SIEMENS

SOMATOM Sessions

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Pushing Boundaries – a Decade of DSCT

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“With dual source technology, it was feasible for the very first time to move from ‘there’s something here’ to ‘what is it then?’.”

Professor Konstantin Nikolaou, MD,
Director of the Department of Diagnostic and Interventional Radiology,
University Hospital Tübingen, Germany

Cover page:
Courtesy of University Hospital Tübingen, Germany (p. 9)

Dear Readers,

Undoubtedly, 2015 has been a very special year for us at Siemens and for CT users around the world. Together, we celebrated the 40th anniversary of Computed Tomography, as many of you may remember that back in 1975, Siemens produced the first ever CT scanner for commercial use.

The year 2015 also marks a decade of Dual Source CT, a concept so fundamentally sound that it has demonstrated clear superiority over other competing technological approaches designs. Around the world, with over 1,500 installations of Dual Source CT, users experience consistent excellence in imaging every day – giving clinicians greater confidence so that they can improve patient outcomes. In the title story, Professor Konstantin Nikolaou, MD, shares his personal experience of this technology. In answer to our question as to where DSCT is routinely used today, he explains: “If you have the scanner, then the answer is everywhere”. This sums up the essence of what we constantly strive for at Siemens: We want to deliver solutions that are not just occasionally relevant, but rather enable users to experience excellence every day with every patient.

In the article ‘Back to the Future’, Professor Thomas Flohr, one of Siemens´ key architects of the unique Dual Source CT concept and design, gives a fascinating account of how it all started and how they made a dream into a reality.

Professor Thomas Voigtländer, MD, and Professor Axel Schmermund, MD, from CCB Frankfurt share their personal understanding of their business concept. Not only were they confident about the unique capabilities of SOMATOM Force, they were also clear as to how this would positively impact patient management and outcomes – both clinically and financially in an interdisciplinary setting. Elsewhere, from Down Under, Debbie Watson and Gillian Long, MD, share their exciting experience of using SOMATOM Force in the field of pediatric care.

On a very different topic, we bring you an interview with Denise Aberle, MD, UCLA Medical Center. Aberle was one of the principal investigators on the U.S. National Lung Screening Trial (NLST). With conviction and commitment, the NLST team conducted a conclusive study involving 53,000 subjects and a follow-up study lasting over 10 years. Thanks to their persistent efforts, they were able to prove beyond doubt that CT-based lung screening[1] enables clinicians to reduce mortality by up to 20 percent. This will have a profound impact on the population and should contribute to the goal of improving early detection and achieving better quality of life. It is worth governments and policymakers around the world taking a closer look at this U.S. model.

About two years ago, we wanted to bring an affordable solution to those who wanted a reliable dual energy capability but could not afford a Dual Source CT. We have already introduced TwinBeam Dual Energy in previous editions. While the range of possibilities with this technology is somewhat limited compared with a Dual Source CT solution, it still offers many clinically relevant and effective capabilities. Sebastian Schindera, MD, from University Hospital of Basel – which was one of our early collaboration sites – shares his experience in the article entitled ‘Exceeding Expectations’.

The journey that we began together 40 years ago in the pursuit of better human health will progress for many more decades. We will continue to focus on providing you with the most innovative solutions that will enable you to constantly improve clinical outcomes and at the same time reduce the overall cost burden of healthcare to society.

I wish you an enjoyable read and warm greetings of the season,

Raghavan Dhandapany,
Vice President CT Marketing and Sales

[1] Under FDA review. Not available for sale in the U.S.

The statements by Siemens’ customers described herein are based on results that were achieved in the customer’s unique setting. Since there is no “typical” hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption), there can be no guarantee that other customers will achieve the same results.

December 2015

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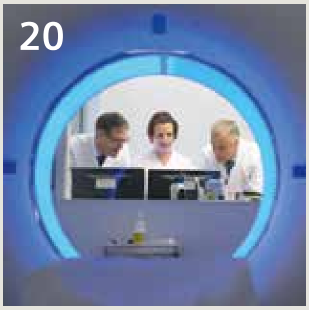
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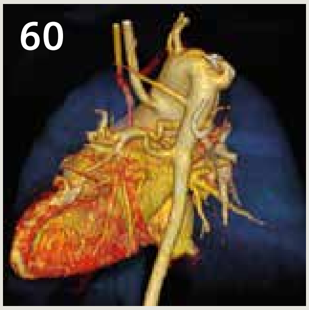
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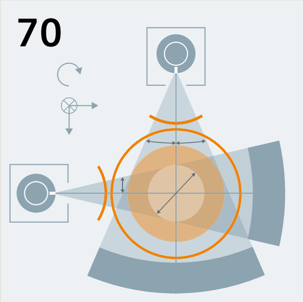
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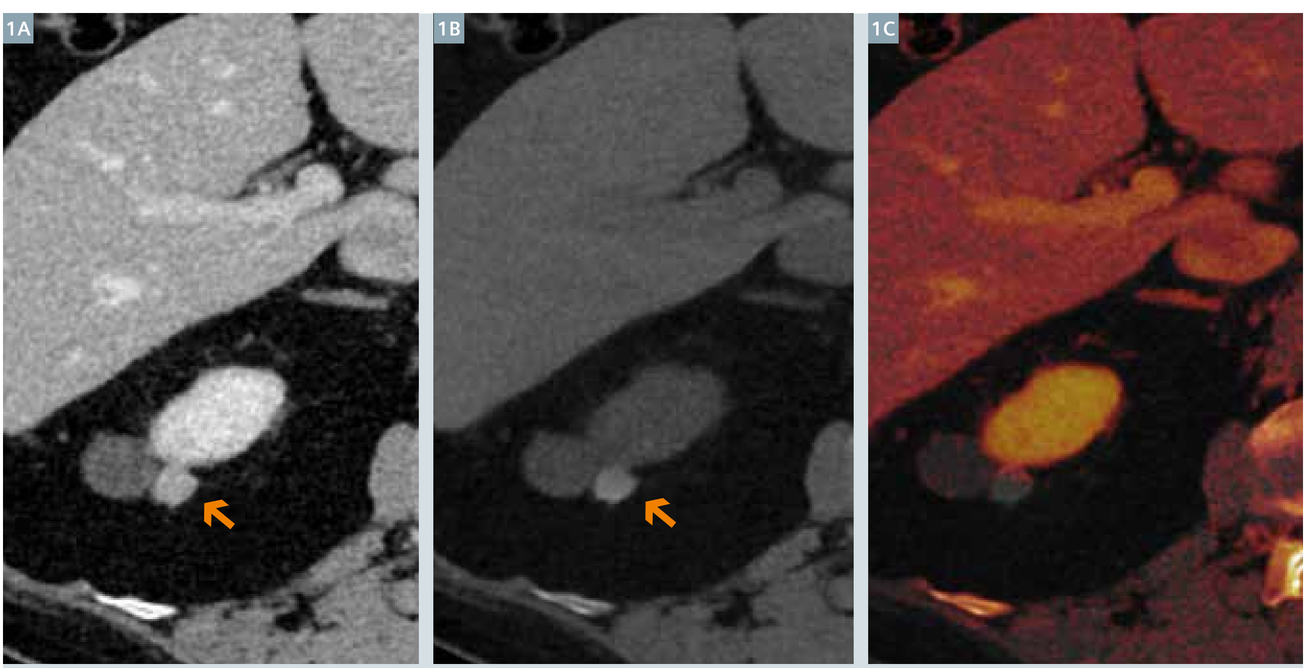
Pushing Boundaries – a Decade of DSCT

Dual source technology has revolutionized the status of computed tomography imaging in clinical routine. Today, ultra fast cardiac imaging with even less than one millisievert is standard. CT is aspiring to provide new imaging biomarkers, and with the SOMATOM Force, scans can now be personalized.

Text: **Hildegard Kaulen, PhD,** Photos: **Detlef Schneider**

The history of CT is characterized by a series of quantum leaps. It all began 40 years ago with sequential technology that produced layered images of the human anatomy. This was followed in 1989 by spiral CT, which enabled the visualization of entire organs in just one breath-hold. In the nineties, multislice CT created a stir with its three-dimensional images. Isotropic resolution made heart CT scans and CT angiography possible. Ten years ago, dual source (DS) technology brought a further quantum leap: Two tubes, two detectors, a temporal resolution of 83 ms, and the capacity to run both X-ray tubes at different energy levels paved the way for ultra fast cardiac imaging and spectral diagnostics. “Suddenly, it was possible to display a beating heart with consistent image quality even at higher and irregular heart rates. This was sensational,” says Professor Konstantin Nikolaou, MD, on the introduction of DSCT a decade ago. “Until then, imaging of the coronary arteries was not sufficiently robust, reliable, or consistent, for full implementation in clinical routine. At that time, a heart CT scan was not really considered to be a viable alternative to a diagnostic heart cath examination.”



1 A 48-year-old male patient with stage IV malignant melanoma underwent oncological whole-body dual energy CT staging in portal venous phase. A 1.3 cm hyperdense lesion in the upper pole of the right kidney was detected on reading (Fig. 1A, arrow). Dual energy based post-processing revealed hyperdensity in the virtual non-enhanced image (Fig. 1B, arrow) and no contrast enhancement in the iodine map (Fig. 1C). Thus, the lesion was classified as a hemorrhagic cyst, which was confirmed in subsequent follow-up examination.
Courtesy of University Hospital Tübingen, Germany

Ten years ago, dual source technology brought a quantum leap in temporal resolution, and the capacity to run two X-ray tubes at different energy levels. This paved the way for spectral diagnostics and ultra fast cardiac imaging. Professor Konstantin Nikolaou was one of the first DSCT users.

Nikolaou became Director of the Department of Diagnostic and Interventional Radiology at the University Hospital Tübingen in Germany, last year. Prior to this, he spent fifteen years at the Institute of Radiology at Ludwig-Maximilians-Universität (LMU) in Munich in various positions, rising to become vice chair of the department. Today, a quarter of all examinations performed in his department are CT scans. Nikolaou was one of the Dual Source CT pioneers. "With DS technology, it became possible to use radiation from two X-ray energy spectra and then differentiate pixels according to their respective absorption levels. Moving on from pure attenuation imaging, we now had the ability to identify material characteristics, as well," comments the radiologist on the potential of dual energy (DE) protocols. In 2005, it was feasible for the very first time to move from "there's something here" to "what is it then?".

DSCT may offer an alternative to diagnostic cardiac catheterization

From the end of the nineties, Nikolaou became involved in cardiac imaging. The temporal resolution of single source CT systems was not sufficient at the time to produce reliable views of the coronary arteries, which are just a few millimeters in diameter and can also move up to ten centimeters per second. "DSCT cut the temporal resolution by half and suddenly achieved an acquisition time of 83 ms. It was revolutionary. We could then seriously begin to look for stenoses or calcifications using heart CT and consider it as an alternative to a heart cath in a clinical routine setting," says Nikolaou. "Thanks to the high temporal resolution of the scan, it was also no longer necessary to reduce the heart rate in each case with artificial and time-consuming use of beta-blockers[1]."

DE protocols also delivered relevant additional information for the first time without the need for extra contrast medium or a higher radiation dose. The iodine content of the contrast-enhanced scan and bones could be excluded automatically and accurately from the volume dataset – even in difficult places such as the skull base or where the bones lie closely adjacent to the vessels. Nikolaou uses automatic bone subtraction during peripheral pelvic-leg angiography, for example, and a comparison of contrast-enhanced scans and virtual non contrast-enhanced scans in cases of unclear lesions. "Let me give you an example from clinical practice," says the radiologist. "A lesion is visible on a contrast-enhanced scan of the kidneys that does not look like a typical cyst. In order to determine whether this is a suspicious tumor, we need to see whether or not the tissue has absorbed iodine. With DSCT, this can be done quite simply by comparing the contrast-enhanced with the virtual non contrast-enhanced scan. Previously, when we just had single source CT, we would have had to perform two scans, one with and one without contrast medium. These wouldn't have been perfectly registered either, and the patient would have been burdened with an increased radiation dose."

The DE protocols also provide critical additional information in the diagnosis of lung embolisms. A thrombus can affect the pulmonary circulation in very different ways. With DS technology, it was possible for the first time to give the patient a bolus of contrast agent and produce a static image of iodine distribution in the lungs. "Although the static image does not allow us to quantify perfusion in the same way as a time-resolved perfusion examination," says Nikolaou, "you can still evaluate the perfusion defect caused by the thrombus. We were able to show that the right ventricular enlargement correlated well with the disturbed perfusion on the DE maps in patients suffering a pulmonary embolism. This could be used for a personalized treatment approach, for example by applying different strengths or types of anti-coagulants, depending on the extent of the perfusion defect." Initial concerns that the two tubes would involve double the dose proved to be unfounded. "Since neither X-ray tube delivers a complete diagnostic image but rather two half volume datasets that are then compiled to form one image, these scans were dose neutral, for example as compared with a conventional 120 kV scan," says Nikolaou.

Initially, there were still technical limitations: Separation between the two X-ray spectra was not particularly effective, which continued to restrict the applications of dual energy; also, the detector in the second tube – known as the B detector – had a limited field of view (FoV) of just 26 cm. "For heart imaging, this was sufficient," explains Nikolaou, "It did, however, prove difficult when scanning the kidneys or the thorax and abdomen, for example." If the patient was very big, it was possible that only the spectral information from the A detector was visible at the edges, with no information from the B detector. "So for a kidney scan, we needed to position the patient in such a way as to be certain that the kidney that we wanted to see, was definitely at the center of the FoV," explains the radiologist.

"With introducing dual source technology, it suddenly was possible to display a beating heart with consistent image quality even at higher and irregular heart rates. This was sensational."

Professor Konstantin Nikolaou, MD, Director of the Department of Diagnostic and Interventional Radiology, University Hospital Tübingen, Germany

Fast scanning without breath-hold

In 2008, Siemens launched SOMATOM Definition Flash – a name that was chosen because it moves the patient through the tube in high-pitch mode. The scan speed reaches up to 45 cm per second and the temporal resolution was reduced to 75 ms. Due to the larger B detector, the FoV is now extended to 33 cm. With SOMATOM Definition Flash, the thorax of an adult can be scanned in 0.6 seconds and a child's thorax in 0.4 to 0.5 seconds. A whole-body scan of an adult takes just 3-5 seconds. Motion artifacts no longer play a significant role thanks to the fast scan speeds. Breath-hold is also no longer required in some patients. This enables the scanning of patients who are not fully able to cooperate due to their particular illness, age or injuries, while improving the workflow.

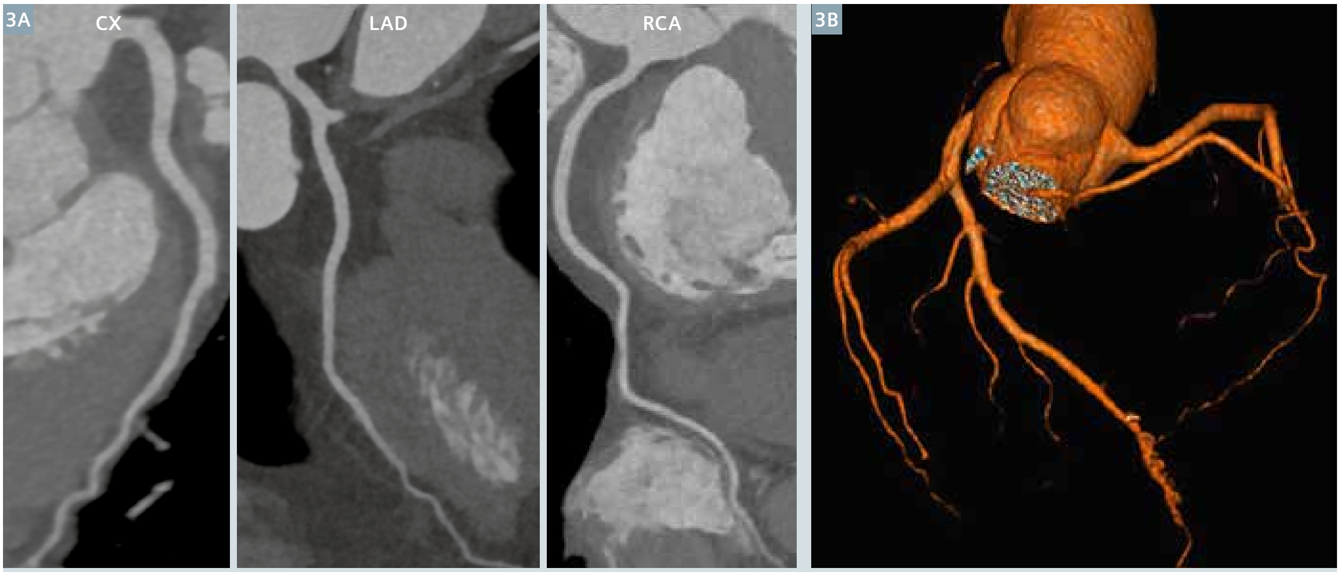
High-pitch Flash mode speeded up heart imaging even further. Whereas three to four diastoles are required for full volume coverage with SOMATOM Definition, as only a section of the heart is scanned during each diastole, just one diastole is necessary in Flash mode. With SOMATOM Definition Flash, no part of the heart is acquired twice. This way, an effective dose as low as 1 mSv can be achieved. This is less than the radiation dose required for an optimized Definition scan of around 2 mSv. "Flash mode changed the whole landscape once again," says Nikolaou. "Take the example of triple rule-out scan: A patient is admitted to the emergency room with pain in the thorax. This pain could be caused by a lung embolism, an aortic dissection, or a coronary stenosis. Previously, or with other single source CT systems, this examination would have taken or even still takes up to 15 seconds, at a radiation dose of up to 20 mSv. Using Flash mode, a triple rule-out scan lasts 0.7 seconds at a dose of below 5 mSv. Thus, for this particular scan type, the scan speed has increased dramatically and the applied radiation dose has been reduced."

Flash mode also helps reduce the need for potentially harmful sedation[2] when scanning children because motion artifacts are significantly reduced. This saves considerable time and valuable resources in preparing for the scan. Depending on their body size, children are scanned in one to two seconds and with less than 1 mSv. "The CT indications for children are strictly limited," says Nikolaou. "But there are times when we can't avoid doing a CT scan, for instance in trauma cases, in situations where children cannot tolerate a long period of sedation, or for example in post-surgical or complex cardiac cases. For this young age group, the lower the dose, the easier it is to decide in favor of performing a CT scan, if needed."

Additional information on tumor perfusion

In SOMATOM Definition Flash, a tin filter is used to more effectively separate the two X-ray spectra, leading to improved contrast. This allows an even better characterization of the microenvironment of a lesion. Subtle differences of tumor morphology and function are crucial in oncology, and this is where dual energy quantification is considered by researches to play a role that supports "image-guided therapy". Nikolaou, whose second clinical specialty beside cardiovascular imaging is oncological diagnostics, scans all cancer patients using dual energy protocols. "We do this because the scan is dose neutral, and we still get the full extent of additional information on tumor characteristics or treatment response at the same time," explains Nikolaou. "Let me give another clinical example to explain what I mean," he says: "Previously, we knew the stage, density value, and size of the tumor. We were able to say whether the tumor had

2 A 35-year-old female patient suffering from dyspnea was admitted. CT images showed a large aortic aneurysm originated between the left common carotid artery and the subclavian artery, compressing the left pulmonary artery.
Courtesy of University Hospital Tübingen, Germany



3 A 47-year-old male patient presented himself to the emergency room complaining of an atypical chest pain. A low dose (0.8 mSv), high-pitch (3.2), prospective ECG-gated cardiac CT scan was performed with 60 mL of iodinated contrast media. Images showed no findings of coronary plaques or anatomical abnormalities. An ACS was ruled out.
Courtesy of University Hospital Tübingen, Germany

> *"With dual source technology, it was feasible for the very first time to move from 'there's something here' to 'what is it then?'."*
>
> **Professor Konstantin Nikolaou, MD,** Director of the Department of Diagnostic and Interventional Radiology, University Hospital Tübingen, Germany

grown or shrunk with treatment, or had remained the same size – these are the classic RECIST criteria. Now, we can also evaluate the iodine uptake of a given lesion, to find out more about tumor perfusion, tumor viability, and treatment response. When an antiangiogenic inhibitor is used, for example, this will help us determine whether the therapy is effective or not. This functional information is highly important in deciding on future treatment steps."

SOMATOM Definition Flash also makes it possible to combine morphological coronary artery diagnostics and functional diagnostics of myocardial perfusion. The device has two types of heart perfusion modes: dynamic myocardial perfusion to measure quantitative perfusion values (blood flow, blood volume) from sets of images reconstructed from dynamic CT data acquired after the injection of contrast media as well as the DE heart perfusion, i.e. for the assessment of the iodine distribution. If a moderate stenosis is discovered using DSCT in a patient without high pre-test probability and with thorax pain, Nikolaou and his colleagues can now use these additional functional information from a cardiac perfusion scan, to asses the effect of a stenosis to the myocardium. This type of perfusion scan is much more difficult to perform in the heart, for instance as compared to the lungs, due to the rapid beating, and was therefore impossible until the introduction of SOMATOM Definition Flash. Scanning the heart with DE technology can offer an alternative to dynamic heart perfusion. "The iodine static image from the DE scan shows the distribution of the contrast medium in the myocardium. Although we're not measuring dynamic perfusion here, in many cases it's often enough to know where less iodine has reached the myocardium, raising suspicion of a significant coronary artery stenosis. This can make the overall diagnosis much more reliable in many cases."

Low dose

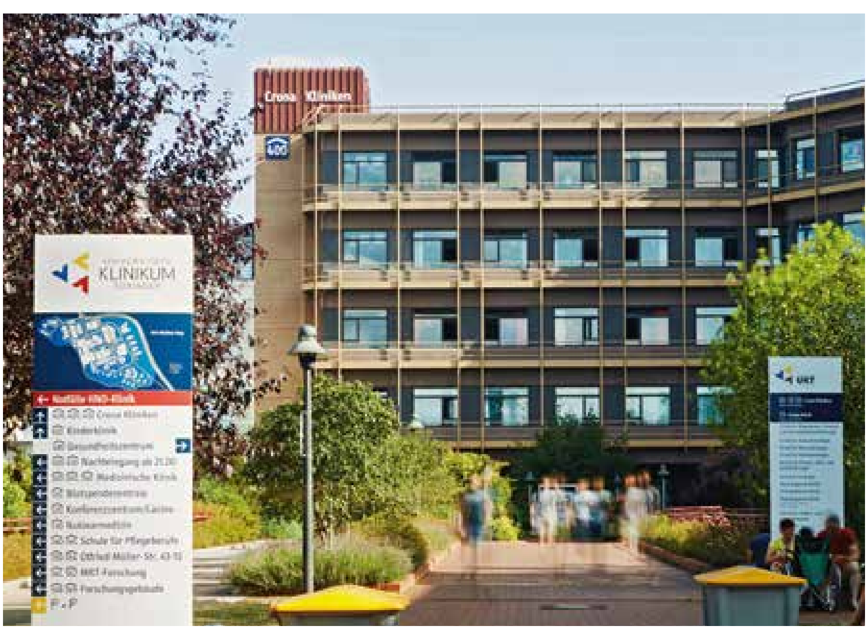
SOMATOM Force was introduced in 2013. This Dual Source CT scanner has a table speed of up to 73 cm per second – which is almost twice as fast as the Flash scanner – and the temporal resolution of the measurement system is significantly higher. A patient can now be completely scanned in 2-3 seconds, and objects of up to 0.2 mm in size can be routinely differentiated. These new speeds are achieved thanks to the 25 percent wider detector and ultra fast rotation time of 250 ms, leading to a recorded temporal resolution of up to 66 ms. Further technical advancements, such as the dual tin filter, mean that the dose required for a CT scan of the lungs, heart, or the paranasal sinuses is not higher than that for a conventional X-ray scan of the thorax. Ranging from 80 to 150 kV, the voltage levels on SOMATOM Force can be adjusted flexibly in increments of 10 kV so that the ideal level can be found for each patient and for every application. As a result, CT scanning becomes personalized, further reducing potential CT contraindications, helping to continually improve the clinical workflow and patient management. “Every patient now gets a personalized scan,” says Nikolaou. “We consider what makes sense and what is reasonable. We evaluate how much dose is required to provide answers to our particular clinical problem and then scan the patient using the appropriate standard, DE, or high pitch protocol. Depending on age, body weight, and clinical indication, we can achieve dose levels far below the standard values. We’d never have been able to scan at such low radiation doses before.”

SOMATOM Force also enables a higher proportion of low-kV examinations. This saves on contrast medium, because X-ray absorption of iodine is then particularly high. This benefits a growing group of patients at risk of chronic kidney failure – for instance, those patients who already have chronic kidney failure, diabetics, or patients with high blood pressure. “Rather than scanning with a previously typical amount of 100 to 120 mL of iodinated contrast medium, now we often give the patient only 40 mL or 50 mL of contrast. This means that the kidneys are better protected and the risk of contrast-induced nephropathy is reduced,” explains Nikolaou. “At the same time, we save on the costs of contrast medium and on the time required for the preparation and follow-up care for a patient with a risk of kidney failure.”

Routine use of dual source technology?

Given the low doses now achievable, could CT imaging play a role in population-wide early detection programs? For lung cancer screening[3], studies support its use, since the lungs have always been scanned at low doses due to the good contrast between air and soft tissue. In cases of lung cancer, it is also possible to identify at-risk groups such as long-term smokers. Nikolaou is positive about the prospects of lung CT for certain high-risk patient groups.

Where is DSCT used routinely today? “If you have the scanner, then the answer is ‘everywhere’,” says Nikolaou. “We perform heart CT in high-pitch mode, scan children at low doses, and use DE information for all oncology patients. Thanks to dose efficiency, high scan speeds, and the large FoV with the B detector, most applications have become true dual source applications. No other system offers this level of flexibility and diagnostic certainty.” Nikolaou also appreciates the fact that DSCT always delivers a reliable diagnosis even in challenging situations, such as obese patients, polytrauma cases, and when there are complex clinical questions. ■



Using the latest Dual Source CT scanner, clinicians at the Department of Diagnostic and Interventional Radiology at University Hospital Tübingen in Germany perform heart CT in high-pitch mode, scan children at low doses, and use DE information for all oncology patients.

Hildegard Kaulen, PhD, is a molecular biologist. After stints at the Rockefeller University in New York and the Harvard Medical School in Boston, she moved to the field of freelance science journalism in the mid-1990’s and contributes to numerous reputable daily newspapers and scientific journals.

[1] SOMATOM Definition Flash’s dual-source technology with a temporal resolution of 75 ms enables freezing of cardiac motion, thus allowing the scanning of patients with high and irregular heart rates. Heart scanning without beta-blockers may even become possible.

[2] The inherent temporal resolution – the “native” temporal resolution acquired by the scanner – is highly important to freeze patient motion, e.g. in lung exams or in patients who cannot hold their breath long enough. This is also important in pediatric CT where it can also help reduce the need for potentially harmful sedation.

[3] Under FDA review. Not available for sale in the U.S.

With the low kV/high mA capabilities of the VECTRON tube, SOMATOM Force allows scanning with a very high tube current of up to 1300 mA at 70, 80, and 90 kV, such that a high tube output even for these low kV settings can be achieved. Along with SOMATOM Force’s unique Turbo Flash Mode, this scan configuration is also available for conventional spiral or sequential scanning. Early clinical experience based on imaging of the left ventricle and aortic root (TAVI studies) demonstrate that a reduction of contrast media administration may be possible using SOMATOM Force’s Turbo Flash Mode and its low kV/high mA capabilities.

The statements by Siemens customers described herein are based on results that were achieved in the customer’s unique setting. Since there is no “typical” hospital and many variables exist (e.g. hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same result.

Further Information

www.siemens.com/dual-source-CT

Four Decades of Experience in Computed Tomography

Forty years ago, Siemens launched its first computer tomograph, the SIRETOM head scanner. Innovation after innovation followed. Modern computed tomography has become indispensable today in image-based diagnostics.

By Bianca Braun

Siemens Healthcare, Germany

The excitement is palpable as a new imaging procedure revolutionizes the world of medicine: computed tomography (CT). Siemens is one of the first companies to explore this technology. On December 1, 1975, the first production model of the Siemens head scanner SIRETOM is delivered to Professor Hans Hacker, MD, at Goethe University Hospital in Frankfurt am Main, Germany. After three years of development, it is ready for clinical use. CT quickly becomes the method of choice for examining brain tissue and the first whole-body CT scanners soon follow. Siemens drives the technology forward: The first heart scans are already successfully performed at the end of the 1970's. Computer tomographs are becoming faster, and the image quality is improving immensely.

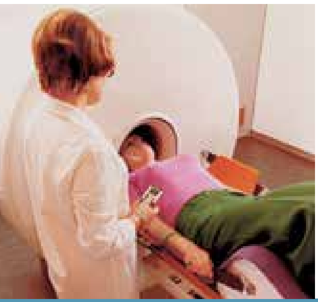
In the ten years after 1977, when Siemens launched the first whole-body scanner, the SOMATOM, the basic technology barely changed: Additional areas of application are identified and different components are optimized, but the existing technology has reached its limitations. By the mid-1980's, engineers and physicians begin questioning what the future holds for CT.

Spiral CT

The answer is spiral CT: Special slip-ring technology enables the gantry to be continually rotated. The patient is gradually moved through the scanning field, resulting in a spiral X-ray scan. Engineers introduce the world's first market-ready spiral CT in 1990. In the years that follow, developers focus on overcoming the challenges of the still young technology – operation is too complicated, installing CT systems is still a lengthy and labor-intensive process, and it takes several days for technicians to adjust the gantry. These are all aspects of CT that are improved over

1975

New insights into the brain



SIRETOM: Siemens' first CT head scanner

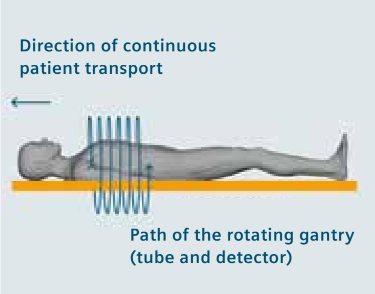
1977

From top to toe

SOMATOM: Siemens' first whole-body CT scanner

1990

An idea with momentum



Spiral CT

1997

Less is more

UFC reduces the amount of radiation

subsequent years. Siemens also launches more affordable models for hospitals and radiology practices on a smaller budget.

Fast and safe

In 1995, Siemens unveils the then fastest scanner in the world – SOMATOM Plus 4. It has a compact form and can be used for a diverse range of applications. A further innovation is added in 1997: A special solid-body detector made of a new ceramic compound material called UFC (Ultra Fast Ceramic) that reduces the radiation dose during CT scan. By the mid-1990's, diagnosis quality, user friendliness, and patient comfort have reached a level that bears no comparison with the beginnings of CT.

Multiple slices for cardiac scanning

In terms of the imaging quality and volume acquisition of individual organs, CT performance has reached its peak. That is, until multislice technology arrives – enabling the acquisition of multiple imaging layers with each gantry rotation. It is an important step toward a breakthrough in cardiac CT. Siemens' first multislice scanner is the SOMATOM Volume Zoom. In 1999, the first CT scan of coronary vessels is performed using a SOMATOM Volume Zoom at Campus Grosshadern, University Hospital in Munich, Germany, taking approximately 40 seconds. Siemens is quick to recognize the potential of this technology and actively furthers its development in the following years in cooperation with clinical partners. For example, the SOMATOM Sensation is launched in 2001 giving physicians insights into even the finest coronary side branches with a previously unseen level of clarity.

A versatile solution

From the beginning of the 2000's, CT systems also play a key role in nuclear medicine. Hybrid CT/PET or CT/SPECT systems can display metabolic processes with the precise anatomical imaging provided by CT. For therapy, too, CT increasingly proves itself indispensable as an imaging procedure in combination with radiotherapy devices.

Another important aim is to make the user interface both consistent and intuitive. Siemens' integrative user interface, *syngo*, is introduced in all of the company's imaging systems in 1999. In the subsequent years, *syngo* and software developments based on *syngo* play a significant role, including numerous CT software packages for new clinical applications, service upgrades, and for dose reduction.

Dual Source CT

From 2000 onwards, the new, powerful Straton rotating envelope X-ray tube is hugely influential in the advancement of CT. Siemens develops the world's first computer tomograph with two X-ray tubes and detectors instead of one. This concept demands a huge amount of research and development, but opens up entirely new possibilities for CT. Unique worldwide, the first Siemens CT scanner with dual source technology is launched in 2005. Siemens remains the only company to manufacture and continually advance this technology.

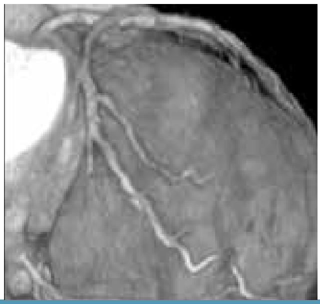
People to the fore

The patient remains the central focus: Gantries become larger, examinations faster and easier, and the dose for CT scans is constantly reduced. Siemens' most advanced high-end system, the SOMATOM Force, can scan a lung with exceptional imaging quality at a dose of only 0.1 millisievert.

The family of scanners available today is the result of cooperation with scientists and physicians across the world stretching back decades – with the aim of giving more and more people access to state-of-the-art CT technology. ■

1998

Vascular imaging becomes routine



On the path to heart CT thanks to multislice technology

2005

Twice the scanning power

DSCT sets new standards in image quality and scan speed

Today

Upper body scan in one second

SOMATOM Force with a volume coverage speed up to 737 mm/s

Tomorrow

New techniques to be evaluated

Cinematic Rendering*: Realistic depiction of CT datasets

* For research use only, not for clinical use.

An Eventful World Summit

By Ulrich Künzel,
Siemens Healthcare, Germany

A special year, a special summit: 40 years after Siemens' first computer tomograph, the SIRETOM, went into serial production in 1975, more than 300 dual source users from all over the world convened in Munich, Germany, for the 12th SOMATOM World Summit in the summer of 2015. It was an ideal opportunity to look back to a time in CT when a whole-body examination was a vision of the future, cardiac imaging was unimaginable, and when dose values below one millisievert were little more than a fantasy. And it provided time to discuss current issues as well as future trends and possibilities in computed tomography.

Dual source users from all over the world convened in Munich, Germany to share experiences.

Siemens Head of Computed Tomography and Radiation Oncology Walter Märzendorfer emphasized: "Together with our clinical research partners and customers, we have made things possible that others didn't even dare to try." He noted the most influential innovation in computed tomography of the last decade: Dual Source CT technology, which made it possible for the first time to confine the use of breath-holding and beta-blockers in many cases; not to mention the drastic reduction in dose levels. Märzendorfer is convinced the ongoing progress is making Siemens technology accessible to more and more people.

Professor Willi Kalender, PhD, Director of the Institute for Medical Physics at Friedrich-Alexander University Erlangen-Nuremberg in Germany, reflected on how computed tomography – which many considered redundant after the market success of magnetic resonance tomography in the 1980's – managed to continually find new fields of application thanks to spiral and multislice technology and to the fine-tuning of cardiac CT. He concluded that, "CT is not just thriving – CT is helping to save lives."

Where next on the path of progress? Thomas Flohr, PhD, Head of CT Physics, Application Predevelopment, and Global Clinical Collaborations at Siemens Healthcare weighed up the technical alternatives: There are still no suitable X-ray tubes for very sensitive phase-contrast CT, while the technology in photon-counting detectors is more promising. Flohr is optimistic that the direct conversion of X-rays into electrical signals will allow for imaging that is ultra-high resolution and ultra-low dose.

The summit focused on "Dual Energy," "Therapy," and "Next four decades of CT" giving participants opportunities to discuss CT applications in the various clinical disciplines.

"It's a journey that we've taken together benefiting from the interplay of medicine, science, and industry over the past 40 years," said Raghavan Dhandapany, Head of Sales and Marketing for Siemens Computed Tomography. The journey together continues. ■

The 12th SOMATOM World Summit was an ideal opportunity to look back on 40 years of Siemens CT.

40 Years of CT – a Reason to Celebrate

By Sandra Kolb, *Siemens Healthcare, Germany*

With an event at the Siemens Med-Museum in Erlangen, Germany, on July 2015, Siemens Computed Tomography celebrated their 40th anniversary – an occasion to look back and ahead. Innovations such as the world's first spiral CT, multislice CT, and, most recently, the unique Dual Source CT technology continue to drive the CT market and clinical diagnostics.

