imaging data can help to determine the needs of entire patient populations. The lack of standardization in MR imaging, however, is impeding progress, said Dr. Pinter. "You can't just simply compare two MRIs done of the same patient in different scanners, like you can with CT, or in different countries, or with different field strengths, or different types of T2- or T1-weighted sequences. If you change one parameter, let alone a combination of parameters, that might change the image contrast significantly, and that can create diagnostic problems."

One new technique that is opening the door to the potential for reproducible MR images is Philips' 3D Arterial Spin Labeling (ASL). It holds the potential to elevate neuro diagnostics with better standardization, quantification and reproducibility.

"The Philips engineers were able to create a 3D acquisition method of the ASL technique, which is highly reproducible with a 95-percent confidence interval," explained Dr. Pinter. "The measurement error range is about five percent when measuring the same subject on different scanners, and even better in consecutive scans on the same scanner. So, if you measure brain perfusion with Scanner A, and then you do the same exact study on Scanners B, C, D and so forth, you will get almost the same CBF (cerebral blood flow) values, regardless of the time and scanner and with an error range that is already very low, and that's a very good start. Why? Because it opens up the door to a perfusion method that can be used as a reliable and accessible clinical tool. Eventually, that five percent will be pushed further down to one percent and that's where we need to be," he said. "Because what I'd like to do for my patients is measure the perfusion of the brain tumor with the 3D ASL study, and then use it as a biomarker throughout their treatment to follow up therapy response. Today's perfusion studies will tell you that there's more perfusion in the tumor than in the normal brain, but you cannot exactly quantify that perfusion. True quantification combined with reproducibility is why this 3D ASL is so exciting."

Today's leading advanced visualization environments utilize multiple modalities and inputs across a complex, widely distributed network. The IntelliSpace Portal meets multiple time and resource demands with one comprehensive platform offering the power to visualize, diagnose, and communicate, across clinical domains and modalities, fast, with one seamless, connected workflow solution.

With respect to better outcomes in health care, Dr. Pinter believes that the adaptive intelligence made possible through 3D ASL will enable broader use of MRI as an evaluation tool for therapy follow-up. With widespread acceptance in the field as a highly reproducible scan, the resulting quantification enabled by 3D ASL will make big data analyses possible and lead to large-scale clinical trials that may inform clinical decision-making about patient populations as well as individuals.

Dr. Pinter has been actively involved in giving user feedback to Philips on his team's experience with the product as well as for ongoing development efforts. "I find Philips is very open, positive, and genuinely interested in the opinions and feedback from the clinicians who are co-developing, testing and using their innovations," he said.

Enabling the administrator with data tools for better practice management

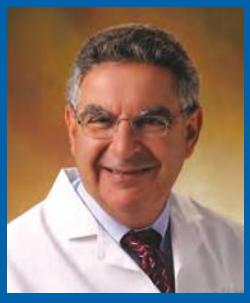
Transformation in imaging would not be complete without simplifying data gathering and sharing for analysis and action by others within health care. The Philips PerformanceBridge Practice is an innovation born to serve this purpose. Part of Philips PerformanceBridge, PerformanceBridge Practice is a comprehensive, data-driven solution that assesses customers' operational challenges and empowers them to make decisions to guide more strategic, efficient and effective practice.

Christoph Wald, MD, Chairman of the Radiology Department at Lahey Hospital and Medical Center in Burlington, MA, remembers how it began. "At the time, Philips PerformanceBridge Practice didn't exist," Dr. Wald explained. "It really started out as a white board session in our department. The clinical solutions team was in its formative stage, and we discovered that our ideas and challenges at Lahey matched the interest of Philips to develop a new portfolio of solutions. Basically, I needed transparency of operations in my practice, including insight into cost and payments, and I couldn't easily get it. I could only get pieces of it from the RIS and others in our PACS. So, when we said to Philips that it would be extremely useful to have one 'go-to' place where all the specific information we needed from our RIS and our PACS was readily available and could be visualized in meaningful ways and could be combined in

It was truly a customer-centric design of a solution. We told them, 'Here's our need,' and then it was really innovation from the ground up

Christopher Wald, MD
Chairman, Department of Radiology, Lahey Hospital & Medical Center

Philips PerformanceBridge Practice integrates data and information from imaging modalities and clinical informatics to unlock actionable insights for optimization and continuous performance improvement.



In our case, the analysis was thorough and very thoughtfully done on Philips' part. It gave us some information that we had not considered when we did our own internal evaluation.

Terence Matalon, MD
Chairman, Diagnostic Radiology, Einstein Healthcare Network

meaningful ways, they said, 'We can probably build something like that.'"

In his explanation of the PerformanceBridge Practice development process, which Dr. Wald said started with a series of meetings, and followed with hours of observation, Dr. Wald was impressed, not only by Philips' rapid prototype development process, but also – as evidenced by the Performance BridgePractice solution itself – by what good listeners the Philips team proved to be during this journey of technology co-creation.

"It was truly a customer-centric design of a solution. We told them, 'Here's our need,' and then it was really innovation from the ground up," said Dr. Wald. "In the discovery phase, the Philips team spent months inside our department looking at how we work, observing how our images were acquired, learning how the technology worked together, and finding out what information the managers needed in order to run their modalities. The design of the solution was informed from real-life observations right in our department."

Since the first release of Philips PerformanceBridge Practice solution, numerous practices and provider sites are now using the solution to monitor and analyze their operations as well as to assist them with strategic business decisions such as practice expansion. Terence Matalon, MD, Chairman of Radiology at Einstein Healthcare Network (Einstein), consulted with the Philips Clinical Solutions team to evaluate if, how, and where best to deploy an additional MRI scanner within Einstein's large network. With three acute care hospitals and five outpatient imaging centers that perform some 400,000 studies per year, there were many options to consider.

In addition to location selection, the analysis gathered for Einstein considered all the factors that might influence the network's overall return on investment. "I think the impact of really utilizing that kind of informatics power is helpful in making the business side of radiology more efficient," Dr. Matalon explained. "It creates a higher confidence level that an investment is going to have a return. In our case, the analysis was thorough and very thoughtfully done on Philips' part. It gave us some information that we had not considered when we did our own internal evaluation of that question."

Dr. Matalon notes that, through solutions such as PerformanceBridge Practice, Philips is bringing meaningful innovation to health care. "Philips is definitely focusing a lot of attention on adding value with meaningful innovation," he said. "The PerformanceBridge Practice solution is definitely a tool that Philips can provide its clients for them to be able to benchmark their

performance against their own historical performance and the performance of other sites. If results show them to be highly inefficient, it's important to point out that it may not be the equipment that's inefficient, but how it's being used. I think the value that Philips can bring to its clients is real … and I think they should pursue those efforts. The appetite for this type of information is only going to increase as greater pressure is placed on providers to become more and more efficient."

Additionally, Dr. Wald said, "I think people have forgotten that just a few years ago, we didn't have any access to these answers at all, certainly not in real or near-real time. Now, we're looking at our operational data from PerformanceBridge Practice daily and weekly to monitor performance and identify opportunities for improvement. And I cannot overemphasize the fact that having the data is one thing, but being able to visualize the data in a way that is informative, interactive and easily understood: That's really key. If it's a huge undertaking to get that information every time you need to, it's no good. I think that a simple interface that's easy to use is a very important aspect of a production-strength system. You shouldn't need five PhDs and six weeks to get an answer. Also, we have recently succeeded to connect real financial data from our billing system with the operational data, which makes our insights that much more real when we speak to management about our results and needs."

