Case Study: Patient-Centered Optimization

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Physicists at Duke University lead efforts to optimize imaging quality and dose using actual patient cases.

By Jenny Jones

Key Takeaways:

- Duke physicists are working with radiologists and other imaging team members to optimize radiation dose and imaging quality based on actual patient profiles for consistent care.
- The team implemented a system that sends every CT and radiography case to a central server, which ascertains radiation dose and image quality information for each image to ensure high-value imaging across the board.
- The approach has spurred a perpetual improvement in the consistency of imaging practice and has helped Duke achieve dose levels below the national average.

For many people, the idea of patient-centered care conjures thoughts of providing warm blankets and delivering exam results directly to patients. At Duke University Health System (DUHS), the radiology team has taken patient-centered care to another level — optimizing image quality and radiation dose through a retrospective and quantitative review of actual patient cases.

Ehsan Samei, PhD, professor of radiology and the chief imaging physicist for Duke University Health System, and his team are leading an ongoing project to quantify the radiation dose and image quality of every radiology exam performed at Duke's three hospitals and outpatient imaging clinics. The information allows the radiology team to optimize dose and quality based on individual patient characteristics — including gender, weight, age, and clinical condition — and based on each piece of radiology equipment.

"We want to make sure our procedures are customized and matched to the specifics of each patient," says Samei, who is also the director of the medical physics graduate and residency programs at Duke. "The whole concept really grows out of the desire to deliver consistent patient-centered care."

Samei and his team, known as the Duke Clinical Imaging Physics Group, (CIPG) started developing the approach in 2012 for modalities that use ionizing radiation. Now they capture dose and image quality data based on image resolution, noise, contrast, and other measures for every exam performed at DUHS, starting with CT and radiography and expanding to fluoroscopy, mammography, and nuclear imaging. They analyze this information for each patient exam and take corrective action, such as adjusting the protocols or patient positioning, when necessary to ensure future exams are of high value systemwide.

"The consistency of imaging in our facilities across the health system has increased as a result of our work," Samei says. "Now, if somebody asks whether the image quality is high and whether we're exposing patients

Ehsan Samei, PhD, professor of radiology and the chief imaging physicist for Duke University Health System, leads ongoing efforts to quantify the radiation dose and image quality of each radiology exam the system performs.

to the correct dose, we can say with confidence that we are, as opposed to just assuming that we are good because we are Duke."

Pushing the Envelope

Before CIPG began focusing on patient-centered dose and image quality optimization, Duke's radiology department did what many groups do and estimated what the radiation dose should be for patient exams. The team was meeting accreditation requirements with no problem, but the physicists knew they could do better.

"You can be accredited and your protocols can all make sense, but you can still find yourself exposing patients to doses that are too high or too low for a particular exam," says Jay A. Baker, MD, professor in the department of radiology and vice chair of clinical affairs at Duke University Medical Center. "Dr. Samei and his group wanted to push the envelope to figure out exactly how much dose is necessary to produce images

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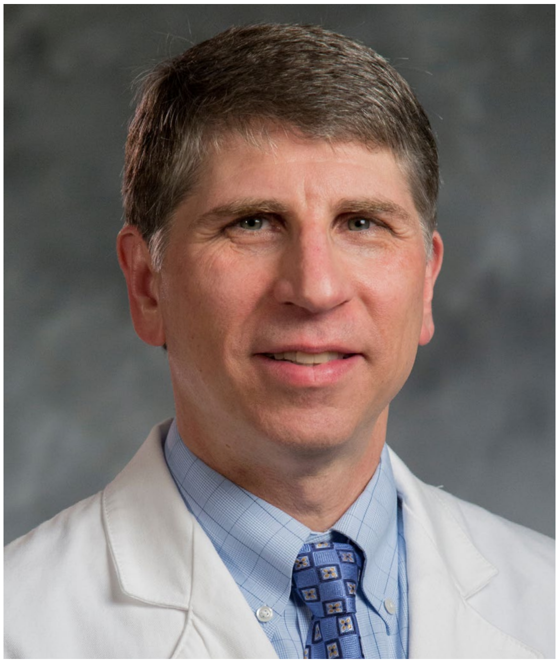

Jay A. Baker, MD, professor in the department of radiology and vice chair of clinical affairs at Duke University Medical Center, says the dose reduction and quality work has the potential to reduce repeat imaging.

at a high enough quality to answer the specific clinical questions. It's really about using the right amount of dose for the right patient for the right study."