Over 80 guests with particular connections to Computed Tomography and Radiation Oncology at Siemens Healthcare, including the very first research and development engineers, as well as leading figures from the political arena, joined the Siemens Healthcare management team for a memorable evening.

Professor Willi Kalender MD, PhD, from Friedrich-Alexander University Erlangen-Nuremberg, Germany – developer of spiral CT, gave a retrospective on the last four decades in CT. Following this, Professor Michael Uder, MD, from University Hospital Erlangen, Germany – an experienced user of the current CT portfolio – described where the journey might take us in the future.

Siemens Healthcare is committed to improving healthcare in partnership with physicians and other clinicians. The aim is ongoing development over the coming decades in cooperation with experts in the field of computed tomography. ■

Further Information

www.siemens.com/CT40

40 Years of CT was celebrated at the Siemens Med-Museum in Erlangen, Germany.

SOMATOM Sessions: Print, Online, and App

By Sandra Kolb, *Siemens Healthcare, Germany*

SOMATOM Sessions is the source of the latest information from the world of Siemens CT scanning. It offers reports on innovations, customer experiences, and clinical applications in clinical fields such as neurology, cardiovascular disease, and acute care, and deals with topics such as low dose and dual energy CT scanning. In addition, readers find hands-on tips & tricks, scan protocols, and clinical cases. All in one go – online or as an app.

SOMATOM Sessions Online and the Sessions App are now available with an updated design and a new range of practical functions.

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Please visit us at: www.siemens.com/SOMATOM-Sessions or download the app. Just type in "CT Sessions" in the App Store or Google Play Store. ■

Further Information

www.siemens.com/SOMATOM-Sessions

Plug in and Go – Mobile Imaging Fills the Gap

By Monika Demuth, PhD
Siemens Healthcare, Germany

Unlike medical diagnostic equipment on a smaller scale, computer tomographs are rather heavy and hard to move. Moreover, the area around the device also has to be shielded from the X-rays that it emits. That is why CT scanners are usually installed as permanent fixtures. However, sometimes a flexible interim solution can be extremely helpful.

SOMATOM Scope goes mobile

SOMATOM Scope is ideally suited for use as a mobile scanner. Its gantry size and table length make it a perfect fit for a trailer, for example. It can be equipped with a so-called MobilKit, a technology package allowing it to operate as a mobile unit. These are the reasons why the healthcare provider Alliance Medical has opted for this particular model.

Customers have a choice of two interim solutions. One is a device installed in a container, for use over several months; the other is a scanner housed in a semi-trailer, for rapid deployment over a short period. Due to their particular suitability for mobile use, Alliance Medical has set up two new SOMATOM Scope scanners as mobile units. Since September 2015, these have been operating in a number of countries across Europe. Alliance Medical estimates that the new scanners will cover a distance of around 60,000 to 70,000 km a year, depending on usage.

A professional solution

Today, hospitals or medical practices often turn to mobile scanners as a stopgap when their own equipment is out of order, perhaps as a result of environmental disasters, water pipe rupture, or fire. Siemens has been producing mobile CT scanners for use in a variety of locations since 1987. Mobile CT scanners may also be put to work in

Alliance Medical

Alliance Medical is Europe's leading independent provider of imaging services. They have over 10 years' experience of providing mobile, modular, and pre-owned equipment for hospitals and clinics across Europe. A combination of service excellence and innovative imaging technologies makes it possible to improve patient care and to support hospitals and independent sector organization with their ongoing image requirements. The company currently operates more than 250 devices.

Alliance Medical has set up two new SOMATOM Scope scanners as mobile units.

Today, hospitals or medical practices often turn to mobile scanners as a stop-gap.

crisis zones, as part of "deployable hospitals". Also, CT has been and is still often used to examine delicate historical artifacts such as works of art or mummies at the site of their archeological excavation.

Interim solutions, however, are generally most in demand by the healthcare sector. According to Kai Marxen of Alliance Medical, "Most of our clients are more than happy if we can offer them a flexible solution that helps them out quickly." Practically all you need to do is to plug in the mobile CT scanner, and the hospital or practice can return to work as normal. ■

Meeting the Smart Dose Standard

By Karol Nguyen*, Mark Palacio*, and Monika Demuth, PhD**
* Siemens Healthcare, USA
** Siemens Healthcare, Germany

In the United States, the National Electrical Manufacturers Association's Medical Imaging & Technology Alliance (MITA) has issued a new industry guideline, referred to as the "Smart Dose Standard". This so-called XR-29 standard sets a baseline for radiation reduction technology and dose reporting. Based on this new guideline, differential payments will be aligned with the use of dose reduction features on CT imaging devices. This new regulation forces healthcare providers to re-evaluate the technological capabilities of their CT systems. Starting in 2016, reimbursements for imaging conducted on systems that do not comply will be subject to a payment penalty of 5 percent. After 2017, this penalty will increase to 15 percent.

Doshi Diagnostic Imaging Services is an imaging center with 18 locations serving the New York City metropolitan area. When they realized that their current CT systems would not meet the new MITA Smart Dose standard, they were compelled either to act or to risk substantial reductions to future reimbursement amounts. Before a purchase decision was made, information was gathered as to which modern CT system would allow these financial penalties to be avoided.

Siemens presented an interesting offer: A package that included new equipment along with service and financing for the same monthly payments planned in their budget. So, in addition to maintaining the same level of payment, Doshi Diagnostic was able to take advantage of newer, more updated technology. They decided in favor of this budget-neutral solution: Several older CT scanners that had a high total cost of ownership (including cost of parts and service) were replaced and upgraded with an entirely new CT fleet of 11 SOMATOM Scope CT systems.

Now, with the combination of iterative reconstruction software, dose reduction techniques, and workflow improvement technologies that SOMATOM Scope offers, Doshi is highly confident that they can both expand their services and meet the new industry requirements. ■

SOMATOM Scope

- 24-row adaptive detector array
- 70 cm gantry with ± 30° tilt
- Minimal system footprint: $8\ m^2$
- Power consumption ≤ 40 kVA

United States. Protecting Access to Medicare Act. HR 4032. Public Law: 113-93

Further Information

www.siemens.com/SOMATOM-Scope

Shared Research Expands Frontiers

By Jesús Fernández León,
Siemens Healthcare, Germany

Algorithms underlying functions such as new scan protocols, monitoring of treatment success, or advanced imaging software need to be thoroughly tested. In 2013, Siemens opened up access to research prototypes[1] for testing to *syngo*.via Frontier[2] users, a highly secure non-clinical platform that also offers the option to join a global network of fellow researchers.

1 Cardiac imaging: CT image data were acquired at University Hospital Zurich, Zurich, Switzerland.

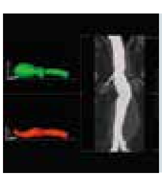
2 Multiple pulmonary nodules: CT image data were acquired at Portuguese Institute of Oncology, Lisbon, Portugal.

Close contact between routine and research

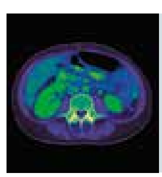
What is the idea behind this research platform? *syngo*.via Frontier is not intended as stand-alone research software, remote from the routine reading location. In order to make it more convenient for research users, it connects the user's clinical server with the *syngo*.via Frontier server. The research prototypes are directly integrated into the standard user interface, allowing direct access from any *syngo*.via client at an institution. Such close connection facilitates the transfer of data and results from routine reading workflow for inclusion in an ongoing study, for instance.

Some people may even be interested in implementing new prototypes of their own. A special development kit supports users in developing their own medical imaging research prototypes for the use with *syngo*.via Frontier.

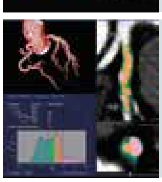
syngo.via Frontier: current prototypes[1]



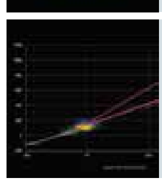
3D Printing for AAA
Create lumen and thrombus segmentations of abdominal aortic aneurysms for 3D printing



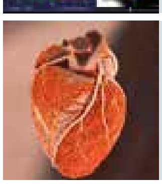
DE Rho/Z Maps
Tissue differentiation based on electron density and effective atomic number



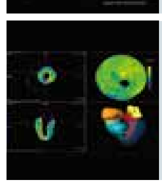
Coronary Plaque Analysis
Volumetric quantification and differentiation of lipid, fibrous, and calcified plaques



DE Scatter Plots
Visualization of energy dependencies for analysis of material homogeneity

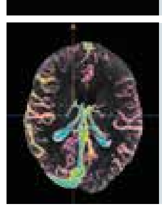


Cinematic Rendering
Novel photo-realistic 3D VRT rendering technology. VRT ranges can be sent back to *syngo*.via or PACS



Cardiac Functional Analysis
Quantitative statistical analysis of 2D polar map-related AHA segments

Best Contrast
Emphasizes the contrast without increasing the noise



Flow Visualization
Provides color code representing the time-point of maximum contrast enhancement in the vessels in a single image

Sharing research and experience across several clinical fields

With *syngo*.via Frontier, researchers immediately become part of an international online community. In numerous sites across the globe physicians are already working with the platform. They have the opportunity to share results and experience both with each other and with Siemens developers. While initially only a few prototypes were available, today researchers can work in a wide range of fields, such as trauma, cardiovascular, dual energy, oncology and many more. Particularly innovative fields can even be explored, such as 3D printing or cinematic rendering.

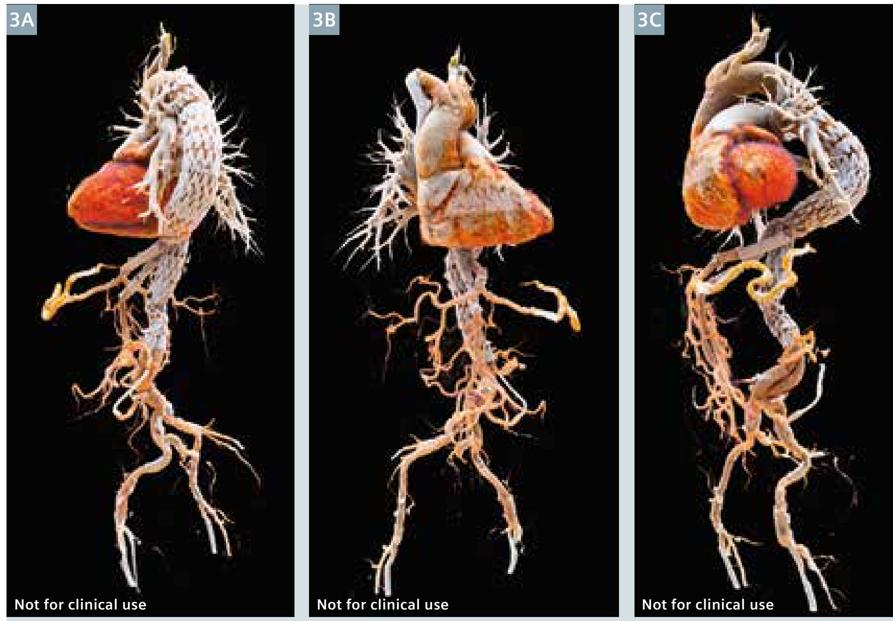
Cinematic rendering technology

This novel, physics-based rendering algorithm is driven by the animation film industry. In contrast to established ray-casting methods, cinematic rendering developed by Siemens Healthcare simulates the complex paths of photons as they travel from light sources to the retina. It can model complex lighting effects such as ambient occlusion, scattering, shadows, and high dynamic range rendering, as well as sophisticated camera models, such as variable apertures and motion blur to achieve high resolution anatomical details within seconds. It offers an example of the ways in which accurate modern medical technology allows fascinating views inside the human body. This can enable completely new approaches to teaching and planning surgical procedures, as well as improving communication between referring physicians and patients. ■

[1] Research prototypes are not intended for clinical use.
[2] *syngo*.via Frontier is a research platform and not intended for clinical use.

Further Information

www.siemens.com/ct-*syngo*-via-frontier



3 Complex endovascular aneurysm repair: CT image data were acquired at Medical University of South Carolina, Charleston, SC, USA. Read the full case report on page 48.

Keep Up with the Future

By Axel Lorz,
Siemens Healthcare, Germany

Evolve is Siemens' innovation protection program that provides the right upgrades for CT system's hardware and software. From May 2015, customers with a SOMATOM Definition Flash, Edge or AS can profit from their Evolve contract with the benefit of an upgrade to the latest software version *syngo* CT VA48A. In addition to a hardware upgrade, a range of advanced features enhance the performance of CT scanners, adding value with:

- **FAST 3D Align** for automatic alignment of FOV, adjustments, and reconstructions of standard views.
- **FAST DE Results**[1] for automatic generation of dual energy (DE) datasets at the AWP with the results sent directly to the PACS for a straightforward DE workflow.

Evolve also offers the opportunity to purchase new state-of-the-art applications:

- **iMAR**[2]**:** iterative metal artifact reduction reduces metal artifacts in various body regions.
- **ADMIRE**[3, 4]**:** Advanced modeled iterative reconstruction has the potential to lower radiation dose while increasing image quality.
- **TwinBeam Dual Energy**[4]**:** Innovative dual energy approach allows simultaneous acquisition of high and low kV datasets in a single spiral scan mode. ■

With Evolve hardware and software can always be kept up to date, exploiting the full potentials of modern CT imaging.

[1] The products/features (here mentioned) are not commercially available in all countries (e.g. the U.S.). If the features are not marketed in countries due to regulatory or other reasons, the service offering cannot be guaranteed. Please contact your local Siemens organization for further details.
[2] iMAR is designed to yield images with a reduced level of metal artifacts compared to conventional reconstruction if the underlying CT data is distorted by metal being present in the scanned object. The exact amount of metal artifact reduction and the corresponding improvement in image quality achievable depends on a number of factors, including composition and size of the metal part within the object, the patient size, anatomical location and clinical practice. It is recommended, to perform iMAR reconstruction in addition to conventional reconstruction.
[3] In clinical practice, the use of ADMIRE 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.
[4] Availability depending on system configuration.

At CCB, a business model has been established that unites an interdisciplinary medical team, high-quality cardiovascular care, and innovative technology.

An Exceptional Business Model Meets High Demands

The Cardiovascular Center Bethanien in Frankfurt am Main, Germany, provides high-quality medical care for both inpatients and outpatients. Its interdisciplinary medical team is available for every patient and supports the use of innovative technologies. SOMATOM Sessions paid a visit to learn about their exceptional business model for medical care and to discover how the latest imaging technology is improving day-to-day work, diagnosis, and treatment planning as a result.

Text: **Matthias Manych,** Photos: **Tim Wegner**

It is late on a weekday morning in Bornheim, a suburb of Frankfurt. As usual, things are busy at the Cardiovascular Center Bethanien (CCB). Ambulances are arriving with emergency cases, while a procession of patients with less acute conditions file their way toward the main entrance. Two floors up, they exit the elevator to be greeted by the many members of staff at reception. An overweight man in his sixties is waiting behind a relatively young woman. Next in line is a fragile elderly patient, who is leaning on her rollator. These are three of the many patients who go on to take their seats in the spacious waiting area. After a short while, they are called in to see their physician.

Cardiovascular care based on innovation and interdisciplinarity

Professor Axel Schmermund, MD, and Professor Thomas Voigtländer, MD, have finished their rounds and procedures for the morning. They are specialists in internal medicine and cardiology and are the CCB medical team's experts in interventional cardiology and tomography. Voigtländer has just performed a catheter intervention to treat narrowing of the coronary arteries in a 65-year-old patient. The key information for this procedure came from images captured the day before using their SOMATOM Force system they have been working with for about a year. They recognized it as an immensely powerful tool from the start. According to Voigtländer, in this case the scan yielded images of far higher diagnostic quality than a cardiac catheterization could provide. "We are now seeing additional information that you can't get from conventional angiography." The center's high-end CT scanner is part of a comprehensive approach to cardiovascular care based on interdisciplinary working and on innovation.

Integrated patient care

Founded in 1978, the CCB became a full medical care center in 2002. This is a form of organization in Germany, known as a "Medizinisches Versorgungszentrum" (MVZ), that allows contracted physicians and a number of salaried physicians to work together on an interdisciplinary basis under one roof. Working alongside their salaried colleagues, the contracted doctors – who take responsibility for the success of the enterprise – are able to offer the full range of medical care. Voigtländer compares the structure of the Frankfurt center to that of a legal firm. Instead of one boss, there are a number of partners. "At the moment there are 10 partners, and we have between 25 and 30 salaried doctors," Voigtländer says, emphasizing the fact that all those working there have equal status as practitioners. It makes no difference whether they hold a doctorate or a professorship – every physician at the CCB has their own specialism and, therefore, their own area of responsibility. At the Frankfurt medical care center, cardiologists, angiologists, radiologists, vascular surgeons, and diabetologists work together closely. For Voigtländer, this interdisciplinary collaboration between specialists on an equal basis is one key to the center's success, as it leads to exceptional quality of care. Many very skilled clinicians are also attracted by the prospect of working in a setting that offers advanced forms of diagnosis and treatment.

Transforming aspirations into reality

Meanwhile, ambulances continue to pull up in front of the building. Emergency cases are examined immediately and given primary care in the chest pain unit. However, the physicians at the CCB remain responsible for their patients even after they have been moved to the intensive care unit at the hospital. This is possible because each of the CCB's two sites in Frankfurt is located within a hospital owned by the Agaplesion healthcare company. Whether as inpatients or outpatients, this means that CCB physicians supervise all their examinations or procedures, invasive or noninvasive. The result is a cohesive approach with short pathways and waiting times, smooth information flows, and a seamless doctor-patient relationship. This is helping the center to achieve the goals that it has been pursuing since 2002 – to provide excellent, comprehensive care in cardiology and angiology, and to make the process fast and uncomplicated, both for patients and the referring physicians. As Schmermund puts it, "everything must be addressed and dealt with after two visits, at most, to our center."

Emergency cases as well as patients with less acute conditions arrive at the reception.

Outside the CCB, too, there is a recognition that the center is living up to its claims. Referring physicians rely on the wide range of expertise at the center and often refer their patients, confident that the specialists there will be able to deliver answers. A growing number of physicians are referring patients to the CCB, while more and more patients are attending on their own initiative. An essential component of their work is the close cooperation and trust that the CCB has with the Frankfurt Diakonie hospitals that are part of the Agaplesion non-for-profit company, in providing cardiology care at the two locations. Across both sites, almost 100,000 outpatients and 11,000 inpatients are treated every year. Meanwhile, over 40 percent of cardiovascular emergency cases in the city of Frankfurt, and more from the surrounding area, are being treated at the chest pain unit.

A growing number of referring physicians rely on expertise at CCB.

Innovative imaging

These developments are the result of a decision made in 2002. Even prior to this, the innovative clinicians working at the center had introduced procedures that were unusual, if not unique, for the time in an ambulatory setting. The medical team then took the key decision to integrate modern imaging technology into its work. “That meant that we had to set up an MVZ so that we could also include radiologists in our group,” Schmermund explains. Acquiring a cardiac MRI scanner was the CCB partners’ first significant investment in new technology, which allowed the center to expand its diagnostic range considerably. With the new diagnostic possibilities came the need to process and network the acquired imaging data and findings. Once installed, the image processing software *syngo*.via then provides access to 3D images almost in real time. Several steps in a cardiac examination can be automatized, accelerating the workflow. All the relevant information for diagnosis is organized and downloadable directly after imaging. This enables a highly efficient workflow, as patients go from the initial consultation to the imaging room and then straight back to the doctor to discuss their results. With *syngo*.via, all data and images can be accessed on any computer. Finally, the data are transferred without the risk of any information loss in the form of rapidly produced and informative reports, to the referring physician or to those responsible for subsequent treatment.

1

1 Very sharp delineation of multiple calcified plaque are shown in this curved multiplanar reconstruction of the left anterior descending (LAD) artery. *Courtesy of Cardiovascular Center Bethanien, Frankfurt am Main, Germany*

An even greater impact on the center’s work came with the purchase of a SOMATOM Force system, which was installed in summer 2014. One of the advanced technical features of this high-end scanner is the ability to reduce radiation doses to a fraction of that which was required in the past. This was a decisive breakthrough. Radiation doses of up to 10 millisieverts used to be required to make an accurate assessment of the state of the coronary arteries, but now a dose of just 0.5-1.0 millisieverts is sufficient. This is a huge advantage especially for relatively young patients with various complaints and unclear medical histories, as the fact that radiation exposure is so low now justifies the use of CT scans to investigate the coronary status of people under 50, allowing preventive and therapeutic measures to be taken early.

The center’s new CT system is also benefiting patients with highly calcified blood vessels, as it enables diagnostically relevant images to be generated as standard for this group. Attempts by physicians to use noninvasive imaging for a third group – patients with arrhythmia – had previously come to nothing, but SOMATOM Force requires just 160 milliseconds to perform imaging of the whole heart. “When we are examining an 80-year-old with atrial fibrillation, we can now get diagnostic images that had previously been unthinkable," Schmermund explains. At the same time, having patients hold their breath is no longer a problem. All patients can manage it for one or two seconds, and even when this is not possible, the diagnostic quality of images is generally unaffected.

"At the moment there are 10 partners, and we have between 25 and 30 salaried doctors."

Professor Thomas Voigtländer, MD,
Cardiovascular Center Bethanien,
Frankfurt am Main, Germany

"We can now get diagnostic images that had previously been unthinkable."

Professor Axel Schmermund, MD,
Cardiovascular Center Bethanien,
Frankfurt am Main, Germany

Advances and changes in cardiology

Cardiac CT imaging with the SOMATOM Force is enabling the CCB to steadily increase its use to a wider circle of patients. Bypass surgery patients can now be examined more precisely. And the fact that only very small amounts of contrast medium are needed means that more and more patients with kidney failure and impaired kidney function can be scanned. Even the accurate placement of metal stents can now be checked. The importance of CT imaging in measuring heart valves has also grown rapidly. Before the minimally invasive procedure of a transcatheter aortic valve implantation (TAVI) can be performed, the natural morphology of the valves must be precisely analyzed, and the aorta and its branch vessels must be visualized on the same image. The scanner is able to capture such images due to its ultra fast acquisition speed.

Furthermore, the cardiologists believe that current cardiac CT technology could change cardiology fundamentally. "With SOMATOM Force, we thought from an early stage that this technology might help us to make the leap from coronary angiography to CT angiography. It is even possible that coronary angiography will be superseded by CT as a means of diagnosis," Voigtländer explains. Unlike a heart catheter, a CT scan gives an exact picture of the vessel wall – "and it all happens in the vascular wall," as Schmermund emphasizes. That is where the plaques are located, and physicians would like to be able to make an accurate assessment of the risk of thrombosis or plaque rupture. Although Voigtländer stresses that there is no point in performing CT scans on completely asymptomatic people with no risk factors, scans can now be offered to people who have diabetes, high blood pressure, cholesterol issues, or non-specific chest pain, or where something has shown up on an ECG. This gives clinicians the basic information on the coronary system that they need in order to plan the follow-up steps.

Preparing the future

With its university hospital, medical care centers, and doctors' surgeries, Frankfurt has a sophisticated healthcare landscape. To enable it to remain competitive and to expand its clinical capabilities further, the CCB is investing in innovative technology. Its physicians are using systems such as the SOMATOM Force to resolve issues for the future. A number of research projects are exploring potential uses of CT imaging in evaluating stents and plaques. Both of these clinical issues are being worked on in close partnership with Siemens. The center has a collaborative project with the University of Duisburg-Essen, Germany, on early detection of arteriosclerosis in the general population. Further research projects are dealing with electrophysiological processes and the replacement of heart valves. "If we want to attract good people, we must continue to offer them the opportunity to pursue scientific research in their specialist areas," Voigtländer explains, highlighting a positive side effect of the center's research activities. ■

Matthias Manych, a biologist, works as a freelance scientific journalist, editor, and author specializing in medicine. His texts appear primarily in specialized journals, but also in newspapers and online.

Further Information

www.siemens.com/ct-cardiology

Screening Study Provides Edge in Lung Cancer

When the National Lung Screening Trial (NLST) launched in the U.S. in 2002, neither American nor European medical organizations endorsed specific lung cancer screening guidelines. Globally, men and women at risk of lung cancer might be offered either a chest X-ray or a wait-and-see approach. These strategies missed crucial lung cancer diagnoses because the disease can be asymptomatic until advanced stages.

By Kathleen Raven

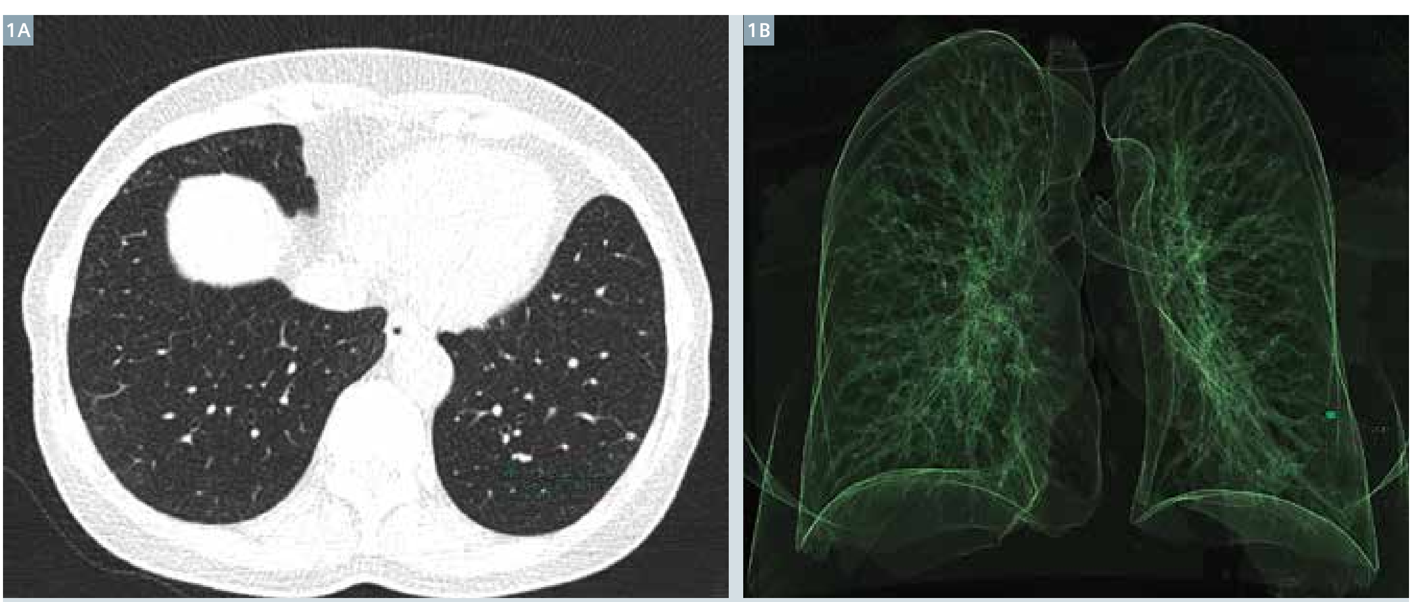
Lung cancer is typically diagnosed in advanced stages, when surgical cure is not an option. The NLST set out to investigate whether lung cancer screening with low-dose computed tomography[1] (LDCT) could tackle the problem.

This study of more than 53,000 men and women with a history of heavy smoking showed that annual LDCT screening is an irreplaceable component in fighting lung cancer (see sidebar). Participants screened with LDCT had a 20 percent lower risk of dying from lung cancer than patients in a control group given standard chest X-rays. This reduction in mortality is likely due to earlier tumor detection and treatment. Notably, the death rate from other causes was lower in the LDCT arm, as well – meaning that the procedure did not carry any disproportionate risks from workups through ensuing biopsies or surgeries. "The important message here is that CT screening itself did not promote early morbidity or mortality. Participants were not exposed to downstream complications they could have died from," says Denise Aberle, MD, Professor of Radiology at UCLA Medical Center in Los Angeles, and one of the principal investigators on the NLST.

David Naidich, MD, Professor of Radiology at New York University School of Medicine who served on the oversight committee of the study, agrees that the trial eliminated concerns that the risks of annual LDCT scans might outweigh the benefits. With modern CT scanners, the radiation exposure involved would be small, explains Naidich.

Stage shift

Indeed, the NLST team achieved a rare feat in the genre of screening studies. "We identified more early-stage lung cancers in the LDCT arm, but found fewer late-stage cancers, which means



1 In the NLST, non-calcified nodules on low-dose CT scans as small as 4 mm were classified as positive, "suspicious" for lung cancer.
Courtesy of University of California, Los Angeles, United States

"We identified more early-stage lung cancers in the low-dose computed tomography arm, but found fewer late-stage cancers, which means we saw a true stage shift."

Denise Aberle, MD, UCLA Medical Center, Los Angeles, United States

we saw a true stage shift," Aberle says. A common concern with cancer screening is that it may result in false-positive findings or lead-time bias, only detecting disease earlier without altering its course. As the NLST mortality results show, however, this was obviously not the case.

The results are all the more important as lung cancer is the leading cause of cancer-related deaths worldwide, and better management of the disease is urgently required. In the U.S., "mortality from lung cancer far exceeds mortality from breast, prostate, and colon cancer combined," Naidich notes. The breakthrough study also caught the attention of the U.S. Clinical Research Forum, which awarded Aberle a clinical research award in 2014.

Translating research into routine care

Meanwhile, the U.S. Preventive Services Task Force (USPSTF), which issues the country's screening guidelines, has recommended that people who fall within the NLST patient population, and who are between ages 55 and 80, should receive annual lung cancer screenings.[1] The procedure is now covered by the country's private and government insurers for older people with a long history of heavy smoking. [2] This could have an important impact on healthcare delivery and the use of CT screening in the U.S. Given the USPSTF recommendations and reimbursement coverage, this could result in up to 8 million additional LDCT screens each year, according to an impact analysis.[3] However, the exact number of additional scans that might occur is unclear.

The NLST results also piqued interest among medical organizations in Europe, Aberle and Naidich say. A lung cancer screening trial called NELSON, taking place in the Netherlands and Belgium, will combine its results with the Danish Lung Cancer Screening Trial (DLCST) to include about 22,000 patients total, Aberle notes. In China, where lung cancer has been increasing rapidly in the past few decades, at least one LDCT cancer screening trial of 3,000 participants is ongoing in Shanghai.[4] Other countries can benefit by running their own trials in order to find the best approach to lung cancer screening, Aberle says.

Indeed, important issues remain unresolved. As the authors of the NLST report point out, many of the centers involved in the trial are recognized for their expertise in cancer diagnosis and treatment, leaving the question open as to whether community facilities would perform equally well. Likewise, the European Society of Radiology and the European Respiratory Society have issued a white paper recommending the use of LDCT screening only at certified multidisciplinary centers that can ensure standardized operating procedures and offer long-term clinical follow-up including smoking cessation programs.[5] In 2014, a group of Swiss experts cautioned that, before implementing large-scale LDCT screening in clinical routine, the population to be screened and

The National Lung Screening Trial – Key Facts

The National Lung Screening Trial (NLST), launched in 2002, randomly assigned around 53,000 current or former heavy smokers to receive either low-dose computed tomography or chest X-ray for three annual screens. Eligible male and female participants in the study were aged between 55 and 74 years and had a history of at least 30 pack-years (e.g. 30 years of smoking a pack per day), and, if former smokers, had quit within the past 15 years. Patients were enrolled at 33 medical centers across the U.S. All of the multi-detector CT scanners deployed were at least four-slice systems. Screening exams were labeled as "positive" if a lung nodule 4 mm in diameter or larger was observed on CT scans, or if a "suspicious" nodule or mass was detected on radiographs (see Fig. 1). The rate of adherence to screening was over 90%, with a portion of lung cancer cases diagnosed only in the post-screening phase, however. About 6 years after the first enrollment, patients in the LDCT group showed 20% lower mortality from lung cancer compared with the radiography arm, likely due to earlier treatment, as well as a 6.7% relative decrease in death from other causes.[8]

"NLST eliminated concerns that the risks of annual low-dose CT scans might outweigh the benefits."

David Naidich, MD, New York University School of Medicine, United States

the possible psychological consequences of taking part in such programs as well as guidelines on a workup of indeterminate screening results would have to be clearly defined.[6] A recent cost-effectiveness study stated that, within the U.S. health system, each quality-adjusted life year gained through LDCT screening could carry additional costs (compared to no screening) of U.S. $81,000, but estimates vary widely.[7]

Another major issue is how to convince high-risk patients, particularly those from underprivileged communities to seek lung cancer screening. These populations suffer disproportionately from lung cancer because they often present with very advanced disease, and may have worse medical outcomes. Aberle suggests that university medical centers could do a better job of community engagement, providing resources and local training to the community healthcare workers who serve these populations. It is unreasonable to expect that such high risk patients will leave their communities to travel to major academic centers for screening and care. Models for community engagement and outreach, where healthcare is incorporated into the community, must replace the outdated model of a major medical center to which patients travel.

What happens next

At the same time, it seems likely that people beyond the parameters of the original NLST study population could also benefit from well-planned lung cancer screening programs. "A lot of people get lung cancer who do not satisfy the NLST eligibility criteria," states Aberle. Indeed, the NLST criteria apply to less than 30 percent of people who are diagnosed with lung cancer in the U.S., she adds. One approach to expand screening eligibility could be to build risk prediction models taking into account patients' exposure to known respiratory carcinogens, air pollution, underlying lung disease, and family history of lung cancer, Aberle says.

Lung cancer screening in connection with other forms of screening and counseling is very attractive. LDCT works for lung cancer screening because it can detect even very small nodules within the aerated lung. Furthermore, other smoking related diseases are detectable with lung screening. Coronary artery calcium assessment has been shown to provide a personalized estimation of the risk of heart attack or death from coronary artery disease. Due to the high contrast between calcium and soft tissues, coronary artery calcium can be evaluated on lung screening to improve risk prediction for cardiovascular events. Similarly, emphysema is a smoking-related condition that is readily identified on LDCT screening, and independently contributes to the risk of lung cancer in individual patients. Finally, the incorporation of smoking cessation counseling and medications into the screening process with significantly reduce tobacco-related diseases. The NLST results should be viewed as just the beginning of our understanding of screening and preventive services for tobacco-related diseases. ■

Kathleen Raven has covered lung cancer clinical trials for Biopharm Insight, consumer health for *Reuters Health* and biomedical news for *Nature Medicine*. She is a freelance writer in New Haven, Connecticut, USA.

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Trending toward Transparency

Greater choice available to patients about where they want to receive care will help providers like Mary Lanning Healthcare stand apart from the competition. Successful organizations will find a way to establish effective processes and deliver the right technology to gain a competitive edge when it comes to key outcomes such as patient safety and patient satisfaction.

By Karen Schweizer and Mark Palacio

Siemens Healthcare, USA

Mary Lanning Healthcare in Hastings, Nebraska, USA, recognizes the trend toward transparency.

Mary Lanning Healthcare is a 183-bed facility in Hastings, Nebraska, USA. With an increasing trend toward transparency in hospital outcome measures, and maybe even public radiation dose reporting one day. They recognize the need to enhance patient experience and position the hospital at the forefront of diagnostic imaging.

Safe for patients, safe for the bottom line

In 2014, radiation dose once again emerged as a national topic in the U.S. with the establishment of NEMA XR-29. It is an industry guideline, referred to as the "Smart Dose Standard", which is setting a baseline for radiation reduction technology and dose reporting. This guideline affects CT scanners used to image Medicare patients. To summarize what is required: These scanners must include pediatric protocols, DICOM-structured reporting, dose check, and automated exposure control.

Mary Lanning Healthcare have to manage a high patient case mix (Daniel J. Herold, MD).

Dose was probably the number one item that Mark Callahan (left) and the doctors considered as they negotiated for a new CT scanner.

"If we can reduce exposure to our patients, make their exams safer, and the images better, then that's what it's all about. We're working to create the safest, most effective care for our patients."

Mark Callahan, COO,
Radiologist, Mary Lanning Healthcare

These tools help ensure a safer procedure. Starting in 2016, there will be a 5% reduction in Medicare reimbursements for imaging procedures using non-compliant technology. In 2017 and beyond, the penalty will increase to 15%.

At most U.S. hospitals, Medicare is one of the single biggest payers. The situation created by XR-29 could have become even more acute for Mary Lannning Healthcare, where Medicare accounts for 53% of the hospital's payer mix. Moving to XR-29 compliant technology should be about more than protecting Medicare reimbursement. It creates an opportunity to do more than just replace outdated technology with new scanners that have the base level of compliant technology. It represents a chance to bring in advanced diagnostic functionality that positions the organization to become a regional leader.

