CT put to the Test

CT units from various manufacturers were recently put through practical tests at the German Heart Center in Munich in order to determine radiation exposure levels for patients during everyday operations. The results indicate that applied doses depend not only on the specific device, but are also significantly influenced by the operator. The study further shows that Siemens has developed particularly efficient radiation-saving equipment.

By Tim Schröder

Computed Tomography (CT) has established itself in the past few years as a non-invasive procedure for obtaining medical imagery. With every new product generation, manufacturers have paid considerable attention to reducing the levels of radiation to which patients are exposed. Never the less, the question of dose is becoming increasingly important as CT-technology becomes more widespread. Not only the technical data provided by manufacturers is of interest, but especially the actual radiation doses to which patients are exposed during treatment. To this end, the German Heart Center in Munich, in cooperation with the American Mayo Clinics in Rochester and Jacksonville, and the Friedrich-Alexander University in Erlangen-Nuremberg,

"It's clear to see that Siemens has quite evidently developed a very radiation-saving system."

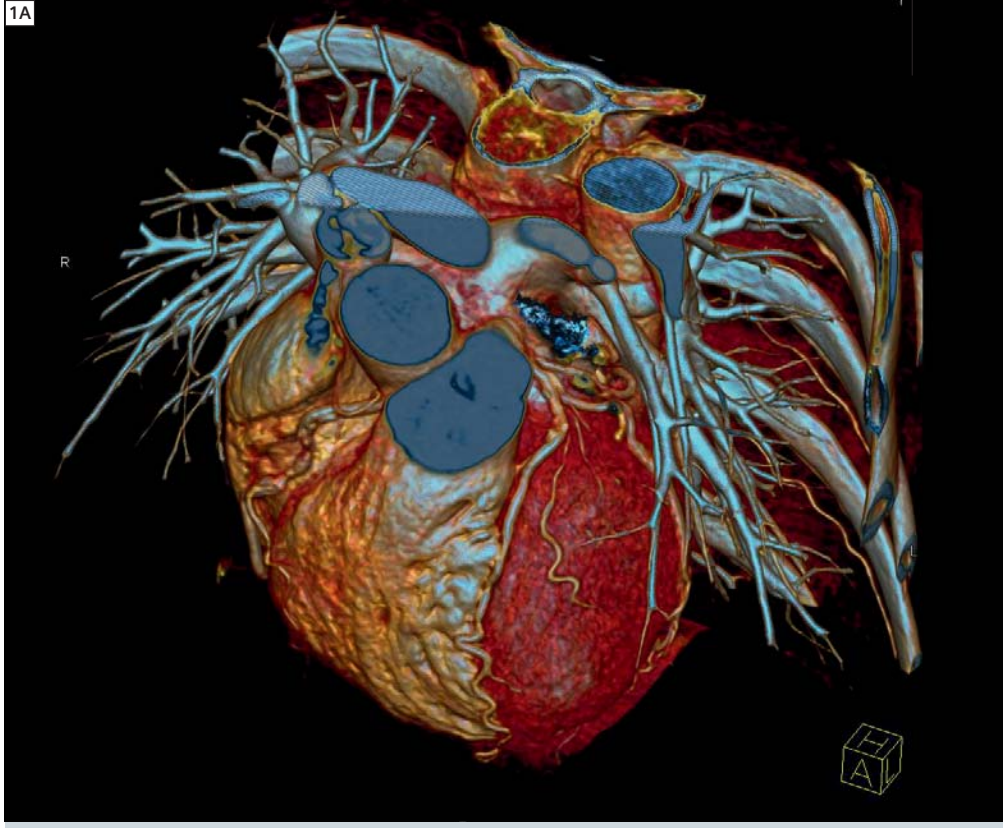
Jörg Hausleiter, MD, Cardiologist, associated Professor of Medicine, German Heart Center Munich, Germany