Experience innovation

Combining design thinking around the patient's healthcare experiences with the science of human factors engineering creates a powerful lens through which to see, simplify and solve problems in the healthcare environment. In its efforts to better understand the patient journey, Philips conducted primary patient research about the actual process of imaging.

"We began conducting new types of patient research in imaging; asking patients about their imaging experience, what concerns they had, and what, if anything, they needed during the process that was not satisfied," said Wesdorp. "We've also done a lot of research on the process of imaging itself, not only recording how patients felt at certain stages of an imaging exam, but also actually measuring their vitals as they underwent an MR exam, for instance. So, we're looking at the patient's experience from the more traditional emotional and physical perspectives, but now additionally from a physiological perspective as they move through an imaging study."

Meaningful healthcare innovation

As an imaging provider that is pursuing insights from the patient and staff perspective with respect to developing new products and services for the healthcare imaging industry, Philips has clearly made an impression through its commitment to bringing meaningful healthcare innovation to its customers with solutions that make sense, and have the most impact on patient care.

"Philips is really embracing the concept of meaningful innovation," concluded Dr. Pinter. "From my perspective, it should always be clinically oriented and include insights from participating clinicians about which innovations should be prioritized. One crucial aspect of meaningful innovations is that they must be accessible. A great innovation without a great interface creates an obstacle to its potential for success and adoption. I think Philips has been listening and is open to our ideas and clinical thinking. Most of all, like us, they are patient-driven. As far as I can tell, in the center of any Philips innovation, you will find the patient. At our institution, we embed MRI into our outpatient clinical and research practices expressly because of the close relationship between imaging, patient care, and clinical decision-making. Philips seems to embrace this critical symbiotic relationship in its pragmatic approach to R&D."

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Nandor K. Pinter, MD
Director of Neuroimaging Research, Dent Neurologic Institute

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Profile in Partnership: Phoenix Children's Hospital and Philips

Claudette Lew

Phoenix Children's Hospital, Phoenix, Arizona

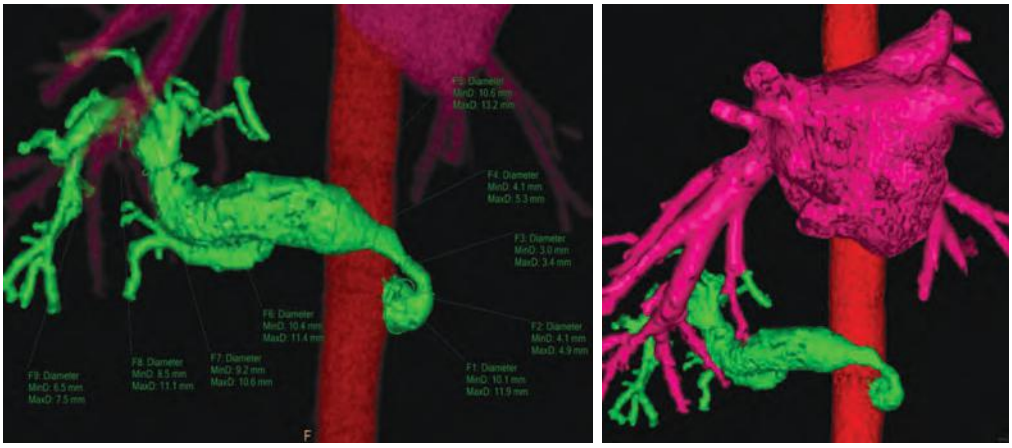
In March of 2017, Phoenix Children's Hospital (Phoenix Children's) was the first stand-alone children's health system to sign a long-term, strategic partnership with Philips. The partnership expands and accelerates collaboration efforts with new research opportunities and innovation with the goal to make health care more seamless and to address the needs of children. Already working closely with Philips for a decade leading up to this enterprise agreement, Richard Towbin, MD, said it all began with the vision he had for Radiology when he took over as Phoenix Children's Radiology Chief in 2007.

"I wanted to create what I called an academic private practice model for us," Dr. Towbin explained, saying he envisioned a world-class radiology department with the goals and ideals of the academic model but with a high priority on customer satisfaction and service and financial success. On the academic side, the focus would be on research and an *avant garde* medical practice, powered by a state-of-the-art technology platform that would enable first-of-its-kind clinical activities, research, and validation of pre-commercial technical innovations. But without endowments and other established funding resources, he realized that success would require thinking outside the box and operating his department like an entrepreneurial private practice.

To achieve his technological 'power platform,' Dr. Towbin gravitated toward a single vendor concept. As a single-vendor department, he believed, Phoenix Children's could access the research opportunities, commitments and resources that would attract top clinical radiology staff, build clinical capabilities, and add new information to the practice of medicine through imaging. On the other hand, the traditional academic model that institutions like Phoenix Children's typically followed constituted a "best of breed" buying pattern – which also made historic sense, as equipment manufacturers were not typically leaders across all modalities. Therefore, developing clinical and research relationships on a modality basis, was and still is, a good strategy.

"A manufacturer might be number one in one modality, and last in another," Dr. Towbin recalled. "And that didn't fit into what I was trying to do at Phoenix Children's Hospital. So, I did something that, even today, is a bit unusual. I decided back then – and I think we're still the only children's hospital in the country that's done this – I decided that Phoenix Children's Radiology would be a single-vendor department if we were serious about becoming one of the best children's hospitals in the country."

"That decision to commit to using one manufacturer's equipment was sort of the central decision that everything else has developed from," Dr. Towbin explained. "So essentially, for nine or ten years now, we've been working with Philips. They have supported us completely,



3D modeling provides details of the pathologic anatomy and allows clinicians to plan the vascular intervention.

and we work together in a very collaborative relationship. And though my vision for Phoenix Children's Radiology has evolved over time, I look back and realize that what we have now is even greater than I thought – and far above and beyond what my vision was for us at the time. And why Philips? One word: People. Working with a single vendor allows for a deeper and more collaborative environment than does best of breed, in my opinion."

With the enterprise agreement underway, Phoenix Children's has expanded Philips' technology beyond MRI, CT and angiography to include its patient monitoring systems and clinical informatics. These technologies and services will help Phoenix Children's expand its high standards of care and integrate its divisions and facilities for a seamless patient experience.

As part of their collaborative efforts, they've created an advanced 3D innovation lab that uses Philips IntelliSpace Portal for high-end 3D post-processing and printing. With Philips IntelliSpace Portal advanced platform, radiologists at Phoenix Children's Hospital can take images, and perform a wide variety of functions that enhance diagnosis, operative and interventional planning.

"The enterprise agreement with Philips is really changing the role of Radiology at Phoenix Children's," Dr. Towbin said. "Instead of an organization chart where radiology is a small circle off to the side someplace, we've become a connector within our organization. We're really doing some exciting things that are bringing people together. Working with other clinicians and surgeons in the 3D Innovation Lab, for example, we're able to use 3D models to visualize and completely plan and surgical interventions. The three-dimensionality gives us the depth dimension and helps us so we can spin it around and look at it."

