Several methods to reduce CT radiation dose have been introduced in recent years. The latest advances offer:

- More options selecting kVp to optimize patient dose and image contrast
- Advanced iterative reconstruction algorithms to decrease image noise, enabling dose reduction while maintaining diagnostic confidence
- Increased detector efficiency to reduce image noise due to scatter
- Using these advanced technologies, radiation dose can be lowered to 1/10th of normal

Considerable concern has been expressed in recent years in regard to the radiation exposure from medical imaging, in particular from CT, which increased dramatically as utilization increased. In response to this concern, a number of techniques have been adopted in recent years to decrease radiation dose. Several of these techniques have been incorporated into standard imaging protocols, including lowered kVp settings for smaller patients, automated exposure control, selective in-plane shielding, and iterative reconstruction algorithms that reduce image noise.

In the latest generation of CT scanners, a number of enhanced capabilities have been added. These include more options for kVp selection from 70–150 kVp (in 10 kVp increments), tin filters, increased detector efficiency, and advanced iterative reconstruction techniques.
There is a quadratic relationship between kVp and radiation dose. Therefore, by minimizing the kVp while maintaining the current (mAs) so that there are sufficient photons to maintain image quality, radiation dose can be substantially reduced (Figure 1). This is especially beneficial to pediatric patients, who are more susceptible to radiation than adults. Imaging with low kVp is also beneficial because iodine, used in contrast agents, has greater attenuation at low kVp (Figure 2). On the other hand, the ability to use high levels of kVp is essential for imaging large patients to ensure sufficient penetration of X-rays for quality images.

Tin filters narrow the spectrum of kVp, resulting in a more efficient X-ray beam, which allows for a reduction in radiation dose. In addition, the narrower beams improve the separation of the two energy spectra used in dual-energy CT, which results in improved post-processing.

For many years, CT image reconstruction has depended on a method known as filtered back projection. Newer iterative methods use a combination of statistical modeling and filtered back projection to decrease image noise. For example, in a recently introduced advanced iterative technique, ADMIRE, which is installed in a third-generation 192-slice CT dual-energy scanner (SOMATOM Force, Siemens Healthcare), iterations are performed to reach a target noise-reduction level in the range of five settings. By lowering noise, it is possible to acquire diagnostic grade images at lower radiation doses.

**Assessment of Image Quality and Sensitivity in Low-Dose Imaging**

Emerging evidence indicates that image noise can be effectively reduced with advanced iterative construction methods while maintaining sensitivity. In one study, sets of images of an anthropomorphic chest phantom simulating an intermediate-sized adult were compared. Some images were acquired with a second-generation dual-source CT scanner (SOMATOM Definition Flash, Siemens Healthcare) and its iterative reconstruction, SAFIRE. Others were acquired using a third-generation scanner and reconstructed using various levels of ADMIRE. Image quality was rated lowest in the images from the second-generation scanner, set at 120 kVp and reconstructed with either filtered back projection or SAFIRE. While image quality was rated highest for standard radiation dose CT and ADMIRE, image quality was rated as good when reconstructed with ADMIRE, even when 1/20th of the standard radiation dose was used. Moreover, the sensitivity for detecting simulated pulmonary nodules in the phantom was comparable or somewhat higher at all radiation doses when ADMIRE was used for reconstruction, compared to the
images from the second-generation scanner and its iterative reconstruction software. The radiation dose for the 1/20th standard radiation dose protocol was estimated at 0.15 mGy. A second study used a chest phantom containing eight different materials of varying density and showed that at all settings of radiation dose (range 1.5-0.15 mGy), reconstruction using ADMIRE reduced image noise and demonstrated more stable image attenuation, compared to image reconstruction with filtered back projection.

Image quality has also been evaluated in a series of patients who underwent abdominal CT examinations using a third-generation scanner and ADMIRE. In this study, image noise was shown to be lower with all settings of ADMIRE compared to filtered back projection and was lowest when set at ADMIRE 5. Image contrast also improved by increasing the ADMIRE level. In addition, the image quality did not suffer from artifacts seen with previous iterative reconstruction algorithms, and the tissues did not appear blotchy, pixelated, or plastic-like, even at the highest setting of ADMIRE. No significant differences in attenuation were observed among the different reconstruction algorithms. However, lower tube voltage settings were associated with higher attenuation measurements in liver, spleen, and kidney.

**Further Information and Scheduling**

For further information on advanced CT techniques, please contact Dushyant Sahani, MD, Director of CT Imaging, Department of Radiology, Massachusetts General Hospital at 617-726-3937.

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