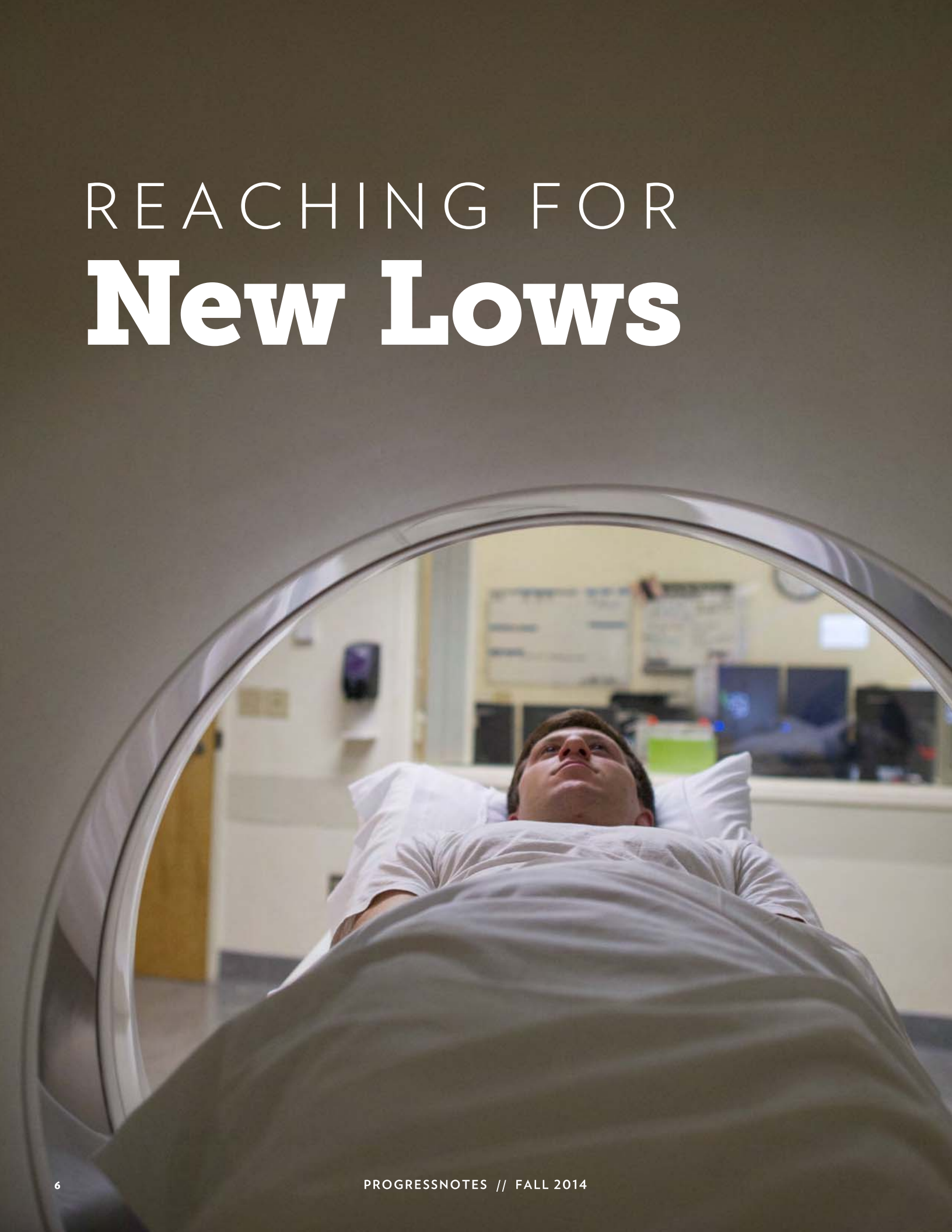
REACHING FOR
New Lows



VIDEO INTERVIEW: Dr. Schoepf describes the benefits of this new technology in the online edition (available at MUSChealth.org/pn)

MUSC collaboration with the CT imaging industry results in new scanner with lowest radiation dose yet

BY LINDY KEANE CARTER
PHOTOGRAPHY BY BRENNAN WESLEY

Since the introduction of computed tomography (CT) four decades ago, physicians have sought to balance the benefit of this unequaled diagnostic tool with its downside of radiation exposure. Now, that risk has dropped with FDA approval in May of a next-generation CT scanner that delivers the lowest radiation dose in the industry. The Somatom Force (Siemens Healthcare USA, Malvern, PA), located in MUSC's Heart and Vascular Center, is so new it is one of only three in the United States.