Dr. Towbin explained they used 3D modeling in one patient's case to identify the connections of an arteriovenous fistula [AVF]. These abnormal connections between the aorta and pulmonary veins in the chest were giving the patient too much blood flow. Using 3D post-processing, we were able to see the details of the pathologic anatomy in a more readily comprehensible manner, plan the vascular intervention, acquire the necessary materials and achieve a successful outcome. All this was completed while minimizing the total anesthesia and procedural time in the interventional suite.

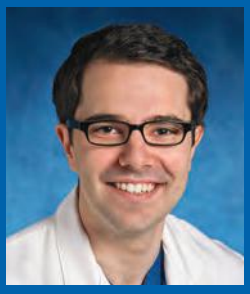
"Our partnership with Philips," Dr. Towbin said, "enables this unique combination of technological developments, innovations, and software developments that allow the radiology department to study the details of normal and pathologic anatomy, make better diagnoses and use data in ways they couldn't previously do, which all contributes to helping us serve children at the highest levels."

That decision to commit to using one manufacturer's equipment was sort of the central decision that everything else has developed from.

Richard Towbin, MD
Radiologist-in-Chief,
Department of Radiology,
Phoenix Children's Hospital

Innovating Together: Collaboration Leads to the Development of Groundbreaking Radiological Assessment Tools

Claudette Lew



As a standardized assessment tool, qEASL provides a very specific scientific end point for the assessment of therapeutic success, and will be key in helping hospitals to evaluate their own success rates.

Julius Chapiro, MD
Associate Research Scientist, Radiology & Biomedical Imaging, Yale School of Medicine

Liver cancer is the second-most common cause of cancer-related deaths worldwide and the fastest-growing cause of cancer deaths in the United States, according to a recent study published by the American Cancer Society.[1] New cases have been on the rise since the mid-1970s, and death rates have doubled in the mid-1980s. With such numbers, it becomes obvious why more and more frequently, academic scientists and clinicians are teaming up with industry partners to bring together different areas of expertise and resources as a means of discovering new solutions for evaluating effectiveness of cancer therapies.

Julius Chapiro, MD, currently the Co-Director of the Interventional Oncology Research Lab in the Department of Radiology and Biomedical Imaging at Yale, was a post-doctoral researcher at the Johns Hopkins University five years ago when the NIH-sponsored laboratory, led by Jeff Geschwind, MD, from Baltimore, teamed up with Philips to advance their important work and find more effective ways to assess tumor response to treatment of liver cancer. Ming De Lin, MD, a Philips' clinical scientist, is working onsite with Dr. Chapiro as a key member of the team.

In liver cancer, most patients are not amenable to surgical therapies due to the fact that tumors mostly become diagnosed at more advanced stages. Such patients mostly have to rely on minimally invasive, catheter-based, image-guided tumor therapies, which have become the mainstay of therapy in patients with intermediate to advanced-stage disease. In all such cases, assessing tumor response to treatment is of major clinical interest. Traditional treatment response tracking methods, such as RECIST (Response Evaluation Criteria in Solid Tumors), are purely size and anatomically based and do not take into account tumor viability or cell death. However, the availability of functional information from imaging modalities such as MR now makes it possible to identify more specific tissue characteristics of solid tumors. This means clinicians can track subtle tissue changes such as tumor viability or cell death over the course of treatment, even when the tumor doesn't shrink immediately.

The outcome of Philips and Dr. Chapiro's collaboration is qEASL (quantitative European Association for the Study of the Liver), a very sensitive post-processing tool that allows radiologists to make a standardized analysis of 3D imaging scans (eg, CT and MRI) to obtain a precise measurement of potentially viable tumor tissue, and thereby permits clinicians to assess treatment effectiveness via a quantitative and visual indication of tumor tissue response to therapy. qEASL has been fully integrated into Philips' powerful Multi-Modality Tumor Tracking application, which itself is part of Philips' IntelliSpace Portal, an advanced visualization platform that offers a single integrated solution to help clinicians work quickly with increased diagnostic confidence – especially for complex cases and follow-up.

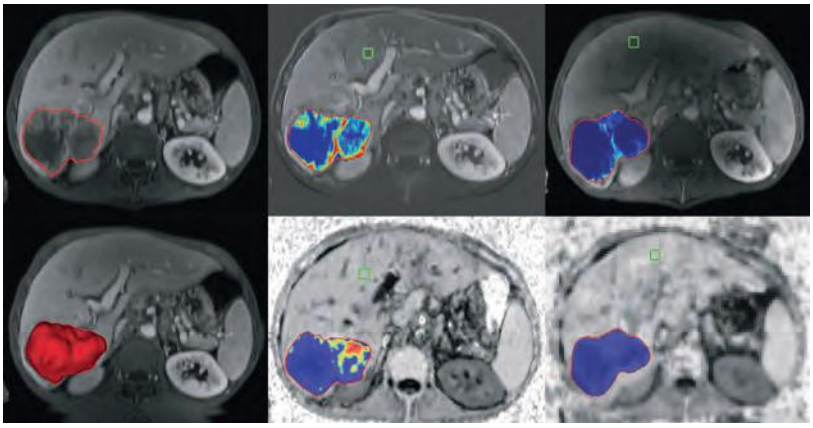
"The [Philips Multimodality Tumor Tracking with the qEASL] tool answers a very important question for the patient," Dr. Chapiro explained. "The patient, as well as his treating physicians, want to know as soon as possible after the therapy whether the tumor responded well, and this tool is able to answer that question with high precision, reproducibility and certainty," said

Dr. Chapiro. Secondly, "this tool standardizes assessment and provides a very specific measure for therapeutic success, putting response in quantifiable numbers rather than giving a vague 'gestalt'-based assessment," said Dr. Chapiro, who was able to validate this technique, together with his team, in a large number of patients, the results of which were published extensively in recent years.

One of the most important qualities of qEASL is that it improves clinical workflow for radiologists and shortens the length of time needed to evaluate whether a treatment is working. Using the RECIST method, a two- to three-month window of time is typically needed to make the assessment on the effectiveness of treatment. "With qEASL," Dr. Chapiro reported, "we usually tested at the one-month time point using imaging, such as MR and CT. And in some cases, we have demonstrated that immediate, intra-procedural assessment using cone-beam CT imaging can directly predict what is typically identified one month after therapy on CT or MR. Thus, qEASL has become a very solid predictor of therapeutic outcomes directly in the procedure room or one month after therapy at the very latest."

If radiologists can assess the effectiveness of a given treatment quicker, the potential impacts on patient care are substantial. The ability to identify non-responders to therapy and to retreat patients early or switch over to alternative treatments may give them a better quality of life and deliver better outcomes. This way, costly, ineffective treatments can be limited; this will be of tremendous benefit both for the patient as well as the entire healthcare system. When a therapy is working for a patient, clinicians have a better chance of predicting successful treatment with the same therapy if the patient develops multiple lesions with similar characteristics.

"As a standardized assessment tool," Dr. Chapiro explained, "qEASL provides a very specific scientific end point for the assessment of therapeutic success, and will be key in helping hospitals to evaluate their own success rates both in daily routine as well as for clinical trials. qEASL will help them guide their patients through the treatment algorithm in a much more scientific way than was done before. It will provide tumor boards with more specific data for clinical decision-making."



The qEASL [quantitative European Association for the Study of the Liver] capability within Multi-Modality Tumor Tracking offers a new method for enhanced measurement of tumor volume based on MRI and CT scans.

