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Radiation Therapy Supplement

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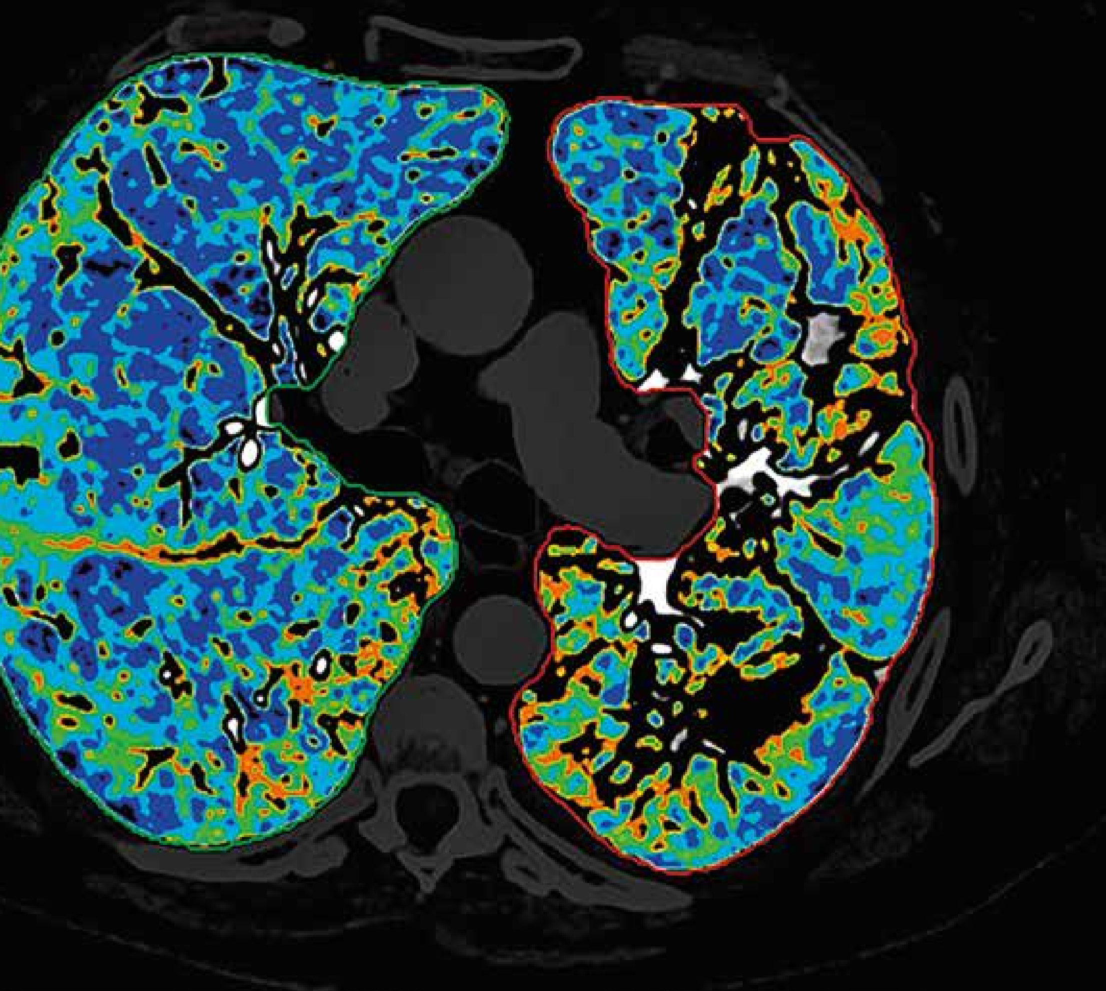

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expertise with the readers of
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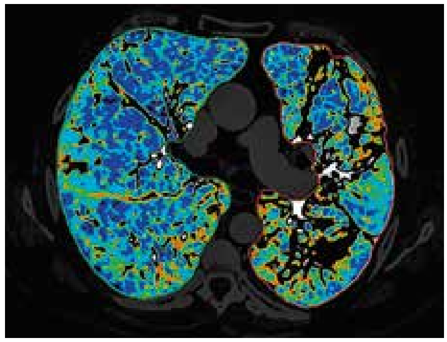
Cover



Monitoring Response to Stereotactic Ablative Radiotherapy for UICC Stage I NSCLC using Dual Energy Dual Source CT: A 9-month follow-up shows no significant changes in lung density.
(Read the full case report on page 18)

Courtesy of LMU Munich, Munich, Germany

December 2016

Contents

Customer Experiences

Clinical Results

Dear Reader,

Imaging plays an increasingly important role in advancing radiation therapy practices. We understand from you that core challenges remain, even as technological and clinical knowledge develop rapidly. Pressures on the healthcare sector as a whole push providers to streamline workflows and maximize the financial performance of their medical equipment while still keeping the patient in focus.