U. Joseph Schoepf, M.D., Professor in the Department of Radiology and Radiological Science and Director of the Division of Cardiovascular Imaging at MUSC, led the clinical evaluation of the new technology. "This scanner, because of its massively increased tube power, enables us to use very low-energy X-rays and photons, the lowest possible to date," Schoepf says. "There is no other system on the market that can image with an X-ray energy of 70kV. Compared to what was required previously in terms of radiation exposure and contrast media, this is a warm breeze of a test."

Diagnosticians can now embrace the benefits of 4-D imaging of organs and the tiniest anatomical structures with less worry about radiation exposure because the Force delivers a dose that is, for certain examinations, considerably lower than that delivered by previous CT systems.

The advances of this technology over earlier technology include:

- More powerful Vectron X-ray tubes that produce higher currents at lower voltages (70 – 150 kV in increments of 10 kV). The lower kV settings produce clearer images with less "noise."
- Two detectors that are bigger than those in Siemens' previous high-end scanner (the Somatom Definition Flash), increasing coverage to 2 x 96 rows (2 x 192 slices) and allowing for a perfusion range of up to 22 cm, thus enabling the imaging of blood flow through entire organs—for example, the brain or the heart.
- A faster table. The Force table has a speed of 737 mL per second and can provide a field of view of up to 50 cm at Flash speed coverage. A body scan can be completed in two to three seconds.
- Higher rotation speed of the scanner gantry, which produces a faster "shutter speed." Thus, the Force is particularly well-suited for capturing crisp and clear images of the beating heart and coronary arteries. It can complete an entire study of the heart within a quarter of a heartbeat.
- Two dedicated spectral filters that optimize the X-ray spectrum as it relates to air-to-soft tissue contrast, which is helpful when imaging the lung or colon.

Schoepf, an internationally renowned expert in cardiovascular imaging, supervised the Force's clinical testing in early 2013 at MUSC. He and his colleagues continue to conduct numerous studies of the efficacy of this third-generation technology and have published widely on the topic.

In one article that reported on a study of contrast medium volume, the researchers validated that CT of heart vessels at 70 kV results in robust image quality for studying the narrowing and blockage of arteries at significantly reduced radiation dose (0.44 mSv) and contrast medium volume (45 ml).[1] In another study, they found that the Force's enhanced ability to analyze the X-ray spectrum enables better tissue characterization of the liver, resulting in improved early detection of liver cancer and metastasis.[2]

Schoepf's relationship with Siemens goes back to 1998 when he worked with that company to develop the first mechanical CT scanner for heart imaging. In 2004, he and **Philip Costello, M.D., FACR,** Chair of the Department of Radiology and Radiological Science, who also worked with Siemens in Boston, arrived at MUSC. They continued to develop every major iteration of CT scanners: the first 16-slice scanner, the first 64-slice scanner, and the first dual-source CT scanner, which advanced through the three iterations. The Somatom Force is the last of these.

Advantages for Patients

For decades, Americans have been receiving increasing doses of ionizing radiation. Between 1980 and 2006, the annual per-capita radiation dose in the U. S. from medical procedures increased 600%.[3] Previously, the sources were natural background, nuclear, occupational, and consumer products.

Lower-radiation, faster CT technology benefits all patients, but in particular the following:

Young patients and children. Because the tissues of their bodies are still developing or turning over faster, younger individuals are more vulnerable to radiation. A 2012 article in *The Lancet* reported that multiple use of CT scans in children can nearly triple the risk of leukemia and brain cancer.[4]

Patients who require frequent surveillance with CT scans. At MUSC's Heart and Vascular Clinic, many patients are monitored periodically via CT scans for progression or resolution of various disorders, for example Marfan's Syndrome (scanned annually) or other aortic pathologies. The Force drastically reduces their cumulative dose.