What's the next frontier for qEASL? Dr. Chapiro first stressed the importance of widespread adoption of qEASL for therapy assessment. "Because qEASL is now really changing our whole approach to the assessment of therapeutic success in liver cancer therapy, I think it has the potential to replace RECIST as the standard method for evaluating tumor response beyond loco-regional therapies, and also to be used in evaluating systemic therapies, where tumor response is a very important marker, for example, when triaging new anti-cancer agents based on imaging response in prospective phase 2 clinical trials."

qEASL has already proven effective in the setting of loco-regional tumor therapies in the liver, and Dr. Chapiro is working to apply it in neurosurgical and radiation oncology cases, as well. In the race to assess emerging therapies for oncology, neurology and gynecology, Dr. Chapiro is committed to co-innovating new applications for qEASL within Philips' IntelliSpace Portal. In this case the victory will belong not to the swift, but to the patient.

Complete picture. Confident diagnosis.

A complex environment on the cutting edge of change

As healthcare transforms, imaging will continue to provide essential value to patients. But in the race to value-based care, imaging professionals face steep challenges and mounting pressures. What's required is a simpler path to clinical decision-making or, simply put: getting the image right the first time.

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Meaningful innovation

Meaningful innovation today means patient-centered solutions to reduce their anxiety and discomfort; staff-centered adaptive intelligence solutions to guide image acquisition; radiologist-centered image processing applications for diagnostic confidence; and administrator-centered data analytics to drive continuous service improvement. It's all connected. And it all starts with seeing the people behind the images.

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When the First Exam is the Right Exam

Claudette Lew

Whether a patient comes in via the emergency department (ED) or has a scheduled imaging exam, conventional CT scans are often the first choice for imaging. And while CT technology is fast and accurate, CT often produces inconclusive data that can lead to supplemental testing to achieve a confident diagnosis. As pressure mounts on radiology departments to image more patients more effectively and cost-efficiently, Philips is focusing its innovation efforts on technologies that get the image right the first time. The IQon Spectral CT scanner was created to address that challenge.

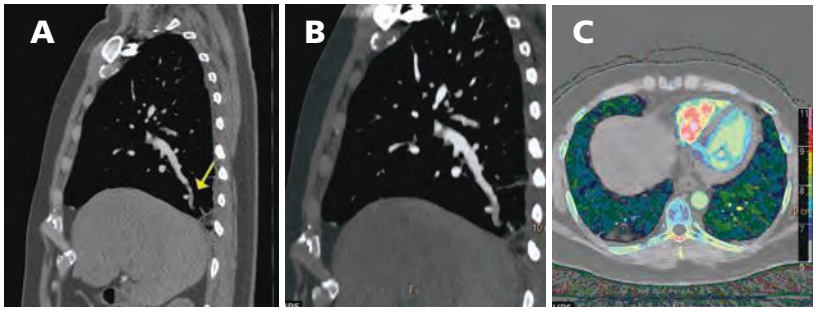

Figure 1. *Acute pulmonary embolism. A 35-year-old man with a history of hypertension and schizoaffective disorder presented to the emergency department with right-sided chest pain and an elevated D-dimer. CTA revealed right lower-lobe sub-segmental pulmonary embolism. Sagittal reformatted image (A, 3mm, iDose4) reveals sub-segmental pulmonary artery thrombus (arrow). Corresponding spectral reconstruction (B, 3mm, MonoE 42 keV) confirms thrombus. Axial spectral reconstruction (C, fused CT and iodine density map) demonstrates perfusion deficit involving right lower-lobe perfusion deficit without pulmonary infarction. (Images courtesy of HCMC Radiology.)*

Unique to the CT market, Philips' IQon Spectral CT technology creates multiple layers of data from a single scan. Much like a prism revealing the multiple energies in the visible light spectrum, the IQon's detection-based solution is able to capture and reveal the spectrum of X-ray energy levels. The spectral data allow image reconstructions per energy-specific layers. As this process is "always on" using the detection-based approach, the IQon offers additional information without additional scans, visits, or radiation.

First look

Pablo R. Ros, MD, Chair of Radiology at University Hospitals Cleveland Medical Center and Case Western Reserve University, was one of the first clinicians to see and test the IQon Spectral CT before it was commercially available.

"When Philips first brought the IQon Spectral CT prototype to our department and we started to work with it, we were in awe. To be able to capture all the data in one scan without having to predetermine the low energy setting — because you could go back, after the fact, and see the energy levels you need to see in the post-processing – is truly innovative technology. Our team was really enamored with that aspect of it," Ros explained.

The IQon Spectral CT can provide this type of on-demand result because of its detection-based acquisition. The technology reconstructs data by capturing high and low X-ray energies at the same time and in the same space. The top layer of the spectral detector-based computed tomography (SDCT) detector selectively absorbs low-energy photons and the bottom layer absorbs high-energy photons, thus providing two distinct energy data sets. In addition to the conventional images obtained by utilizing combined data from both detector layers, spectral analysis can be obtained by decomposition of the low- and high-energy data — permitting tissue characterization based on material content.

Results from case studies are not predictive of results in other cases. Results in other cases may vary.