In this supplement of SOMATOM Sessions, practitioners share their experiences of how imaging solutions can enable clinical capabilities to be broadened. Moreover, clinicians report on how efficiency can be driven through a leading reputation, which therefore attracts more patient referrals. The shared goal, however, is always ultimately to improve patient outcomes and standardize the quality of care.

Brachytherapy is a valuable treatment option. At the Gunma Prefectural Cancer Center in Japan, the clinical team has created a dedicated image-guided brachytherapy suite with an in-room CT sliding gantry. They describe how this setup has enabled great improvements in efficiency while still allowing them to provide quality care to their patients. (page 4)

In Montpellier, France, the Centre de Cancérologie du Grand Montpellier was confronted with a tight budget and room constraints. By opting for the modern capabilities of SOMATOM Scope, the team explains how a 70 cm bore is entirely adequate for RT planning, supports the treatment of moving tumors, and even goes beyond expectations when it comes to planning therapy for the increasing number of patients with metal implants. (page 8)

In radiation therapy, the constant challenge is to control the cancer while sparing healthy tissue. As lung cancer is a major indication for RT, which approach can help clinical teams to save healthy lung tissue and reduce side effects? Experts from Rigshopitalet in Copenhagen, Denmark, show how mid-ventilation is a good alternative for patients. (page 12)

Constantly striving to deliver the precision and certainty required in all types of oncology treatments – from routine brachytherapy to advanced SBRT and proton therapy – Siemens offers CT solutions that deliver high image quality with minimal artifacts for confident contouring and planning. Our constantly evolving portfolio tailored for RT ranges from SOMATOM Scope to Dual Source CT scanners, such as SOMATOM Drive and the brand new SOMATOM Confidence® RT Pro[1]. These imaging devices are now complemented by *syngo*.via RT Image Suite, an integrated and comprehensive imaging software based on our proven *syngo*.via platform. *syngo*.via RT Image Suite supports efficient decision-making and contouring by providing high-quality and comprehensive multimodality easy image handling, flexible workflows, and modern delineation tools.

Our commitment to you is to continue to push the boundaries in CT and also in multimodality imaging for radiation therapy so that you can be more confident in treating more accurately and monitor more reliably. Your cooperation drives our innovation, so we look forward to hearing about your ideas and experience.

Warm regards,

Gabriel Haras, MD
Head of Radiation Oncology,
Advanced Therapies,
Siemens Healthineers,
Forchheim, Germany

[1] The product is pending 510(k) clearance, and is not yet commercially available in the U.S.

Fighting Cervical Cancer with Image-guided Brachytherapy

To Ken Ando, MD, the question is not whether to use brachytherapy; it is how to use this effective therapy with maximum accuracy and minimum patient discomfort. His choice of solutions is worthy of consideration.

Text: **Charles T. Whipple,** Photos: **Hans Sautter**

Ken Ando, MD, Director of Gynecology Radiation Therapy is a warrior in Japan's battle against cancer. He constantly works to reduce cervical cancer mortality.

In 2016, the National Cancer Center expects more than a million Japanese people to be diagnosed with cancer. Women will account for some 43 percent of these diagnoses, with some 30,000 of them suffering from uterine or cervical cancer.[1] In fact, according to the Japan Journal of Clinical Oncology, cervical cancer incidence and mortality began to increase from 1990, and while the rate of increase is not a rapid climb, the cancer has become the second most lethal among women aged 15 to 45.[2]

This is the last year in the Japanese government's Basic Plan to Promote Cancer Control Programs, which places cancer treatment at the top of the list of goals. Based on the Basic Plan, each prefecture develops its own plan to promote cancer control. In Gunma Prefecture, northwest of Tokyo, Gunma Prefectural Cancer Center (GPCC), with its 357 beds and fifteen departments, provides diagnosis and therapy for the prefecture as well as for the neighboring prefectures of Saitama and Tochigi. And it is very much a part of Japan's battle against cancer.

Ken Ando, MD, is a warrior in that battle. As Director of Gynecology Radiation Therapy, he constantly works to reduce cervical cancer mortality, and his work has brought him to brachytherapy.