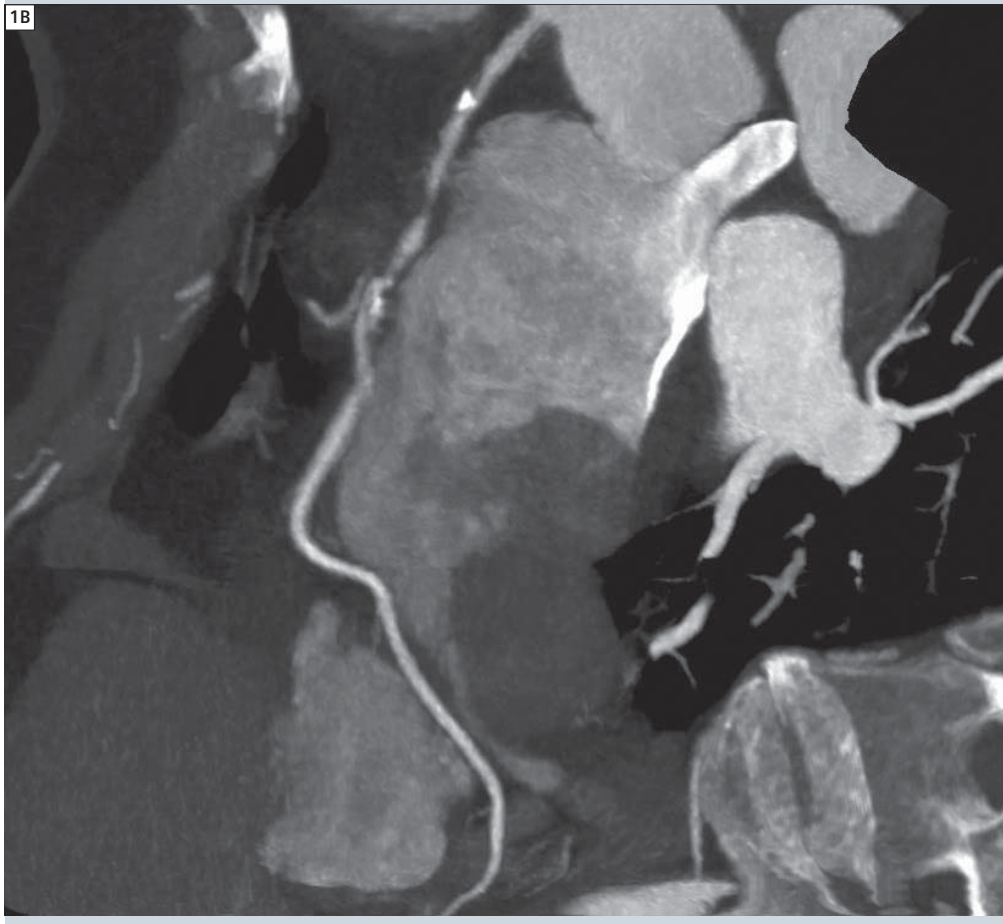
Germany, conducted an International Prospective Multicenter Study on Radiation Dose Estimates of Cardiac CT-Angiography in Daily Practice (PROTECTION-I). The study compared five CT units from four different manufacturers. The basis of the study was 1,965 cardiac CT scans that were carried out in a total of 50 clinics and heart centers. The study showed clear differences in radiation doses depending upon both the CT system manufacturer and the behavior of the operator. The study especially underlines that radiation can be significantly reduced by more consistently using already existing technologies for dose reduction in CT systems.

"Until now the only information available for evaluating individual devices has been to use systematic phantom measurements or physical readings provided by the manufacturers," said Jörg Hausleiter, cardiologist and associate professor of medicine, German Heart Center in Munich. "Conversely, the new study delivers, for the first time, data obtained from individual patients, including abundant patient data such as size and weight."

As was shown, the radiation dose varies considerably, by as much as a factor of six. Hausleiter: "An emphasis of our work was to test the effectiveness of the different software tools for reducing radiation." This included the so-called " Automatic Exposure Control," which automatically adjusts the CT radiation intensity to the anatomy of the patient. Generally more radiation must be used when conducting tests of larger bodies. The Automatic Exposure Control is already well established for noncardiac scanning, but it was not specifically developed for cardiac CTs. All of the devices tested were equipped with it.

"ECG-Pulsing" is also implemented in all devices. This synchronizes CT radiation to the ECG, so that the image is recorded during the late diastolic phase, when the heart is not moving. It is only at this time that the apparatus increases the radiation intensity to the necessary high level. During the in-between phases, X-ray emission is kept to a minimum. Additionally, Hausleiter's team researched the influence of the 100 kV Scan Protocol.





1 49-year-old patient, former smoker with high cholesterol, who repeatedly developed symptoms of dyspnea in combination with a difficult to adjust hypertension. SOMATOM Definition with Adaptive Cardio Sequence revealed with a quick 1.8 mSv low dose cardiac examination a high grade lesion in the right coronary artery. The patient was transferred from CT directly to the cath lab for a percutaneous intervention.