According to the American Hospital Association, Medicare patients present with a growing prevalence of chronic conditions and risk factors, such as obesity. Still, even meeting the needs of the aging population is one of the concerns associated with having such a high Medicare case mix. This can lead to a rise in Medicare beneficiaries' use of healthcare, which has implications for resource utilization and payment.[1]

Dose reduction as a differentiator

The NEMA XR-29 Smart Dose Standard established a baseline for CT technology specifically includes functionality for reporting radiation dose levels. With trends toward greater transparency in other hospital outcomes, it is reasonable to think that in the near future the average dose for a hospital's top CT procedures might be public information. If that becomes the case, investments in dose-optimized CT technology could play a significant role in a healthcare organization's reputation. "Dose was probably the number one item we were looking at as we negotiated for a new CT scanner," said Mark Callahan, COO at Mary Lanning Healthcare. "I also think dose values could certainly be a market differentiator for hospitals like ours."

To meet all these requirements, Mary Lanning Healthcare upgraded their eight-year-old computed tomography (CT) system with a new, 128-slice SOMATOM® Definition Edge. The SOMATOM Definition Edge is already helping Mary Lanning Healthcare lower the radiation dose compared with its previous CT scanner. "We compared average dose from our old scanner with the average dose from the SOMATOM Definition Edge," said Jenny Utecht, CT technologist. "After adjusting for patient size, using SAFIRE[1] we see overall dose reductions from 45% to greater than 50% in procedures such as chest imaging, abdomen/pelvis, and chest pulmonary embolism studies. With chest pain and shortness of breath representing two of the most common reasons people present to the emergency department, the SOMATOM Definition Edge is helping us consistently provide safer imaging to patients." In addition, with its high table weight limit and ability to support fast, high-quality exams and higher patient volumes, the new scanner can help Mary Lanning Healthcare offset some of the

"Our patient population is generally older. Many of our older patients have a hard time holding their breath. Now, with the SOMATOM Definition Edge, the scan is so fast that they hardly have to hold their breath at all."

Jenny Utecht, CT Technologist,
Mary Lanning Healthcare

concerns associated with having a high patient case mix. The SOMATOM Definition Edge even helps Mary Lanning Healthcare better meet the needs of the aging population while putting the hospital in a position to attract younger patients in the community.

Potential for expanded services

Mary Lanning Healthcare's leadership sees dose reductions as a testament to the value it places on patient safety. The ability to dramatically lower the dose may also open up the potential to increase pediatric imaging at Mary Lanning Healthcare, which means expanding services for the benefit of the community and the hospital. Pediatrics is one of several potential growth areas for expanded CT capabilities at Mary Lanning Healthcare. They will also use the SOMATOM Definition Edge to expand services in cardiology and interventional imaging. "For physician and patient satisfaction, the SOMATOM Definition Edge can have a huge impact, especially for cardiologists," said Tami Lipker, Director of Imaging. "The cardiologists have spoken to me personally about radiation dose reduction. It is a huge safety and patient satisfaction issue."

Physician perception is equally as important as patient perception, especially when trying to recruit the best available talent. So the SOMATOM Definition Edge has become an important part of the organization's physician recruitment efforts. Many of the hospital's prospective physicians come from academic medical centers and they are accustomed to practicing medicine with premium diagnostic tools at their disposal. They tend to want to continue practicing in an environment that lets them work with a similar level of diagnostic confidence. This is why the SOMATOM Definition Edge is one of the first pieces of equipment that prospective hires see.

Changing vendors, easier than anticipated

As with any change in CT vendors, technologists at Mary Lanning Healthcare had some concerns. The new scanner uses Siemens FAST CARE (fully assisting scanner technologies and combined applications to reduce exposure) to automate and standardize many of the exam preparation steps. The CARE applications are aimed at helping technologists consistently optimize exam protocols for each patient and study type. "Some of the technologists were worried about the change," said Utecht. "We thought imaging would be too automated, and we wouldn't be able to make adjustments. So, we were skeptical about the scanner at first." Installation and applications training were successful and technologists now have a higher level of comfort with the new CT system as a result.

Positioned for the future

The SOMATOM Definition Edge is helping Mary Lanning Healthcare meet its short-term patient care objectives while positioning the hospital to continue to be a leader in the community for years to come. ■

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Further Information

www.siemens.com/SOMATOM-Definition-Edge

[1] In clinical practice, the use of SAFIRE may reduce CT patient dose 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. The following test method was used to determine a 54 to 60 percent dose reduction when using the SAFIRE reconstruction software: Noise, CT numbers, homogeneity, low-contrast resolution, and high-contrast resolution were assessed in a Gammex 438 phantom. Low-dose data reconstructed with SAFIRE showed the same image quality compared to full-dose data based on this test. Data on file.

The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results.

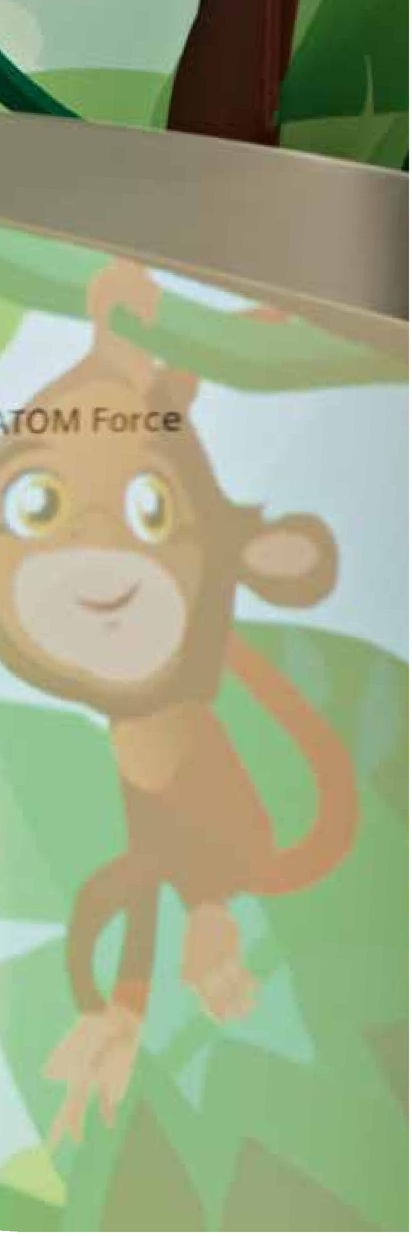
United States. Protecting Access to Medicare Act. HR 4032. Public Law: 113-93.

In Lady Cilento Children's Hospital, the gantry is not white and clinical, but rather is transformed into a video projection screen where animals come to life. This helps nervous children to calm down as radiographer Debbie Watson knows.

Entertainment Supports Child-friendly Scanning

Modern technology and family-centered care are helping to establish the brand new Lady Cilento Children's Hospital in Brisbane as a pediatric center of excellence. The imaging concept at the Australian hospital is already setting standards in pediatric CT.

Text: **Jana Schlütter,** Photos: **Dean Whitling**



"In comparison with previous 64-slice CT scanners, SOMATOM Force allows us to achieve substantial dose reductions in the abdominal region and chest."

Debbie Watson, Radiographer, Lady Cilento Children's Hospital, Brisbane, Australia.

With its beady yellow eyes, the Tyrannosaurus rex surveys its surroundings. The dinosaur sniffs at the children, then roars to show its strength. A boy in a wheelchair is not afraid as the dinosaur dips down toward him. For a moment, the puppeteer underneath the elaborate costume, transports the children in the atrium of Lady Cilento Children's Hospital in Brisbane, Australia, to a world beyond their illnesses.

A few floors up, the daily routine is underway. In the Department for Medical Imaging and Nuclear Medicine, tears are streaming down the face of a four-year-old girl. The memory of the needle used to insert a cannula for contrast medium injection into her body is still fresh. She knows she is there for some kind of photo and that photos don't hurt. Yet, she's still nervous. Her gaze drifts across the jungle scene on the walls, resting on a monkey swinging between the branches, before jumping up onto the high-end CT. The gantry is not white and clinical, but rather is transformed into a video projection screen where the animals come to life. Music is playing in the background, and a parrot nods its head to the beat.

As radiographer Debbie Watson knows only too well, these distraction methods do not always work. She walks around the CT scanner with the girl once more, explaining that there is nothing to be scared of. Debbie Watson shows the little girl how the table is lowered, and lets her press the button herself. Now calmer, the girl climbs up onto the table, lies on her back, and watches birds flapping across the ceiling. Her mother leaves the room for a moment as the device takes the cross-sectional images. With particularly nervous children, a parent will sometimes stay in the room and be given a lead apron to protect against the radiation.

This scene ideally illustrates the concept behind Lady Cilento Children's Hospital, the largest and most modern pediatric hospital in Queensland, named after the Australian physician and reformist Phyllis Cilento. The hospital was opened in 2014 together with a neighboring wing of research labs, and combines state-of-the-art technology with family-centered care. The 359 private rooms are designed to allow relatives to stay overnight. Eleven rooftop terraces and gardens, a special radio and television station for children, play rooms, schooling options, visits from an interactive circus, and live shows like the one featuring a T. Rex allow the children to temporarily escape the world of medicine.

Sick children from Brisbane and beyond are referred to the hospital, which cooperates with a number of universities. As a tertiary referral center, patients come from all over the state to see specialists for cancer, heart defects, rare hereditary diseases and many other conditions. The imaging department covers all aspects of pediatric medicine. Debbie Watson and her team perform around 270 CT examinations each month, of which approximately 100 are for outpatients.

"Pediatric radiology involves a number of tough challenges," Debbie says. An important issue with computed tomography – which is being used more and more frequently for children over the past few decades – is the

As a tertiary referral center, patients come from all over the state to Lady Cilento Children's Hospital to see specialists for cancer, heart defects, rare hereditary diseases and many other conditions.

Modern technology and patient-centered care help children and their parents to feel safe and relaxed during their time at Lady Cilento Children's Hospital.

ionizing radiation: CT is considered one of the major sources of medical radiation exposure in children.[1]

"Although the risk of cancer is low, it should not be ignored," says Gillian Long, MD, a radiology consultant at LCCH and colleague of Debbie Watson. "Patient safety must remain our top priority". The radiation dose for imaging procedures should follow the ALARA principle ("as low as reasonably achievable") as proposed by the International Commission on Radiological Protection,[2] and of which we are reminded by the international "Image Gently" campaign that was launched especially for pediatric radiology.[3]

Dose is particularly significant in pediatric scanning. Ionizing radiation can cause strand breakages in DNA. Such defects are usually fixed by molecular repair mechanisms in the body, but with the rapid cell multiplication that occurs in children, the potential of this repair mechanism may be exceeded, causing a defect to be passed onto daughter cells and, in the worst-case scenario, can contribute to the growth of a tumor. Since children have a long life expectancy, it is statistically more likely that DNA damage caused by radiation may result in cancer in the following decades than is the case with older people.

This is why Gillian Long and her colleagues strive to carefully check the clinical indication for all pediatric CT referrals and review existing images from other hospitals or medical practices. "This can be problematic," says Gillian. "Since different institutions store their images on different IT systems, accessing the data can be challenging but is important in order to protocol the proposed CT study appropriately and to avoid unnecessary repeat imaging". Good communication between the referring physician and the radiologist is important before performing a scan. "The radiologist needs to know what exactly the clinican is looking for in order to target the study accordingly and limit the range of CT imaging to a minimum, and there are situations where reduced image quality may be acceptable," she explains.

Despite the radiation dose, CT is often the best choice imaging modality, not least because of its speed. MRI may be an alternative, but MRI usually takes 30 minutes or longer and lying still for this long is a challenge for many young children. Patients below the age of four usually require general anesthesia. For CT image acquisition takes only a matter of seconds. In emergency situations, CT is often the only option to make a fast clinical decision.

"For babies and small children being treated in intensive care for a congenital heart defect, the situation is very similar," says Mark Phillips, MD, a radiologist who specializes in pediatric cardiac patients. "They're too unstable to lie in a tube for a long time, and if they have a pacemaker, this automatically rules out MRI."

For this reason, Mark Phillips is especially excited about the high-speed CT scanners – two SOMATOM Force devices – at the Lady Cilento Children's Hospital. He recalls a two-year-old girl whose pulmonary artery was three times larger than normal. The blood vessel appeared to be applying a dangerous amount of pressure on her respiratory tracts, and an operation was planned. "A CT scan in 4D mode enabled us to eliminate breathing artifacts and to display her heart and bronchial tubes with such clarity that we were able to decide as a team to postpone the operation and wait." The anatomical defect will most likely be resolved by the child's natural growth process. For Mark, this is a good example of

1

A 10-day-old baby was admitted due to pneumonia. VRT images revealed a dilated main pulmonary artery (PLA), and a hypoplastic right pulmonary artery (RPA). The left pulmonary artery was disconnected and arose from the descending aorta. A number of major aortopulmonary collateral arteries (MAPCAs), arising on the right, appeared to supply the right lower and part of the right middle lobes. A right-sided MAPCA supplying the right upper lobe was also suspected.

Courtesy of Lady Cilento Children's Hospital, Brisbane, Australia how high-end imaging can change the course of a patient's treatment.

Alongside the technical possibilities, the child-oriented approach is also necessary to avoid fear and panic, and the motion artifacts that these produce. Before a scan is performed, the parents of outpatients at the Lady Cilento Children's Hospital receive a letter explaining the examination procedure and the steps that can be practiced at home. Occupational therapists based at the hospital use picture books or iPads to talk through the details with the children. They explore the CT rooms together, looking at the animal projections on the gantry. Some children bring their own DVDs to the appointment. "Frozen is very popular," Watson says. "It's a good distraction from the scanning preparations." This is important for both children and their parents.

Australia's state insurance system (Medicare) provides reimbursement for hospitals and radiology practices at the same rate irrespective of the patient's age and makes no allowance for the extra time required for pediatric imaging. Using a child-friendly approach has clear advantages in gaining patient cooperation with associated improvement in image quality in addition to the psychological benefits for patients, their families and staff. The extremely fast image acquisition time of the SOMATOM Force, typically between 0.5 and 2.5 seconds is likewise of great benefit for children. Depending on whether contrast medium is required, the child's anxiety level, and how well he or she can follow instructions, even very young children can be scanned without sedation[1].

The progress made using high-end devices is already undeniable, according to Watson, especially when it comes to reducing radiation. "In comparison with previous 64-slice CT scanners, SOMATOM Force allows us to achieve substantial dose reductions in the abdominal region and chest. With head CT, we also manage slight dose reductions," Watson reports.

Although they see the SOMATOM Force as main reason for these achievements in lowering the radiation dose, their goal is still to further optimize the protocols for subgroups in the pediatric population, such as neonates. To achieve this, they are working closely together with the CT specialists at Siemens Healthcare.

"Numerous trials using phantoms of different body sizes, together with consultation with colleagues from other hospitals, have helped to adapt the imaging protocols for pediatric purposes," says Debbie Watson. In the future, her team would like to use their findings for clinical research. Having proven successful in the role of encouraging cooperation, T. Rex and his animated friends will continue to distract children and their parents from any feelings of nervousness and help them to feel safe and relaxed during their time at Lady Cilento Children's Hospital. ■

For radiologist Mark Phillips, MD (upper image), pediatric radiologist Gillian Long, MD, and his colleague the radiologist Dean McCoombe, MD, (image below), the progress made using high-end devices is already undeniable, especially when it comes to reducing radiation.

Jana Schlütter is a graduate of the Journalism School at Columbia University in New York City. She is a Science Editor with the Berlin-based newspaper *Tagesspiegel*. Her articles appeared in major German daily and weekly newspapers, as well as in the specialist publication *Nature*.

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[1] The inherent temporal resolution – the "native" temporal resolution acquired by the scanner – is highly important to freeze patient motion, e.g. in lung exams or in patients who cannot hold their breath long enough. This is also important, in pediatric CT where it also can help reducing the need for potentially harmful sedation.

Exceeding Expectations

Sebastian Schindera is an associate professor at the University of Basel and senior consultant for abdominal and oncological diagnosis at University Hospital Basel. Recently, he and his team have experienced greater standardization in their daily routine workflow due to newly purchased clinical equipment. Moreover, they have been able to limit the burden on patients even further than before.

By Ralf Grötker, MD

Operating independently since 2012, the University Hospital in Basel is one of the leading medical centers in Switzerland and the largest employer in the region. This is reflected in the number of cases it treats. Where Sebastian Schindera, MD, works at the Department of Radiology and Nuclear Medicine, for example, around five and a half thousand computed tomography scans are carried out each year for abdominal and oncological diagnostics alone.

Reduced burden on patients

"One major clinical field for computed tomography is oncology. Here we run tests in the case of a suspected tumor or to check how a tumor has reacted to a certain treatment," explains Sebastian Schindera. In challenging cases, it is not possible to conclude from the HU value alone whether there is a cyst or tumor tissue. In these cases, however, dual energy data can provide further information: By evaluating the iodine content in mg/mL in the suspected lesion one can conclude whether it takes up iodine (lesions) or not (cyst).

"Previously, when we had patients whose CT scans posed new questions, we often had to schedule a second appointment for them at the hospital. This caused additional costs, and was of course a considerable stress for the patients who had to live with this uncertainty until the next appointment."

Since June 2014, the hospital has a SOMATOM Definition Edge available for tumor monitoring, laser biopsies, and also for classification of kidney stones. Sebastian Schindera sees the advantages of the new technologies such as TwinBeam Dual Energy, iMAR, and ADMIRE above all in their ability to reduce exposure to radiation and also to provide greater comfort to patients. Other advantages include the increase in diagnostic value through improved image quality and the optimization of workflow procedure in everyday clinical routine.

SOMATOM Definition Edge, with the assistance of the TwinBeam Dual Energy technology, makes it possible to gener-

At the Department of Radiology and Nuclear Medicine at University Hospital Basel, around five and a half thousand computed tomography scans are carried out each year for abdominal and oncological diagnostics alone.

“We always take great care when acquiring any device or software for the hospital that it can be integrated into the workflow, and that it is able to be operated intuitively.”

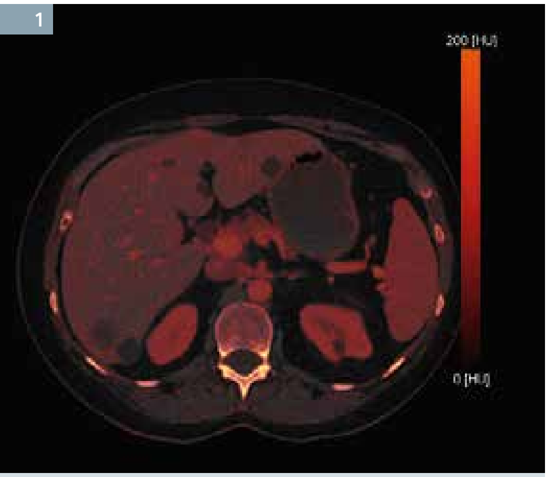
Sebastian Schindera, MD

ate a virtual non-contrast image (VNC), whilst simultaneously generating a contrast-enhanced image. This VNC image is similar to the native image in terms of image quality and image data, but does not require a separate scan. A new type of tube design makes this possible by splitting the X-rays into two different spectra, before they reach the patient. An immediate practical advantage of this method is that it allows fused images to be generated, while simultaneously representing the morphological structure, and also the reaction of the tissue to the contrast agent. This not only saves more time as it means no longer having to constantly switch between the different datasets – it also leads to a more precise diagnosis.

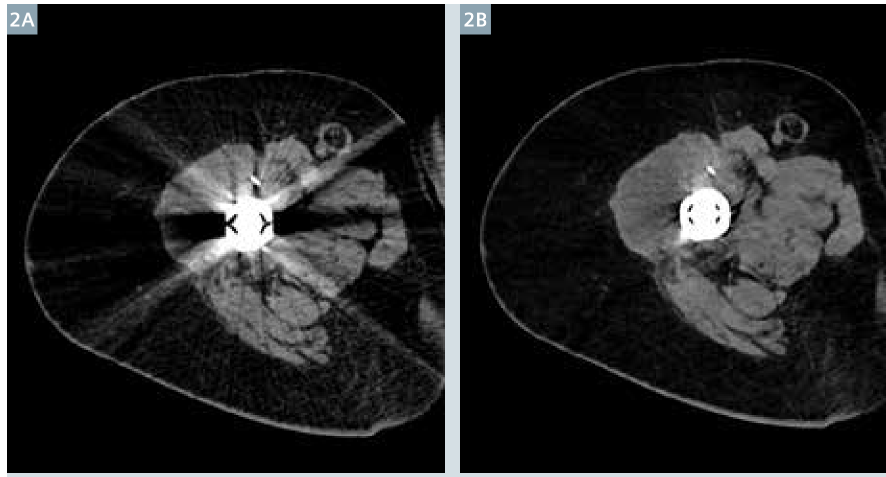
Standardization instead of ad-hoc decisions

Dual energy is now used on the SOMATOM Definition Edge as a matter of routine at Basel’s Department of Abdominal and Oncological Diagnostics. “This also makes it easier for the MTA’s, as they now no longer have to seek reassurance from the physician about which protocol they should use before they do each scan,” says Schindera. A positive effect is that it is no longer necessary for complex training of medical technical assistants to teach them to decide under which circumstances a second, native image is necessary. This makes the whole process much easier – especially in times where there is sometimes a turnover in staff.

Another aspect: “During my residency in Switzerland about ten years ago, I used to sit next to the MTA’s in the examination room and dictate notes on the technical parameters and contrast phases to them. Here in Basel, however, but also in other hospitals where I have worked in the last few years, it is quite normal for MTA’s and radiologists to work in separate rooms. On the one hand, it is an advantage in that both can concentrate on their respective tasks. On the other hand, however, the opportunity for an immediate exchange of ideas and experience is lost. This is why it’s helpful if the work of MTA’s is better supported through clear and standardized protocols”. Dual energy makes this possible – also because



1 An iodine/VNC-fused DE image shows a significant difference in the liver metastasis and in the benign simple cyst. Please read the details in the case report on page 66.



2 Conventionally reconstructed CT image (left) showed extensive metal artifacts, caused by the prosthesis. Theses artifacts, which impaired the proper visualization of the hypodense lesion, were significantly absent in the image reconstructed using iMAR and ADMIRE (right). Please read the details in the case report on page 68.

the technology can be operated in an intuitive way.

“We always take great care when acquiring any device or software for the hospital that it can be integrated into the workflow, and that it is able to be operated intuitively,” says Sebastian Schindera. “If the technology is too complicated, then we may use it in the initial phase. But you often quickly forget the details of how to use it. And then you’re left with devices or software solutions that are hardly ever used in practice.”

Improved process controls

In terms of workflow, another advantage of dual energy becomes apparent in monitoring the growth of a tumor. In the case of conventional CT scans, it is only possible with great difficulty to pinpoint how much of the iodine-containing contrast agent has really been absorbed by the tissue. When images are then compared to monitor the development of the tissue, this lack of precision makes it difficult for radiologists to make a diagnosis. Dual energy removes this problem, however, by making it possible to evaluate the respective amount of the iodine-containing contrast agent that has been absorbed by the tissue. A further benefit of the technology: Increasingly often, physicians realize in hindsight that it would be helpful to have the native scan from an earlier time in addition to the current image. This would make it easier to assess the process of the tissue development. “Now that we are using dual energy as standard practice, it is no problem to retrieve the scan later from the system,” explains Schindera. “The only issue we’re still concerned about at the moment is whether it makes sense in certain cases to retain the data relating to the virtual non-contrast scan in our system, as opposed to sending them automatically to PACS to speed up data transfer. Compared to the situation we previously faced, however, this really is just a luxury concern.”

Extensive studies

To be certain that dual energy could really achieve the desired results, Sebastian Schindera and his colleagues tested the scanner thoroughly: Before the scanner was used to examine the first patients at the hospital, extensive phantom studies were carried out, for example, using a liver phantom with simulated hypodense lesions. “What immediately struck us was that with TwinBeam Dual Energy, we were able to achieve better image quality with the same dose of radiation,” reports Schindera.

After successfully completing the phantom studies, Schindera and his colleagues began to test different scanner technologies with parallel groups of patients. One of two ongoing studies involves the characterization of kidney concretions, focusing predominantly on image quality and radiation dose.

No interference from implants

An additional challenge at the Department of Abdominal and Oncological Diagnosis is dealing with patients with metal implants or prosthetics in and around the hip area. When CT scans are carried out on organs in the pelvic area, such as on the prostate, the bladder, or on the female internal reproductive organs such as the uterus and the cervix, metal implants regularly cause parts of the images to be almost completely missing. Here, the physician from Basel found that the integrated technology for iterative metal artifact reduction (iMAR) proved to be a real help. “The difference is like day and night. Also, iMAR is so perfectly integrated into the workflow, and can even be used retrospectively for post-processing of the results.”

Since June 2014, the Department of Radiology and Nuclear Medicine at University Hospital Basel has a SOMATOM Definition Edge available for tumor monitoring, laser biopsies, and also for classification of kidney stones.

iMAR is used at the Basel Department of Radiology and Nuclear Medicine for metal artifact reduction around tumors and in the context of other implants that can influence pathogens and their diagnosis. “We once had an extreme case in the hospital where, after the implant of electrodes as part of treatment for Parkinson’s, an abscess developed on the tip of an electrode. The abscess was not visible on the normal CT scan, but was clearly visible after iMAR had been applied,” recalls Schindera.

Lower doses of radiation

Radiation dose is a huge issue for the Basel hospital. One reason for this is the public attention. “Patients always ask about this,” says Schindera. The background: The number of CT scans has substantially increased in recent years. “This may in part be because we physicians are always under pressure to protect ourselves against the backdrop of possible legal consequences.” The stated aim, however, is still to keep the total dose constant, or even to lower it, through the use of new technologies – despite the quantitative growth in examinations. What helps here is not just the Stellar detector, which is included in the SOMATOM Definition Edge, but also the latest generation of iterative image reconstruction with ADMIRE (advanced modeled iterative reconstruction). This is used to improve the quality of CT images that were produced with a low dose of radiation. “We once did a scan of the thorax-abdomen-pelvis to examine a tumor patient, once with a dose of 5 and then with a dose of 10 millisieverts. There was no discernible difference between both images,” reports Schindera. “Three years ago, here at the hospital we were using about 8.3 mSv on average per CT examination. Thanks to the new CT technology, however, we have since been able to reduce this to about 5 mSv. Overall, the new technical possibilities of the SOMATOM Definition Edge with TwinBeam Dual Energy, iMAR, and ADMIRE have truly exceeded our expectations.” ■

Ralf Groetker, Dr. Phil., works as a science writer for research organizations, foundations, and companies as well as for various print and online media. He possesses expertise in Bioethics, STS, and Sustainability.

Dual energy is now used on the SOMATOM Definition Edge as a matter of standard procedure at Basel’s Department of Abdominal and Oncological Diagnostics.

Further Information

www.siemens.com/SOMATOM-Definition-Edge

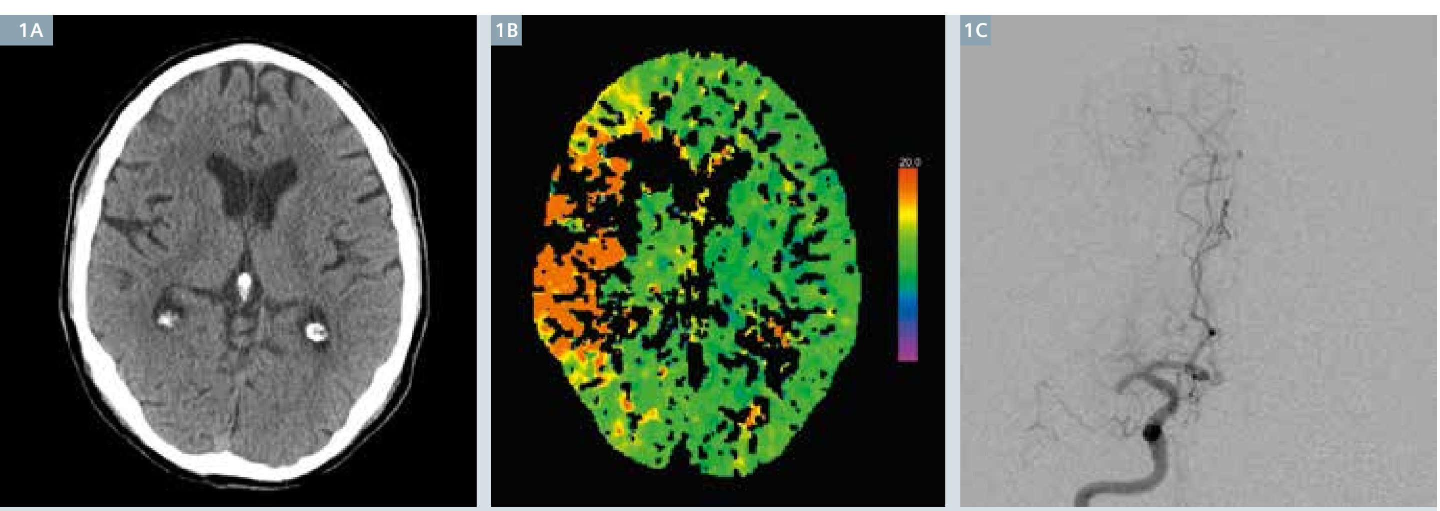
Mechanical Thrombectomy – Faster than Ever

When caring for a patient with acute ischemic stroke, Professor Martin Bendszus and his team are racing against the clock. Using a combination of a CT scanner and mobile C-arm they cut the transfer time between stroke diagnosis and mechanical thrombectomy. The patient is diagnosed and treated in the same room on the same table, without transfer. Already in the first three patients, picture-to-puncture time was as little as 35 minutes.

Text: **Hildegard Kaulen, PhD** Photos: **Carsten Buell**

The world of stroke has changed. For a long time, the only proven effective treatment for acute ischemic stroke was intravenously administered thrombolysis with recombinant tissue-type plasminogen activator (r-tPA). Now, mechanical thrombectomy has advanced to become an important option. Clinical studies with intriguing names such as MR CLEAN, ESCAPE, EXTEND-IA, SWIFT-PRIME, and REVASCAT have demonstrated that interventional clot retrieval improves the outcome for certain stroke patients. The evidence was so convincing that the American Heart Association/American Stroke Association updated its guidelines back in June – giving the strongest recommendation possible for patients who meet certain criteria: class 1, level of evidence A.

Around 100 mechanical thrombectomies were performed last year in Heidelberg – this number was reached this year within the first six months. “Since the studies were published, we have received many more referrals from hospitals in the area and are doubling our numbers this year,” says Professor Martin Bendszus, MD, from Heidelberg University Hospital in Germany. Bendszus is Head of Neuroradiology. His department is a key component in the Heidelberg University Hospital stroke center, one of the leading stroke centers in Germany treating hundreds of stroke patients per year. With strict eligibility criteria, Bendszus estimates that around 15 percent of the 270,000 strokes per year in Germany could potentially be considered candidates for mechanical



1A–C A 74-year-old male patient was admitted due to an acute stroke. An initial native CT (Fig. 1A) image showed no signs of an early stroke. The perfusion image (Fig. 1B) revealed a delayed time-to-peak (TTP) in the right hemisphere. Angiographic imaging (Fig. 1C) demonstrated a right-sided M1 occlusion.
Courtesy of Heidelberg University Hospital, Germany

"Since the studies showed that mechanical thrombectomy is a safe and effective treatment for acute ischemic strokes, we no longer ask why we should perform one, but rather why we shouldn't."

Professor Martin Bendszus, MD,
Head of Neuroradiology,
Heidelberg University Hospital, Germany

thrombectomy. With broader criteria, he estimates this number may increase to 20 percent.

In the case of a stroke, the decisive factor – in addition to the patient's age and the National Institutes of Health Stroke Scale (NIHSS) – is the time it takes to restore perfusion. "In recent trials it was shown that if the blocked artery can be recanalized 20 minutes faster, this increases the chances of a better clinical outcome in the range of 10-15%," says Bendszus. Unfortunately, in most hospitals critical time is lost while patients are transferred between emergency room, diagnostic imaging, and interventional suite, as well as with negotiations between parties preceding each transfer. In Heidelberg, the CT and biplane angiography systems are located in adjacent rooms, yet it still takes fifteen to twenty minutes to move a patient. If the rooms are located further apart, as is the case in a number of hospitals, the move takes much longer. During the time the brain is not perfused approximately two million brain cells die every minute. This is why, when planning his second thrombectomy suite, Bendszus looked for a solution that avoided the need to move the patient, and with a better picture-to-puncture time. He wanted the diagnostic imaging and the mechanical opening of the artery to take place on one table and in one room. In a combined system, the technical personnel can begin preparing for the intervention directly after the patient has been scanned – the best way to minimize picture-to-puncture time.

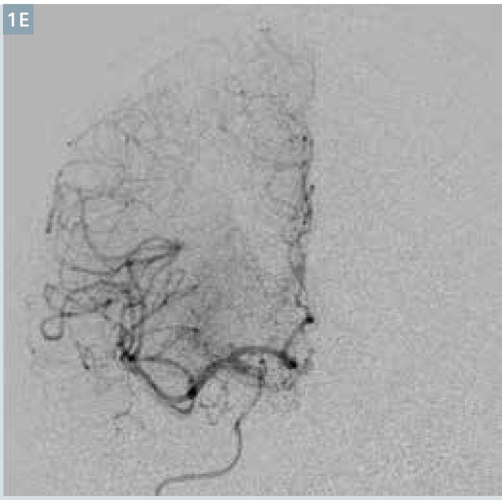
Bendszus had three requirements for the new intervention suite: It had to be a solution that would not restrict normal CT operation. His department performs over 15,000 CT examinations per year, so the room had to be used for normal daily routine, too. In addition, everyone who would be performing a mechanical thrombectomy

1D

The patient was treated with mechanical thrombectomy. The picture-to-puncture time was 38 min; the groin to the first recanalization time was 24 min; and the groin to final thrombolysis on the cerebral infarction scale (TICI) 3 was 50 min.

The patient's NIHSS had improved from 16 (initial) to 2 (after 24 hrs.) and then to 0 (at discharge, day 4).

1E



1D, E A native CT image acquired after treatment (Fig. 1D) showed a small infarct (hypodense area) in the right basal ganglia. An angiographic image (Fig. 1E) demonstrated a complete recanalization of the right cerebral middle artery.
Courtesy of Heidelberg University Hospital, Germany

in the room should be immediately familiar with the system, with similarities to a standard angio system, and the system should provide sufficient image quality to perform the procedure safely. Finally, it was important for Bendszus to be able to switch from CT operation to the interventional procedure very quickly in the case of an acute indication for a thrombectomy. "We had a Formula One pit-stop approach in mind," he says, "where everything is ready and available for use within a few minutes."

CT and mobile C-arm in a single room

How were his requirements met? The new suite is equipped with a SOMATOM Definition AS for diagnostic imaging. In the adjacent room, a mobile Cios Alpha C-arm with flat detector technology is available for the mechanical thrombectomy. It takes five minutes to set up. The CT table is placed at a distance of 95 cm from the gantry so that the C-arm can slot into this space during the intervention. The standard CT table is made of carbon and, using a commercially available extension, is longer than usual so that it is also suitable for the thrombectomy. The CT table, CT scanner, and C-arm can be controlled using remote controls mounted at the tableside, or on a trolley, similar to a standard angio system. The two monitors are mounted on the ceiling. A radiation protection wall was also installed. "What makes this CT and C-arm system so special is its simplicity," explains Bendszus. "We're using a 64-slice CT system and a mobile C-arm without any expensive reconstruction costs, and achieve a high level of flexibility and accessibility."

In a feasibility study supported by Siemens, Bendszus and his colleagues have shown that diagnosing and treating stroke patients with the combined system is feasible. "The combination is equally suited for this procedure, compared to conventional angiography systems," says Johannes Pfaff, MD, the physician in charge of the study. "The excellent performance and large field-of-view of the Cios Alpha deliver an image quality that is more than adequate to safely maneuver the instruments. The system has all the essential elements for angiography," Pfaff explains. The feasibility study was published in May 2015 in the *Journal of Neurointerventional Surgery* (doi:10.1136/neurintsurg-2015-011744).

Average picture-to-puncture time of 35 minutes

Pfaff and Bendszus treated three patients as part of the feasibility study: An 84-year-old with an occlusion in the M1 segment of the left-middle cerebral artery; a 51-year-old with an occlusion in the basilar artery following a wake-up stroke; and an 83-year-old with an occlusion in the M2 segment of the left-middle cerebral artery. "The average time between the diagnostic scan and puncture of the femoral artery was 35 minutes," says

The new suite at Heidelberg University Hospital is equipped with a SOMATOM Definition AS for diagnostic imaging. In the adjacent room, a mobile Cios Alpha C-arm with flat detector technology is available for the mechanical thrombectomy and it takes five minutes to set up.

