Newer Iterative Reconstruction Algorithms Reduce Dose Without Impacting Diagnostic Power

Concerns regarding CT radiation dose have been a topic at the forefront of medical imaging from the late 2000s. Since that time, several initiatives—from the US Food and Drug Administration, Joint Commission, the American College of Radiology, and Society for Pediatric Radiology—have been launched to raise awareness of the issue and reduce patient radiation dose across exams.

CT has played a pivotal role in the delivery of healthcare by providing detailed anatomical images that help clinicians improve patient diagnosis and guide treatment, including avoiding unnecessary medical and surgical procedures. The industry has also responded with a keen focus on new technologies designed to help providers lower dose without impacting the diagnostic quality of CT imaging.

CT scanners used to rely on filtered back projection (FBP) for image reconstruction. Credited with fast processing times due to simplifying assumptions about the image chain, FBP had been the industry standard for almost 30 years. Today, iterative reconstruction (IR) algorithms/methods have emerged as the primary technique in reconstruction. The primary advantages of IR are its ability to incorporate attenuation corrections, reduce image noise, model the scanner itself, and even improve image quality through cyclic image processing.

Implementing IR

At the University of Washington Medical Center, William Shuman, MD, FACR, Professor of Radiology and Director of Clinical Radiology Operations at UW Medical Center, has helped to spearhead the adoption of IR and a dose management program. UW Medicine owns or operates four hospitals, the UW School of Medicine, and UW Neighborhood Clinics, a network of community-based clinics located throughout the Puget Sound region. Across all facilities, UW operates 12 CT scanners.

According to Dr. Shuman, dose management efforts at UW Medical Center began over a decade ago, well before it was publicized as an important health safety issue. Initially, the focus was on the proper imaging technique—patient centering, z-axis coverage, and the use of bismuth body shields—as well as the implementation of weight-based kVp and contrast selection protocols. Tube current modulation was also utilized.

UW has a committee comprised of several radiologists and technologists along with medical physicists and an administrator to help continually refine CT imaging protocols—including dose reduction—based on the type of study. Each patient receiving a CT study is further protocoled by a radiologist according to body habitus, age, and clinical indication.

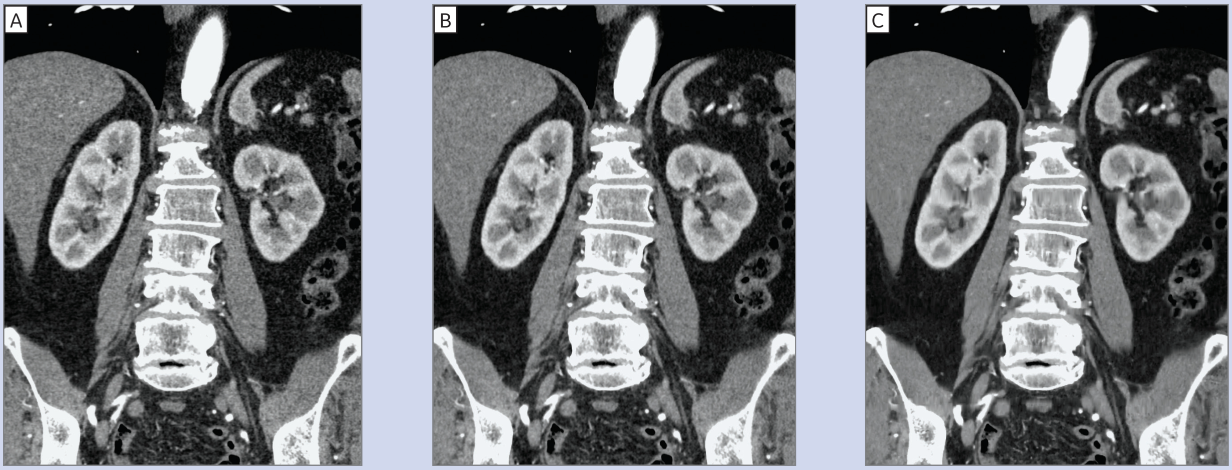

Figure 1. Images depict the progression of image reconstruction techniques, from (A) ASiR, to (B) ASiR-V, to (C) Veo. All images acquired at 100 kV and 140 mAs: (A) 50% ASiR; (B) 50% ASiR-V.