This protocol is not integrated by all manufacturers, but is available, for example, with the Siemens systems. Until now, it was unclear as to how much of a reduction of dose came with the 100 kV technology in comparison to the conventional 120 kV protocol. As a further tool, the researchers evaluated the so-called, step-and-shoot method. In contrast to Spiral-Scan, this procedure does not expose the entire heart area to radiation through the entire test. Once again, thanks to synchronization with the ECG, exposure is limited to the diastolic phase. Then the CT device moves the patient forward so that the next heart segment can be examined. At the time the study was enrolling patients, this low dose scan mode was only available in a preliminary research version at selected Dual Source Computed Tomograph (DSCT) SOMATOM Definition sites. Thus, this mode had been used infrequently on DSCT systems in PROTECTION I and patients could not benefit from the tremendous dose saving potential of the system at that time. However, shortly after the publication of the study, the Siemens proprietary step-and-shoot mode, "Adaptive Cardio Sequence," and the software upgrade *syngo* 2008G has become available for all DSCT customers.

100 kV Tube Reduces Dose by Half

Hausleiter primarily noted during the analysis of the data how often the individual software solutions were implemented. It became evident that the established Automatic Exposure Control was employed in more than a third of all cases, but, ultimately, hardly contributed at all to dose reduction. ECG-Pulsing was employed in 78.7 percent of the cases and reduced the dose by about 20 percent. This is minor though, in comparison to the effect of the 100 kV tube that reduced dose by half – while providing the same image quality in adequately selected, non-obese patients. However, this technology has so far been used in only 5.8 percent of all cases. "When testing patients, physicians want to be secure and are afraid that by using the 100 kV mode the image quality will be inadequate for confident findings," said Haus-leiter. The situation is similar with the step-and-shoot technology. In comparison to the spiral-scan, this method reduces the dose by 68 percent, but so far has only been used in 6.2 percent of all cases. According to Hausleiter, the multivariate analysis of the PROTECTION-I study does not permit a direct comparison of devices, since operator behavior has an influence. However, the Siemens 64-slice scanner was associated with the lowest radiation dose in cardiac CT-Angiography and served as the reference value for assessing the other systems. Close behind, in third place, was the DSCT SOMATOM Definition. Despite this, in comparable clinical situations in the study, the average radiation dose of the DSCT SOMATOM Definition was considerably lower than that of the competing scanners ranked in fourth and fifth place. "It's clear to see that Siemens has quite evidently developed a very radiation-saving system," said Hausleiter. The multivariate data additionally allows another interpretation: satisfactory dose values were only attained in the PROTECTION-I study when the radiation reduction software was frequently employed. "Based on the available results we can conclude that Siemens evidently belongs to those manufacturers, that provide especially good systems training for their customers, so that operators can take advantage of the total radiation reduction potential of the device."

Dual Source-Scanner Unique Worldwide

Thomas Flohr, head developer of the SOMATOM Definition Dual Source CT at Siemens Healthcare in Forchheim, Germany, believes that, "the DSCT would have performed even better if it had already been equipped with current, improved version of the step-and-shoot technology during the study." At any rate, the Dual Source scanner is worldwide the only CT equipped with two X-ray tubes and two detectors, that are connected to one another at an angle of 90 degrees. This means that the heart is simultaneously scanned from two different angles. With a gantry rotation speed of only 0.33 seconds, one achieves a temporal resolution of 83 milliseconds – so quick that sharp images are possible from even rapidly beating hearts. Despite having two X-ray sources, the total dose is less than that of conventional single source devices, thanks to the extremely short exposure time.

"In discussions about radiation reductions, one should not get carried away," said Hausleiter. "To date, the level of radiation of cardiac CT-Angiography is very comparable with other diagnostic CT studies, such as multiphase abdominal and pelvic CTs, which we perform in daily routine without worrying so much about radiation exposure." Naturally, Hausleiter knows that, despite this, caution is required, especially when testing children and youths. "To this extent, it makes sense that manufacturers continue to reduce the dose. Though particularly in applications such as cardiac CT, the advantages of the method and the superior image quality weighs much more positively than any possible radiation risks."

Immense Potential

Hausleiter is currently advancing the follow-up studies, PROTECTION-II and PROTECTION-III. PROTECTION-II systematically compares the image quality when using 100 and 120 kV tubes. PROTECTION-III studies the influence of step-and-shoot technology in the same way. At the end, Hausleiter wants to provide physicians with clear suggestions, with which the technologies can be used without any loss of image quality – up to approximate body volumes or weights. The goal is clear: In the future, radiologists and cardiologists should be less hesitant to use the technologies. Hausleiter: "Nevertheless, the potential is immense. Until now with conventional CT technology the average radiation dose during a CT test was in the average 13 to 15 mSv. By consistently using dose reduction tools, today we can already achieve an average of less than 3 mSv."