“The time needed from high-quality CT stroke imaging to groin puncture could become as low as 28 min. None of us has ever been this fast. And we are pushing even further.”

Johannes Pfaff, MD,
Heidelberg University Hospital, Germany

Pfaff. “The time needed from high-quality CT stroke imaging to groin puncture could become as low as 28 min. None of us has ever been this fast. And we are pushing even further.” Time was saved crucially by keeping the patient in one place. If a patient has to be moved from the CT room into the neighboring angio suite, the picture-to-puncture time was 57 minutes in previous studies, and the picture-to-recanalization time was 250 minutes. In Heidelberg, all emergencies are now treated in the new suite. That is, unless two emergencies have to be treated concurrently. “We now have the problem that we’re so fast that the logistics have to be adjusted,” says Bendszus. “The anesthetist should theoretically already be in the room for the diagnostic CT scan.” Following the feasibility study, a larger study will now be conducted with fifty patients in order to confirm the incredibly impressive times. “We already included 34 patients,” says Pfaff. “We hope to publish the results next year.”

Decision-making based on the infarct core and penumbra

Who is eligible for mechanical thrombectomy? “We decide on the basis of the infarct core and the size of penumbra, not only on the basis of the time elapsed after symptom onset,” says Bendszus. The infarct core is the amount of irreversibly damaged tissue. The penumbra is malperfused tissue that may still be saved through fast recanalization. Core and penumbra are both measured using CT perfusion imaging. In studies that have been published, mechanical thrombectomy was performed within twelve hours following the onset of symptoms. “If the infarct core is small and the penumbra is large, the time elapsed is less relevant,” says Bendszus. “Since the studies showed that mechanical thrombectomy is a safe and effective treatment for acute ischemic strokes, without an increased risk of complication, we no longer ask why we should perform one, but rather why we shouldn’t.” Bendszus also considers a wider range of indications. The published studies report on the treatment of patients with occlusions in the internal carotid artery and the proximal middle cerebral artery. In Heidelberg, also more distally located thrombi are removed using stent retrievers. The primary risk is that part of the thrombus is lost during its retrieval, causing a new embolization in another place. “We can perform a diagnostic CT scan at any point during the intervention, which allows us to react immediately to any complications,” says Pfaff. “This is a significant safety factor.”

Need for structured training

Which hospitals should offer mechanical thrombectomy? “Maximum care hospitals with a Department of Neurology have to offer this procedure,” says Bendszus. “However, proper training is essential for the intervention. You have to understand the approach and learn how to probe the vessels. You also have to understand the diagnostic images.” This is why Bendszus calls for structured training, emphasizing that it is now up to professional medical associations to ensure that high-quality care is available across Germany in the near future.

Bendszus also envisages a new trauma room concept. Following the diagnostic CT scan, various vascular interventions can be performed on the same table. The effectiveness of the treatment can then be checked as required during the intervention using CT imaging. “The amazing thing is that it’s so easy to implement without needing any additional construction work,” says Bendszus. “Here, the technology is driving forward the clinical applications.” ■

Hildegard Kaulen, PhD, is a molecular biologist. After stints at the Rockefeller University in New York and the Harvard Medical School in Boston, she moved to the field of freelance science journalism in the mid-1990’s and contributes to numerous reputable daily newspapers and scientific journals.

Case 1

Combined Coronary and Carotid CTA with 60 mL Contrast Agent and a Radiation Dose of only 1.7 mSv

By Cíntia A. Melo, MD; Maria Eduarda M. Siqueira, MD; Mayra Dias, MD; Rainer Haetinger, MD, PhD; Luis A.G. Gabure, MD; Milena C. Gravinatti; Cesar A.M. Cattani, MD, PhD; Caroline B. de Paula*

Department of Radiology, Beneficência Portuguesa de São Paulo Hospital, São Paulo, Brazil
* Siemens Healthcare, Brazil

History

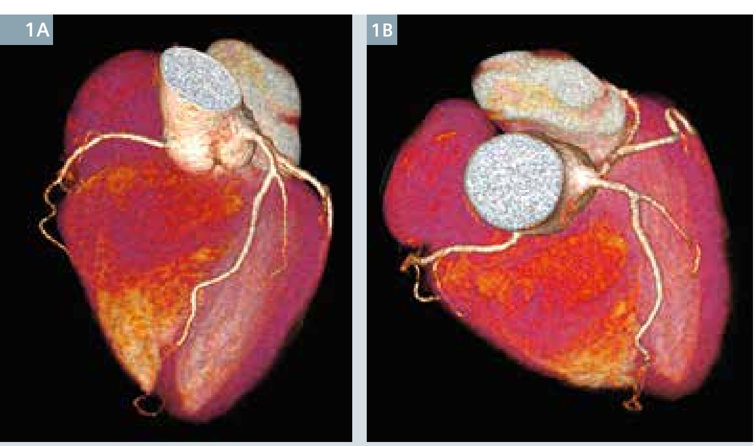
A 55-year-old male patient, with atypical chest pain, syncope, hyperlipidemia, and a family history of coronary artery disease (CAD), underwent a treadmill test. This was inconclusive due to a left-bundle branch block. A coronary and a carotid CT angiography (CTA) were requested by the referring physician to rule out coronary and/ or carotid artery disease.

Diagnosis

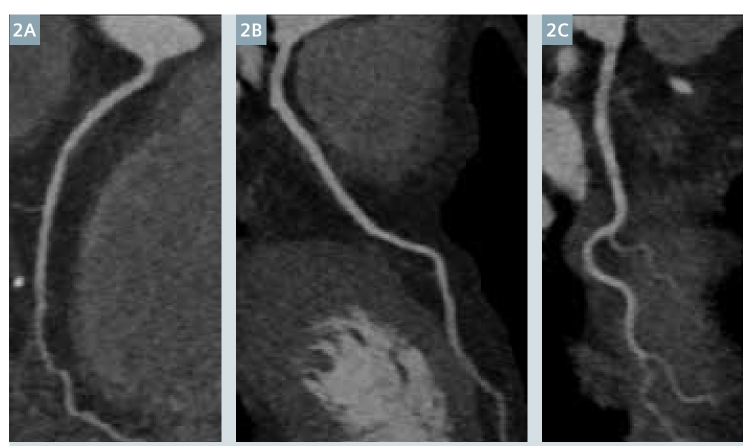
The coronary CTA (cCTA) showed no evidence of coronary plaques or stenoses. A small calcification area in the pericardium, next to the right atrium posterior wall, was seen. There were also no clinical findings in the carotid CTA.

Comments

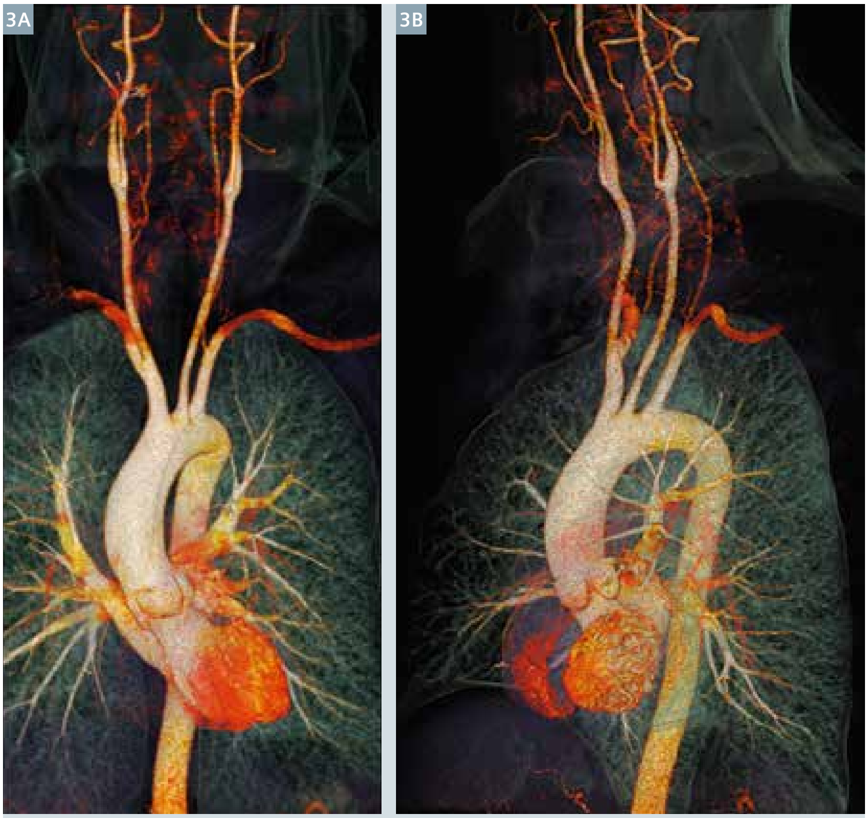
cCTA and carotid CTA are valuable, noninvasive imaging examinations that support the physician in diagnostic accuracy. Previously, with a single source CT scanner, two separate acquisitions had to be performed resulting in a higher radiation dose and the need for contrast agent of 70 mL for cCTA and 50 mL for carotid CTA. Using a Dual Source CT scanner (SOMATOM Definition Flash), both acquisitions are combined into one, necessitating only 60 mL contrast agent. This is made possible by performing a spiral scan in Flash mode with a very high pitch of 3.2. Radiation dose is also reduced due to advanced technologies such as a Stellar detector and sinogram affirmed iterative reconstruction (SAFIRE[1]). A slice width of 0.5 mm also improves the definition of the vessel lumen and reduces blooming of the stent material. ■



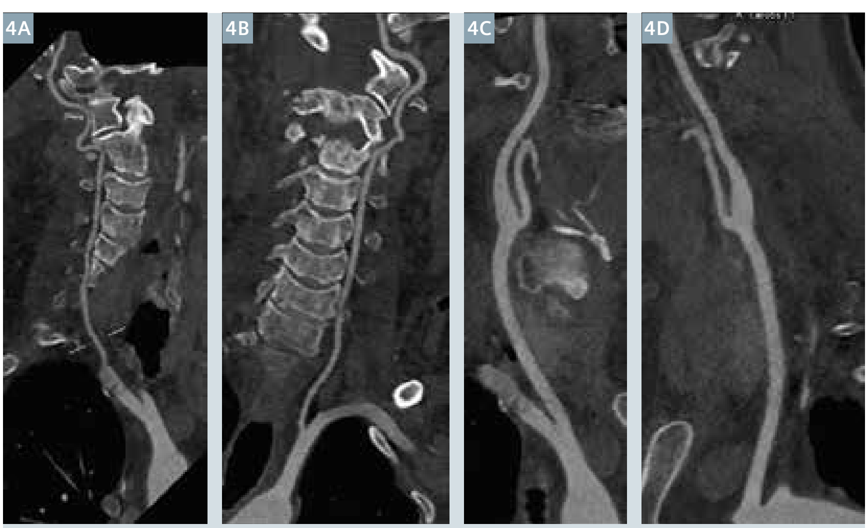
1 VRT images from the cCTA show no evidence of coronary plaques or stenosis.



2 Curved MPR images of the RCA (Fig. 2A), the LAD (Fig. 2B) and the Cx (Fig. 2C) show no evidence of coronary plaques or stenosis.



3 VRT images show an overview of the whole scan range.



4 Curved MPR images show normal bilateral vertebral and carotid arteries.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Neck/Thorax
Scan length	416.5 mm
Scan direction	Caudo-cranial
Scan time	0.91 s
Tube voltage	100 kV
Tube current	282 mAs/rot.
Dose modulation	–
$CTDI_{vol}$	2.75 mGy
DLP	129 mGy cm
Effective dose	1.73 mSv
Rotation time	0.28 s
Pitch	3.4
Slice collimation	128 × 0.6 mm
Slice width	0.5/0.6/0.75 mm
Reconstruction increment	0.3/0.4/0.5 mm
Reconstruction kernel	I26 (SAFIRE)
Temporal resolution	75 ms
Heart rate	60–73 bpm
Contrast	
Volume	60 mL
Flow rate	5 mL/s
Start delay	Test bolus + 5 s

[1] In clinical practice, the use of SAFIRE 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. The following test method was used to determine a 54 to 60% dose reduction when using the SAFIRE reconstruction software. Noise, CT numbers, homogenity, low contast resolution, and high contrast resolution were assessed in a Gammex 438 phantom. Low-dose data reconstructed with SAFIRE showed the same image quality compared to full dose data based on this test. Data on file.
The statements by Siemens' customers described herein are based on results that were achieved in the customer's unique setting. Since there is no "typical" hospital and many variables exist (e.g., hospital size, case mix, level of IT adoption) there can be no guarantee that other customers will achieve the same results.

Case 2

Ultra-fast Low-dose Coronary CTA at 0.37 mSv and with 35 mL Contrast Agent

By Julian L. Wichmann, MD; Carlo N. De Cecco, MD; U. Joseph Schoepf, MD

Department of Radiology and Radiological Science, Medical University of South Carolina, Charleston, SC, USA

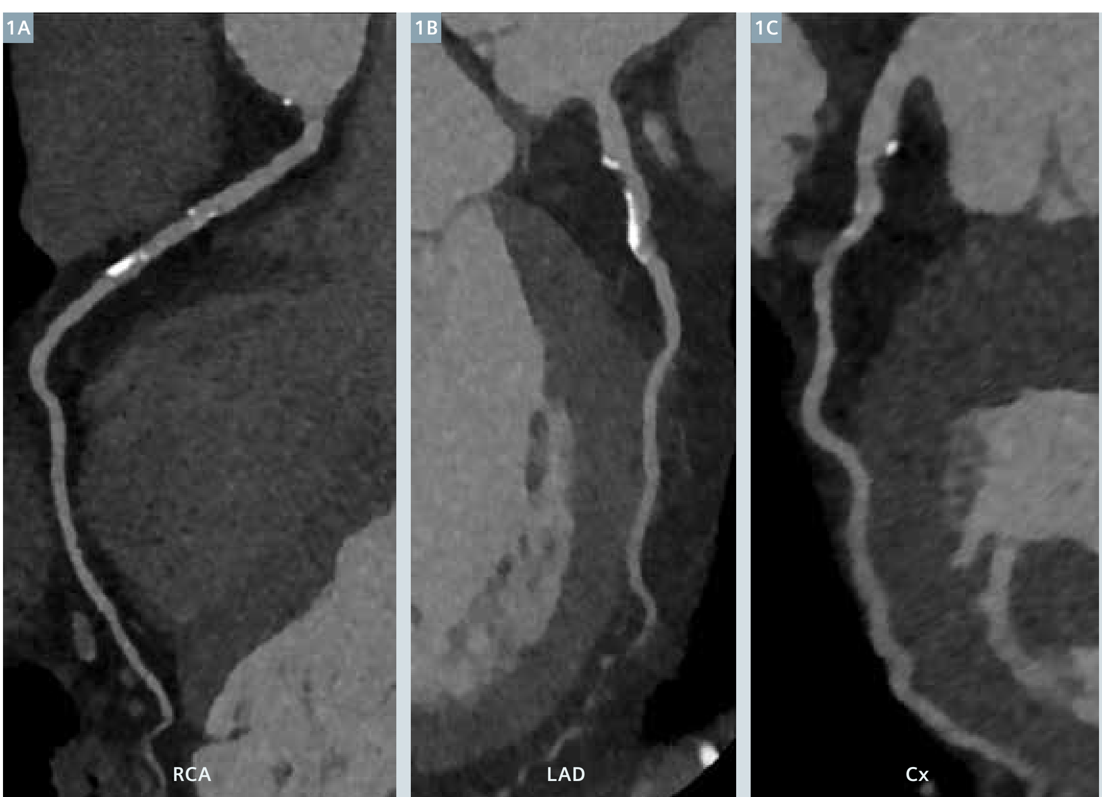
History

A 77-year-old male patient, with multiple risk factors including hypertension, hyperlipidemia, and history of cigarette smoking, was admitted with recent onset of chest discomfort and shortness of breath at rest. The physical examination was unremarkable. Patient characteristics, including body mass index (25 kg/m^2), blood pressure (130/80 mmHg) as well as ECG and echocardiography, were normal at admission. The chest discomfort and shortness of breath persisted after admission and an initial set of cardiac troponin I showed a level of 0.04 ng/mL. The patient was subsequently referred for coronary CT angiography (cCTA) for further evaluation.

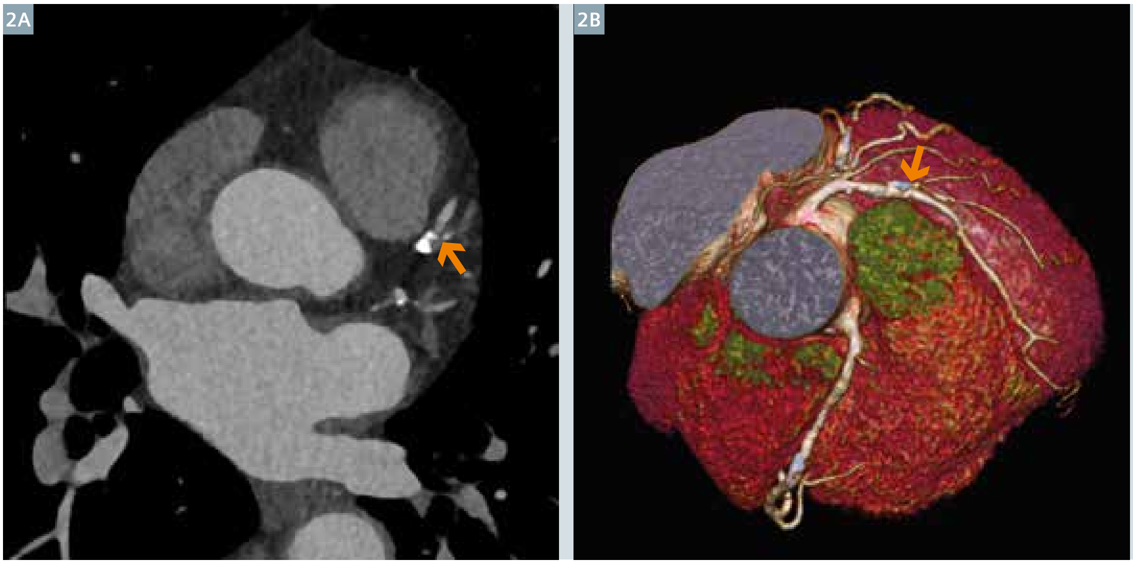
Diagnosis

Calcium scoring revealed multiple calcifications in the left main (LM), left anterior descending (LAD), right (RCA) and circumflex (Cx) coronary arteries, most distinct in the LAD. The total calcium score was 509, corresponding to the 61st age, race, and gender adjusted percentile.

cCTA images demonstrated an approximately 50% stenosis of the mid LAD segment and mid CX without LM stenosis. An extensive calcified plaque caused significant stenosis (>50%) of the ostium of the first diagonal branch off the LAD. The RCA showed only mild luminal irregularities in the mid-vessel segment.



1 Curved MPR images show mild stenosis in the LAD and the Cx, as well as luminal irregularities in the RCA.



2 Axial (Fig. 2A) and VRT (Fig. 2B) images reveal extensive calcified plaque in the proximal LAD which causes a severe stenosis at the ostium of the first diagonal branch (arrows). Multiple calcified plaques are shown in all 3 coronary arteries (Fig. 2B).

Invasive cardiac catheterization was performed, confirming the stenosis (> 70%) of the first diagonal branch. An everolimus-eluting stent was successfully deployed after balloon angioplasty. An excellent angiographic result was achieved. The patient was safely discharged 24 hours after the procedure without recurrence of symptoms during follow-up.

Comments

In this case, cCTA helped obtain a definitive diagnosis and aided immediate treatment in a patient with atypical chest pain and a medium risk for coronary artery disease. Excellent image quality, despite diffuse coronary calcifications, allowed for the detection of hemodynamic-relevant stenosis and facilitated planning of the percutaneous interventional procedure. Timely diagnosis is a decisive factor in the management of unstable angina considering that “time is myocardium”.

All available latest Dual Source CT radiation dose-saving techniques were applied in this case. ECG-gated ultra-high-pitch acquisition was performed, automated tube current modulation (CARE Dose4D) was activated, and automated tube voltage modulation (CARE kV) resulted in a 70 kV image acquisition. The estimated effective dose was only 0.37 mSv. Performing the scan at 70 kV allowed restricting the contrast media bolus to only 35 mL due to the increased intravascular attenuation of iodine. To further decrease image noise associated with the low tube voltage, advanced image-based iterative reconstruction (ADMIRE[1], level 3, 4, 5) was performed. ■

Examination Protocol

Scanner	SOMATOM Force		
Scan area	Heart	Rotation time	0.25 s
Scan mode	Turbo Flash mode	Pitch	3.2
Scan length	125.7 mm	Slice collimation	192 × 0.6 mm
Scan direction	Cranio-caudal	Slice width	0.5 mm
Scan time	0.17 s	Reconstruction increment	0.3 mm
Tube voltage	70 kV (CARE kV)	Reconstruction kernel	Bv40 (ADMIRE)
Tube current	555 eff. mAs	Heart rate	62 bpm
Dose modulation	CARE Dose4D	**Contrast**	370 mg/mL
$CTDI_{vol}$	1.56 mGy	Volume	35 mL + 50 mL saline
DLP	26.1 mGy cm	Flow rate	2.2 mL/s
Effective dose	0.37 mSv	Start delay	Bolus tracking + 4 s

[1] In clinical practice, the use of ADMIRE 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.

Case 3

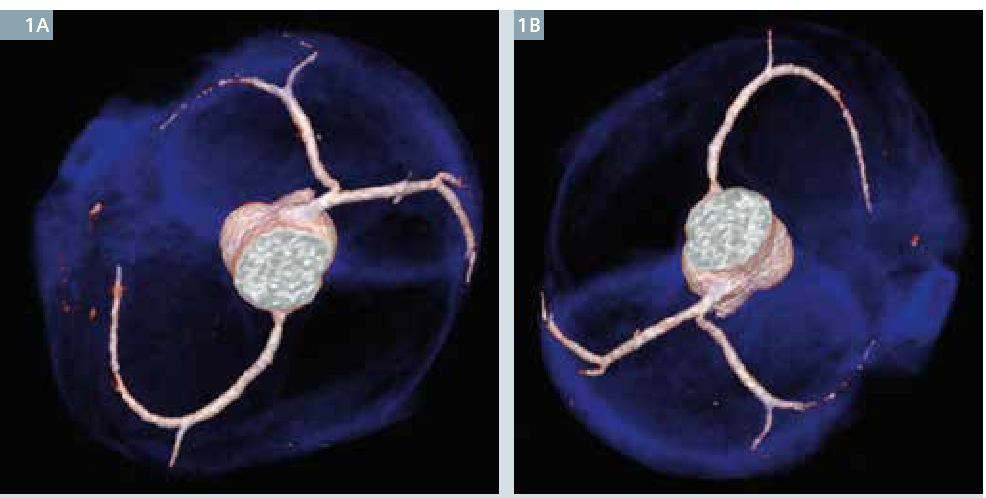
Unknown Partially Anomalous Pulmonary Venous Connection in a Symptomatic Adult

By Adriano Camargo de Castro Carneiro, MD; Valéria de Melo Moreira, MD; Tiago Augusto Magalhães, PhD, MD; Mariana Macedo Lamacié, MSc, MD; Helder Jorge de Andrade Gomes, MD; Matheus de Souza Freitas, MD; Paulo César Ferraz Dias Filho, MD; Fábio Vieira Fernandes, MD; Bernardo Noya Alves de Abreu, MD; Juliana Hiromi Silva Matsumoto Bello, MD; Carlos Eduardo Elias dos Prazeres, MD; Carlos Eduardo Rochitte, PhD, MD and Caroline Bastida de Paula, BD*

Department of Cardiovascular CT and MRI of the Heart Hospital (HCor), São Paulo, Brazil
* Siemens Healthcare Brazil

History

A 42-year-old female patient, with a known history of paroxysmal atrial tachyarrythmia for the past 27 years and exertional dyspnea for the past two, had undergone various exercise stress tests and echocardiographs. All these results were within the normal range. She developed exertional chest pain within the past month and a coronary CT angiography (cCTA) was requested to rule out coronary anomalies.



1 VRT images show normal coronary arteries.

2 VRT image acquired from the first scan reveals only one right pulmonary vein, the right inferior (arrow), connected to the left atrium.

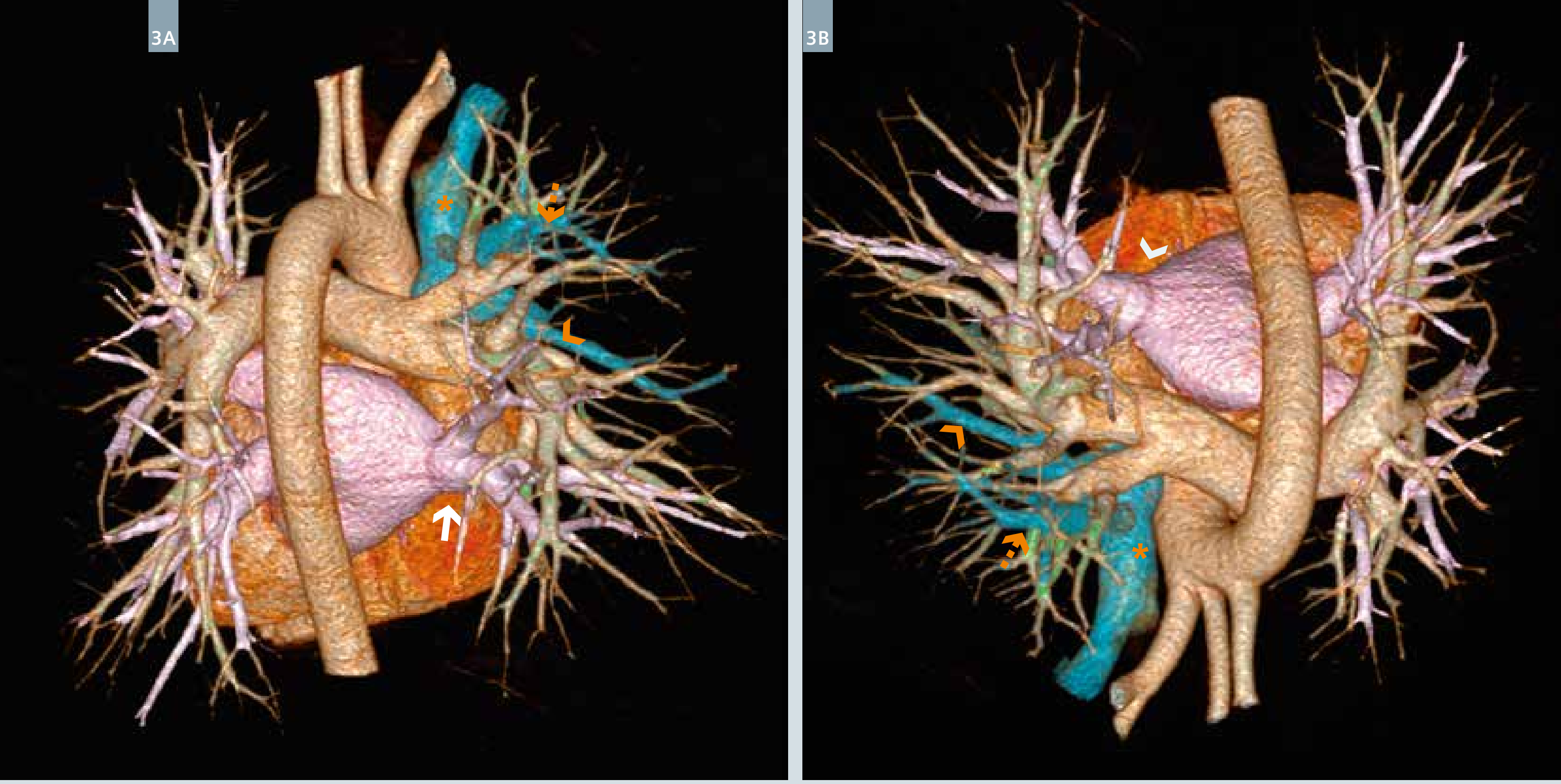
Diagnosis

cCTA images demonstrated normal coronary arteries (Fig. 1). However, contrast was unexpectedly seen in the right cardiac chambers, which were moderately dilated. Beyond that, mild dilatation of the pulmonary trunk and the pulmonary arteries was also seen. Only one right pulmonary vein, the right inferior pulmonary vein, was demonstrated and was connected to the left atrium (Fig. 2).

Another high-pitch acquisition of the thorax was performed and these images showed two right pulmonary veins, the right upper and the right middle, anomalously connected to the superior vena cava (Fig. 3). A diagnosis of partially anomalous pulmonary venous connection (PAPVC) was clearly established by the physician.

Comments

PAPVC is defined when one or more pulmonary veins are connected to the right (rather than to the left) atrium. These may be directly connected to the right atrium or indirectly via the superior or inferior vena cava. Children with isolated PAPVC are usually symptomatic whereby the development of symptoms, depends on how many pulmonary veins are anomalously connected to the right atrium. The most common symptoms, include exertional dyspnea, palpitations from atrial tachyarrythmia, and, in the latter course of the disease, chest pain and symptoms from right heart failure and pulmonary hypertension.



3 VRT images acquired from the second scan show anomalous connections of the right upper (dashed arrows) and the right middle (arrowheads) pulmonary veins to the superior vena cava (asterisk). The right inferior pulmonary vein (arrows) is connected to the left atrium.

Although echocardiography is the primary noninvasive imaging method for this investigation, it is limited in providing the necessary anatomical information concerning the pulmonary veins. CT angiography (CTA) can evaluate the origins, the courses, and the connections of the anomalous pulmonary veins and is useful in pre-operative planning.

In this case, a high-pitch acquisition with the SOMATOM Definition Flash scanner was performed to evaluate the coronary arteries and the pulmonary veins, resulting in a very low radiation dose. The scan provided all the necessary anatomical information to plan a surgical intervention with no need for an additional invasive angiography. ■

Examination Protocol

Scanner	SOMATOM Definition Flash	
Scan area	Heart	Thorax
Scan length	138 mm	262.8 mm
Scan direction	Caudo-cranial	Caudo-cranial
Scan time	0.3 s	0.57 s
Tube voltage	120 kV	100 kV
Tube current	350 mAs	360 mAs
Dose modulation	CARE Dose4D	CARE Dose4D
$CTDI_{vol}$	5.72 mGy	3.52 mGy
DLP	114 mGy.cm	114 mGy.cm
Effective dose	1.6 mSv	1.6 mSv
Rotation time	0.28 s	0.28 s
Pitch	3.4	3.4
Slice collimation	128 × 0.6 mm	128 × 0.6 mm
Slice width	0.6 mm	0.6 mm
Reconstruction increment	0.4 mm	0.4 mm
Reconstruction kernel	B26f, I26f	B26f, I26f
Heart rate	53 bpm	55 bpm
Contrast		
Volume	50 mL + 40 mL saline	40 mL + 20 mL mixed with 20 mL saline
Flow rate	5 mL/s	4 mL/s
Start delay	Test bolus + 5 s	Test bolus + 5 s

Case 4

Aortic Aneurysm with Complex Endovascular Repair

By Stefanie Mangold, MD; Carlo N. De Cecco, MD; U. Joseph Schoepf, MD

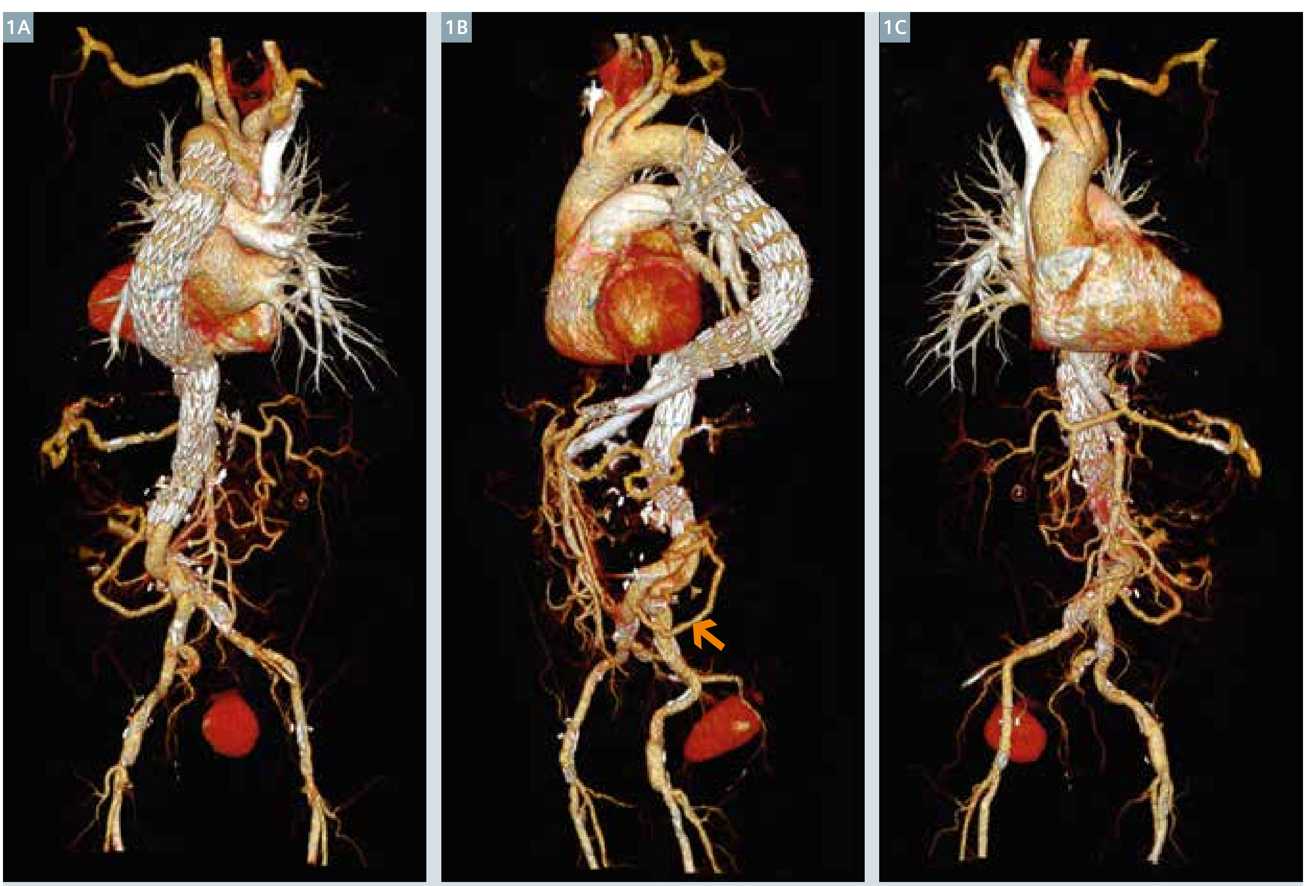
Division of Cardiovascular Imaging, Department of Radiology and Radiological Science, Medical University of South Carolina, Charleston, SC, USA

History

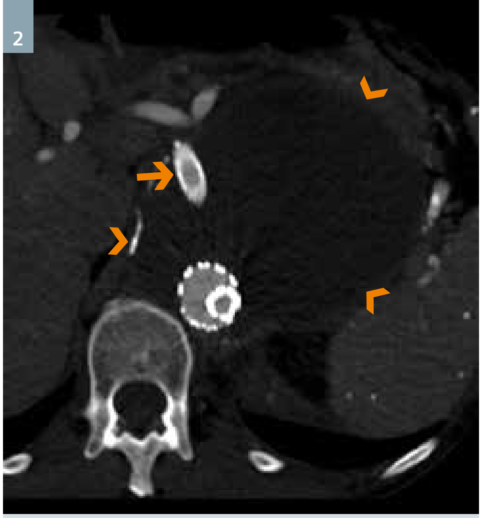
A 66-year-old male patient, with a known history of thoracic and abdominal aortic aneurysms, had undergone multiple aneurysm repairs. Four months ago, a further aneurysm repair was performed on a contained rupture of the abdominal aortic aneurysm (AAA), which was secondary to a large endoleak following complex branched helical endovascular aneurysm repair. The patient was referred for a follow-up CT angiography (CTA) of the entire aorta. At admission, he was asymptomatic with a normal body mass index (22.1 kg/m^2) and normal blood pressure (133/69 mmHg).