Benefits of brachytherapy

Prostate, head, and neck cancer are generally treated at the Cancer Center using intensity modulated radiation therapy (IMRT). Radiation oncologists treat as many as 80 patients per day. Brachytherapy, however, is used mostly for cervical and uterus cancer patients. Ando says, "There are some cases of stump reoccurrence and vaginal cancer, but basically we deal with gynecological cancers. That's when we turn to brachytherapy, and for years our situation was far from optimal. In the radiation section of the hospital, we did our rather complicated brachytherapy planning based on 2D C-arm images. Applicators were placed and the patient then lifted onto a stretcher and transferred to a CT room, where we did CT imaging and later fused 2D C-arm with the 3D CT images."

At GPCC, brachytherapy is used mostly for cervical and uterus cancer patients.

According to Ando, the procedure held a team of doctors, technicians, and nurses on site for three hours in complicated cases. Plus, if the CT scan showed that the applicators had shifted, more time was needed to restore them to the proper place. He wanted a system in which the entire brachytherapy could be done in the same room. Ken Ando finally applied for approval to set up an image-guided brachytherapy (IGBT) suite centered around a SOMATOM Scope Power-Sliding Gantry from Siemens Healthineers. With the system, the workflow changed.

"In this day and age, brachytherapy is a must, and I think that should mean in-room CT systems."

Ken Ando, MD,
Director of Gynecology Radiation Therapy,
GPCC, Japan

"The biggest advantage of the in-room CT is not having to move the patient."

Ken Ando, MD,
Director of Gynecology Radiation Therapy,
GPCC, Japan

A perfect fit

"The biggest advantage of the in-room CT is not having to move the patient from the table," says Ando. "We can plan, place the applicators, do 3D imaging with our CT scanner, and do the fusion all in the same place. Before, two nurses had to be with the patient throughout the procedure. Now, one nurse is sufficient. A procedure that went smoothly used to take three hours to complete; now it takes two hours and a few minutes."

Ken Ando seems more than happy that the entire compact system fits in a single room within the Radiation Therapy department.

"The CT aperture is 70 centimeters, ample for patients, producing very clear images – and it makes all the difference in the world to have a good clear picture of the problem area during therapy," says Ando. "You could even say I'm a little proud of the fact that the system I suggested fits in our available space."

IGBT: A must

IGBT is still not widely used for cancer therapy in Japan: Only about one-third of the cancer facilities which have brachytherapy capabilities in Japan have IGBT systems. However, Ando pointed out that in-room CT systems have been discussed at the brachytherapy meetings of the Japanese Society for Therapeutic Radiology and Oncology (JASTRO), and he said the opinion leaders in the industry virtually all use such systems. "In this day and age," says Ando, "IGBT is a must, and I think that should mean in-room CT systems."

MRI can also be used as an imaging modality in brachytherapy in Europe, but Ken Ando does not think that option is ideal for his situation. MRI would take more manpower. "I've talked with MRI technicians and prepared applicators for this purpose. Still, my experience is that the images we get from our CT are really good, even compared to those we might get from MRI."

With the installation of an image-guided brachytherapy suite centered around a SOMATOM Scope Sliding Gantry, the workflow changed at GPCC. The entire brachytherapy can now be done in the same room.

Gunma Prefectural Cancer Center with its 357 beds and fifteen departments is very much a part of Japan's battle against cancer.

As mentioned, Gunma Cancer Center serves a wider area than just one prefecture. Outlying hospitals and clinics learn of its expertise and refer their patients to the Cancer Center. Further, Ando is one of few oncologists in Gunma with extensive experience of IGBT, and he is called upon to help train more physicians, technicians, and nurses in this vital therapy. Now, with the SOMATOM Scope Sliding Gantry CT system and the skills of Ken Ando and his team in image-guided brachytherapy, the enemy called cancer faces competent warriors using accurate and effective weapons. ■

Charles T. Whipple is an international award-winning author and journalist based in Japan. His articles have appeared in magazines and newspapers such as *Time*, *Newsweek*, the *Chicago Tribune*, and the *International Herald Tribune*. He has lived in Japan since 1977 and is fluent in Japanese.

Facts and Figures

1 million Japanese people expected to be diagnosed with cancer.

Women will account for **43 percent** of these diagnoses

30,000 of them will suffer from uterine or cervical cancer.

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[1] Otake T, Cancer diagnoses in 2016 expected to top 1 million for first time. The Japan Times. 2016

[2] ICO HPV Information Centre. Human Papillomavirus and Related Diseases Report. Japan. 2016

More efficiency and more radiation directed at tumors – these are the goals that drive CCGM, as physicist Stéphane Muraro explains.

Crystal Clear Images for Precise Cancer Treatment

A particular challenge in imaging is posed by cases where implants, pacemakers, and hip replacements produce noise on clinical images. *SOMATOM Sessions* asked physicians at the Centre de Cancérologie du Grand Montpellier (CCGM) in the south of France how they manage to achieve clean images.