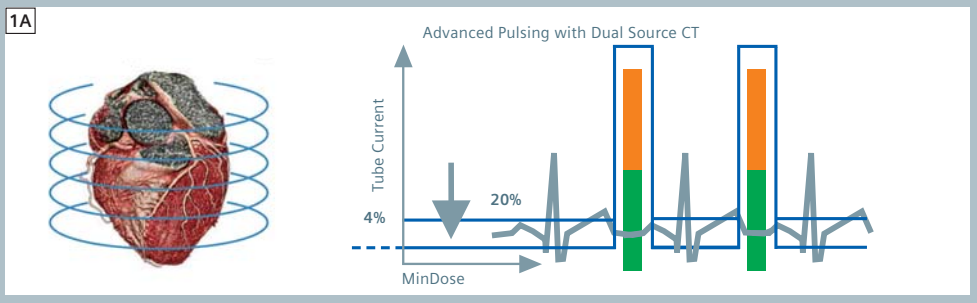
Tim Schröder *is a biologist and former editor of the science section of the Berliner Zeitung. He is now a freelance writer in Oldenburg, Germany, and publishes regularly in scientific journals such as the german edition of Scientific American, Max-Planck-research and Fraunhofer-Magazin.*

Siemens benchmarks in low dose

Three of Siemens' latest and most effective dose saving features – and with the SOMATOM Definition Flash the further development in dose reduction technology continuously proceeds (see Cover Story).

MinDose: – 30% dose compared to conventional ECG-Spiral dose

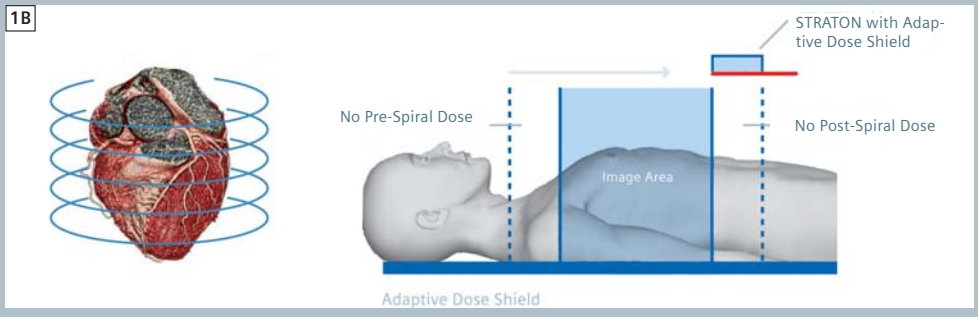
1A



1A Spiral Acquisition: MinDose reduces the tube current from 20% to 4% during the systolic phase of an RR interval to lower the dose to the patient leading to a dose reduction of about 30%. In combination with reduced tube current of 100 kV dose levels of 3.9 mSv can be achieved in routine clinical use.

Adaptive Dose Shield: – 25% dose for spiral acquisition

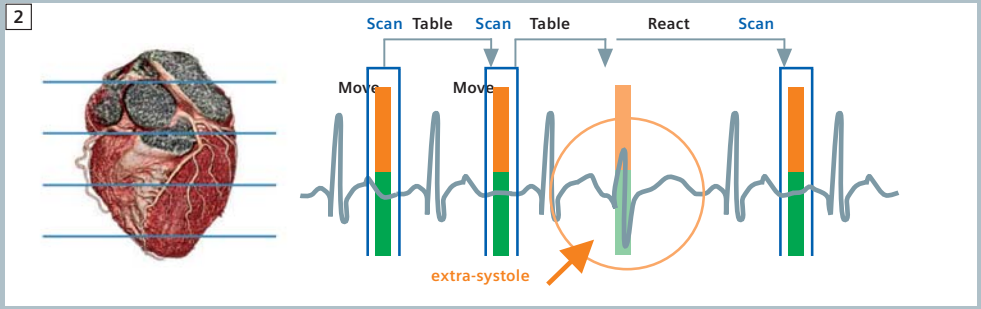
1B



1B Adaptive Dose Shield: The SOMATOM Definition AS is the first commercially available CT-scanner that addresses the problem of over-radiation with a dynamic collimation technique reducing spiral over-radiation up to 25% for a heart scan.

Adaptive Cardio Sequence: – 68% dose compared to conventional ECG-Spiral dose

2



2 Conventional Step & Shoot is vulnerable for extrasystolic heart beats. Adaptive Cardio Sequence, with arrhythmia compensation enables the system to react on extra systoles. In clinical routine, dose levels of 1.2 – 2.6 mSv can be reliably achieved.