Diagnosis

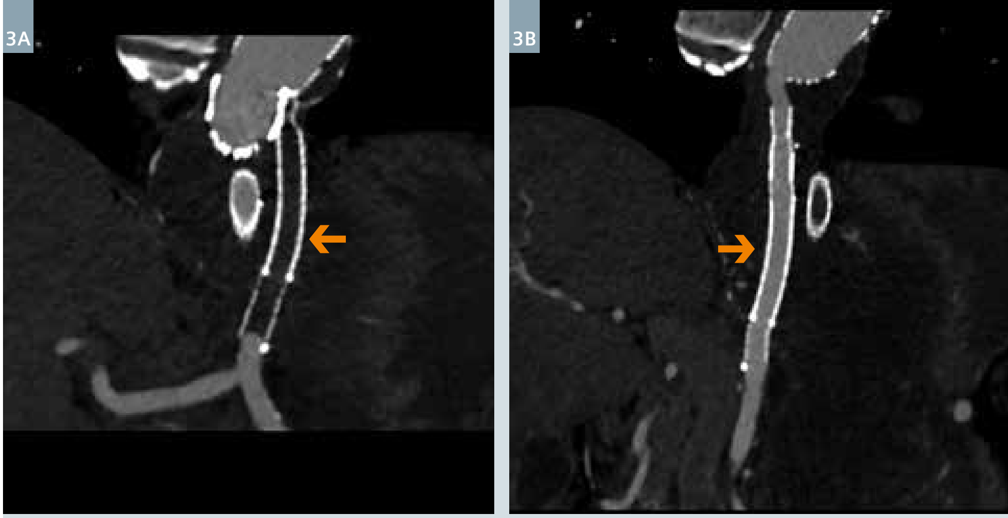
CTA images demonstrated a stent graft within the aneurysmal descending aorta and a bifurcated stent graft extending through the abdominal aortic aneurysm. Additionally, stent grafts were revealed in the superior mesenteric artery (SMA) and in the celiac trunk. A re-implantation of the left renal artery,



1 VRT images show stent grafts in the aneurysmal descending aorta, the abdominal aorta, the SMA,and the celiac trunk (Fig. 1A). The left renal artery is a re-implantation with takeoff from the right common iliac artery (Fig. 1B, arrow). The distal flow of the celiac trunk is reconstituted by the collateral arteries (Fig. 1C).



2 An axial image shows a large aneurysm sac (arrowheads) as well as the patent stent graft within the abdominal aorta and the SMA (arrow). No signs of contrast extravasation, indicating a residual endoleak, were seen.



3 Curved MPR images show stent grafts in the celiac trunk (Fig. 3A, arrow) and in the SMA (Fig. 3B, arrow). The origin of the celiac trunk is occluded and its distal flow is reconstituted. The stent in the SMA is patent.

with a takeoff from the right common iliac artery, was also visualized (Fig. 1). The stent graft within the celiac artery was occluded at its origin, with reconstitution of the flow distal to the collateral arteries as it exited the aneurysm sac (Fig. 3A). The stented superior mesenteric artery (Fig. 3B) and the re-implanted left renal artery were patent. No signs of contrast extravasation indicating a residual endoleak, were evident (Fig. 2).

Due to his stable clinical condition and the lack of a residual endoleak, the patient was scheduled for a follow-up CTA in 6 months.

Comments

CARE kV automatically recommends the optimal tube voltage for the individual patient and clinical indication. Simultaneously, CARE Dose4D (Real-time Anatomic Exposure Control) adjusts the tube current. The combination of CARE kV and CARE Dose4D enables an optimized, automatic adjustment of tube current and tube voltage – individualized for each patient and the clinical indication. In this case, 70 kV was applied which resulted in an excellent intravascular contrast enhancement with only 50 mL contrast medium and a significant effective dose reduction to 3.9 mSv. To further reduce the increased image noise, associated with the lower tube voltage setting, images were reconstructed using ADMIRE (advanced modeled iterative reconstruction).

Due to the availability of the various new technologies, diagnostic confidence is greatly enhanced, even in such cases of complex vascular repair. ■

Examination Protocol

Scanner	SOMATOM Force		
Scan area	Entire aorta	Rotation time	0.5 s
Scan mode	Routine Spiral	Pitch	0.6
Scan length	66.1 cm	Slice collimation	2 × 96 × 0.6 mm
Scan direction	Cranio-caudal	Slice width	1.5 mm
Scan time	9 s	Reconstruction increment	1.5 mm
Tube voltage	70 kV	Reconstruction kernel	Bv36
Tube current	528 eff. mAs	Iterative reconstruction	ADMIRE, level 3
Dose modulation	CARE Dose4D	**Contrast**	350 mgI/mL
Automated tube voltage selection	CARE kV, semi mode	Volume	50 mL + 50 mL saline
$CTDI_{vol}$	3.47 mGy	Flow rate	5.0 mL/s
DLP	229.4 mGy cm	Start delay	Bolus tracking + 4 s
Effective dose	3.9 mSv		

Case 5

Diagnosis of an Aneurysm and an Arteriovenous Malformation using CTA

By N. Tjongarero, FcRAD. Diag., SA.

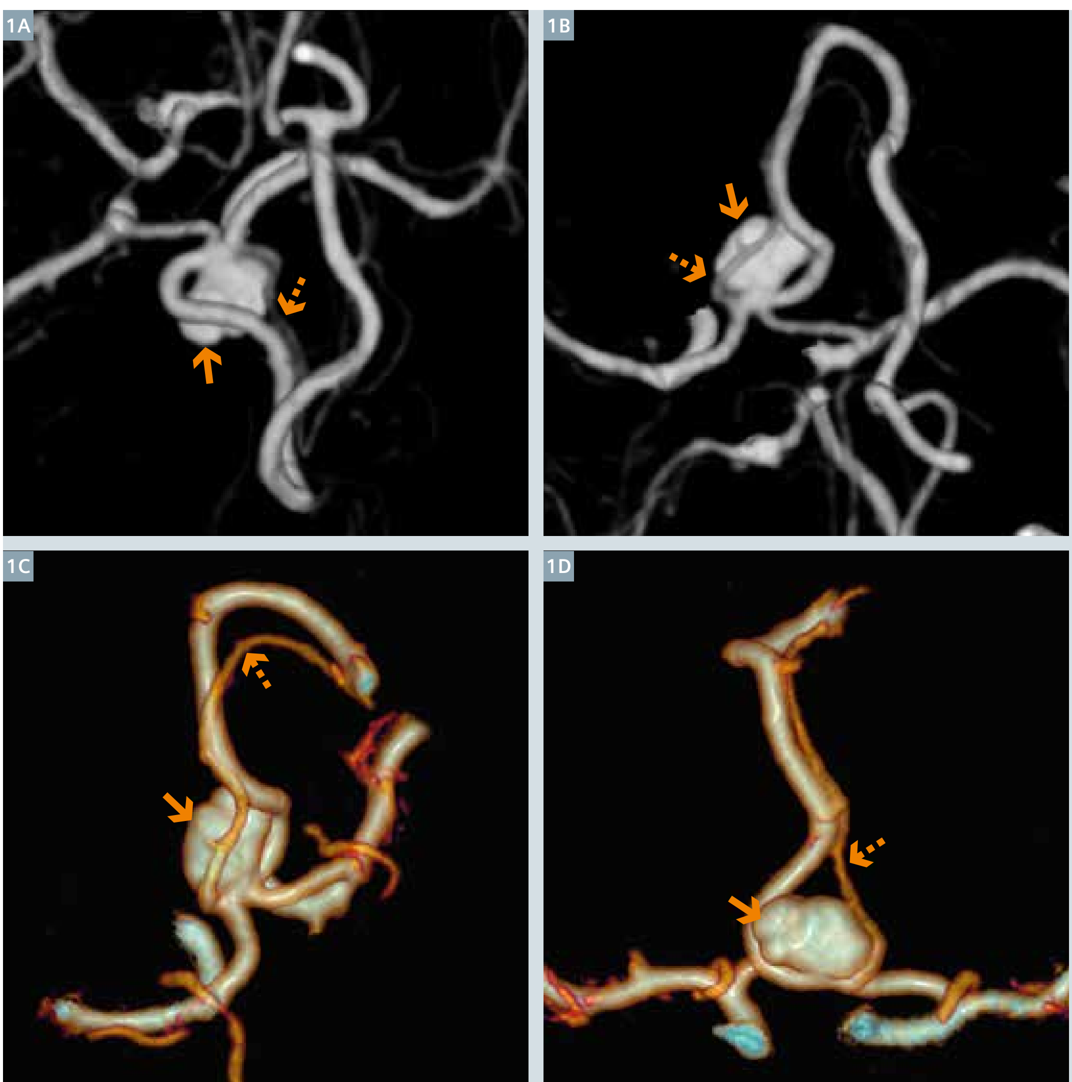
Department of Radiology, Welwitschia Hospital, Walvis Bay, Namibia

History

A 51-year-old male patient, complaining of a first episode of convulsions, generalized convulsions, and severe headaches after convulsions, was referred for a cerebral CT scan. The result of a native CT scan suggested a subarachnoid hemorrhage, featuring a ruptured ANCOM aneurysm. A cerebral CT angiography (CTA) was performed for further investigation.

Diagnosis

CTA images showed an aneurysm arising from the anterior communicating artery (Fig. 1), as well as a large arteriovenous malformation (AVM) nidus with enlarged arterial feeders and



1

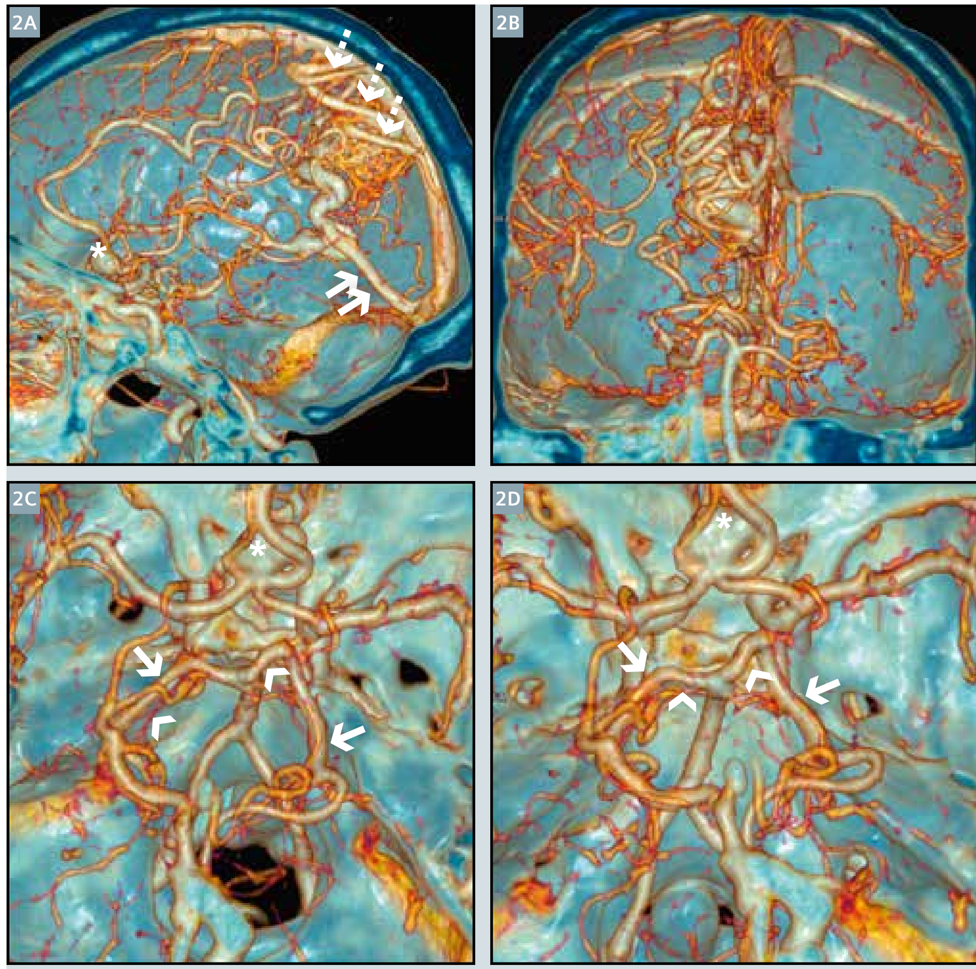
VRT images from different views show an aneurysm (arrows) arising from the anterior communicating artery, whereas the right ACA (dashed arrows) appears to be smaller in caliber.

dilated draining veins. The AVM was located para-midline in the right posterior parietal area (Fig. 2). The aneurysm measured 10.4 (AP) × 12.4 (TRV) × 9.2 (CC) mm in size and the right anterior cerebral artery (ACA) appeared to be relatively smaller in caliber. The arterial feeders of the AVM seemed to originate bilaterally from the posterior communicating arteries (PCA) and the superior cerebellar arteries (SCA). The draining veins appeared to be the posterior parietal cortical veins (PPCV) and the straight sinus (SS).

CTA confirmed a right ANCOM aneurysm as well as a right posterior parietal AVM. The aneurysm was the most likely cause of the extensive subarachnoid hemorrhage with intra-ventricular extension. An urgent neurosurgical referral was recommended.

Comments

The diagnosis of the cerebral aneurysm relied on the CTA as there were no facilities for conventional DSA at this site. Three-dimensional demonstration of the cerebral vascular structures provided morphological information, such as the relationship between the aneurysm and the surrounding brain tissue, the bony landmarks and the feeding and draining vessels of the AVM, and was critical for treatment planning. ■



2 VRT images demonstrate a sagittal (Fig. 2A) and a coronal (Fig. 2B) overview of the cerebral vascular system, with zoomed views (Figs. 2C and 2D) showing the arterial feeders from bilateral PCA (arrows) and SCA (arrowheads), and the draining veins from the PPCV (dashed arrows) and the SS (double arrows). The aneurysm is also shown (asterisk).

Examination Protocol

Scanner	SOMATOM Scope		
Scan area	Head	Rotation time	1 s
Scan length	165 mm	Pitch	1.5
Scan direction	Caudo-cranial	Slice collimation	16 × 0.6 mm
Scan time	11.48 s	Slice width	1 mm
Tube voltage	110 kV	Reconstruction increment	0.5 mm
Tube current	80 eff. mAs	Reconstruction kernel	H30s
Dose modulation	CARE Dose4D	**Contrast**	
$CTDI_{vol}$	12.68 mGy	Volume	100 mL
DLP	240.92 mGy cm	Flow rate	5 mL/s
Effective dose	0.5 mSv	Start delay	Bolus tracking + 4 s

Case 6

Ultra-low Dose and Ultra-fast Scan in a Patient with Dyspnea

By Guoqiang Chen, MD; Kai Sun, MD; Xiaolin Liu; Ruiping Zhao; Xi Zhao, MD*

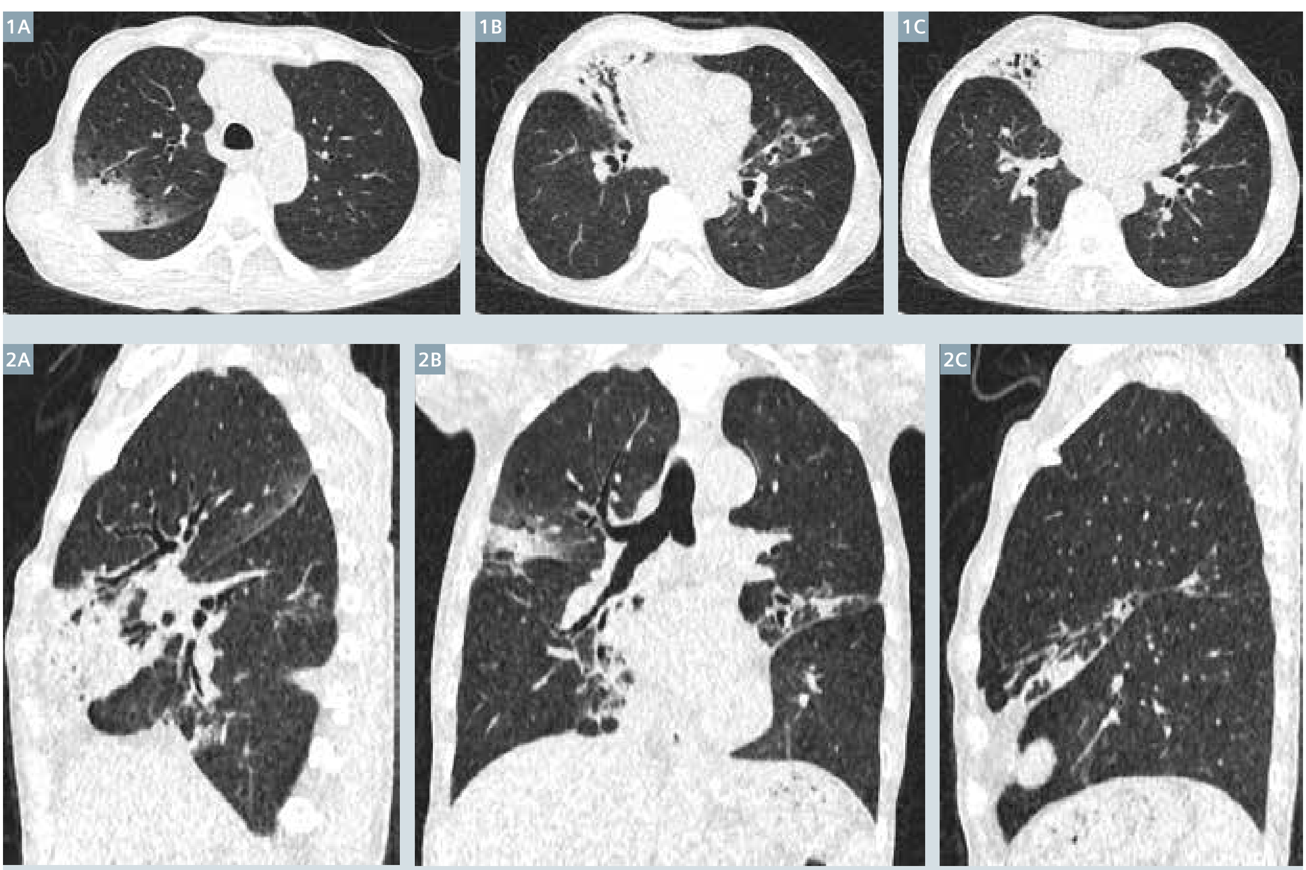
Department of Radiology, Baotou Central Hospital, Inner Mongolia, P.R. China
* Siemens Healthcare, P.R. China

History

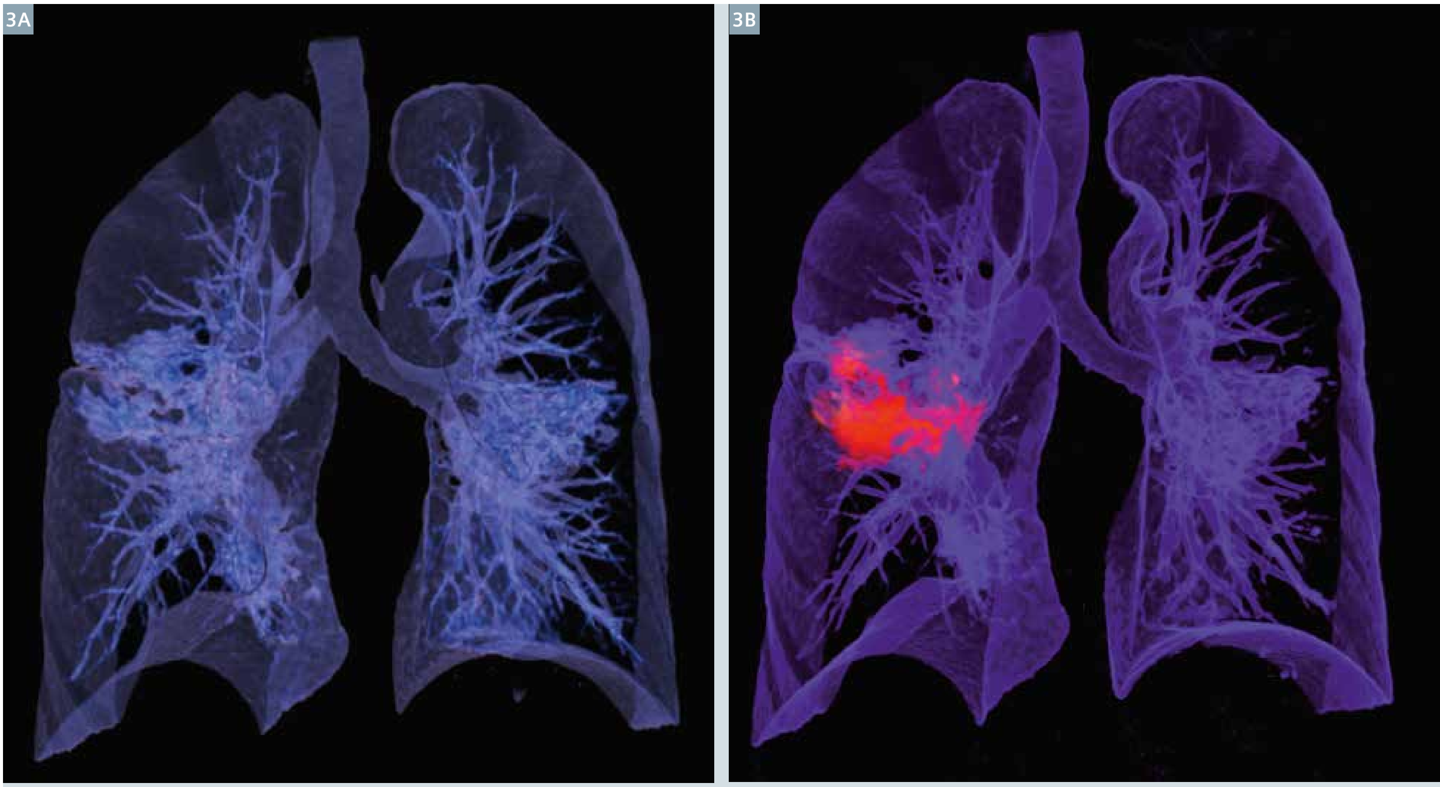
A 77-year-old male patient, until recently a heavy smoker, was hospitalized complaining of dysphagia and emaciation for the past month. He had neither fever nor chest pain upon admission but a recurrent cough with white sputum and progressive dyspnea gradually developed. A chest radiography revealed right upper lung infiltrates and pulmonary atelectasis in the right middle lobe. A thoracic CT scan was requested for further evaluation.

Diagnosis

The CT images revealed areas of air-space consolidation in the right upper, right middle, right lower, and left lingular lobes with associated areas of ground-glass attenuation and signs of air bronchogram. Bilateral diffuse bronchial wall thickening and interlobular septal thickening were present. The minor fissure was inferiorly displaced, suggesting a volume loss of the right middle lobe. Pleural thickening in the posterior wall of the right lower lobe and of the lateral wall of the left lingular lobe were present. No suspicious findings were seen in the mediastinum.



1, 2 1.5 mm axial (Fig. 1) and MPR (Fig. 2) images reveal multiple areas of air-space consolidation with associated areas of ground-glass attenuation and signs of air bronchogram in both lungs. Diffuse bronchial wall thickening and interlobular septal thickening are present. The minor fissure is inferiorly displaced suggesting a volume loss of the right middle lobe. Pleural thickening in the posterior wall of the right lower lobe and the lateral wall of the left lingular lobe are also present.



3 VRT images with different presets show bilateral areas of air-space consolidation in three dimensions.

The patient was treated with empiric antibiotic therapy, and a follow-up CT scan was recommended.

Comments

Thoracic CT scans have been performed in clinical routine for decades. Recent developments in CT technology have greatly improved CT performance in terms of speed and radiation dose reduction. In this case, the patient suffered from dyspnea and could not hold his breath during the scan. A scan in Turbo Flash mode was performed in free breathing and completed in a total scan time of 0.42 s. Another highlight was the Selective Photon Shield (SPS) II featuring two special tin filters applied to both tubes. The filters optimize the X-ray spectrum and significantly improve the air/soft tissue contrast. A total effective dose of only 0.04 mSv was achieved, which is less than the dose of a standard X-ray radiography examination.[1]

The combination of Turbo Flash and the SPS has great potential for routine ultra-low dose thoracic CT scans. ■

Examination Protocol

Scanner	SOMATOM Force
Scan area	Thorax
Scan length	311 mm
Scan direction	Cranio-caudal
Scan time	0.42 s
Tube voltage	Sn100 kV
Tube current	24 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.09 mGy
DLP	2.8 mGy cm
Effective dose	0.039 mSv
Rotation time	0.25 s
Pitch	3.2
Slice collimation	192 × 0.6 mm
Slice width	1.5 mm
Reconstruction increment	1 mm
Reconstruction kernel	Br40 ADMIRE 5

References

[1] AAPM Report No. 96: The Measurement, Reporting, and Management of Radiation Dose in CT-Report of AAPM Task Group 23 of the Diagnostic Imaging Council CT Committee http://www.aapm.org/pubs/reports/rpt_96.pdf.

Case 7

Pulmonary CTA in the Setting of Venoarterial Extracorporeal Membrane Oxygenation

By Michael Malinzak, MD, PhD; Lynne M. Hurwitz, MD

Department of Radiology, Duke University Medical Center, NC, USA

History

A 43-year-old male patient, with a history of chronic thromboembolic pulmonary hypertension with progressive dyspnea and worsening functional status presented for definitive surgical treatment. He underwent thromboendarterectomy which was complicated by acute right ventricular dysfunction requiring venoarterial extracorporeal membrane oxygenation (VA ECMO). Post-operative attempts to wean the patient from VA ECMO were unsuccessful, and echocardiography revealed worsening right heart failure. A pulmonary CT angiography (CTA) was requested to assess for recurrent pulmonary artery thrombosis on post-operative day 11.

Diagnosis

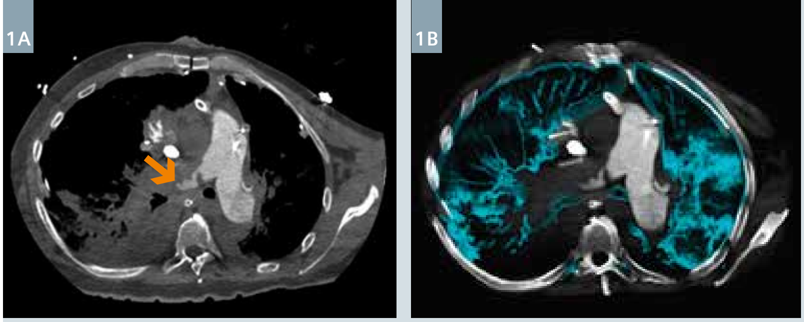
Pulmonary CTA demonstrated new multifocal PE with complete occlusion of the right arterial system (Fig. 1). Perfusion of the left lower lobe pulmonary artery and veins was preserved (Fig. 3). Extensive right-sided pulmonary infarction was present (Fig. 2). The superior vena cava, right atrium, and right ventricle filled with contrast, and contrast refluxed into the hepatic veins and inferior vena cava (Fig. 5A). Attenuation sampled from the main pulmonary artery was greater than 250 Hounsfield unit, allowing the physician to confirm the diagnostic quality of the scan. The arterial limb of the ECMO system and aorta were unopacified, reflecting good bolus timing (Fig. 4).

Comments

VA ECMO acts much like a cardiopulmonary bypass. For optimal contrast opacification of the pulmonary arteries via an intravenous injection, VA ECMO needs to be withheld. Prior attempts to wean the patient off VA ECMO had resulted in cardiac arrest. To ensure adequate pulmonary arterial opacification and to maintain systemic perfusion in the setting of diminished cardiac output during the CTA acquisition, 1 mg of epinephrine was administered simultaneously with the discontinuation of VA ECMO in coordination of contrast injection through a peripheral antecubital 18-gauge IV. Pulmonary CTA was performed using a dual source image acquisition at a pitch of 2.5 to reduce acquisition time to limit time off VA ECMO. Following contrast administration and the 1-second image acquisition time, VA ECMO was restarted without incident. The total time within which VA ECMO was withheld, was approximately 12 seconds (scan time to move table during contrast administration and image acquisition). The patient completed the study without complication.

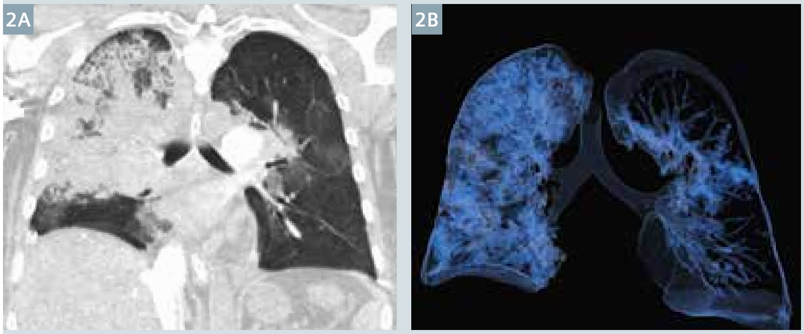
Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan length	340 mm
Scan direction	Cranio-caudal
Scan time	1 s
Tube voltage	140 kV
Tube current	157 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	13.44 mGy
DLP	457 mGy cm
Effective dose	6.4 mSv
Rotation time	0.28 s
Pitch	2.5
Slice collimation	0.6 mm
Slice width	1 mm
Reconstruction increment	1 mm
Reconstruction kernel	B30f
Contrast	370 mg/mL
Volume	95 mL + 50 mL saline
Flow rate	5 mL/s
Start delay	20 s (time to reach 150 HU within the main pulmonary artery + 9 s)



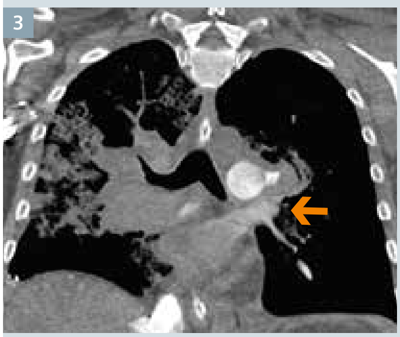
1

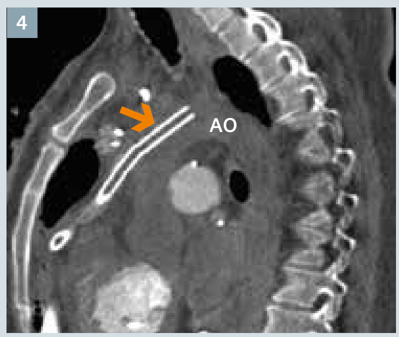
Axial contrast-enhanced (Fig. 1A) and VRT (Fig. 1B) image at the level of the main pulmonary artery: There are irregular filling defects (arrow) in the occluded right main pulmonary artery consistent with thrombosis.



2

Coronal contrast-enhanced MPR (Fig. 2A) and VRT (Fig. 2B) image at the level of the pulmonary hila: Extensive right lung consolidative opacities represent pulmonary infarction.



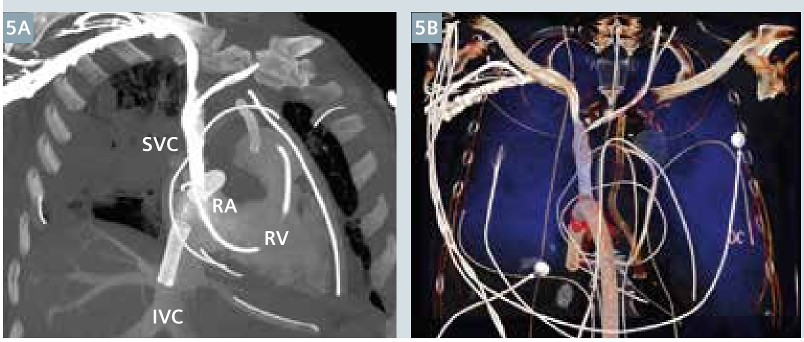


3

Coronal contrast-enhanced image at the level of the pulmonary hila: Perfusion to the left lower lobe is partially preserved; as seen through contrast opacifying the left pulmonary veins (arrow).

4

Contrast-enhanced sagittal oblique image of the aortic arch: The main pulmonary artery is well opacified with contrast and the aorta and arterial ECMO limb (arrow) are unopacified with contrast.



5

Contrast-enhanced coronal oblique MPR (Fig. 5A) and VRT (Fig. 5B) image at the level of the right heart: Contrast injected via a right arm peripheral IV opacifies the superior vena cava (SVC), right atrium (RA), and right ventricle (RV). There is reflux of contrast into the hepatic veins (Fig. 5A) in the setting of elevated right heart pressures. Surgical drains, central venous catheters, and ECMO cannulae are in place.

High-pitch Dual Source CTA technique is commonly used to minimize respiratory and cardiac motion artifacts by way of offering improved temporal resolution. We report a case in which VA ECMO had to be withheld to achieve a diagnostic study, and in which rapid image acquisition was needed to minimize the time off VA ECMO for patient safety. A 1-second scan technique served to limit the duration of systemic hypoperfusion and to decrease the attendant risks to the patient. The diagnostic information gained from this scan directly impacted patient management and ultimately factored into the family's decision to withdraw support. The patient died on post-operative day 12.

Although a lower kV setting would normally be applied for a contrast scan, 140 kV was chosen in this case to reduce the artifacts that might be caused by both arms being in the scan field alongside the patient. As a result, a slightly higher dose (13.4 mGy) than that of a standard routine chest scan was applied. However, it was the appropriate dose considering the patient's size and the critical situation, which left no room for compromised image quality. In keeping with the ACR guidelines,[1] this is still a much lower dose than the dose reference level (DRL) specified for an adult chest CT scan (21 mGy) in the USA. ■

References

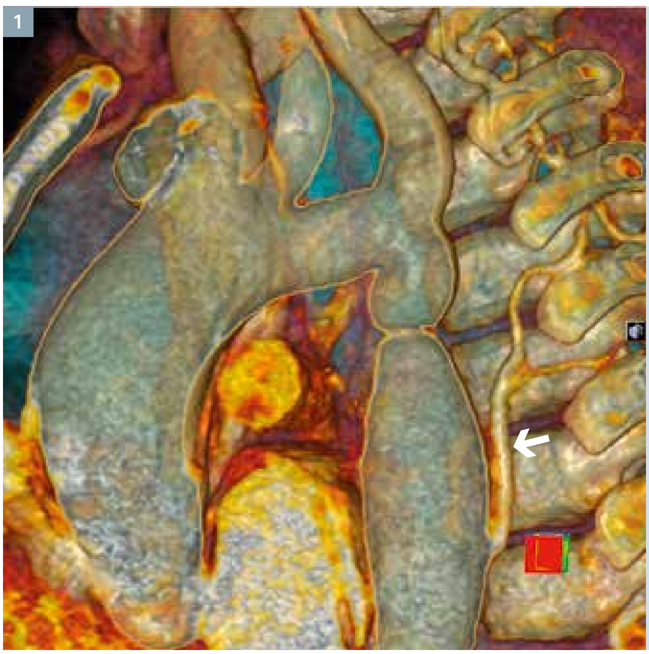
[1] CCR–AAPM Practice parameter for diagnostic reference levels and achievable doses in medical x-ray imaging. (http://www.acr.org/~/media/796DE35AA40744 7DB81CEB5612B4553D.pdf).

Case 8

Turner Syndrome with Aortic Coarctation and Thin Intraluminal Obstructive Ring: A Critical Stenosis Preserved by Iterative Reconstruction

By Frandics P. Chan, MD, PhD

Department of Radiology, Stanford University Medical Center, California, USA



1
Volume-rendered view of the aortic arch: Note the hour-glass outer contour and the web-like ring within the flow lumen. A prominent intercostal artery drains into the distal aorta (arrow).