Obese patients. There is an overwhelming need for adequate diagnostic and treatment tools that are scaled for the obese. In the past, these patients were a challenge during CT scans because either an excessive radiation dose was necessary to generate sufficient penetration power, or the images were poor and of little diagnostic value because of insufficient photons. The Force has sufficient power to bestow the benefits of low tube voltage and low-radiation-dose techniques even upon obese patients.

Patients who are unable to hold their breath. The capability to scan a trauma victim, a critically ill patient, or an intubated person in less than one second produces images with fewer respiratory motion artifacts that make accurate diagnosis difficult.

Patients with impaired kidney function. By producing low-energy X-rays and the resulting weaker photons that are more readily absorbed by iodine contrast medium, the Force provides scans of higher attenuation and higher iodine contrast. Therefore, radiologists can use less contrast dye. "The weaker the photons we use," says Schoepf, "the higher the signal we get from the dye that we inject for studies. That means we can reduce the volume from the usual 100-150 ml to between 30 and 50 ml."

Patients on the brink of congestive heart failure. Any reduction of contrast medium used during vascular studies on these patients is beneficial, as the injection of dye can trigger volume overload.

MUSC as a Productive Proving Ground

Why was MUSC chosen as one of only three U. S. locations for installing this ground-breaking technology, the others being the Mayo Clinic in Rochester, MN and the National Institutes of Health in Bethesda, MD?

"We lead the country in imaging innovation," explains Costello.

MUSC's radiology department benefits from strong collaborative relationships with other departments, says Costello, particularly with cardiology, pediatric cardiology, vascular medicine, vascular surgery, emergency medicine, and cardiothoracic surgery. Because of this, the clinicians are able to develop innovations more rapidly. The department is highly productive in producing publications and presentations that demonstrate the clinical utility of these innovations, resulting in high visibility. Furthermore, Costello feels that the department's support staff is engaged and supportive. "We have a well-trained and interested group of technologists who help us with these innovations," he says. "They are willing to learn the technology and software that makes it happen. So, the whole environment is positive."

"Overall, this is a safer, gentler way of imaging our patients from a radiation perspective as well as a contrast media dye perspective." — Dr. U. Joseph Schoepf

Dr. Joseph Schoepf has contributed to the development of three generations of CT scanners.

The innovative spirit of MUSC's imaging programs is internationally recognized as well, says Schoepf. "Physicians from all over the globe come here to get trained in advanced imaging methods and perform research in cutting-edge non-invasive, diagnostic applications," he notes. In addition, MUSC has become an important training ground for many U. S. physicians who seek to update their qualifications and obtain credentials in some of the more advanced imaging techniques.

"Our biggest goal with an industry relationship," says Costello, "is to introduce new technology that advances patient care by providing accurate diagnostic tests that decrease invasive procedures and shorten hospitalization times. We have the opportunity to bring into our institution devices or equipment that eventually will be introduced in a broader market, but the central benefit is to prove feasibility and enhance clinical utility at the same time."

One of the markers of medicine's vigilance about radiation exposure is the Joint Commission's mandate that CT radiation doses must be documented in a patient's medical record. With the increasing scrutiny of cumulative dosage, it is clear that industry and academic medicine must continue to work together to refine technology to achieve the safest possible patient outcomes.

References

[1] Meyer M, Haubenreisser H, Schoepf UJ, et al. Closing in on the K edge: Coronary CT angiography at 100, 80, and 70 kV—initial comparison of a second- versus a third-generation dual-source CT system. *Radiology* 2014; 140244.

[2] De Cecco CN, Spearman J, Schoepf UJ, Canstein C, et al. Value of an advanced image-based technique to calculate virtual monoenergetic CT images using third-generation dual-energy dual-source CT to improve contrast-to-noise ratio in liver examinations (abstract). Radiological Society of North America Annual Meeting 2014.

[3] Mettler FA Jr, Bhargavan M, Faulkner et al. Radiologic and nuclear medicine studies in the United States and worldwide: frequency, radiation dose, and comparison with other radiation sources—1950-2007. *Radiology 2009*; 253(2):520-31.

[4] Pearce M, Salotti, J, Little M. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. *The Lancet,* August 2012; 380(9840):499-505.