Samei and his team are embedded within Duke's radiology department, so the dose and quality optimization project developed organically through conversations among physicists, radiologists, technologists, and other department members. The radiologists were on board with more meticulously quantifying dose and quality when Samei explained that doing so could lead to more precise and consistent care.

"It's like counting calories: If you don't put the calorie quantities on the menu, you don't really know how many calories you've consumed; you can make a reasonable guess, but you don't really know," Samei says. "What we did with our project is essentially put numbers next to those 'calories' or, in this case, our exam dose and quality. So we know what the dose is, and we know what the image quality is for each exam, and therefore, we can be more informed about the way we approach, monitor, and optimize imaging."

While radiology groups have been attuned to dose for years, measuring image or exam quality as part of those efforts is relatively new, says Donald P. Frush, MD, FACR, former professor of pediatrics and radiology and vice chair of quality and safety at Duke. "To develop a performance quality program that considers both dose and quality is really a quantum leap above what most anyone else has right now," says Frush, who is now professor of radiology and medical director of operations at Lucile Packard Children's Hospital at Stanford.

It was a concept that some Duke radiologists hadn't considered possible. "You don't know what you don't know," says Baker, who is also the division chief of breast imaging at Duke. "What Dr. Samei's group did was show us that we could do more in-depth analysis and learn more about our protocols, our dose, and the impact on quality down to the machine level for each patient. It has the potential to reduce repeat imaging, because we're considering dose and quality together, rather than simply lowering the dose and hoping the quality remains high enough to answer the clinical question. We know we're getting the best image we can get at the lowest possible appropriate dose."

Analyzing Actual Cases

To achieve this level of dose and quality optimization, Samei and his team knew they needed to measure radiation dose and image quality on actual patient cases — not just test cases conducted with phantoms. "Traditionally in radiology, we use phantoms, which are essentially single-sized plastic objects, to ascertain some of the aspects of dose and image quality," Samei explains. "The challenge is that a phantom image doesn't have the same properties as a patient image, so your estimation of dose and image quality is a bit removed from what is actually happening to the patients in your clinic. The hallmark of our work is that we're looking at actual patient cases."

The Duke team looked for a commercial product to analyze patient cases, but they couldn't find what they needed. Instead, they worked with Duke's IT team to develop an in-house system that sends every case to a central server, which ascertains radiation dose and image quality information for each image through an automatic process. In addition to dose exposure level, the system analyzes image resolution, noise, contrast, and other measures.

"These attributes are not just things that physicists cooked up; we actually interviewed our radiologists and asked them, 'So when you say an image is bad or an image is good, what do you mean?'" Samei explains. "Then we put numbers to their responses. With the numbers, we can measure the quality and dose, we can target it, and we can optimize it. Without the numbers, you cannot do any of those things. In the same way that you can't really come up with a diet if you cannot quantify calories and servings."

While the system reviews all of the cases, the radiologists can also manually flag noteworthy cases as they

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read them. These cases might contain suboptimal artifacts, or they might be highly optimal cases that the radiologists want to hold up as ideal examples. The radiologists and physicists discuss these cases along with system-identified outliers during regular meetings, which technologists, clinicians, and other stakeholders also attend.

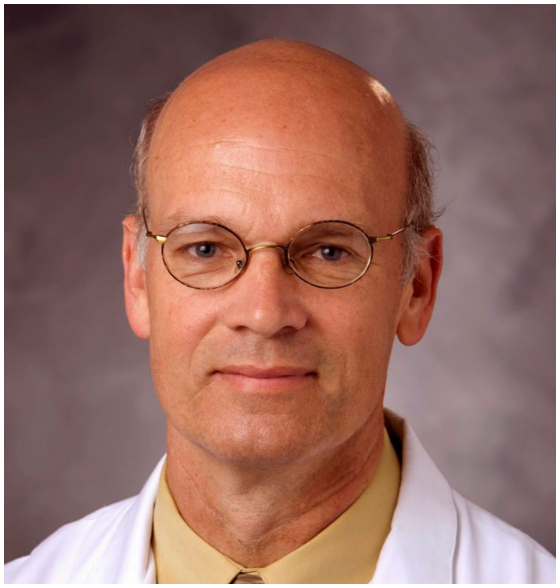
"We set up open lines of communication with team members who are focused on dose and quality optimization," says Lynne M. Koweek, MD, cardiothoracic imaging specialist at Duke. "We try to give the physicists input about the challenges we're facing on the clinical side, so they can understand how to best help us on the technical side. It's really collaborative."