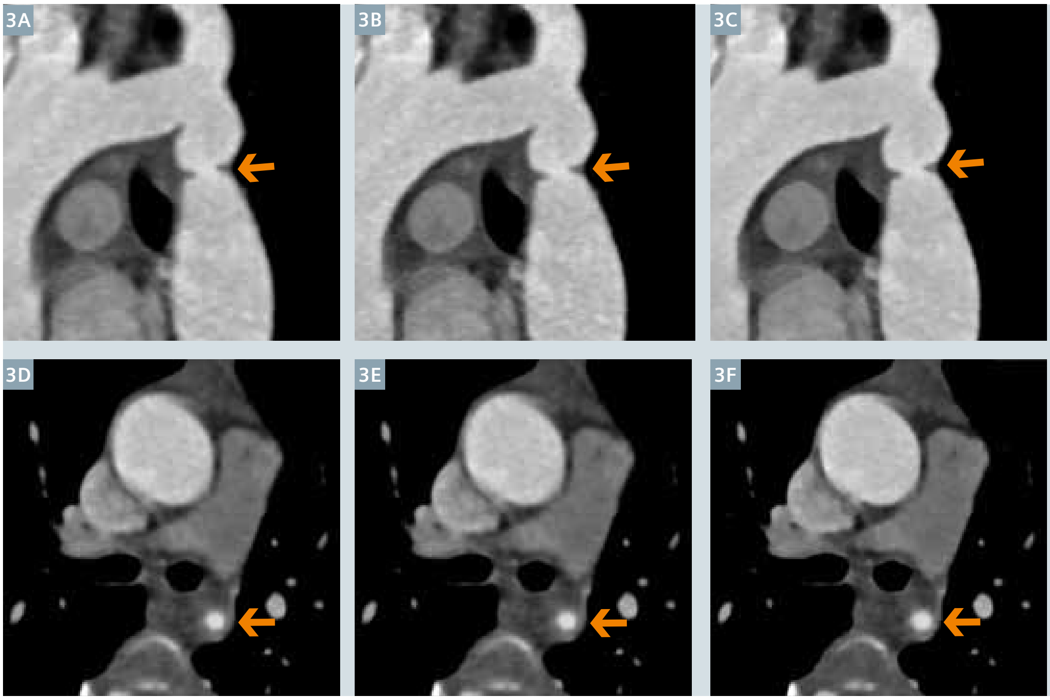
2
Volume-rendered view from the top of the aortic arch: It shows the opening of the intraluminal ring.

History

A 7-year-old girl was presented for an evaluation of her small stature when compared to her peers. She was evaluated by an endocrinologist and diagnosed with Turner syndrome. Due to the association of Turner syndrome with cardiovascular abnormalities, an echocardiography was performed. The echocardiography showed a discrete aortic narrowing, consistent with an aortic coarctation. The peak pressure gradient estimated by echocardiography was 50 mmHg. In order to decide between endovascular treatment with angioplasty and stenting versus surgical repair, a CT angiography of the chest was performed to define the length and narrowness of the coarctation, its distance to the cervical arteries, and any stenoses in these arteries. The coarctation was surgically resected and the aorta repaired with an end-to-side connection.

Diagnosis

The aortic arch was right-sided with a normal branching order of the cervical arteries. The coarctation was located distal to the left subclavian artery at the juxtaductal position (Fig. 1). All cervical arteries were patent. Prominent intercostal arteries (arrow) conducted retrograde collateral flow into the distal aorta, bypassing the obstruction. The outer contour of the coarctation had an "hour-glass" shape with a diameter of 9 mm at the waist, but inside the coarctation there was a web-like ring that further narrowed the flow lumen to a diameter of 4 mm (Fig. 2).



3

Multiplanar reformat of the web-like obstruction (arrows) in the sagittal plane (Figs. 3A–3C) and in the axial plane (Figs. 3D–3F) at different SAFIRE levels: Figs. 3A and 3D: none; Figs. 3B and 3E: SAFIRE level 2; Figs. 3C and 3F: SAFIRE level 4. The geometry of the obstruction is essentially unchanged.

Comments

Turner syndrome is a genetic disease in which the patient has only one copy of the sex-determining chromosome, an X-chromosome, without a second X- or Y-chromosome. Patients with Turner syndrome are phenotypically female. The disease is associated with a number of congenital cardiovascular abnormalities including coarctation of the aorta, bicuspid aortic valve, aortic valve stenosis, partial anomalous pulmonary venous return, and others. Coarctation, which occurs in 17% of these patients, is the most frequent and clinically important abnormality.

Management guidelines for Turner syndrome include noninvasive imaging, such as echocardiography and MR angiography, to detect coarctation.[1] CT angiography is an alternative examination if MR angiography is contraindicated or high-resolution imaging is needed for endovascular or surgical treatment planning. Surgical repair is preferred in young patients when their aortas have yet to grow to full size. An endovascular approach may be used in older patients with fully developed aortas.

The use of iterative image reconstruction, such as SAFIRE, enables CT scans with reduced radiation dose without associated increase in image noise. However, the image reconstruction must not obscure or alter diagnostically important features. This case demonstrated that an obstructive ring as thin as one millimeter was preserved by SAFIRE (Fig. 3). Accurate representation of a vascular obstruction was important not only for diagnostic assessment and treatment planning, it also enables the calculation of hemodynamic information, such as pressure gradients, shear stress, and ventricular loading by computational fluid dynamics.[2] ■

References

[1] Bondy CA and for The Turner Syndrome Consensus Study Group. Care of Girls and Women with Turner Synbdrome: A Guideline of the Turner Syndrome Study Group. J Clin Endocrinol Metab. 2007, 92(1): 10-25.

[2] Coogan FP, et al. Computational Fluid Dynamic Simulations for Determination of Ventricular Workload in Aortic Arch Obstructions. J Thorac Cardiovasc Surg. 2013, 145(2): 489-495.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan length	160 mm
Scan direction	Cranio-caudal
Scan time	0.4 s
Tube voltage	80 kV
Tube current	60 eff. mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	0.97 mGy
DLP	25 mGy cm
Effective dose	1 mSv[1]
Rotation time	0.28 s
Pitch	3
Slice collimation	128 × 0.6 mm
Slice width	0.6 mm
Reconstruction increment	0.6 mm
Reconstruction kernel	B26f /I26f (SAFIRE)
Contrast	350 mg /mL
Volume	30 mL
Flow rate	2 mL /s
Start delay	Bolus tracking

[1] Estimated by applying a conversion factor of 0.018, and an additional factor of 2.3 converting the reported DLP (32 cm) into the DLP (16 cm).

Case 9

Diagnosis of Tetralogy of Fallot using ECG-Triggered Adaptive Sequential Cardiac CT Scan

By Guilin Bu, MD; Ying Miao, MD

Department of Radiology, Guangxi Nanxi Shan Hospital, Guangxi, P.R. China

History

A 9-month-old baby girl, with a history of a "heart murmur" for the past 6 months, was admitted for diagnosis and treatment. Physical examination revealed a cyanosis, an acropachy, and a heart murmur (level 3/6) on the left side of the sternum. An echocardiography showed a Tetralogy of Fallot, a patent ductus arteriosus (PDA), a persistent left superior vena cava (PLSVC) and a suspected double-outlet right ventricle (DORV). Cardiac CT examination was requested to specify the diagnosis of a DORV.

Diagnosis

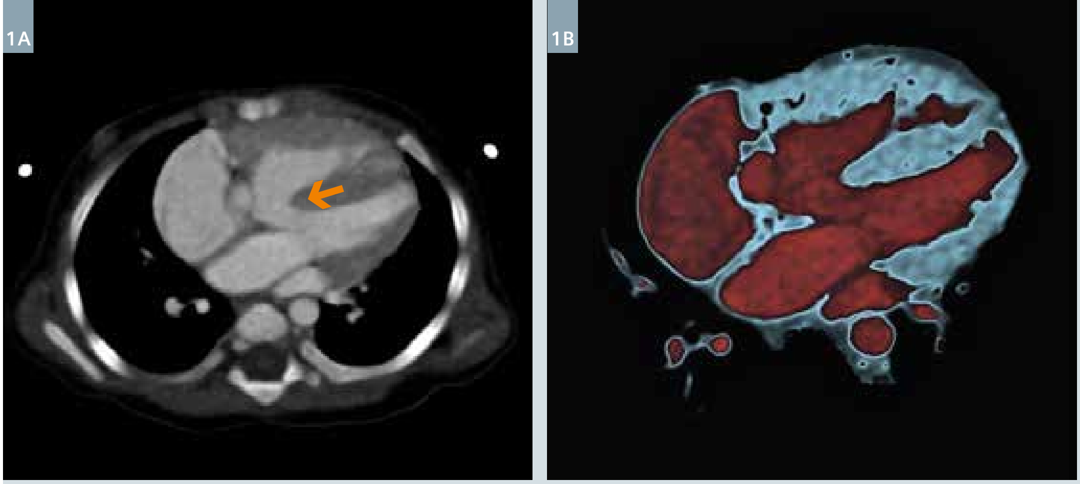
CT images showed the characteristic findings of a Tetralogy of Fallot: A ventricle septal defect (VSD, Fig. 1), an overriding aorta (Fig. 2), and an infundibular pulmonary stenosis (Fig. 3). Additionally, a PDA (Fig. 4) and a PLSVC (Fig. 5) were also clearly demonstrated. There was no evidence of a DORV.

Comments

The Tetralogy of Fallot is the most common cyanotic congenital heart defect and normally requires surgical repair. It is important to specify the diagnosis and the associated abnormalities for treatment planning. In this case, a DORV was clearly ruled out. Taking into consideration the higher heart rate (127 – 130 bpm) and the dose reduction, an ECG-triggered adaptive sequential scan was performed in the systolic phase which resulted in excellent image quality and a definite diagnosis. ■

Examination Protocol

Scanner	SOMATOM Definition AS+		
Scan area	Thorax	Slice collimation	128 × 0.6 mm
Scan mode	ECG-triggered adaptive sequential scan	Slice width	0.75 mm
Scan length	102.5 mm	Reconstruction increment	0.5 mm
Scan direction	Cranio-caudal	Reconstruction kernel	B26f
Scan time	2.8 s	Temporal resolution	150 ms
Tube voltage	80 kV	Heart rate	127 – 130 bpm
Tube current	68 mAs	**Contrast**	350 mg/mL
$CTDI_{vol}$	0.79 mGy	Volume	13 mL
DLP	8 mGy cm	Flow rate	1 mL/s
Effective dose	0.78 mSv	Start delay	22 s
Rotation time	0.3 s		

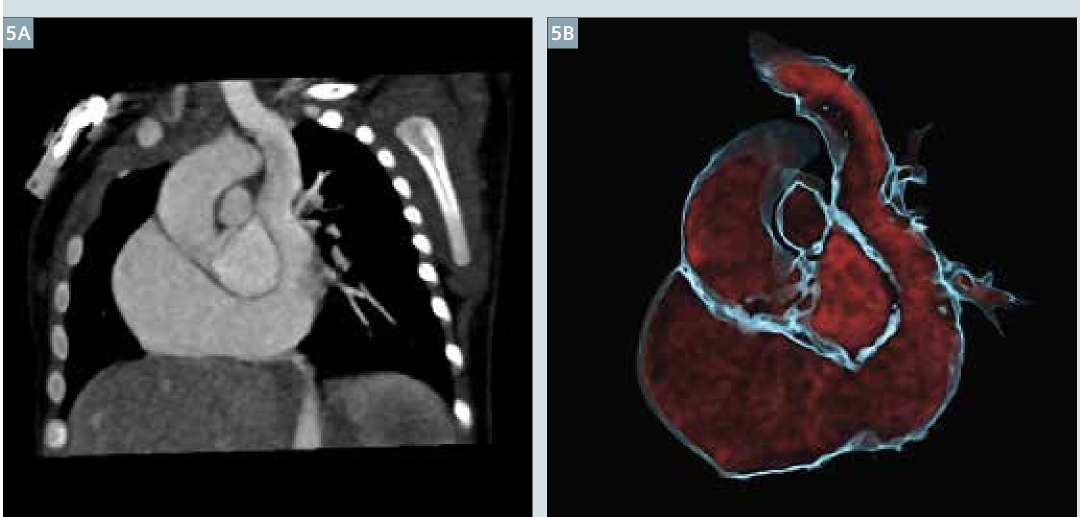


1–3

MPR (row A) and VRT (row B) images show the characteristic findings of a Tetralogy of Fallot: a VSD (Fig. 1A, arrow), an overriding aorta (Figs. 2), and an infundibular pulmonary stenosis (Fig. 3, arrow).

4

VRT image shows a PDA (arrow).



5

MPR (Fig. 5A) and VRT (Fig. 5B) images demonstrate a PLSVC draining into the coronary sinus.

Case 10

Pulmonary Atresia with Major Aortopulmonary Collateral Arteries

By Marilyn Siegel, MD

Department of Radiology, Washington University School of Medicine, St. Louis, Missouri, USA

History

An 11-month-old girl with pulmonary atresia associated with ventricular septal defect underwent CT examination to evaluate the size of the multiple major aortopulmonary collateral vessels and the integrity of flow to the lungs prior to surgical repair.

Diagnosis

The axial and coronal (Fig. 1) blended images (0.5 blend of Sn140 kV and 80 kV data) revealed large aortopulmonary collateral vessels arising from a right-sided aorta and feeding the lungs bilaterally. There was also cardiomegaly with leftward deviation of the cardiac axis and apex. The main pulmonary artery was absent and there were small caliber right and left pulmonary arteries. The VRT angiographic images (Fig. 2) also showed the right aortic arch and multiple aortopulmonary collateral vessels. The additional dual energy (DE) perfused blood volume (PBV) axial images (Fig. 3) showed normal perfusion bilaterally. Overall, the lungs were well perfused via the collateral vessels.

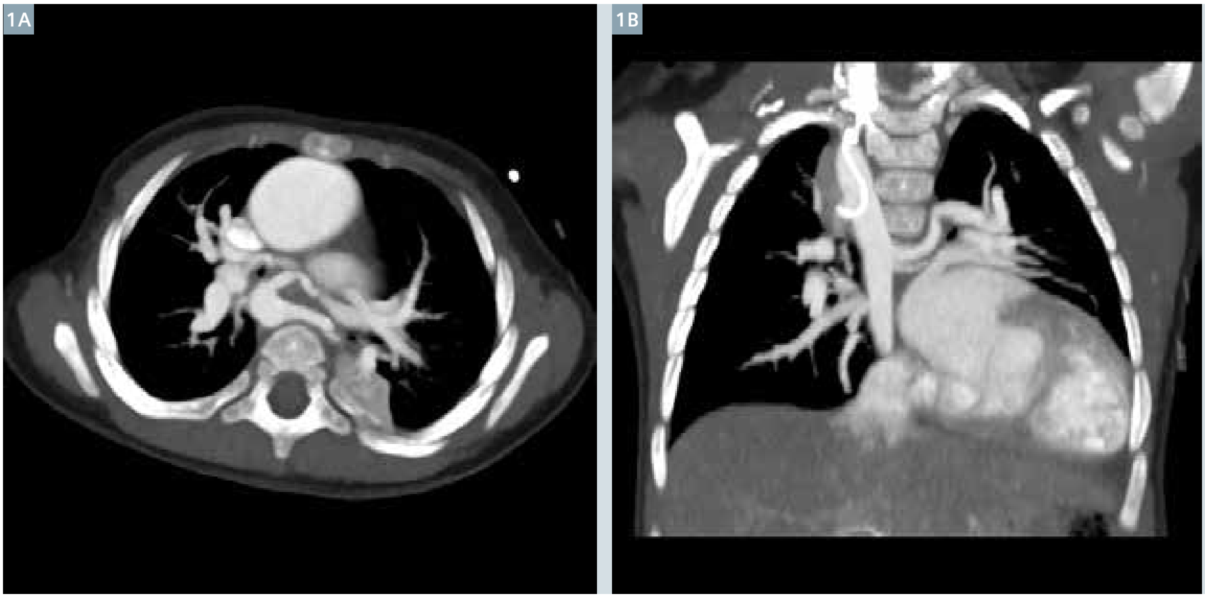
Comments

Major aortopulmonary collateral arteries (MAPCAs) represent primitive arteries that usually originate from the descending aorta in utero and usually involute as the normal pulmonary arteries develop. In certain heart conditions, such as pulmonary atresia with ventricular septal defect, the native pulmonary arteries do not develop normally. The number and caliber of MAPCAs can increase and can serve as the main supply of blood to the lungs. If untreated, this systemic-to-pulmonary shunt can lead to pulmonary hypertension.

syngo DE Lung PBV analysis delivers morphological and functional information in a single examination. The blended and angiographic images can contribute to a comprehensive evaluation of the pulmonary vessels and cardiac anatomy. In this case, the blended and angiographic images provided an excellent overview of pulmonary vasculature and showed the sites of origin and caliber of the MAPCAs. The DE PBV information allowed the physician to confirm that the collateral vessels were adequately perfusing the lungs. DECT at an incredibly low dose (1 mGy) provided the diagnosis and might obviate further imaging, such as standard catheter angiography or magnetic resonance imaging. ■

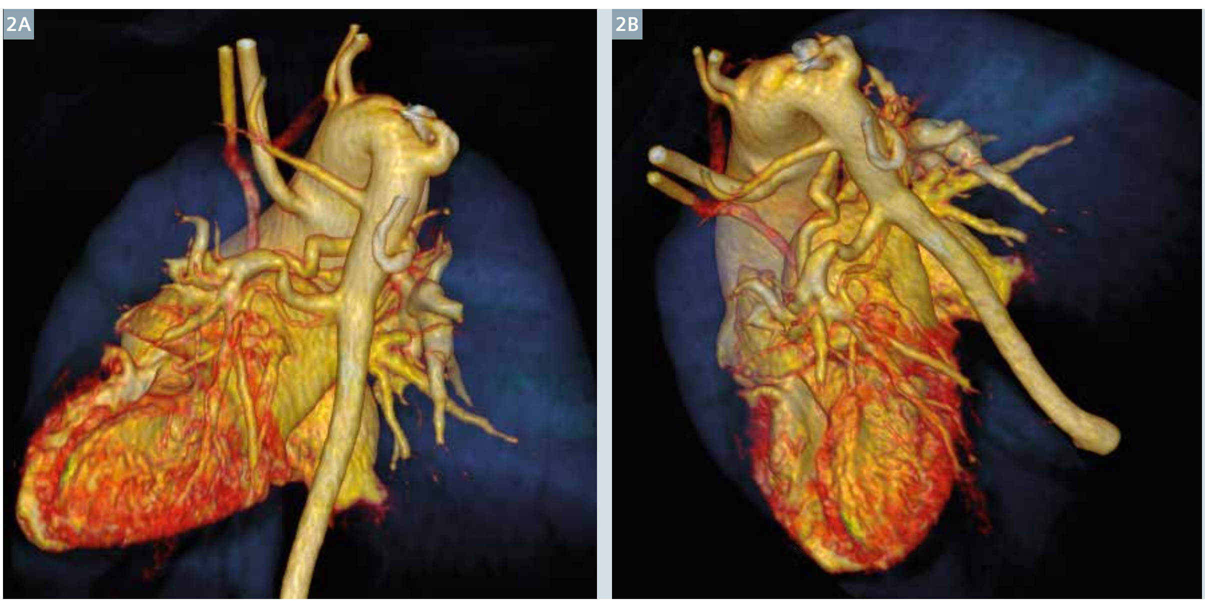
Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan length	127.5 mm
Scan direction	Cranio-caudal
Scan time	0.79 s
Tube voltage	80 kV/Sn 140 kV
Tube current	24/15 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	1 mGy
DLP	21 mGy cm
Effective dose	1.26 mSv
Rotation time	0.28 s
Pitch	1.2
Slice collimation	128 × 0.6 mm
Slice width	3 mm
Reconstruction increment	3 mm
Reconstruction kernel	D30f
Contrast	320 mg/mL
Volume	12 mL
Flow rate	2.5 mL/s
Start delay	Bolus tracking + 4 s



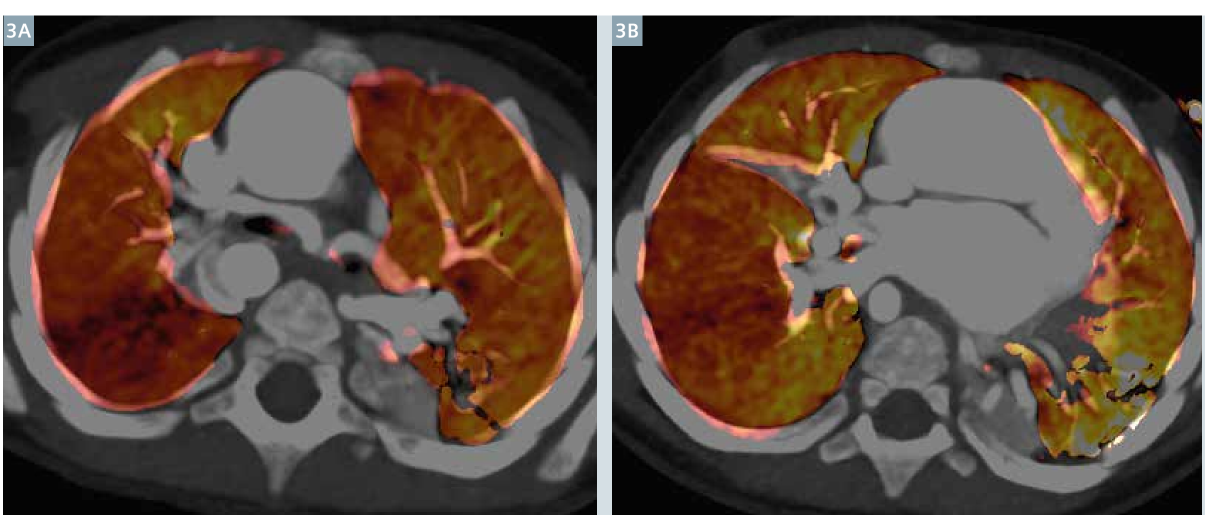
1

Axial (Fig. 1A) and coronal (Fig. 1B) images acquired with 0.5 blended ratio of high and low energies show multiple large aortopulmonary collateral vessels arising from a right-sided aorta. The main pulmonary artery is absent and there are small caliber right and left pulmonary arteries.



2

Two VRT angiographic images also show the right multiple aortopulmonary collateral vessels feeding the lungs.



3

DE PBV axial images show the lungs well perfused via the collateral vessels.

Case 11

Volumetric Perfusion CT for Early Assessment of Response to Anti-angiogenic Therapy in Metastatic Renal Cell Carcinoma

By Alexander Sterzik, MD; Melvin D'Anastasi, MD; M. Staehler, MD; Maximilian Reiser, MD; Anno Graser, MD

Departments of Clinical Radiology and Urology, Campus Grosshadern, University Hospital Munich, Germany

History

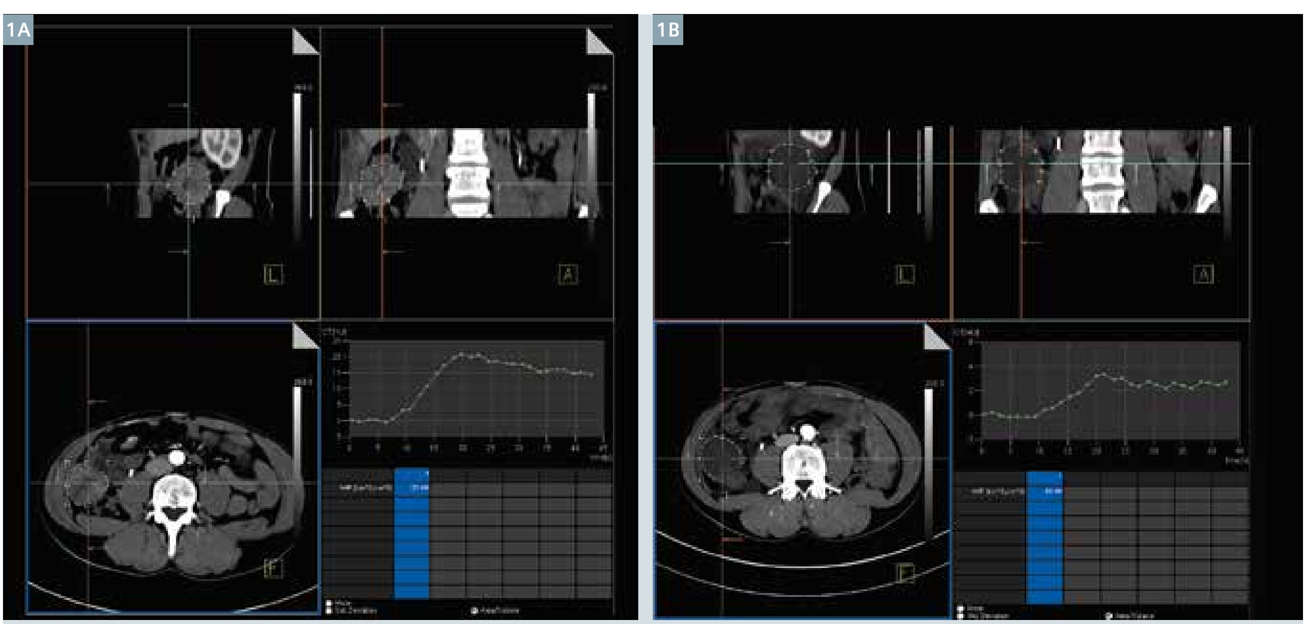
A 46-year-old male patient, with a right-sided partial nephrectomy due to papillary renal cell carcinoma one year ago, presented with tumor recurrence and new metastases in the right paracolic gutter and right abdominal wall. He was scheduled for anti-angiogenic tyrosin-kinase-inhibitor (TKI) therapy. Serial volumetric perfusion-CT scans of a selected representative metastatic lesion were performed, before as well as seven days after commencement of the anti-angiogenic TKI therapy, for noninvasive monitoring of early treatment response.

Diagnosis

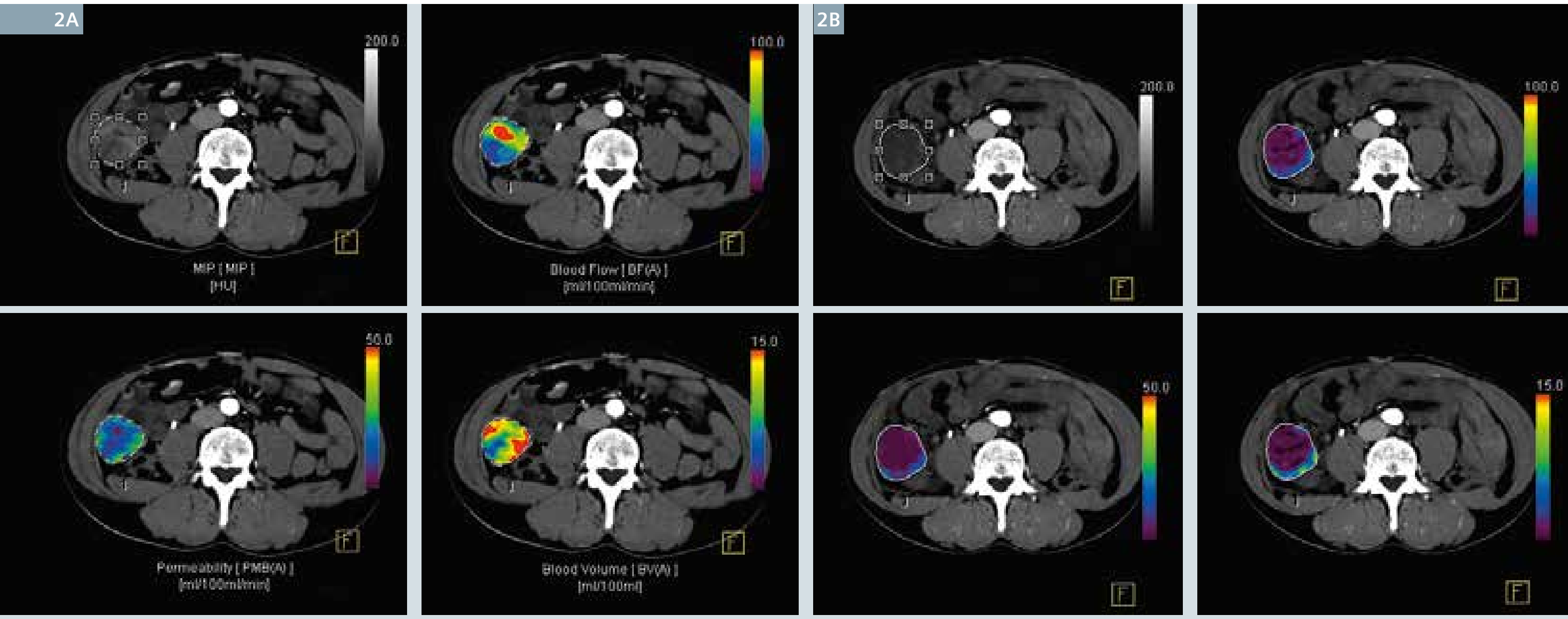
Volumetric perfusion CT analysis of the assessed target lesion, in the right paracolic gutter, (Fig. 1) showed increased baseline levels of tumor blood flow (BF), blood volume (BV) and vessel permeability (PMB) as features of tumor angiogenesis (Fig. 2A). A further perfusion CT scan performed after one week of TKI treatment which revealed a remarkable reduction in tumor perfusion indices (Fig. 2B) with a reduction in BF, BV and PMB levels of 70–80%, compared to their respective baseline values. On the other hand, tumor volume increased from about 53 mL (pre-treatment) to 89 mL (post-treatment) due to substantial tumor necrosis (Fig. 1). Based on the information from the perfusion CT scan, treatment was continued – despite the substantial increase in tumor size. Under ongoing TKI therapy, the patient is still in stable disease without further tumor growth (18 months after therapy begin).

Comments

With the introduction of anti-angiogenic therapy as a standard treatment in patients with metastatic renal cell carcinoma, new diagnostic challenges



1 Temporal MIP images of two serial perfusion CT scans centered around the metastatic target lesion in the right paracolic gutter, covering the entire tumor volume. After one week of TKI therapy, tumor volume increased from about 53 mL before therapy begin (Fig. 1A) to 89 mL post-treatment (Fig. 1B). However, as indicated by the time-resolved enhancement curves in the lower right quadrant of each figure, the contrast uptake within the tumor tissue had been reduced dramatically on day 7. Please note different scale of y axis in Figs. 1A and 1B.



2 Axial semi-quantitative color-coded VPCT parameter maps of the tumor perfusion indices (tumor blood flow, tumor blood volume and vessel permeability), acquired before treatment begin, depict regional heterogeneity of tumor vascularity with a mixture of hypervascular (colored in red) and hypovascular (colored in blue) areas (Fig. 2A). After 7 days of TKI therapy, the tumor has become almost completely hypovascular showing only small spots with residual perfusion (Fig. 2B).

arise in the assessment of therapeutic efficacy. Large clinical studies have shown that classical response criteria such as RECIST, which only take into account changes in tumor size, are of limited use in predicting long-term outcome in patients with metastatic renal cell carcinoma (mRCC).[1–3] This is – given the cytostatic rather than cytotoxic profile of anti-angiogenic agents – not unexpected. Functional imaging techniques, which quantitatively assess tumor perfusion such as perfusion CT, are currently being investigated as new biomarkers for predicting a response to anti-angiogenic therapy in cases of mRCC.[4] As changes in tumor vascularity precede morphological changes, perfusion CT may have the potential to aid physicians in evaluating therapeutic response in patients with mRCC at an early stage. This case nicely illustrates that perfusion CT can depict therapy-induced changes in tumor vascularity, as early as 7 days after commencing anti-angiogenic treatment. Whether CT-perfusion imaging can be a valuable adjunct to monitor response and aid physicians in predicting the outcome of anti-angiogenic therapy, must be evaluated in further studies.

Considering the broad dissemination profile of mRCC, with possible tumor manifestations to virtually all organs, the assessment of tumor perfusion in this tumor entity is challenging. With its integrated motion correction and semi-automated tumor segmentation algorithms – automatically excluding intra-tumoral vessels or bony structures from the analysis – VPCT software is a versatile tool for quantitative analysis of volumetric CT-perfusion data of patients with systemic tumor manifestations such as mRCC. ■

References

[1] Motzer, R.J., et al., Pazopanib versus sunitinib in metastatic renal-cell carcinoma. N Engl J Med. 369(8): p. 722-31.

[2] Motzer, R.J., et al., Sunitinib versus interferon alfa in metastatic renal-cell carcinoma. N Engl J Med, 2007. 356(2): p. 115-24.

[3] Sternberg, C.N., et al., Pazopanib in locally advanced or metastatic renal cell carcinoma: results of a randomized phase III trial. J Clin Oncol. 28(6): p. 1061-8.

[4] Braunagel, M., et al., The role of functional imaging in the era of targeted therapy of renal cell carcinoma. World J Urol. 32(1): p. 47-58.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Mid abdomen
Scan length	100 mm
Scan direction	Adaptive 4D Spiral
Scan time	44 s
Tube voltage	100 kV
Tube current	120 mAs
Dose modulation	N/A
$CTDI_{vol}$	125.83 mGy
DLP	1483.6 mGy cm
Effective dose	22 mSv
Rotation time	0.28 s
Slice collimation	32 × 1.2 mm
Slice width	3 mm
Reconstruction increment	2 mm
Reconstruction kernel	B20F
Contrast	300 mg/mL
Volume	50 mL + 50 mL Saline
Flow rate	6 mL/s
Start delay	8 s

Case 12

Pulmonary Metastases from Renal Cell Carcinoma: Follow-up CT scan after Nephrectomy

By Prof. Yuzhang Wu, MD; Jinghai Wang, MD; Tiesheng Zheng, MD; Hongtu Sun, and Xi Zhao, MD*

Department of Radiology, Panshi City Hospital, Jilin, P.R. China
* Siemens Healthcare China

History

A 47-year-old female patient, with a history of nephrectomy due to renal cell carcinoma (RCC) 18 months previously, was presented for a follow-up CT scan. A combined thoracic and abdominal contrast CT scan was performed.

Diagnosis

CT images showed bilateral pulmonary lesions with contrast enhancement, suggesting multiple metastases (Fig. 1). The lesions with feeding arteries, as well as the absence of the left kidney and its artery, were highlighted in the VRT images (Fig. 2).