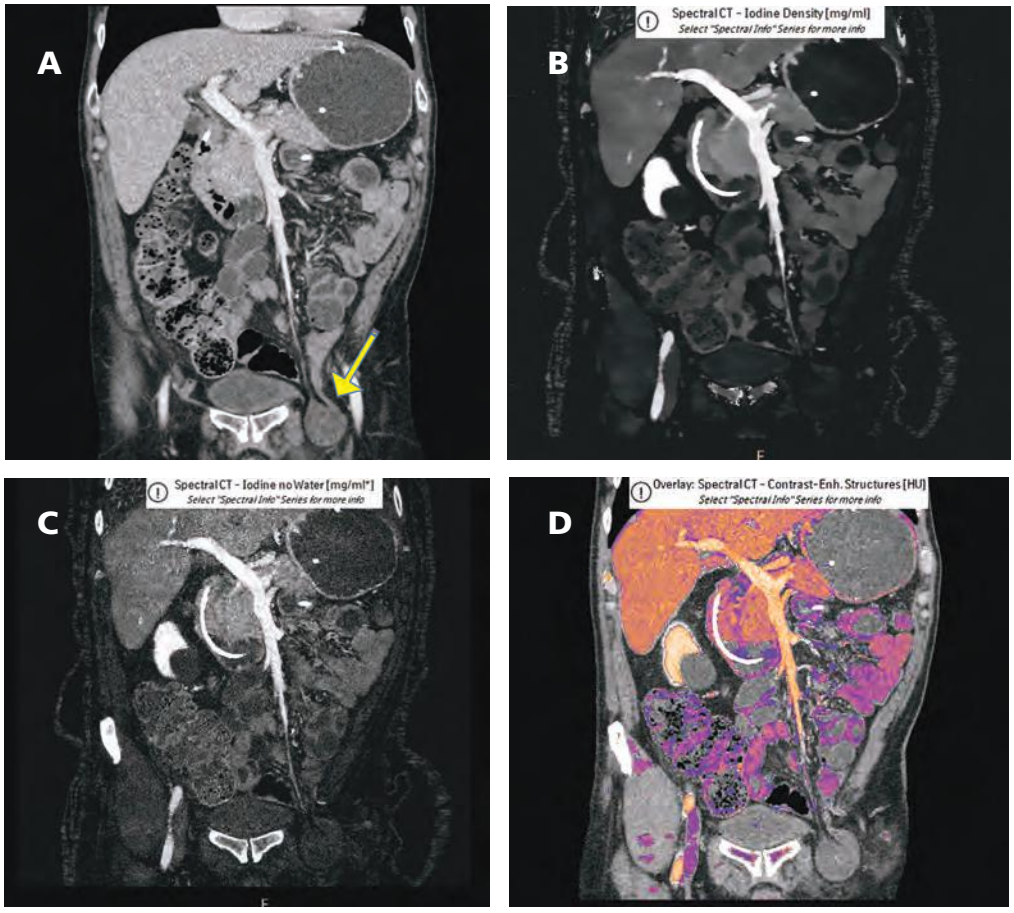

Figure 2. *Acute bowel infarction within strangulated hernia. A 55-year-old man with a medical history including stage IV oropharyngeal cancer presented with an acutely painful bulge in his left groin that had progressed in size and pain over several hours. Coronal reformatted image (A, 3mm, iDose4) reveals mass in left groin (arrow). Iodine density spectral reconstruction (B) shows absence of enhancement. Iodine/no water spectral image (C) confirms absence of iodinated contrast within mass. Colorized fusion map (D) shows normal enhancement of liver, bowel and vasculature, but absence of enhancement within strangulated, ischemic bowel in hernia sac. (Images courtesy of HCMC Radiology.)*

Ros and his team have been using the IQon system to perform very-low-dose, contrast-enhanced exams for renal failure patients. "We get spectacular images injecting only 30 cc of iodinated contrast material, instead of the typical 100 cc. Because contrast material is harmful to the renal function, in patients with borderline renal failure, we're using less than a third of the routine dose, which in addition reduces costs, while decreasing the risk for complications; and we're getting very good images," he said.

Among the clinical areas about which he is most excited, in Ros' department the IQon Spectral CT system is used to characterize kidney stones, and to determine if a fluid collection in the body is hemorrhagic. Ros' team is also using the spectral post-processing capabilities to remove artifacts caused by metal implants or objects in the body.

IQon on the front lines

Hennepin County Medical Center Radiology Chief Chip Truwit, MD, and his team have taken a different approach in using their IQon Spectral CT scanner. Serving to stabilize patients with any number of conditions on the front

We can upload [a scan] into the spectral system, represent it using the spectral software, and all of a sudden you can rescue a scan.

Chip Truwit, MD
Chief Innovation Officer, HHS Chief, Radiology, Hennepin County Medical Center

Results from case studies are not predictive of results in other cases. Results in other cases may vary.

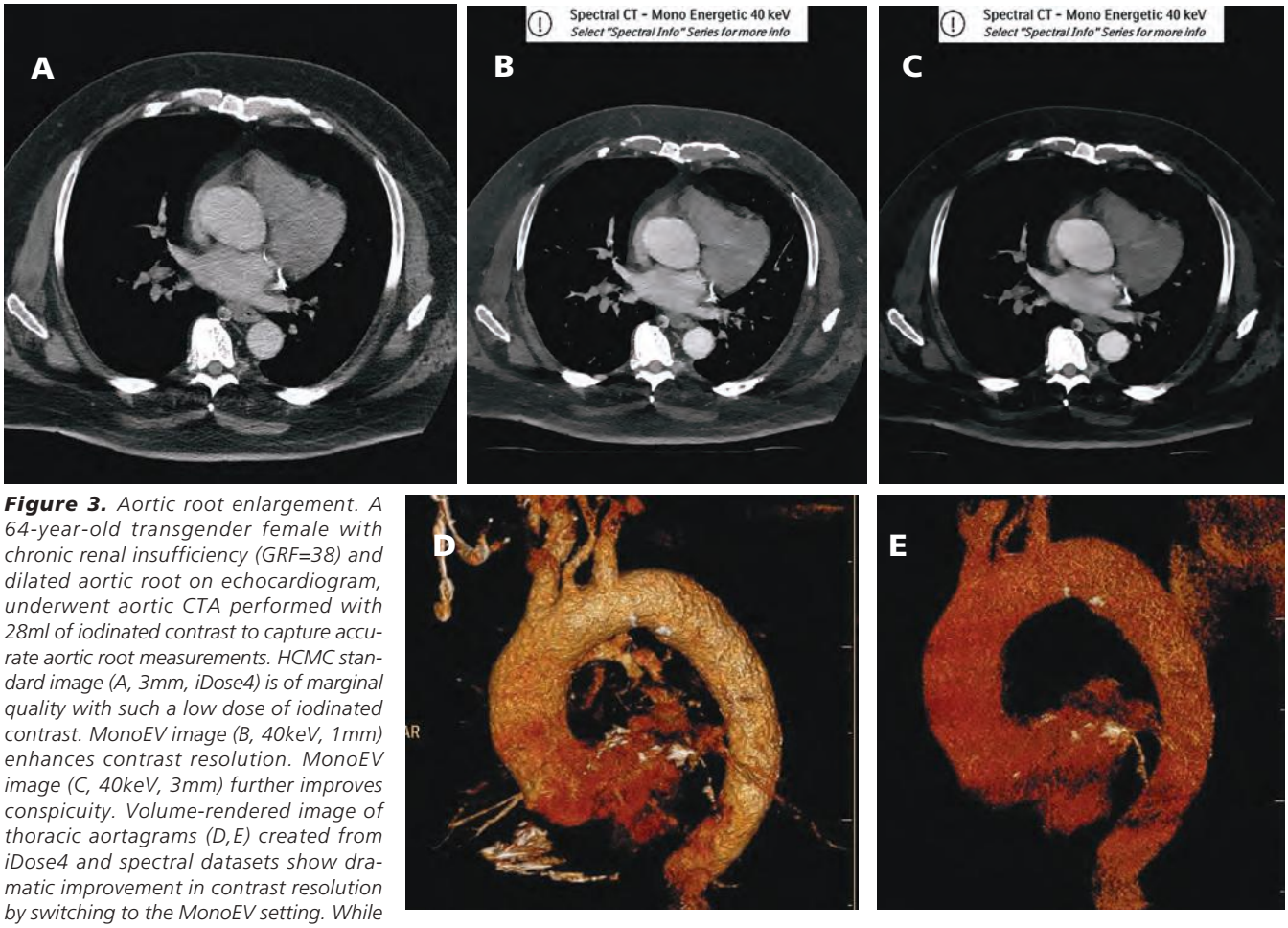

Figure 3. *Aortic root enlargement. A 64-year-old transgender female with chronic renal insufficiency (GRF=38) and dilated aortic root on echocardiogram, underwent aortic CTA performed with 28ml of iodinated contrast to capture accurate aortic root measurements. HCMC standard image (A, 3mm, iDose4) is of marginal quality with such a low dose of iodinated contrast. MonoEV image (B, 40keV, 1mm) enhances contrast resolution. MonoEV image (C, 40keV, 3mm) further improves conspicuity. Volume-rendered image of thoracic aortagrams (D,E) created from iDose4 and spectral datasets show dramatic improvement in contrast resolution by switching to the MonoEV setting. While image measurements could be made from any of three cross-sectional images, monoenergetic spectral scan at 40keV offers contrast resolution of typical contrast CT (80-100ml at most institutions), despite injection of only 28ml of iodinated contrast. (Images courtesy of HCMC Radiology.)*

lines in the ED, Hennepin's clinicians turn to the IQon first — not as the supplemental scan that's ordered after an inconclusive CT. It's the first scan Hennepin's ED patients get when they would traditionally be sent for a CT. And according to Dr. Truwit, it should always be that way.