Implementing Improvements

When the system or the radiologists identify a suboptimal case based on the quality and dose score, the physics team reviews the entire imaging chain — from the time an exam was ordered to the time the radiologist read the study and reported their findings — to determine why that particular study was an outlier. It's a different approach to medical physics, which usually involves just qualifying imaging equipment, Samei says. "We look at the imaging equipment, how the technologist used the equipment, what protocol was used, what dose was used, what position the patient was in — everything up the imaging chain," he says. "It's like a forensic investigation to find out what went wrong."

In one instance, the physicists noticed a discrepancy in the dose and quality of two different classes of CT scanners that the hospital uses. For one class, the dose was increasing as the patient size increased (which is normal), but for the other class, the dose was not changing with patient size. "The smaller patients were getting beautiful image quality and the larger patients were getting not so beautiful images," Samei explains. "We saw this pattern, and we scratched our heads. It turned out that for the class of cases where the dose was not changing, the setting of the scanner had to be changed. After we fixed the setting, everything was working as it should, and we could verify that improvement in our results."

While correcting the scanner class discrepancy involved a simple setting change, other issues require more in-depth adjustments to protocols and patient positioning. In these cases, the CIPG team develops potential solutions to the issues and tests them on phantoms before recommending them for practice. "We still acquire phantom data, but as one of the pieces of the puzzle, not the whole thing," says Samei, who shares tested solutions with the radiologists,



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technologists, and other team members for discussion and implementation.

The collaborative approach ensures that everyone remains committed to dose and quality optimization. "It helps keep the words dose and image quality on the technologists' tongues," says Tammie Bateman, chief technologist for CT radiology at Duke. "People can become desensitized to dose due to the fact that ionizing radiation isn't visible. But it's important to keep both dose and image quality at the forefront of our minds when imaging patients."

The approach is having a positive impact on patient care, driving a gradual decrease of repeat imaging since 2015, Samei says. What's more, a comparison of CT dose levels with the benchmarks of the ACR Dose Index Registry shows lower dose levels compared to national averages as a result of Duke's efforts. "Over time, we have seen more consistency and adherence to targeted quality and dose levels," Samei says. "Through this system, we're ensuring that we use the minimum radiation dose to obtain the actionable information that we need for diagnosis and treatment."

Expanding the Project

With the system initially working for modalities that use ionizing radiation, Samei and his team intend to gradually expand it to non-radiation-based modalities, including ultrasound and MRI. "With those modalities, radiation dose is not a concern. But we still care about the image quality, scan parameters, dose of the

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contrast medium, and, of course, about the imaging condition and performing the exam exactingly to meet the need of the individual patient," Samei says. "We think the system we have in place can help ensure quality in these areas, as well."

Samei also hopes to eventually make the system that Duke developed to measure the dose and quality of actual patient cases available to other institutions and practices. He hopes it will encourage more groups to make consistent patient-centered quality and dose a priority. "I would like to see a situation where I don't have to wonder whether the CT scan at one institution or another provides the same information; that is an obligation that we have to every patient who entrusts us with his or her care," Samei says. "We need to start deploying comprehensive monitoring systems, such as the one we have employed here, to look at the consistency and quantification of care, as consistency and quantification are hallmarks of high-quality evidence-based medicine. With medical images, we should be capturing the exact information that we need — nothing more and nothing less."

Next Steps

- Prioritize optimization of imaging dose and quality beyond what's required for accreditation.
- Commit to analyzing actual patient cases, not just phantoms, and implement a system to do so.
- Collaborate with radiologists and other team members to quantify optimal radiation dose and image quality and implement adjustments as needed.
- Partner with other institutions to assure the ability to distribute a program with efficient and effective implementation and function.

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