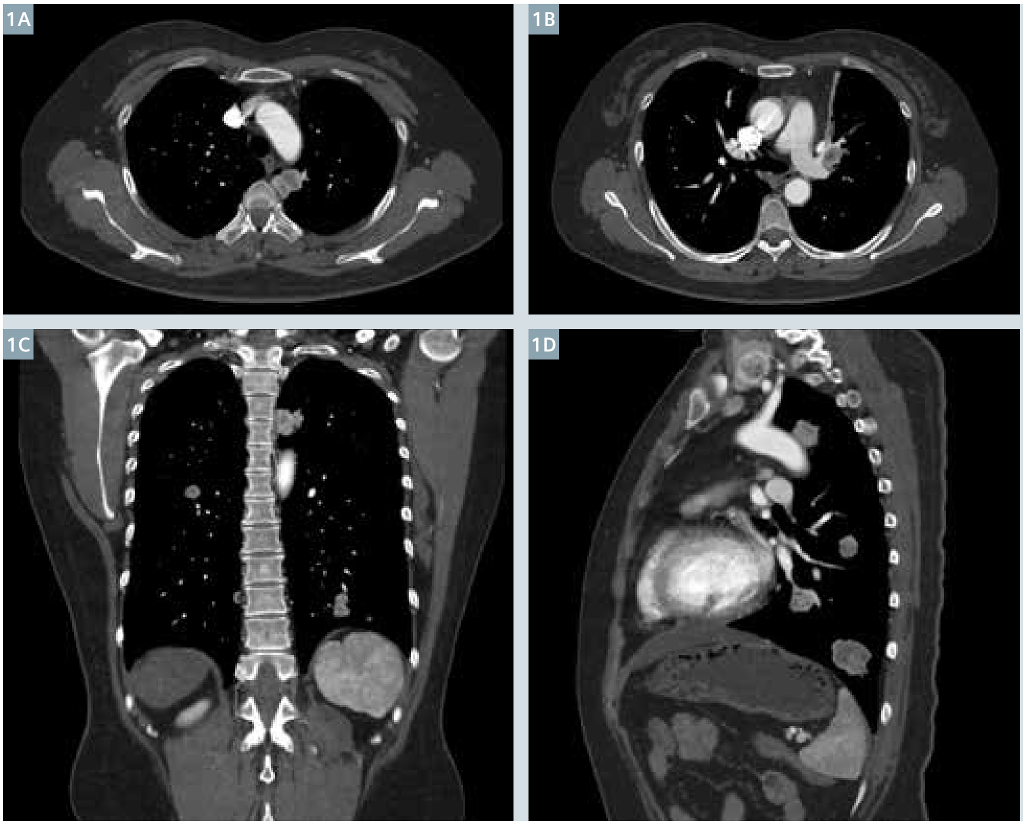
Examination Protocol

Scanner	SOMATOM Perspective
Scan area	Chest/Abdomen
Scan length	786 mm
Scan direction	Cranio-caudal
Scan time	12 s
Tube voltage	80 kV
Tube current	171 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	4.81 mGy
DLP	378 mGy cm
Effective dose	5.67 mSv
Rotation time	0.6 s
Pitch	0.9
Slice collimation	0.6 mm
Slice width	1.0 mm
Reconstruction increment	0.7 mm
Reconstruction kernel	I31s (SAFIRE)
Contrast	
Volume	80 mL + saline
Flow rate	4 mL/s
Start delay	Bolus triggering in the ascending aorta with a threshold of 100 HU and an additional delay of 7 s

Comments

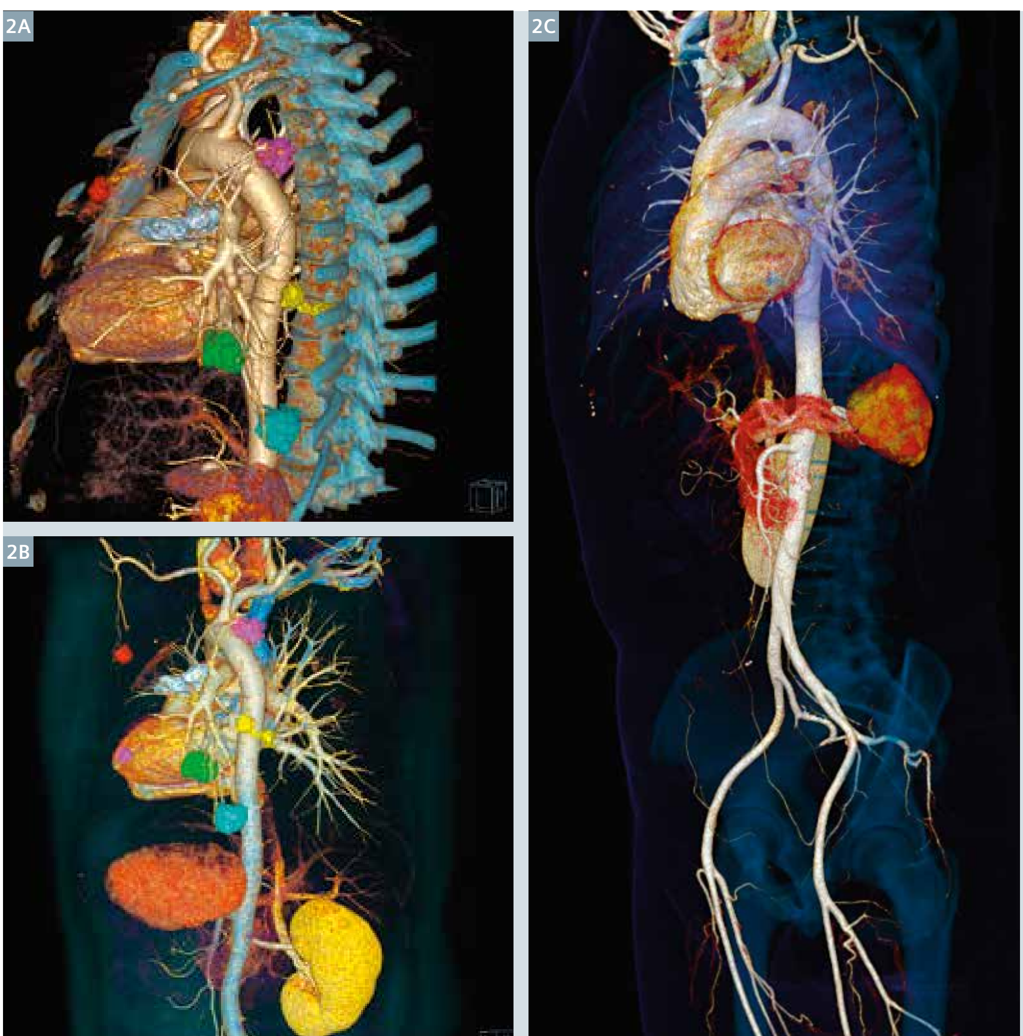
Follow-up CT scans are routinely performed on oncology patients to detect or to rule out recurrence and metastases of the tumor. In this case, 80 kV was applied to enhance the contrast and to reduce the radiation dose combined with CARE Dose4D (real-time anatomic exposure control). Image quality was greatly improved by using the iterative reconstruction technique SAFIRE (sinogram affirmed iterative reconstruction). Additional three-dimensional reconstructions of the pulmonary metastases provided a clear overview. ■

In clinical practice, the use of SAFIRE 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. The following test method was used to determine a 54 to 60% dose reduction when using the SAFIRE reconstruction software. Noise, CT numbers, homogeneity, low-contrast resolution and high contrast resolution were assessed in a Gammex 438 phantom. Low-dose data reconstructed with SAFIRE showed the same image quality compared to full dose data based on this test. Data on file.



1

Axial (Figs. 1A and 1B), coronal (Fig. 1C) and sagittal (Fig. 1D) MPR images show bilateral pulmonary lesions with contrast enhancement, suggesting multiple metastases.



2

The pulmonary metastatic lesions with feeding arteries, as well as the absence of the left kidney and its artery, are highlighted in the VRT images.

Case 13

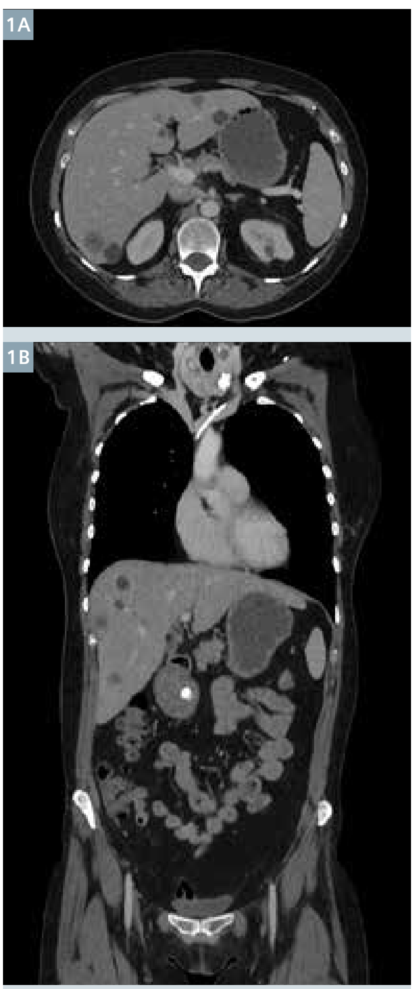
Differentiation of Liver Metastases from Benign Cysts

By Anushri Parakh, MD; and Sebastian Schindera, MD

Department of Radiology and Nuclear Medicine, University Hospital Basel, Switzerland

History

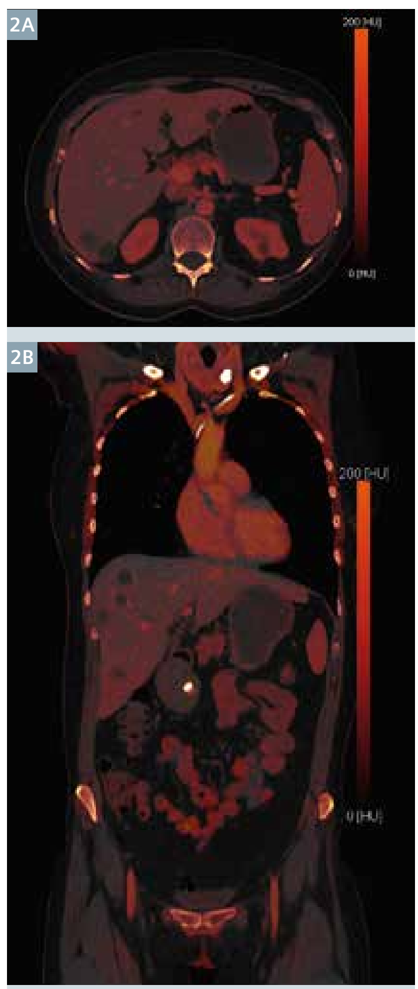
A 54-year-old female patient with breast cancer, post-lumpectomy status, underwent thoracoabdominal CT for the assessment of metastatic disease. A contrast-enhanced TwinBeam Dual Energy CT (TBCT) was performed.



1 Axial (Fig. 1A) and coronal (Fig. 1B) views of the mixed AuSn 120 kV dataset (blending of 0.8) show multiple lesions in both liver lobes.

Diagnosis

Composed TBCT images (Figs. 1A and 1B) revealed multiple liver lesions in both lobes. Some of these lesions could be clearly diagnosed as simple hepatic cysts, as the measured values were below 10 HU. However, some lesions showed higher CT values of up to 32 HU. The radiologists were unable to definitely classify these lesions as hepatic metastases since hepatic cysts can sometimes rupture resulting in higher CT attenuation values. Since the examination was acquired using dual energy, the iodine maps (Fig. 2 and Fig. 3) were calculated, enabling iodine uptake evaluation in the hepatic lesions. The significant differences in the iodine concentration evaluated in the lesions helped to differentiate between the simple benign hepatic cysts and the metastatic lesions (Fig. 3). Figure 4 demonstrates the virtual unenhanced images (VNC) generated from the contrast-enhanced TBCT data-set, which can be used for analyzing CT attenuation values of organs (e.g. liver, adrenal gland) in the absence of a true unenhanced image.

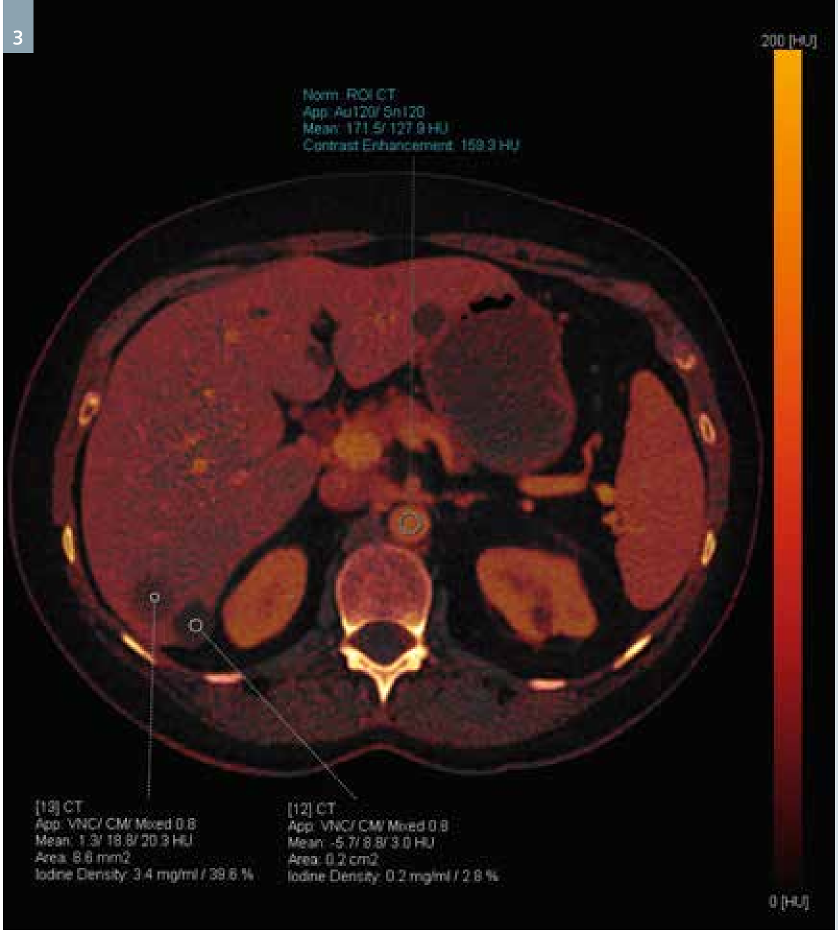


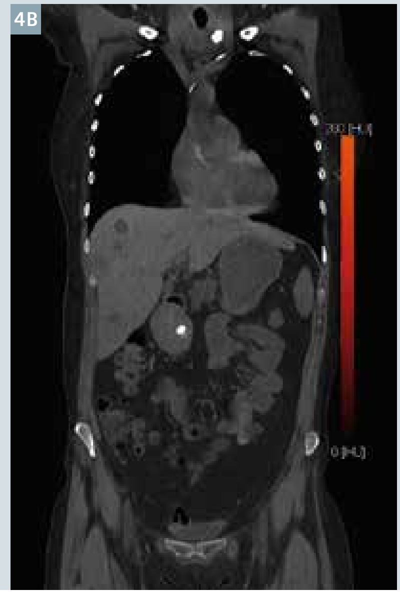
2 Fused VNC/iodine maps demonstrate the increased conspicuity of liver lesions in axial (Fig. 2A) and coronal (Fig. 2B) sections.

Comments

Dual Energy CT plays a pertinent role in oncological imaging by virtue of its ability to assess the amount of iodine uptake in suspicious lesions. This could be associated with tumor vascularity and could become useful in therapy monitoring.[1] Because of a series of virtual unenhanced images, can be extracted from the contrast-enhanced images, there is an opportunity to reduce radiation dose by avoiding having to perform a second CT study.[2]

TwinBeam Dual Energy is a new technology that creates two X-ray spectra simultaneously from a single X-ray tube. The X-ray beam is pre-filtered using two different materials: gold (Au) and tin (Sn). As a result, the 120 kV X-ray beam is split into a high- (Sn) and low-energy (Au) X-ray spectrum before reaching the patient. The full number of projections is available for both





3 The evaluated iodine concentration in suspicious liver lesions shows a significant difference in the liver metastasis (ROI#13) and in the benign simple cyst (ROI#12). ROIs were also placed in the aorta (blue) for normalization.

4 VNC images generated from the post-contrast dual energy dataset show the same axial (Fig. 4A) and coronal (Fig. 4B) section.

spectra. The simultaneously acquired low- and high-energy data can be reconstructed separately to provide a high- and low-energy image series or composed to give a single energy image dataset. The full field-of-view of 50 cm as well as advanced dose reduction techniques, such as advanced modeled iterative reconstruction (ADMIRE) and real-time anatomic exposure control (CARE Dose4D), are all available.

TwinBeam CT is capable of providing morphological and functional information in oncological examinations and has tremendous potential in replacing the routine use of single-energy scans in the future. This is accompanied by the advantage of providing a dose-neutral dual energy imaging approach compared with a standard 120 kV single-energy study. ■

In clinical practice, the use of ADMIRE 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.

References

[1] De Cecco CN, Darnell A, Rengo M, et al. Dual-energy CT: oncologic applications. AJR Am J Roentgenol 2012; 199:S98-S105

[2] Agrawal MD, Pinho DF, Kulkarni NM, Hahn PF, Guimaraes AR, Sahani DV. Oncologic applications of dual-energy CT in the abdomen. Radiographics 2014; 34:589-612

Examination Protocol

Scanner	SOMATOM Definition Edge		
Scan area	TAP	Rotation time	0.33 s
Scan length	650 mm	Pitch	0.3
Scan direction	Cranio-caudal	Slice collimation	64 × 0.6 mm
Scan time	18 s	Slice width	1.5 mm
Tube voltage	AuSn 120 kV	Reconstruction increment	1.2 mm
Tube current	355 mAs	Reconstruction kernel	Q30f (ADMIRE 3)
Dose modulation	CARE Dose4D	**Contrast**	370 mg/mL
$CTDI_{vol}$	7.6 mGy	Volume	90 mL
DLP	508 mGy cm	Flow rate	2 mL/s
Effective dose	7.6 mSv	Start delay	70 s

Case 14

CT-guided Biopsy Assisted by Iterative Metal Artifact Reduction

By Christoph J. Zech, MD

Radiology und Nuclear Medicine, University Hospital Basel, Basel, Switzerland

History

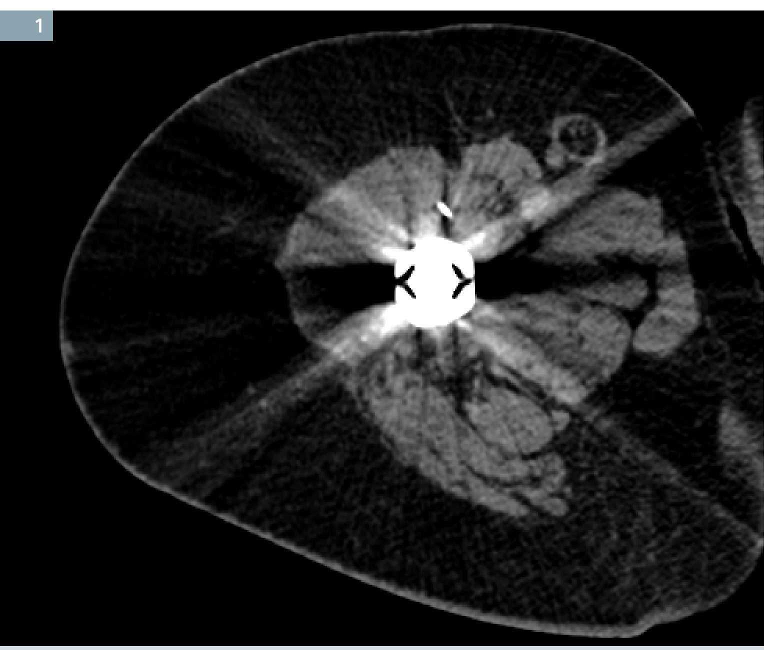
A 65-year-old female patient, with a known history of pleomorphic soft-tissue carcinoma G3 at the proximal end of the right thigh, had undergone neo-adjuvant combined radio-chemotherapy, followed by resection and prosthetic replacement. A follow-up MRI showed a vague contrast enhancing mass lateral to the prosthesis. The image visualization however, was compromised by the metal artifacts.

A CT-guided biopsy was requested for a histopathological diagnosis of scar versus recurrent tumor tissue.

Diagnosis

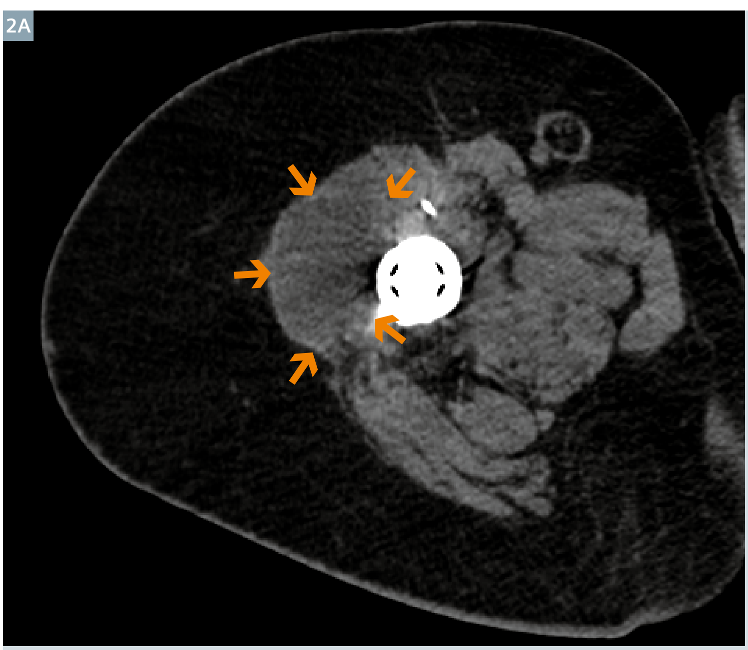
Conventionally reconstructed CT images showed extensive metal artifacts, caused by the prosthesis (Fig. 1). Theses artifacts, which impaired the proper visualization of the hypodense lesion, were significantly absent in images reconstructed using iMAR (iterative metal artifact reduction) and ADMIRE[1] (advanced modeled iterative reconstruction) (Fig. 2). The biopsy was performed under CT guidance (Fig. 3) and confirmed the suspicion of a recurrence of the pleomorphic soft tissue sarcoma. The patient was treated with a wide resection followed by adjuvant chemotherapy.

1



1 An axial conventionally reconstructed CT image for planning of the CT-guided biopsy: Note the extensive artifacts caused by the prosthesis. The hypodense lesion cannot be properly visualized.

2A



2A An axial CT image reconstructed with iMAR: Note the significant reduction of the artifacts and a much better visualization of the hypodense lesion (arrows).

Comments

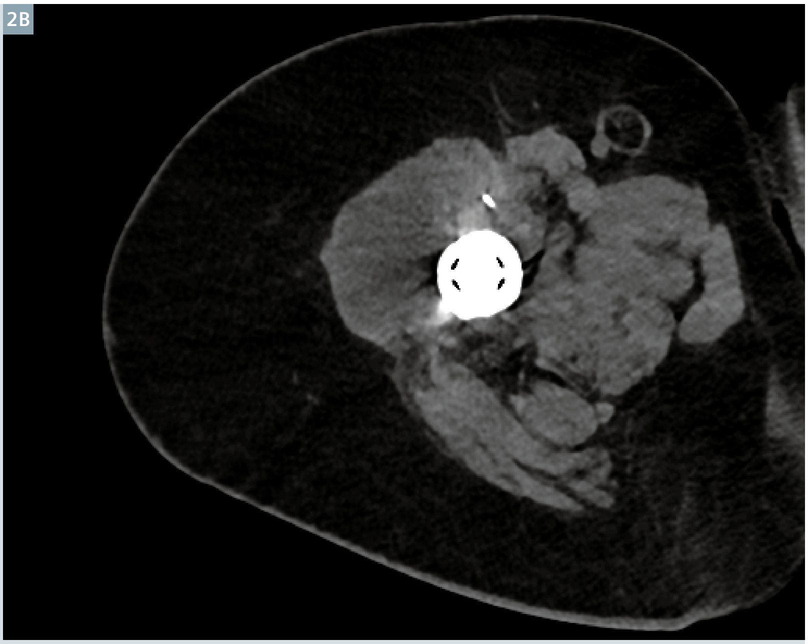
Metal artifacts caused by implants or a prosthesis may lead to non-diagnostic images possibly concealing relevant pathologies. In this case, the lesion was not well visualized on the MRI and was not seen in ultrasound. Without artifact reduction, the needle positioning during CT-guided biopsy would have been vague and difficult. iMAR is an image reconstruction algorithm which uses an iterative approach for metal artifact reduction. ADMIRE allows dose reduction while maintaining a natural image impression.[2] The combination of both was very helpful in performing a successful biopsy and in establishing the diagnosis. ■

[1] In clinical practice, the use of ADMIRE 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.

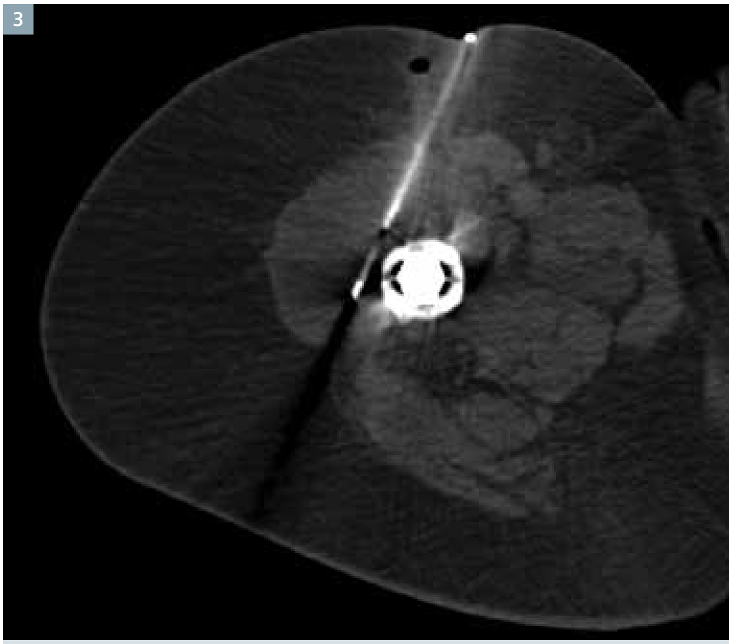
[2] In terms of outliers in the pixel noise structure.

Examination Protocol

Scanner	SOMATOM Definition Edge
Scan area	Femora
Scan length	147 mm
Scan direction	Cranio-caudal
Scan time	4.4 s
Tube voltage	120 kV
Tube current	157 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	10.6 mGy
DLP	173.3 mGy cm
Effective dose	2.6 mSv
Rotation time	0.5 s
Pitch	0.8
Slice collimation	128 × 0.6 mm
Slice width	3 mm
Reconstruction increment	3 mm
Reconstruction kernel	B30f / I30f (ADMIRE)



2B With ADMIRE additionally applied to the image reconstruction, the visualization is further improved.



3 A low-dose CT-fluoroscopy image serves as a final documentation of the CT-guided biopsy with a 15G coaxial needle and a 16G core biopsy needle, prior to the retrieval of the biopsy specimen.

Back to the Future: 10 Years of Dual Source CT

More than 40 years ago, Siemens set out on a journey that has taken CT from morphological diagnosis to functional imaging. It is 10 years since radiology was revolutionized by the exciting concept of Dual Source CT. This was a technology with fantastic potential, both for users of DSCT and for Siemens.

By Ruth Wissler, MD

The history of CT technology at Siemens began in 1974. With Siemens' CT scanner SIRETOM, it became possible for the first time to perform cranial scans in a scan time of seven minutes.

During the 1980's, CT became part of clinical routine. Using fan-beam detectors, a complete cross section of the patient's body could be captured in a single run, while the acquisition time per image was reduced to a few seconds.

A key development was the introduction of spiral CT in 1989. With a rotation time of one second, whole organs could now be examined within one breath-hold of the patient.

At the end of the century, multislice CT opened up the way for new clinical applications: CT angiography and cardio CT.

Spurred on by competition: In the 1990's, the team of researchers and developers at Siemens faced a particular challenge, the electron beam CT scanner produced by the U.S. firm Imatron. While mainly experimental, the electron beam scanner was the first device to achieve an exposure time of 50 ms per image, making cardiac CT possible. However, while temporal resolution was good, spatial and contrast resolution were restricted, limiting the amount of information that could be derived from a heart scan. A further weakness was that the heart was the only organ for which images at acceptable quality could be produced.

A (r)evolutionary concept in cardiac CT with 64-slice

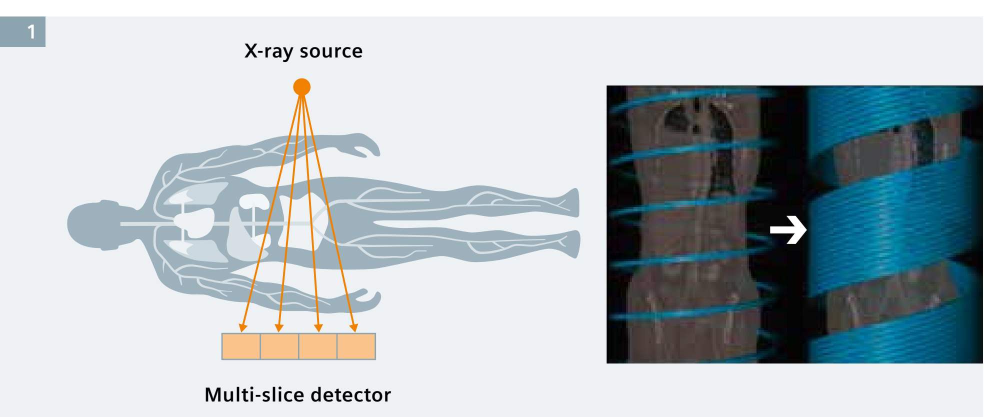
Using multislice technology, Siemens pioneered the development of cardiac imaging with conventional CT. In 1999, the 4-slice CT scanner SOMATOM Volume Zoom was the first mechanical CT scanner capable of imaging the heart and the coronary arteries with diagnostic image quality. The introduction of 64-slice CT in 2003 meant that examination times could be reduced. The use of thin slices in clinical routine allowed for improved spatial resolution, and interactive three-dimensional image displays replaced analysis of individual slices. With a rotation time of 0.33 s and temporal resolution of 165 ms per image (a half-rotation was needed to capture enough data for one image), cardiac imaging was routinely feasible at low to moderate heart rates, and a whole heart could be scanned in five seconds.

With 64-slice CT, cardiac CT scans with reliably good quality were only possible for patients with heart rates below 70 beats per minute. Therefore, drugs were frequently used to lower the heart rate but that is not an option for some patients. Although the potential of cardiac CT was recognized, the limitations of 64-slice imaging prevented it from becoming part of clinical routine in cardiology.

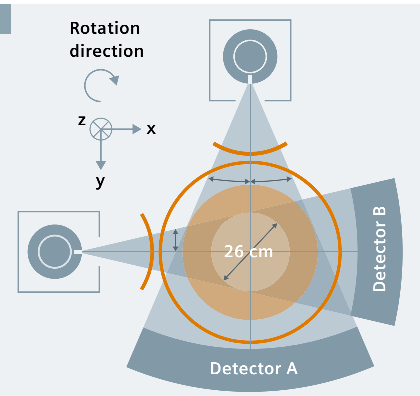
In 2002, the Siemens research team began discussing with clinical specialists how cardio CT could be improved, given that the temporal resolution of single source CT could not be increased beyond a certain point. It was recognized that no device based on this principle would be able to match the temporal resolution range of 50 ms achievable using electron beam CT.

A breakthrough with Dual Source CT

Despite its lower temporal resolution, the conventional third-generation CT scanner had a higher spatial resolution than the electron beam scanner and was better at showing slight differ-



1 Multislice detectors and spiral CT were Siemens' key developments in the 1980's and 1990's and opened up the way for new clinical applications.



2 Technical realization of a DSCT system: one detector (A) covers the entire scan field-of-view with a diameter of 50 cm, while the other detector (B) covers a smaller, central field-of-view.

ences in contrast, meaning that overall image quality was significantly better. Taking this as their starting point, in 2002 the development team came up with an ambitious idea. In place of the single source principle, they argued that faster imaging could be achieved by installing two detector systems in one gantry, at an angle of 90° to each other. The foundations for the development of dual source technology had been laid.

This innovative idea was not embraced by everyone. Some critics would have rather followed the traditional way of simply increasing the detector width. In addition, there were many physical obstacles, such as the limited space on the gantry, the complex system control, or cross-scattered radiation. However, the highly motivated team at Siemens were convinced that the dual source principle could be implemented in practice. The more doubts and objections they encountered, the more determined they became to overcome this challenge.

Professor Thomas Flohr, PhD, a member of the dual source research team, reports: “We had recognized the opportunities presented by cardio CT and were also convinced that a Dual Source CT system would have applications beyond cardiology. There was something of a gold-rush mood in the team. We were electrified by the idea.”

Intensive collaboration with medical advisory boards then effectively led to the development of the first dual source scanner that could be used in practice, with new, compact tube technology and high performance (the rotating envelope Straton tube).

In 2005, following a three-year development phase, Siemens launched the first Dual Source CT scanner, the SOMATOM Definition.[1,2] Its introduction caused a sensation in the field. SOMATOM Definition could achieve a temporal resolution of 83 ms per image, and a quarter-rotation was sufficient to allow each of the two detector systems to capture enough data to produce an image. For the first time, the heart could now be imaged without motion artifacts at high heart rates or in cases of arrhythmia.[3]

The introduction of Dual Source CT was critical in enabling cardio CT to become part of clinical routine over the next few years. It has also played a major role in shaping the potential applications of CT in the field of cardiac imaging.[4]

Expanding the application for Dual Source CT

From the start, Dual Source CT was intended to have application not just in cardiology but also in other specialties such as oncology and pediatrics. To achieve this, the principle of scanning at different voltages was integrated: dual energy CT.

Dual energy CT reveals not only the morphology, but also the chemical composition of the scanned organs. This new technology aims at developing CT into a tool for functional as opposed to purely morphological imaging.[5] Physicians can use it to evaluate the local iodine uptake in contrast-enhanced scans and to compute virtual non-enhanced images, to automatically remove the bones from CT angiographic studies. Another example is the characterization of tissue or differentiation of deposits such as kidney stones. The absorption of iodinated contrast medium by a tumor can also serve as an indicator of local perfusion and thus as a marker of tumor dignity.

The introduction of the SOMATOM Definition Flash in 2009 led to further optimization. This had its origins in a suggestion by Professor Jacques Remy from Lille, who was particularly enthusiastic about the high scan speeds that could be achieved by utilizing both measurement systems of a Dual Source CT. In a discussion with Thomas Flohr, the idea to use a very fast spiral scan to image an entire heart during one heartbeat was born. This became the basis for the Flash scan mode.Thanks to its high scan speed of 458 mm/s, a heart could be scanned in only 0.22 seconds, meaning that at low heart rates a CT scan could be carried out in a single heartbeat. In terms of radiation dose, Flash mode is the most efficient method of cardiac imaging, as it captures only the minimum amount of data needed

3 Cardiac imaging – in Turbo Flash mode, scanning can be sped up to 737 mm/s. With CARE kV and CARE Dose4D, exposure dose can be individualized automatically. This case was acquired in 0.12 s at 80 kV, 0.28 mSv, using 30 mL contrast agent only. Coronary diseases can be excluded confidently as shown in VRT and curved MPR images in great detail.
Courtesy of Baotou Central Hospital, Baotou, Inner Mongolia, P. R. China

“We were highly confident that dual source would offer possibilities beyond cardiology.”

Thomas Flohr, PhD

for image reconstruction. This means that a heart can be imaged with a radiation dose of only 1 mSv, one tenth of that required by other systems.

Today, SOMATOM Definition Flash is the gold standard in cardio CT, with excellent image quality and at low radiation dose. The entire heart can be imaged with a temporal resolution of 75 ms. In addition, flexible scan modes allow clinicians to obtain morphological findings, examine coronary arteries, plan TAVI procedures, and capture data for assessing myocardial perfusion. Even heart-scanning without beta-blockers may become possible.

Young patients are a challenge, as generally they need intensive preparation, sedation, and subsequent monitoring when undergoing a CT scan. As the Flash mode combines a scan speed of 458 mm/s with a temporal resolution of 75 ms, the average time for a pediatric scan is less than a second, allowing physicians to reevalute the need for sedation.

Dual source dual energy CT (DSDE) is improved with the SOMATOM Definition Flash because of the increased coverage offered by its second detector (33 cm). A tin filter can be used to optimize spectral separation, which significantly reduces the radiation dose necessary for dual energy imaging and allows for “dose-neutral” dual energy scans. Dual energy CT has many potential applications in oncology. It meets all the diagnostic requirements for detection and visualization. That enables physicians to evaluate the iodine uptake of tissue lesions in one scan, with radiation doses similar to those for a conventional 120 kV scan.

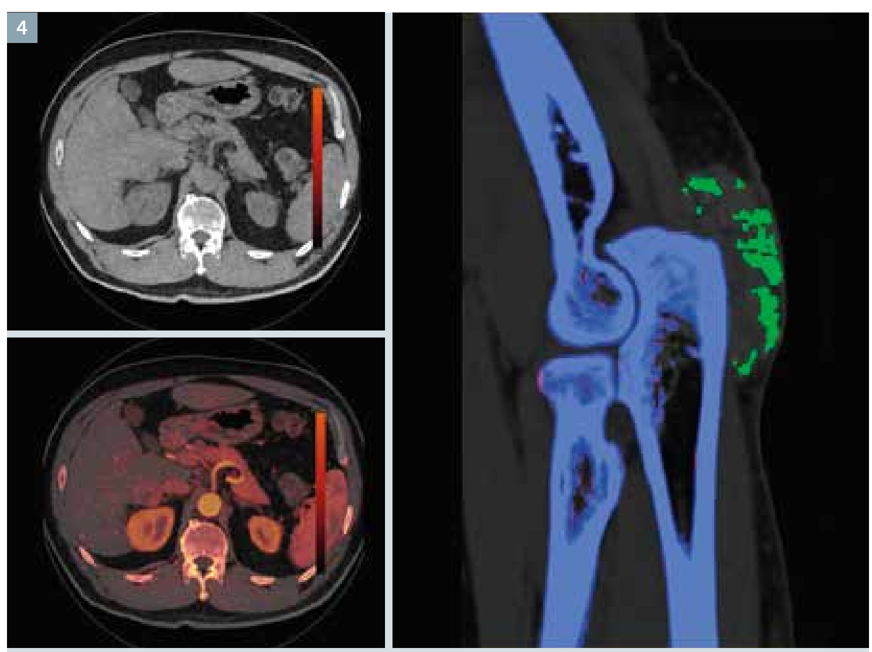
State-of-the-art in morphological and functional imaging

Siemens has worked consistently to enhance the temporal and spatial resolution of its DSCT. The result is the SOMATOM Force. Using the newly developed Vectron X-ray tube, good image resolution and high image quality can be maintained even at very high tube currents and low tube voltages.