"We started discovering all sorts of things that we never expected to find," Dr. Truwit said. "We'd do a chest CT on a trauma patient and discover a pulmonary embolism or a pulmonary infarction that we weren't even looking for, simply because we were able to shift the iodine curve, so to speak, and look at the spectrum of energies in a whole new way (Figure 1). In addition, we find splenic and hepatic lacerations much more easily and earlier than before. As well, bowel infarction becomes much more obvious on the iodine maps (Figure 2). In our trauma population, these diagnoses are now being made much earlier and therefore, with improved patient outcomes."

Without the need for prospective scan-time decision-making, the IQon Spectral CT makes perfect sense for the ED and Level 1 Trauma Center and has served Hennepin well.

Serving the Minneapolis/St. Paul area, Hennepin is committed to being a safety net hospital that provides care for low-income, uninsured and vulnerable populations. Dr. Truwit explained that seeing patients with a fragile IV in the ED is quite common and, in the past,

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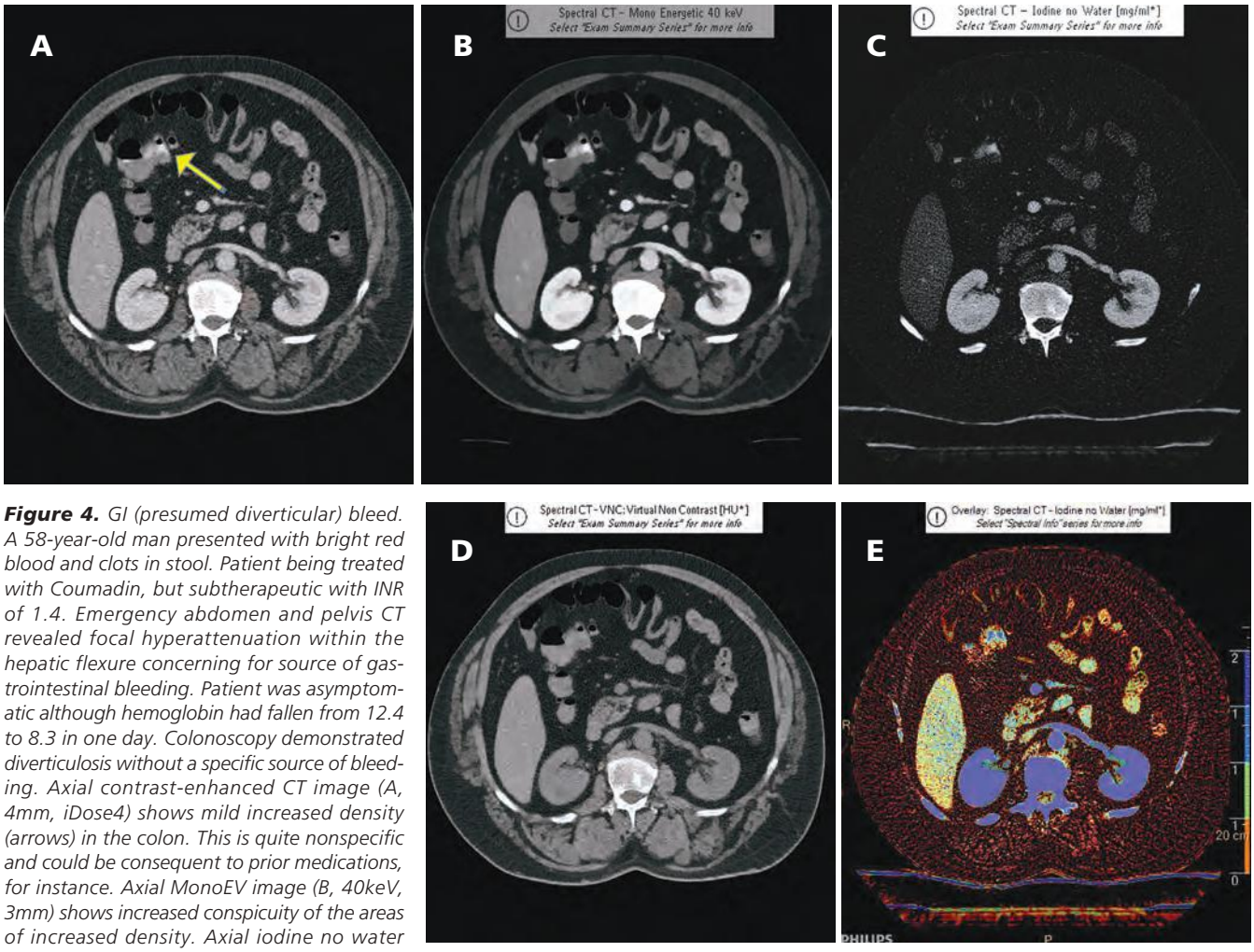


Figure 4. *GI (presumed diverticular) bleed. A 58-year-old man presented with bright red blood and clots in stool. Patient being treated with Coumadin, but subtherapeutic with INR of 1.4. Emergency abdomen and pelvis CT revealed focal hyperattenuation within the hepatic flexure concerning for source of gastrointestinal bleeding. Patient was asymptomatic although hemoglobin had fallen from 12.4 to 8.3 in one day. Colonoscopy demonstrated diverticulosis without a specific source of bleeding. Axial contrast-enhanced CT image (A, 4mm, iDose4) shows mild increased density (arrows) in the colon. This is quite nonspecific and could be consequent to prior medications, for instance. Axial MonoEV image (B, 40keV, 3mm) shows increased conspicuity of the areas of increased density. Axial iodine no water image (C) shows persistent hyperattenuation, confirming that this is likely iodine. Axial virtual noncontrast image (D) shows no hyperattenuation. Colorized image (E) shows the large-bowel hemorrhage presumably consequent to a diverticular bleed. Smaller amount of hemorrhage is layering in the bowel, adjacent to the right. (Images courtesy of HCMC Radiology.)*

has been an obstacle to quality imaging results. Until the IQon Spectral CT, scans would either have to be repeated, or clinicians would have to accommodate lesser-quality scans. Like the CaseWestern group, HCMC also reports performing studies with significantly reduced iodinated contrast in patients with renal failure (Figure 3).

"When that happens now, we can upload it into the spectral system, reprocess it using the spectral software, and all of a sudden you can rescue a scan," he said. "You can pick up a pulmonary embolism or a subtle bleed that you might not otherwise see because of the quality of the scans (Figure 4). So, we're able to generate better, diagnostic-quality scans out of something that we otherwise might not have."

"This is the first scanner that's come out where you have the opportunity to use this — always," Dr. Truwit concluded. "That's the benefit. Should every scanner be spectral? Absolutely. The spectral CT scanner is as transformative today as the CT scanner itself was disruptive in the 1970s."

Results from case studies are not predictive of results in other cases. Results in other cases may vary.