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>
> *Dr. William Shuman*

"When IR was introduced in 2008, we rapidly and aggressively implemented the technology," Dr. Shuman says. UW started with 40% adaptive statistical IR blended with FBP, and then increased it up to 70% IR blended with FBP. When model-based iterative reconstruction (MBIR) was introduced in 2011, UW was swift to implement it by suggesting its use on any patient under age 45. Then, when blended iterative reconstruction—a combination of both adaptive statistical IR and model-based IR—was introduced in 2013, the facility quickly implemented the technology.

"There is no question each method subtly changes the appearance of the images," Dr. Shuman says. "But the important question is: does it have the same diagnostic power?"

That's the question Dr. Shuman posed to his radiology colleagues with each implementation. He found that radiologists need to work with the new image reconstruction technology for a period of time—between 30 and 60 days—to become accustomed to the new look of the clinical images.

"After 90 days, many radiologists hardly notice the difference in how the images appear, especially with adaptive statistical IR," he adds. "Generally, when we ask them after several months of use whether the new algorithm impacted diagnostic capability, they often reply that the new algorithm is equal to the prior dose reduction technique."

Even the published literature on adaptive statistical and model-based IR supports this assertion that the diagnostic power is slightly better, Dr. Shuman adds. A recent study found that for detailed analyses of lung nodules, model-based IR delivered diagnostically more acceptable image quality by reducing image noise and streak artifacts with sharper depictions of lung structures than adaptive statistical IR.[1]

While the implementation described above worked for UW, Dr. Shuman recommends that each facility and group practice needs to find the appropriate tradeoff between appearance and diagnostic capability—one that works equally well for the radiologists and the patients.

"Adapt the rate of change to your culture and local institution," Dr. Shuman recommends. "Don't push change too fast or it can become counterproductive."

Keeping pace with technology

CT technology has also changed dramatically in the past decade, further enabling use of dose reduction techniques without impacting diagnostic capability. Temporal and spatial resolution has jumped significantly along with rotation speed; automated tube modulation and auto kV selection help support and reinforce good imaging technique, which further enhances dose reduction; and on some systems, a larger bore size helps ensure the patient's anatomy doesn't fall outside the field of view.

Dr. Shuman shares a recent experience with a CT study on a patient who was also imaged 10 years prior on what was one of the most advanced scanners at that time. The 2006 exam utilized every available technique to lower dose, although IR was not yet available. The 2016 exam applied blended IR for dose reduction in addition to technique. The difference: the same study on the same patient performed 10 years apart dropped from a DLP of 1490 to 290. As important, Dr. Shuman says the image quality on the new technology was better, even with a dramatic dose reduction.

While the MBIR algorithm can often deliver a higher level of dose reduction compared to adaptive statistical IR, the tradeoff is in the reconstruction time, which typically takes 30 to 40 minutes. With the implementation of MBIR, Dr. Shuman says the true "stress test" of the algorithm may be its use in the ER.

"In the ER, triage is so fast that we thought the physicians would not be willing to wait for image reconstruction using MBIR," Dr. Shuman explains. "We found the exact opposite to be the case. ER physicians are very dose conscious and their motivation to use CT is very high—they have to triage quickly and be very accurate. So their desire for the correct answer the first time propels them to use CT. With MBIR, even though they have to wait the ER physicians think it's fantastic. They often remind us to go for the lowest dose possible by ordering studies to be done with MBIR."

Dr. Shuman recommends that facilities also utilize technology to track the results of a dose reduction strategy. "Know over time what you are achieving in dose reduction so you can adapt with changes in the technique and technology," he advises.

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"Second, you need to track the radiology assessment of the diagnostic power of the images over time. Have radiologists communicate what they think, either informally or formally through a scale. You need some mechanism to know when you've lowered the dose too much."