Vectron X-ray tubes have a power capacity of 120 kW, while the tube voltage can be set at between 70 and 150 kilovolts (kV). In many examinations, especially those involving contrast media, using low voltages can be beneficial, as it makes for a better contrast-to-noise ratio. Due to technical limitations, 70 kV or 80 kV CT used to be reserved exclusively for children and slim patients. With the Vectron tubes and its enormous power reserves at low kV (up to 2x 1300 mA), adults and even patients with a high body weight can be examined in a short time window and at low tube voltages. This means that contrast can be maintained while reducing radiation dose.

Alternatively, the high contrast-to-noise ratio at low tube voltages may be used in a different way: Early clinical experience based on imaging of the left ventricle and aortic root (TAVI studies) demonstrated that a reduction of contrast media administration may be possible using SOMATOM Force’s Turbo Flash Mode and its low kV/high mA capabilities.

A study on coronary CT angiography was recently published: The authors report that using SOMATOM Force at



4 Dual energy imaging – the Selective Photon Shield allows dedicated filtration and better separation of the low and high energy spectrum, which significantly improves material differentiation in dual energy imaging. A virtual non-contrast (VNC) and a fused VNC/iodine image (left) reveal an enhanced lesion in the right hepatic lobe, segment VI, indicating a metastasis. Gout crystals are demonstrated in the posterior elbow (right).
Courtesy of University Hospital Zurich, Zurich, Switzerland (left), and Gyeongsang National University Hospital, Jinju, Korea (right)

70 kV results in a lower radiation exposure (0.44 mSv at 70 kVp instead of 0.92 mSv at 100 kVp) as well as less contrast medium volume (45 mL instead of 80 mL) compared to a state-of-the-art CT scanner employing 80 kV or 100 kV tube voltage settings. Concurrently, image quality could be maintained. The study is based on the examination of 45 patients. Image quality was measured using image-based objective criteria, such as contrast-to-noise ratio and image noise, and by the subjective assessment of two radiologists.[6] This is particularly beneficial for older and chronically ill patients with impaired renal function, whose kidneys have low tolerance for iodinated contrast media.

In Turbo Flash mode, the scan speed is increased to 758 mm/s. This, together with a reduction in radiation dose, makes this CT scanner the ideal diagnostic tool for examining small children, even if they will not lie still.

As SOMATOM Force incorporates dual energy technology, physicians are able to differentiate tissue and materials chemically even where they have the same density value. This functional imaging opens up the path to new approaches to cancer diagnosis. Based on information of this imaging, the physician, for example, can characterize tumors and assess how a patient responds to treatment. Moving beyond dual energy data capture, the use of temporally resolved perfusion measurements – already well-established in stroke diagnosis – is now finding its way into oncology.

With its excellent temporal resolution, SOMATOM Force is able to minimize movement artifacts, meaning that it can be used with patients who are unable to hold their breath due to illness, age, asthma or shortness of breath, or trauma.

Future potential of Dual Source CT

Dual Source CT technology has opened up some promising avenues for research institutions. SOMATOM Force has set the benchmark for mechanical features such as temporal resolution, scan speed, and low radiation dose, but there are many applications that continue to be developed. Some of these relate to scan specificity, for example. A 60-percent stenosis of the coronary arteries can be accurately diagnosed using SOMATOM Force. However, at the moment further examinations are needed to clarify whether a stenosis is affecting the blood supply to the heart muscle. In the future, it may be possible to determine this using Dual Source CT alone, rendering further examinations with a heart catheter, MR, or SPECT unnecessary.

SOMATOM Force allows the lungs to be imaged at extremely low radiation doses. The Selective Photon Shield optimizes the X-ray spectrum in high-contrast applications without iodinated contrast medium, such as pulmonary imaging. This may potentially play a supportive role in screening[1] for lung cancer.

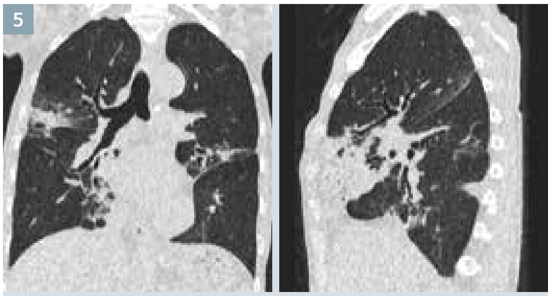
In the field of abdominal and pelvic medicine, the ability of Dual Source CT to capture the function as well as the morphology of the tissue to be examined opens up the possibility of using local tissue perfusion as a marker in treatment monitoring – for example, in the diagnosis and treatment of hepatic and gastrointestinal tumors and in the detection of bone metastases.

With the help of biochemical markers, it will be possible to offer tomorrow's patients diagnosis and treatment tailored to their individual needs. SOMATOM Force provides strong hopes that we will be able to provide the diagnostic data needed for early detection, precise characterization, and removal of tumors and metastases.

Professor Thomas Flohr: "This isn't the end of the story. We remain committed to exploring the whole range of possible applications for Dual Source CT."

Another focus for the future is workflow automation. Overall, users require better and simpler integration of CT into clinical routine. There is, therefore, scope for optimizing the quality standards of clinics and practices in relation to diagnosis and treatment. Patients also benefit from workflow automation in terms of waiting times, treatment processes, and outcomes. Not least, improved automation of workflows could give impetus to clinical research projects and the development of new approaches to diagnosis and treatment. ■

5



5 Pneumonia – the Selective Photon Shield II optimizes the X-ray spectrum, which significantly improve the air/soft tissue contrast. MPR images demonstrate bilateral areas of consolidation and ground-glass attenuation with superimposed interlobular septal thickening. CT scan was performed without breath-hold in Turbo Flash mode, with an effective dose of only 0.04 mSv, which is less than a standard X-ray radiography examination.
Courtesy of Baotou Central Hospital, Baotou, Inner Mongolia, P. R. China

Ruth Wissler, MD, studied veterinary and human medicine. She is an expert in science communications and medical writing.

[1] Under FDA review. Not available for sale in the U.S.

References

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[4] Petersilka M et al. European Journal of Radiology 2008; 68: 362–368
[5] Johnson TRC et al. Eur Radiol 2006 DOI 10.1007/s00330-006-0517-6
[6] Mathias Meyer, et al. Radiology 2014 273:2, 373-382

Further Information

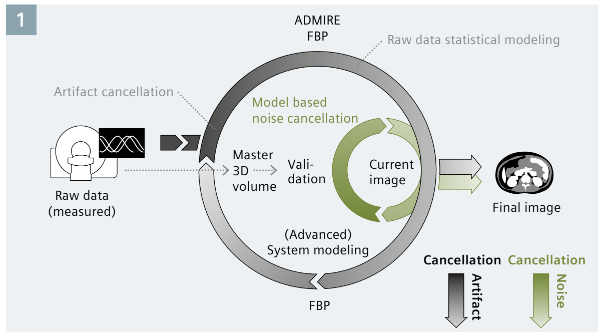
www.siemens.com/dual-source-CT

Advanced Modeled Iterative Reconstruction in Clinical Routine

By Ivo Driesser

Siemens Healthcare, Germany

In modern medical care, patients deserve the lowest possible dose and radiologists desire the best image quality. The major challenge is to realize this in daily routine. Siemens has overcome this challenge by applying several iterative reconstruction algorithms. The latest iterative reconstruction technology is known as ADMIRE – advanced modeled iterative reconstruction (Fig. 1).

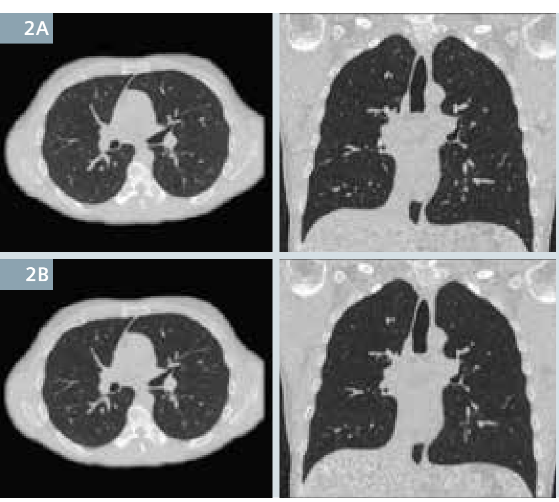


1 ADMIRE schematic: The algorithm is a model-based iterative reconstruction method.

ADMIRE has three fundamental features:
1. It uses an advanced statistical weighting of all projections in the raw-data space.
2. Advanced regularization intelligently separates noise from actual anatomical structures within the image.
3. It incorporates a more complete modeling of the CT geometry and of scanner components and characteristics such as detector type.

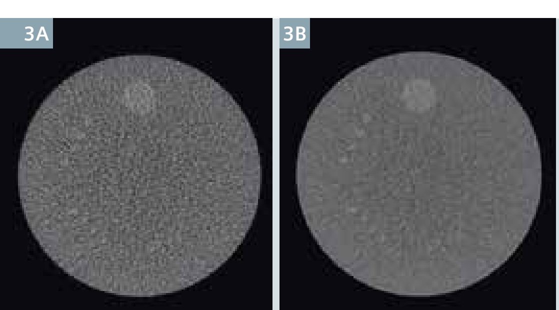
The full benefits of ADMIRE for spatial resolution improvement and noise and artifact reduction are best achieved with the concurrent use of the latest detectors available in SOMATOM Force and selected CT scanners in the SOMATOM Definition family.

In addition to its compatibility with Dual Energy CT, ADMIRE enables 'ultra-low' dose acquisitions for non-enhanced CT examinations such as chest CT. The case in Fig. 2 shows the example of a patient undergoing two consecutive unenhanced CT scans. The first scan used a routine protocol at 120 kVp and reconstructed with weighted filtered back projection (WFBP) (Fig. 2A), while the second scan used Sn100 kV and ADMIRE (Fig. 2B). Remarkably, with the Selective Photon Shield and ADMIRE, only 8% scanner radiation output was required compared with the routine acquisition (0.34 vs 4.27 mGy).



2 The example shows images of a patient who underwent a routine chest CT protocol at 120 kVp ($CTDI_{vol}$ = 4.27 mGy, DLP = 171 mGy cm) (Fig. 2A), reconstructed using conventional WFBP, followed by a reduced dose chest CT protocol at 100 kVp and Selective Photon Shield II ($CTDI_{vol}$ = 0.34 mGy, DLP = 13.6 mGy cm) (Fig. 2B), reconstructed using ADMIRE strength 4.
Courtesy of Clinical Innovation Center, Mayo Clinic Rochester, Minnesota, USA

Surpassing previous iterative reconstruction approaches, ADMIRE has the potential to reduce noise even further and improve low-contrast detectability. This is combined with well-maintained noise texture of the reconstructed images, which closely resembles the familiar filtered back projection (FBP) noise impression (see Fig. 3). The algorithm also achieves an efficient improvement in image quality, and a reduction in substantial image noise in low-dose datasets and object regions with strongly non-isotropic CT attenuation. Furthermore, ADMIRE allows for improved resolution at high-contrast edges in the image compared with images reconstructed using FBP. ■



3 Low-contrast module of the ACR accreditation phantom, reconstructed using FBP (Fig. 3A) and ADMIRE strength 5 (Fig. 3B). Image noise is reduced and low-contrast detectability is improved. Note the four small cylinders on the bottom left that are barely visible on the FBP image.
Courtesy of Clinical Innovation Center, Mayo Clinic Rochester, Minnesota, USA

In clinical practice, the use of ADMIRE 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.

Further Information

www.siemens.com/ADMIRE

Scanning at Low kV: An Important Trend in CT

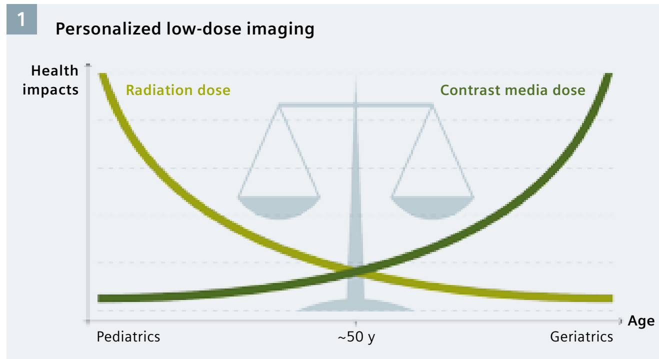
By Ivo Driesser

Siemens Healthcare, Germany

Reducing doses of radiation or contrast media has a significant impact on all patients. With this in mind, physicians, researchers, and providers strive constantly to apply these two critical components in CT scanning, X-ray and contrast media, in doses that are as high as necessary and as low as possible.

Saving iodine by lowering tube voltage

Tube potentials between 70 and 100 kVp have shown to be most effective for clinical contrast CT examinations. The basis for low kV imaging is the mass attenuation coefficient, which is a property that depends on the chemical composition and density of a material. Early clinical experience based on imaging of the left ventricle and aortic root (TAVI studies) demonstrate that a reduction in contrast media administration may be possible using SOMATOM Force's Turbo Flash Mode and its low kV/high mA capabilities. Phantom scans show a linear relationship between the iodine concentration and enhancement, and how much iodine can be saved if the attenuation is kept constant. For example: Compared with a 120 kV baseline protocol, the iodine enhancement at 100 kV is higher and therefore the contrast can be reduced by 20 mL if the original volume was 100 mL. (For all other values, please see the dedicated white paper). The principle works on every CT scanner.



1 Contrast media and radiation dose affect health differently depending on age.

However, meaningful savings of contrast media dose require a significant decrease in kV. An animal study in pigs demonstrated that an identical temporal enhancement curve for the 120 kV reference protocol (Fig. 2A) and 70 kV protocol (Fig. 2B) can be obtained with constant injection duration and adapted iodine delivery rate (IDR) while reducing the contrast media from 64 mL to 32 mL (see Fig. 2).[1]

Adapted contrast injection protocol for reduced iodine load

To reduce contrast agent dose and change from a reference scan protocol to a low kV protocol, the contrast injection protocol must be adapted to reduce the iodine load. The easiest way to adapt the iodine load would be to reduce the contrast volume without changing any other injection parameters. However, a reduction in contrast volume leads to shorter injection duration and, therefore, to significant changes in contrast enhancement over time: Peak enhancement occurs earlier, requiring adaptation of the scan delay, and scan timing becomes more critical because of a narrower enhancement curve.

Various institutions pursue the concept of low kV scanning. Researchers from the University of Frankfurt have published initial clinical results from 70 kV ultra-low dose CT scans of the paranasal sinus.[2] Researchers at University Hospital Mannheim reduced the amount of contrast agent for dedicated angiographic CT examinations to 20 mL for a diagnostic CT angiography of the chest, abdomen, and pelvis.

To find out more about the use of contrast enhancement at lower kV to reduce the contrast agent dose while maintaining high image quality in terms of contrast-to-noise (CNR), please follow the link below to the related full-length white paper. ■

2 A preclinical animal study demonstrated the peak width, peak height and peak time remain the same with a reduction in the iodine delivery rate.[1]

References

[1] Lell MM, Jost G, Korporaal JG *et al*. Optimizing contrast media injection protocols in state-of-the art CTA. Invest Radiol. 2015 Mar;50(3):161-7

[2] Bodelle B, Wichmann JL, Klotz N *et al*. Seventy kilovolt ultra-low dose CT of the paranasal sinus: first clinical results. Clin Radiol. 2015 Jul;70(7):711-5

Further Information

www.siemens.com/ct-low-kV

How to Acquire CTA of Both Pulmonary Arteries and Veins Separately with one Contrast Bolus Injection

By Norinari Honda, MD; Yoshiharu Kobayashi, RT; Ryosuke Miyano, RT and Hiroki Matsuzawa, RT

Department of Radiology and Radiology Service, Saitama Medical Center, Saitama Medical University, Japan

A 69-year-old male patient was referred for diagnosis and treatment of an incidentally detected right-lung nodule.

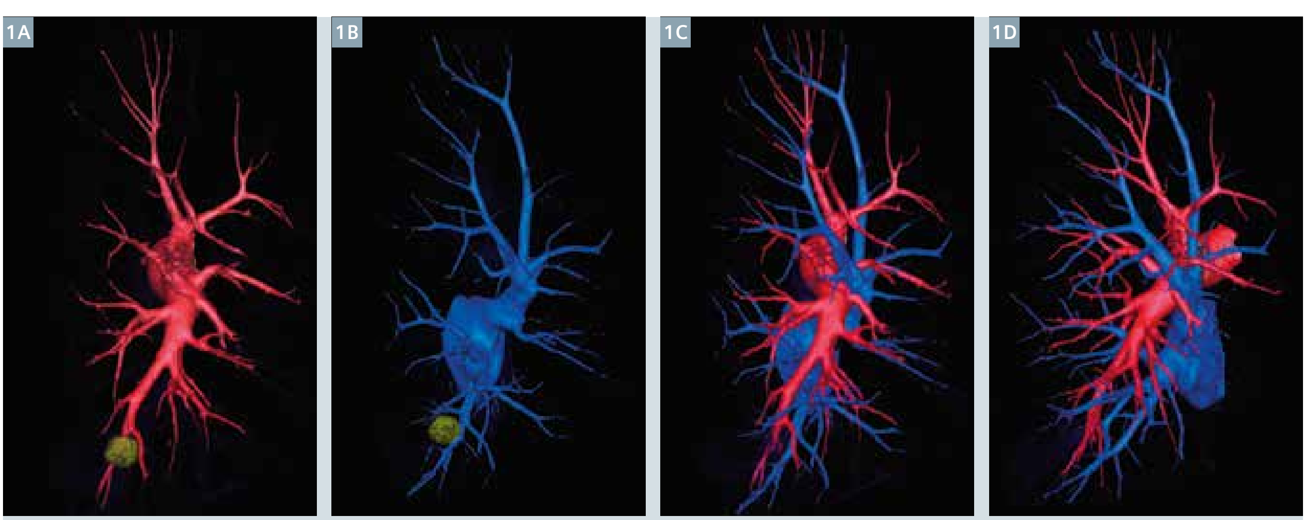
Thin slice CT images showed a circumscribed mass with a lobulated and notched contour accompanied by pleural puckering, suggesting pulmonary cancer.

These CT findings prompted a chest physician to perform a bronchoscopy for biopsy, which confirmed the diagnosis of an adenocarcinoma.

Thoracic surgeons planned to resect the tumor using thoracoscopic surgery and wished to evaluate the vascular anatomy of the right lung.

Examination Protocol

Scanner	SOMATOM Definition Flash
Scan area	Thorax
Scan mode	Adaptive 4D Spiral (PA-PV scan)
Scan length	381 mm
Scan direction	Caudo-cranial
Scan time	2 /2 s
Tube voltage	100 kV
Tube current	124 mAs
Dose modulation	–
$CTDI_{vol}$	12.46 mGy
DLP	504 mGy cm
Effective dose	7.06 mSv
Rotation time	0.5 s
Pitch	–
Slice collimation	128 × 0.6 mm
Slice width	1.0 mm
Reconstruction increment	0.5 mm
Reconstruction kernel	B45f
Contrast	370 mg/mL
Volume	30 mL + 20 mL saline
Flow rate	5 mL/s
Start delay	Test bolus



1 CTA images show the tumor and the right pulmonary vasculature.

In this case, a double head injector was used – one head for contrast media (CM) and the other for saline. For the monitoring CT scan, a test bolus of CM and saline were simultaneously injected at 2.5 mL/s for 6 seconds, followed by a saline flush of 5 mL/s for 4 seconds. Thus, a diluted CM volume of 30 mL ([2.5+2.5] x6) and saline flush of 20 mL were applied.

The monitoring CT scan was started 6 seconds after the start of the injection at a level containing both the pulmonary artery (PA) and the left atrium (LA) under suspended inspiration. Scanning was manually stopped by a radiology technician when CM in the LA had disappeared. Afterwards, an analysis of the monitoring scan was performed to plan pulmonary artery-pulmonary vein (PA-PV) scan.

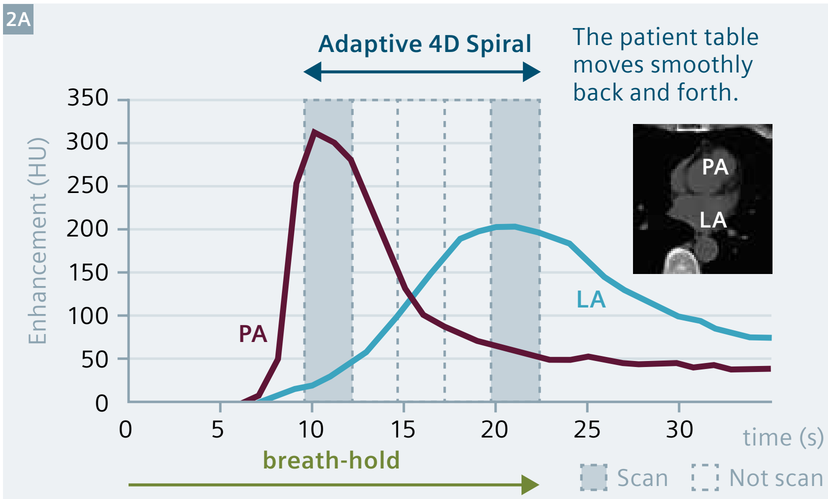
Time-density curves (TDCs) with the region of interest (ROIs) in the PA and in the LA were obtained using "DynEva" application. The peak times of the PA and the LA were measured and the difference between the two peak times was calculated. Note that the delay time (time difference between the start of the CM injection and the start of the monitoring scan) should also be added to obtain an accurate peak time. Two windows for the PA-PV scan were planned to begin around the peak time of the PA and the LA, maximizing the density difference of the PA and the PV (Fig. 2A). The window widths were set equal to the PA-PV scan durations.

To plan a PA-PV scan, an Adaptive 4D Spiral protocol was applied (Fig. 2B). In the "Scan" tab, set the delay time to the beginning of the PA scans, and the scan time to 2.5 s. Click on the right mouse button on "Cycle time" to pop-up the "Cycle time table". Check the upper two lines to set the number of scans to "2", and the cycle time of the first line to the interval of the two peaks.

The PA-PV scan range depends on the length of the patient's lung.

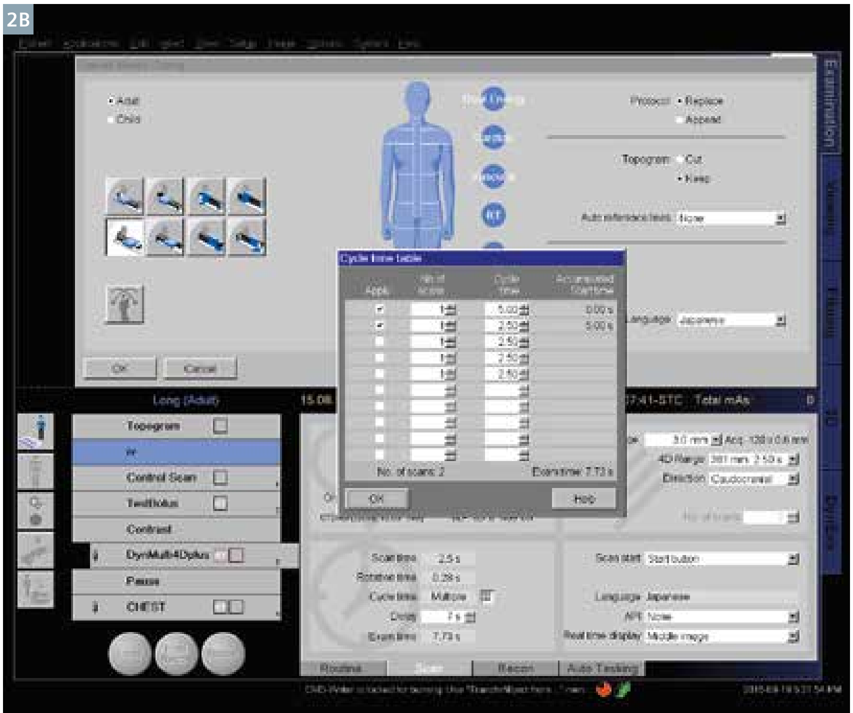
When performing the PA-PV scan, the patient was instructed to suspend at full inspiration until two scans, covering PA phase and PV phase, were finished. The amount of CM for the PA-PV scan was 5 mL/s for 6 seconds followed by a saline flush of 5 mL/s for 4 seconds. Thus, the total CM volume applied was 30 mL with a saline flush of 20 mL. ■

2A



2A Time-density curve of the test scan illustrates the evaluation and the planning.

2B



2B Screenshot of the user interface shows the planning of the PA-PV scans.

Training Tradition Ongoing in 2015

By **Axel Lorz,** *Siemens Healthcare, Germany*

True to its tradition, in 2015 Siemens Healthcare CT has been focusing on continued clinical training, seen as a major pillar in helping to advance healthcare. Evidence of this was seen in the fully booked *Clinical Workshop on Dual Energy* (May 7–8) headed by associate professor Ralf Bauer, MD, from the Department of Radiology, University of Frankfurt. Experts from Siemens R&D department outlined the physical principles of single source and dual source dual energy, while Professor Bauer provided clinical content covering the complete application spectrum. Supervised hands-on studies of clinical datasets at *syngo*.via workstations followed by interactive feedback and discussion rounded off the workshop and received very positive feedback from the attendees.

During his Dual Energy Workshop, Holger Haubenreisser, MD, from the University of Mannheim, Germany, focuses on dose monitoring in clinical routine.

Another established workshop is dedicated to CT physics (March 24–25, October 27–28) with a focus on radiation dose optimization. Siemens physics experts guide participants through tailored lectures covering topics such as CARE Dose4D, CARE kV, Turbo Flash scanning, and iterative reconstruction techniques. To complete this valuable lesson, Holger Haubenreisser, MD, a radiologist from the University of Mannheim in Germany shares his experiences of institutional dose monitoring in daily routine. ■

Further Information

www.siemens.com/SOMATOMEducate

2016 Multislice CT Symposium in Garmisch

By **Monika Demuth, PhD,** *Siemens Healthcare, Germany*

From January 20 – 23, 2016, the 9th International Symposium for Multislice CT will take place in Garmisch-Partenkirchen, Germany.

The 9th International Symposium for Multislice CT focuses on the constant drive for innovation.

The program of this year's symposium is defined by the constant drive for innovation in the field of computed tomography. It offers participants scientifically sound training with a strong emphasis on modern practice and clinical application. Insights into cutting-edge methodological and technological developments – including fascinating advancements in lung imaging – will be used to demonstrate innovation in oncology imaging as well as new possibilities for structural analysis. Together with the attendees, the future role of radiology will be explored. The program kicks off with a series of parallel events looking at different case studies, aimed at residents and medical-technical radiology assistants. Legal specialists will discuss the medico-legal aspects of radiology, and some well-known experts will be talking about interesting case histories in a more interactive forum. Participants are warmly invited to share their own experiences in the discussions.

The symposium is accredited by the Bavarian "Landesärztekammer", and participants will have the option of registering for CME credits. The conference language is German. ■

Further Information

www.ct2016.org

Clinical Workshops 2016

As a cooperation partner of many renowned hospitals, Siemens Healthcare offers continuing CT training programs. In a wide range of workshops, clinical experts share latest experiences and options in clinical CT imaging.

Workshop Title / Special Interest	Date	Location	Course Language	Organizer – Course Director	Link
Myocardial CT Perfusion Workshop	January 28–29, 2016	Forchheim, Germany	English	Siemens Healthcare	www.siemens.com/ SOMATOMEducate
Optimized TAVI Procedural Planning: CT and Angiography	March 08, 2016	Erlangen, Germany	English	Siemens Healthcare – Prof. Stephan Achenbach, MD Mohamed Marwan, MD	www.siemens.com/ SOMATOMEducate
Workshop for Physicists	March 22–23, 2016	Forchheim, Germany	English	Siemens Healthcare	www.siemens.com/ SOMATOMEducate
Workshop on Dual Energy	May 12–13, 2016	Forchheim, Germany	English	Siemens Healthcare – Prof. Ralf Bauer, MD	www.siemens.com/ SOMATOMEducate
Hands-on at the ESGAR Workshop/Colonography	May 18–20, 2016	Gothenburg, Sweden	English	ESGAR: Prof. Andrea Laghi	www.esgar.org
Advanced Cardiovascular CT (Spring)	tbd	London, UK	English	Imperial College London	www.imperial.ac.uk
Hands-on at the ESGAR Congress/Colonography	June 14–17, 2016	Prague, Czech Republic	English	ESGAR: Prof. Vlastimil Valek	www.esgar.org
Oncology Imaging Course 2016	June 30– July 2, 2016	Dubrovnik, Croatia	English	OIC – Prof. Maximilian F. Reiser, MD Prof. Christian Herold, MD Prof. Hedvig Hricak, MD	www.oncoic.org
Hands-on at the ESC	August 27–31, 2016	London, UK	English	Siemens Healthcare	www.siemens.com/ESC
Advanced Cardiovascular CT (Autumn)	tbd	London, UK	English	Imperial College London	www.imperial.ac.uk
Workshop for Physicists	October 25–26, 2016	Forchheim, Germany	English	Siemens Healthcare	www.siemens.com/ SOMATOMEducate
Coronary CTA Interpretation Workshop	November 10–11, 2016	Erlangen, Germany	English	Siemens Healthcare – Prof. Stephan Achenbach, MD	www.siemens.com/ SOMATOMEducate

In addition, you can always find the latest CT courses offered by Siemens Healthcare at **www.siemens.com/SOMATOMEducate**

Upcoming Events & Congresses 2015/2016

Short Description	Date	Location	Title	Contact
Radiological Society of North America	November 29–December 04, 2015	Chicago, USA	RSNA	www.rsna.org
Internationales Symposium Mehrschicht CT	January 21–23, 2016	Garmisch-Partenkirchen, Germany	Mehrschicht CT	www.mehrschicht-ct.org
Arab Health	January 25–28, 2016	Dubai, UAE	Arab Health	www.arabhealthonline.com
European Society of Radiology	March 2–6, 2016	Vienna, Austria	ECR	www.myesr.org
European Stroke Conference	April 13–15, 2016	Venice, Italy	esc	www.eurostroke.eu
Cardiac Magnetic Resonance Imaging & Computed Tomography	April 16–18, 2016	Cannes, France	Cardiac MRI & CT	www.cardiacmri-ct.medconvent.at
European Conference on Interventional Oncology	April 17–20, 2016	Dublin, Ireland	ECIO	www.ecio.org
European Society for Radiotherapy & Oncology	April 29–May 03, 2016	Turin, Italy	ESTRO	www.estro.org
European Society of Paediatric Radiology	May 15–20, 2016	Chicago, USA	IPR	www.espr.org
Particle Therapy Co-Operative Group	May 22–28, 2016	Prague, Czech Republic	PTCOG	www.ptcog.ch
European Society of Thoracic Imaging	May 26–28, 2016	Istanbul, Turkey	ESTI	www.myesti.org
American Society of Clinical Oncology	May 29–June 2, 2016	Chicago, USA	ASCO	www.am.asco.org
Annual Meeting of the Association for European Paediatric and Congenital Cardiology	June 1–4, 2016	Rome, Italy	AEPC	www.aepc2016.org
European Society of Gastrointestinal and Abdominal Radiology	June 14–17, 2016	Prague, Czech Republic	ESGAR	www.esgar.org
Jahrestagung der Deutschen Gesellschaft für Radioonkologie	June 16–19, 2016	Mannheim, Germany	DEGRO	www.degro.org
International Society for Computed Tomography	June 20–23, 2016	San Francisco, USA	ISCT	www.isct.org
Society of Cardiovascular Computed Tomography	June 23–26, 2016	Las Vegas, USA	SCCT	www.scct.org
The American Association of Physicists in Medicine	July 31–August 4, 2016	Washington, USA	AAPM	www.aapm.org
European Society of Cardiology	August 27–31, 2016	Rome, Italy	ESC	www.escardio.org
American Society for Radiation Oncology	September 25–28, 2016	Boston, USA	ASTRO	www.astro.org
European Society for Medical Oncology	October 7–11, 2016	Copenhagen, Denmark	ESMO	www.esmo.org
Annual Meeting of the Japanese Society for Therapeutic Radiology and Oncology	November 25–27, 2016	Tokyo, Japan	JASTRO	www.jastro.or.jp
Radiological Society of North America	November 27–December 2, 2016	Chicago, USA	RSNA	www.rsna.org

Tips & Tricks: How to Optimize Dual Energy Results

By Patricia Jacob, *Siemens Healthcare, Forchheim, Germany*

Dual energy delivers detail beyond morphology in CT imaging. It is now commonly used in clinical routine in a range of applications, such as kidney stone differentiation, VNC imaging, bone removal, and more. If a user wants to configure the algorithm parameters for CT Dual Energy pre-processing in *syngo*.via Dual Energy, he or she can select the ‘Algorithm Parameters’ tab. The default values for ‘Material Definitions’ and ‘Resolution’ are influenced by the voltage combination for the datasets. The correct values are automatically selected for the calculation. These parameters can also be altered within certain limits according to operator’s needs.

Potential challenges are:

- Images are very noisy
- Small structures have to be evaluated
- Different HU ranges have to be excluded

Noisy images

Changing the resolution value modifies the voxel size of the resulting image. Lower values mean that fewer voxels are used in the analysis. This yields sharper images and therefore improves spatial resolution – however, image noise may increase. Higher values mean that more voxels are used. This produces a smoother image impression at the expense of detail loss.

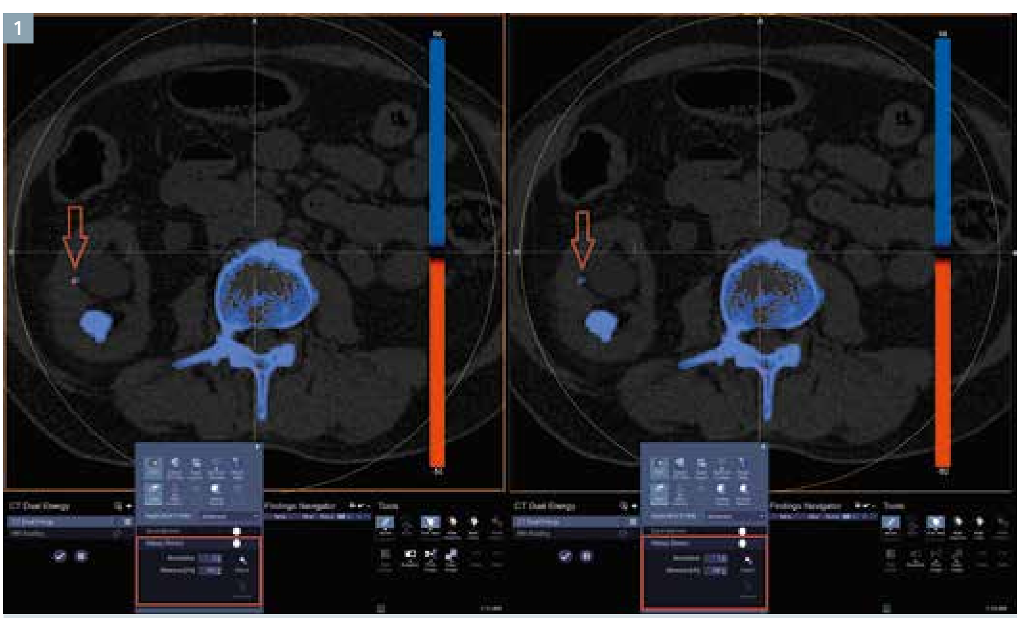
Detecting small structures

Small kidney stones are better depicted by reducing the resolution value. To detect small stones in obese patients, lowering the resolution value sometimes does not help. If this is the case, then decrease the minimum HU value to approximately 150 HU in order to color-code small stones.

In general, the resolution value should be increased to reduce image noise. This effect can be better appreciated in the VNC images. By increasing the resolution value from 1 to 3, the images show reduced noise and a smoother image impression. However, image definition is better in the images with a lower resolution value.

Excluding certain HU ranges

In certain images, it is necessary to exclude small bone fragments or calcifications from images for a clearer diagnosis. Lowering the resolution value may potentially remove them. Otherwise, if small vessels are missing that should be displayed, the same applies in reverse. ■



1 When changing any of the parameters within the ‘Advanced Parameter Definition’, a calculation must be performed to obtain the desired new result. Therefore, select ‘Calculate’.

2 Dual energy imaging can depict the chemical differences in the stones. It permits differentiation between uric acid and non uric acid stones.

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