Improving Patient Outcomes in Advanced Molecular Imaging

Claudette Lew

Putting patients at the center of every Philips innovation also extends into the latest development efforts and collaborations in Advanced Molecular Imaging (AMI). Here, Philips and clinicians are working together to simplify the path to critical decision-making and improve clinical outcomes for patients. This means seeing small things sooner – with more assurance and accuracy for the radiologist, and less dose and scan time for the patient.

"Advanced Molecular Imaging is so much more than another diagnostic test," says Piotr Maniawski, Director of Clinical Science for CT and AMI at Philips. "It's also a therapeutic tool for therapy planning and monitoring." Because of the unique clinical insight it provides, molecular imaging plays a critical role in addressing treatment effectiveness in complex disease cases. And with the expansion of agents available for use, the benefits of AMI imaging are now available to a broader set of patients.

Indeed, AMI carries significant weight on the patient care continuum, not only supporting confident diagnostic decisions but also guiding patient treatment pathways; when done faster and more accurately, both capabilities hold the potential to improve outcomes and reduce costs.

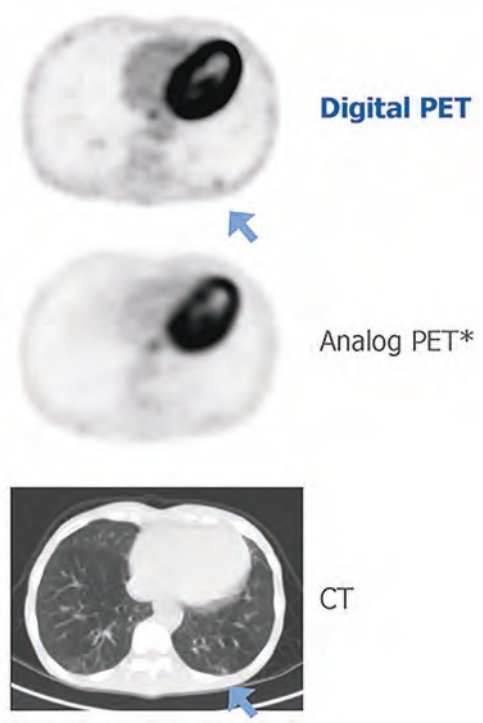
Increasing lesion detectability

The patient-centered goals driving Philips' innovation efforts in AMI are to increase lesion detectability, improve quantification and, always important, to reduce patient radiation exposure. As advances in AMI afford clinicians the opportunity to detect ever smaller lesions, Philips' team, together with their clinician collaborators, are striving to document how these technical innovations are translating into better patient care.

"Working directly with our customers, we are developing and implementing new applications as well as conducting studies on our commercially released products," Maniawski said. "We have proven with our digital PET that better spatial resolution improves lesion detectability. So, we are working with the team at Ohio State University to conduct a clinical evaluation of our digital PET/CT. We know that we can detect smaller lesions. So, the next question we're asking is, 'What is changing because of it?'"

FDG whole-body PET is approved for reimbursement and is being utilized today in oncology primarily for initial and subsequent tumor staging and to locate metastatic disease for a number of clinical indications that, in Maniawski's opinion, are still quite limited. To support further expansion of AMI into more clinical areas, Philips integrated the powerful data and analytics available in its molecular imaging applications into the IntelliSpace Portal to facilitate disease visualization, diagnosis and communication. The Portal is the means by which interdisciplinary clinical teams can use advanced data sharing, multi-modality tumor tracking, and characterization applications to assess complex cases.

"Sharing this information is very relevant for referring physicians. They're getting a quicker,



Vereos, the world's first and only fully digital PET/CT, provides improved detectability and characterization of small lesions.[1] In a case study performed at The Ohio State University, researchers compared analog to digital PET images. These images show improved detectability of small lesions with digital PET/CT relative to the same patient acquired on analog PET/CT.

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1. Hussain T, Nguyen QT. Molecular Imaging for Cancer Diagnosis and Surgery. Advanced drug delivery reviews. 2014;66:90-100. doi:10.1016/j.addr.2013.09.007.

and more confident diagnosis of their patient's disease, and more accurate staging of that disease," Maniawski explains. "The definitive result we're looking to validate is that AMI provides clinicians with better guidance, and informs more effective therapy choices for patients, thus enhancing the potential for improved clinical outcomes."

Improving quantification

Clinicians can monitor and assess therapy effectiveness via multiple imaging studies. One major challenge preventing AMI's more widespread utilization is a lack of quantification within the modality. Nuclear medicine physicians and physicists can collaborate with other clinicians through Philips' Intellispace Portal as part of an interdisciplinary approach, but the variability in AMI quantification continues to impede AMI's broader utilization over more traditional imaging modalities, such as CT, for monitoring therapy.

In PET, some of that variability stems from the Standard Uptake Value (SUV) quantification, which carries with it a significant error of measurement. Maniawski mentioned that several studies have been looking into what factors influence the SUV value, and that Philips is moving forward with innovations in this area.

"While most of what influences the SUV comes from the system itself, the other influence on SUV is patient preparation," he explained. "Managing the patient during study preparation and the imaging itself is as important as the PET system performance."

Reducing exposure

Considering that many of the patients sent for AMI studies are very ill, Philips innovations in molecular imaging are focused on effectively limiting the radiation exposure.

"To really advance the value of AMI for patients, we are tasked with the triple challenge of improving lesion detectability and standardization decreasing scan times and lowering dose," Maniawski explained. "Our technology itself really needs to address all of these. The main benefit of moving to digital PET detection with improvements in our Time of Flight (TOF) technology was to be able to do this and keep patient dose to a minimum. As indications evolve, we're going to see more disease-specific protocols that will reduce the scan time with more targeted scanning, as opposed to today, where 93 percent of clinical exams are FDG whole-body PET."

Using more specific indications, or imaging protocols, he said, will allow clinicians to tailor patient protocols better and further reduce radiation exposure. For both patients and clinicians, that's meaningful innovation.

New Perspectives in Imaging at Phoenix Children's 3D Innovation Lab

Claudette Lew

Everything is in our IntelliSpace Portal, so even in a fast-paced surgical conference situation, I can manipulate the image on the spot ... to show them a particular view of something in a live situation.

Dianna Bardo, MD
Director of Body MR & Co-Director, 3D Innovation Laboratory, Phoenix Children's Hospital

Applied Radiology recently had the opportunity to speak with Dianna Bardo, MD, Director of Body MR and Co-Director, 3D Innovation Laboratory at Phoenix Children's Hospital in Phoenix, Arizona, about some of the game-changing work that's going on in their 3D Innovation lab.

