CUSTOMER SPOTLIGHT

# Routine 100 kVp Imaging Delivers High Image Contrast at Low Dose

As one of the leading hospitals in the US, Massachusetts General Hospital (MGH) is focused on revolutionizing patient care through innovation, research and education. In 2017, MGH was the only hospital ranked in all 16 specialties by *U.S. News & World Report*.[1]

It's this focus on subspecialty excellence that drives MGH's radiologists like Dushyant V. Sahani, MD, to push the limit of advanced technology. For the last seven years, he's been focused on exploring low kVp CT imaging and exploiting the potential of a low X-ray beam to reduce patient radiation dose.

Initial challenges to this approach include overcoming poor image quality. He explains, "If the low energy phase is not supplemented with enough tube current—or photons—then image quality suffers and that leads to poor diagnostic performance."

However, low kVp provides a gain in image contrast. Since many CT exams are performed with iodinated contrast media, a gain in image contrast could also translate to a reduction in contrast dose. Dr. Sahani saw the potential for this gain in image contrast using low kVp to enhance lesion conspicuity without impacting diagnostic performance.

"We knew the benefits, but we couldn't apply it extensively due to limitations of the CT scanner and X-ray tube," he explained. "Also, the CT console software now suggests which kV to select based on the patient's size."

With the implementation of Revolution™ CT in September 2016, this scanner-related limitation was removed with the system's more powerful X-ray tube, 16 cm detector coverage, ASiR-V™ iterative reconstruction (IR) and more flexible protocol development.

"Revolution CT is a marvelous scanner that makes it easy for the technologist to apply our low kVp protocol in the most demanding cases," he says. "It consistently provides high image quality, delivers more tube power and can accommodate larger patients with a wider bore and maximum table weight."

ASiR-V also enables high image quality if the X-ray current is not sufficient, reducing the chance of a non-diagnostic exam due to low dose. Another feature, kV Assist, enables users to tailor protocols for each patient, clinical indication and scan area. After the scout image is obtained, the software helps determine the appropriate kVp based on the patient's body composition and clinical indication.

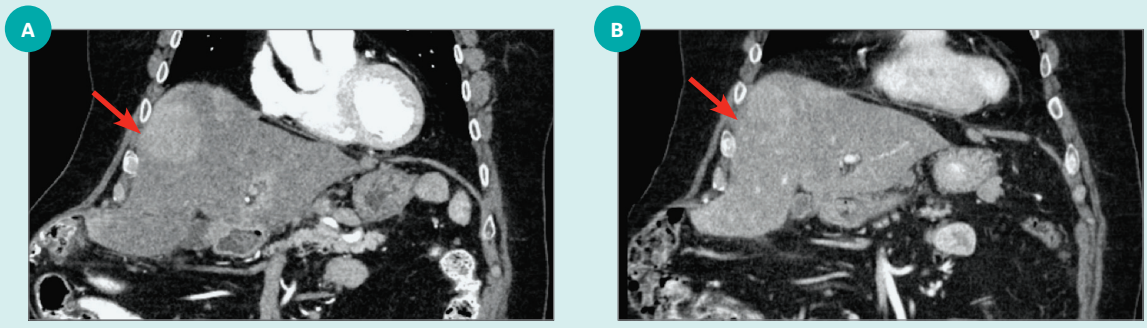


**Figure 1.** In the same patient, hepatic metastasis (arrow) is more conspicuous at (A) 100 kVp than (B) 120 kVp.

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"The scanner is assisting the technologist rather than leaving it to guesswork," Dr. Sahani says. "Looking back, we had a significant number of patients where 120 kVp was used yet it would have been advantageous to use a lower kVp of 100 or 80, depending on the clinical indication. Advancements in the scanner technology delivers the image quality that, in most cases, exceeds what we need for a confident diagnosis."

## Using low kVp

Oncology imaging is one area where low kVp may assist with small lesion detection and characterization. CT remains the modality of choice for diagnosis, staging and clinical work-up across a wide variety of cancers. Also, CT is often used for oncologic surgical planning and it is important for the surgeon to visualize the anatomy and vasculature.

In screening applications, such as lung and colon, low-dose CT is a requirement. "Low kVp can deliver both low dose and high image quality for these indications," Dr. Sahani says. CT can also provide the information clinicians need for organ donation or transplant surgeries, such as kidney or liver.

Low BMI adults and pediatric patients, in particular, benefit from both low radiation dose and low contrast media dose. In some instances, Dr. Sahani has used 70 kVp for high image contrast in these patients.

Before and after imaging in interventions for pulmonary embolism, peripheral arterial disease or abdominal aortic aneurysms help clinicians with patient management. It is these patients who may also have renal insufficiency where Dr. Sahani believes the ability to lower contrast media dose and achieve a gain in image contrast may be most beneficial.

"Revolution CT gives us that opportunity to provide a high-quality service to our patients and referring physicians," Dr. Sahani says. "CT is a great technology for lesion detection. The literature and our own success stories validate that, especially in time critical situations."

Detection of low contrast volumes in an organ can be difficult to confidently distinguish between lesion enhancement and normal tissue, even for an experienced radiologist. It is not uncommon for the iodine contrast to involve both the lesion and the organ. In these cases, if the image contrast is improved by lowering kVp to 100, then the lesion will appear brighter after the administration of contrast media and the lesion will appear more conspicuous than at 120 kVp. By decreasing the kVp from 120 to 80, Dr. Sahani has found that image contrast will increase.

"The subtle lesions start to pop and are easier to detect," he explains. "If we compare to a prior exam, we can clearly see the benefit."