With the ACR now requiring a dose management program for ACR-certified sites and the Joint Commission likely not far behind, it is important for facilities to begin putting a systematic program in place—one that includes dose tracking and management. As a profession, Dr. Shuman believes that radiology should continue to raise awareness of radiation safety as well as embrace advances in technique and technology that can further enable all imaging facilities to deliver safe and effective CT imaging care to all patients. ■

Reference

1. Yasaka K, Katsura M, Hanaoka S, Sato J, Ohtomo K. High-resolution CT with new model-based iterative reconstruction with resolution preference algorithm in evaluations of lung nodules: Comparison with conventional model-based iterative reconstruction and adaptive statistical iterative reconstruction. Eur J Radiol, 2016;85:599–606.

GE CT Image Reconstruction Technologies

Adaptive statistical iterative reconstruction (ASiR™) is an image reconstruction technique that reduces noise and improves image quality. GE Healthcare was the first company to introduce this kind of technology in CT, using an iterative statistical image reconstruction algorithm to generate images using lower radiation dose of similar image quality with lower noise. Introduced in 2008, ASiR was the first big step in terms of dose reduction and image quality improvement. ASiR models the noise in the raw CT data and, through multiple iterations, filters it out for a clearer final image. Today, ASiR is the industry's most used iterative reconstruction technology, benefiting tens of millions of patients from its use to date.

ASiR-V is a blended reconstruction technology and reduces noise even at very low signal levels. This technology is designed to deliver reduced noise levels, improve low-contrast detectability and routinely reduce dose up to 82% for patients of all ages.*‡

Veo™ is the world's first model-based iterative reconstruction product that enables imaging less than 1 mSv with profound clarity. With Veo, lower noise and higher resolution can be achieved within a single image. At the same time, significant dose reduction capabilities are now available, opening up new possibilities for challenging cases and sensitive patients. This breakthrough is changing the way physicians use CT imaging, delivering a combination of high-performance images and low dose that was previously unthinkable.* ■

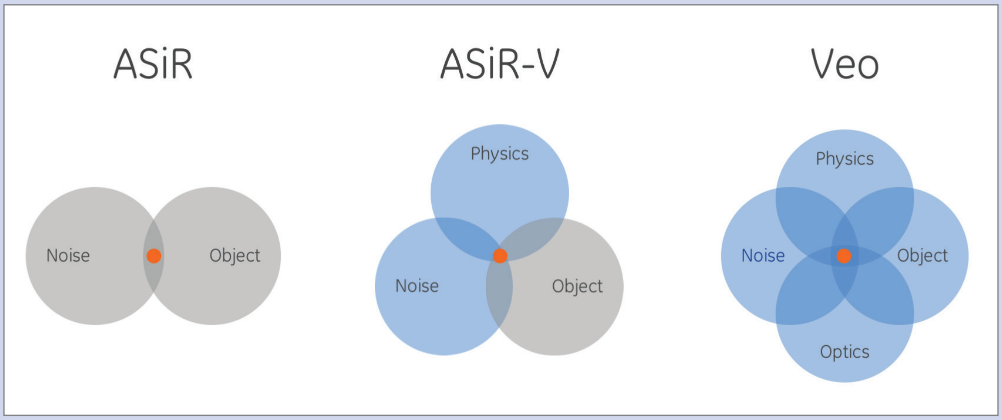

Figure 2. ASiR provides real-time performance (up to 35 ips); ASiR-V delivers dose reductions up to 82%; Veo, a full model-based IR, enables profound image quality under 1 mSv.

* In clinical practice, the use of ASiR, ASiR-V, and Veo may reduce CT patient dose depending on the clinical task, patient size, anatomical location, and clinical practice. A consultation with a radiologist and a physicist should be made to determine the appropriate dose to obtain diagnostic image quality for the particular clinical task.

‡ Low contrast detectability (LCD), image noise, spatial resolution and artifacts were assessed using reference factory protocols comparing ASiR-V and FBP. The LCD measured in 0.625 mm slices and tested for both head and body modes using the MITA CT IQ Phantom (CCT183, The Phantom Laboratory), using model observer method.