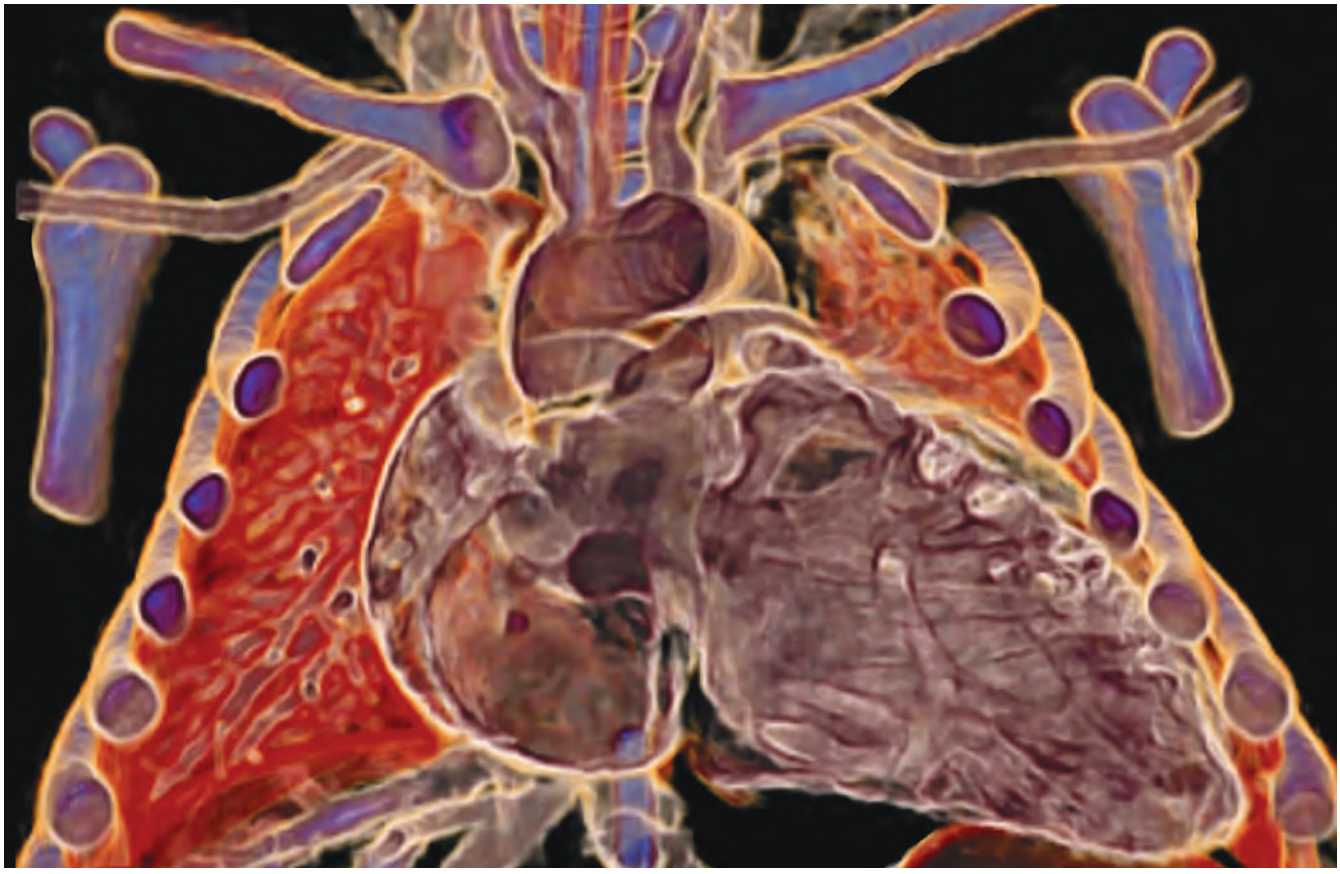
AR: How is the 3D Innovation lab using advanced visualization to improve care at Phoenix Children's?

DB: Our 3D Innovation lab is really sort of a unique situation where we have some extremely talented technologists with unique knowledge of cross-sectional anatomy using Philips' IntelliSpace Portal, an advanced visualization platform that offers a single integrated solution to help clinicians work quickly with increased diagnostic confidence — especially for complex cases and follow-up, to process clinical images in multiple ways. With all that technical expertise and computing power our radiologists envision diagnoses more efficiently and enable our clinicians to utilize CT and MR images in a more intuitive manner.

We all believe that we can sort of make that 3D image in our minds just by viewing the 2D axial images , but as it turns out, we are not really very good at it. If we show the image in a virtual 3D environment — or sometimes using a 3D print — by virtue of seeing it that way, we are helping clinicians or surgeons to actually *see the images better* and understand the pathology, or even the normal anatomy, better than we ever imagined we could.

AR: What are some types of cases or particular types of images that you've worked on for clinicians?

DB: With post-processing techniques and advanced visualization, we can segment out a tumor, a vascular structure, or even the heart, and really have a much more thorough understanding of what that anatomy looks like. We often meet with a clinician in the lab or in the reading room, where we can manipulate the image even further to show them things they are specifically interested in seeing, answering detailed anatomic questions about their patient. Oftentimes, they have additional questions, or want to see structures from a different perspective that requires us to alter the image based on



A 3D view of the right atrium and ventricle is reconstructed from CT data using a transparent algorithm within Philips IntelliSpace Portal. Transparency enables optimal visualization of important details of cardiac structure.

information they need to prepare for a surgical procedure, for example.

AR: How has having the 3D Innovation lab changed the way you practice at Phoenix Children's?

DB: It's been really interesting to see the level of variability that exists between each reader, how we measure things, and how our visual perception plays into that. We did a study here where we asked eleven radiologists to look at and measure tumors, myself included. Next, we were asked, without using 3D, what shape do you think this tumor is? From the radiologist's measurements made on axial, sagittal, and coronal 2D images we calculated a volume of the perceived tumor shape. Our calculated results were all over the board. Our 3D lab technicians used IntelliSpace Portal software to segment these same tumors and make direct volumetric measurements. Their results were very similar and more accurate than the radiologists' because they used the advanced visualization 3D software.

AR: A great exercise, but how does that translate into better outcomes for Phoenix Children's Hospital patients?

DB: In a tumor situation, if we're more accurate in how we're measuring it, then we know from

one time point to the next that the treatment might be working better — or if that treatment isn't working because the tumor is growing. In that case, the oncologist knows sooner to change a treatment method. If the patient is getting chemotherapy and the tumor is still growing — and we know that because we've been more accurate in calculating its volume or its size — then we know it's time to change that course of treatment. Maybe the patient needs to go back to the OR, or maybe they need a different type of chemotherapy. If the tumor is really shrinking, perhaps we can take a child off of chemotherapy sooner.

Because 3D visualization is more easilty understood, everyone is drawn to utilizing it. It has resulted in a more complete and collaborative clinical approach for our patients. I was just in cardiology conference this morning, and brought up an active case to show an idealized image. Everything is in our IntelliSpace Portal, so even in a fast-paced surgical conference situation, I can manipulate the image on the spot, adding anatomy back or subtracting anatomy to show them a particular view in a live situation. It's a very powerful tool. The Portal has been loaded into all of the conference room computers, and it's a thin client so it can go anywhere.

AR: I've heard you have printed out special 3D models for some pediatric cancer patients. Can you tell me about those experiences?

DB: A 3D printed model is often made to supplement virtual 3D images; the printed model provides a tactile experience which helps our physicians and surgeons plan treatment for our patients. Holding that life-size model of a patient's heart allows the surgeon to rehearse a surgical approach or plan maneuvers before the patient is in the operating suite. Surgeons can dry fit a stent or implant and make certain that the surgical plan is optimized.

Virtual and 3D printed models are great educational tools for patients and families who often struggle to understand the diagnosis of a complex condition or anomaly. Models illustrate their child's anatomy and pathology and can ease the stress of comprehending surgical or treatment plans. This visual and touchable tool allows them to better understand some of the complex terms and concepts presented by their medical team which really helps drive the road to progress and recovery.

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