Overall, Dr. Sahani believes low kVp with IR provides advantages in most cases, but especially in high-risk patients with compromised renal function. Yet conversely, in large-sized patients new scanners like Revolution CT allow selection of higher kVp and together with new IR, higher table weight capacity and larger bore sizes, they allow excellent image quality.

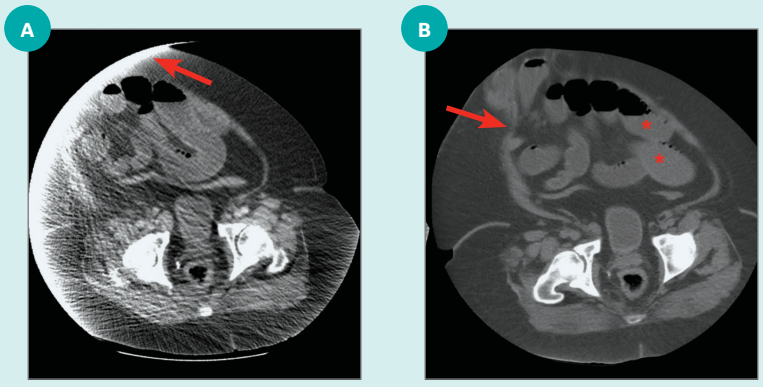


**Figure 2.** A 51-year-old male weighing 361 lbs (164 kg) presented with acute abdominal pain and underwent (A) abdominal CT on a 16-slice scanner with 120 kVp. However, the bore size restrictions limited the field-of-view causing artifacts (arrow) that obscured peripheral portions of the image. (B) Repeat CT on Revolution CT performed at 140 kVp had better image quality and depicted the cause of abdominal pain, incarcerated anterior abdominal wall hernia (arrow) causing small bowel obstruction (asterisks) that was otherwise obscured by the artifacts on the 16-slice CT scanner.

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Initially, Dr. Sahani's low threshold was 100 kVp; however, it was only being used in 4% of patients. He and his colleagues then took a closer look at patient body weight and determined they could use a reference of 100 kVp in patients under 300 pounds, enabling kV Assist to use either 100 kVp or 80 kVp in 95% of patients (Figure 3). For patients over 300 pounds, MGH continues to use a reference of 120 kVp to ensure diagnostic image quality.

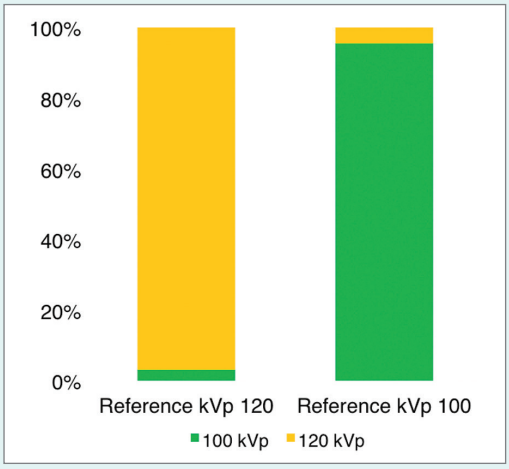


**Figure 3.** Bar graph with data showing percentage of non-vascular soft tissue abdominal CT scans that were performed in a month with 100 kVp (green) and 120 kVp (yellow) when reference kVp was set at 120 and 100 kVp. Note the increase in the number of scans performed with 100 kVp in our clinical routine. All scans possessed diagnostically acceptable good image quality.

Contrast media volume is also based on weight as well as body part and clinical indication. For patients under 300 pounds, contrast media is reduced by 30-35% in total volume. For soft tissue exams, 15-20% less iodine is utilized. In CT angiography, Dr. Sahani believes they can reduce contrast media volume even further and still obtain high image quality compared to 120 kVp.

"In CTA, we have found that lower doses of contrast media can provide diagnostic image quality by exploiting a lower kVp between 70 and 100 based on the patient size. The smaller the patient, the lower the kVp," Dr. Sahani says. In patients over 300 pounds, contrast media is only reduced if their kidneys are compromised.

He adds that newer imaging technology should be expected to provide better results. "We should expect this and, as radiologists, need to transition and adapt to these benefits. At our institution, we have found that the image contrast is so much better at 100 kVp that people really appreciate it."

## Differences in Hounsfield Units

One concern often voiced by radiologists is the change in Hounsfield Units (HU) at 100 kVp and how to handle it in their diagnosis and reports. Dr. Sahani addresses this concern by pointing out HU values are only one part of the equation—he is often not comparing HU values—and in soft tissue exams there is not a significant change in the value. In cases of renal mass evaluations, the kVp is kept consistent across exams. In exams with different acquisition phases, he does not see this as an issue as there is also a difference in attenuation.

Comparing priors with current exams is where radiologists need to be cognizant of different kVp levels. "We've been using low kVp for some time, so we just caution our colleagues to look at the kVp when comparing HU values. However, they rarely make decisions based solely on absolute HU. Keep in mind that the HU may vary across different scanners, even those by the same manufacturer."

Dr. Sahani's advice is when evaluating a multiphase exam with and without contrast, be sure to use the same kVp. "With new technology, not everything is the same as before. Embrace innovation and disruptive technologies, and use common sense and training when needed."

There is no way out from low-dose imaging, whether it is ionizing radiation or contrast media, he adds. "I think we all understand that new technology presents challenges but also great opportunity. If the technology can positively impact patient care, adopt it slowly, look at the big gains and start there. Then, open it up to make full use of the advancements in technology." ■

**Reference**

1. 2017-2018 Best Hospitals. U.S. News & World Report, August, 2017. Available at: https://health.usnews.com/best-hospitals.