Text: **Bill Hinchberger,** Photos: **Gregoire Bernardi**

The patient walked in with birdshot embedded in his skull – the remains of a childhood accident Lead shrapnel would normally wreak havoc on a CT scan, but Stéphane Muraro, physicist at Centre de Cancérologie du Grand Montpellier (CCGM) shrugged it off. A CT system with the ability to reduce metal artifacts would give the physician a crystal clear image. Of course, the metal artifacts that Muraro and his colleagues usually deal with are caused by implants such as pacemakers and hip replacements.

Under a setup common in France, the CCGM radiology unit is physically located within a larger hospital complex but remains independent in terms of ownership and operations.

“For good radiotherapy treatment, we obviously need accurate preparation.”

Emmanuel Beguier, MD, radiation oncologist, CCGM, France

Precise treatment despite metal implants

Under a setup common in France, the CCGM radiology unit is physically located within a larger hospital complex but remains independent in terms of ownership and operations. CCGM averages about 1,400 radiotherapy patients a year. It handles all comers, apart from children. Breast (500 per year) and prostate (120 per year) patients figure prominently. About two-thirds receive RapidArc® Radiotherapy Technology (Varian Medical Systems), also known as volumetric arc therapy (VMAT). More recently, CCGM has begun using stereotactic treatments. Stereotactic approaches are very precise treatments in terms of location and support delivery of high treatment doses in a small number of sessions for the patients, explains Muraro.

“For good radiotherapy treatment, we obviously need accurate preparation,” says radiation oncologist Emmanuel Beguier, MD. “It must be reliable, accurate, and fast. When we intervene, we want good images that properly show the tumor that is to be irradiated.”

Asked about his greatest challenges, Muraro answers instantly: “The most striking example is when we want to treat prostate cancer and the patient has one or two hip replacements. “If we have no metal artifact reduction algorithm, we see nothing,” says the physician. “So you can’t move onto treatment. A single prosthesis is hard enough to deal with, but two is almost impossible.”

Refurbished versus new

In 2015, CCGM planned to purchase a new CT scanner. Actually, the clinic was looking for a used scanner it could refurbish. Then, Muraro bumped into the Siemens representatives at last year’s ESTRO conference in Barcelona. They helped change his mind. “The idea at first was to get a used scanner, for cost reasons,” he recalls. “But given maintenance and the cost of changing the tube, the used option would have been more expensive than a new SOMATOM Scope Power.” Finally, they decided for the latter option.

Recently, CCGM has begun using stereotactic treatments. These approaches allow physicians to be both more aggressive with doses and more precise in terms of location.

"The most striking example is when we want to treat prostate cancer and the patient has one or two hip replacements."

Stéphane Muraro,
CCGM, France

And the new machine came with customer service that no used machine could offer. Muraro describes Siemens customer service as "very good" – and goes further to credit the company representative for much of CCGM's recent progress.

By Siemens standards, the private clinic is making swift progress in adapting to the new machine. Patient outcomes already look better in recent months. CCGM has also moved more quickly than most to make full and effective use of all of the scanner's features, with iterative metal artifact reduction technology (iMAR) and high definition field of view (HD FoV) scoring particularly high marks from Muraro and everyone at CCGM.

Overall balance

This was no coincidence, Muraro hastens to add: It all came at a very affordable price. To make his point, the physician uses a car metaphor: "You go slower in a Renault Clio than in a Mercedes," he says. "Everything is a budget issue, but for an operation like ours this is an extraordinary scanner."

CCGM has, in fact, picked up the pace with the SOMATOM Scope Power. Previously, the clinic was only able to schedule up to ten patients a day. "Now that number can be as high as 15. If we have a fast team and the necessary equipment, we tend to treat more patients," Muraro explains.

Reliability, accuracy, and speed

"We are happy with the result," adds Beguier. In the days before we had the SOMATOM Scope Power, he notes, patient implants posed problems. Thanks to the 4D capabilities of the CT system, for example, physicians at CCGM have been able to pinpoint radiation to the exact spot of a moving tumor instead of shooting at a wider range – thereby increasing the effectiveness of the treatment while minimizing the negative side effects for the patient. "Without 4D, the patient would have received much more radiation to healthy tissue," says Muraro.

For everyone at CCGM, it was important that the new machine meshed well with our Varian Eclipse™ treatment planning system – which helps calculate doses and with which everyone was familiar. "When we bought the Scope Power, it was tested and it worked perfectly," says Muraro.

Size considerations

CCGM operates in an early 20th century building where space matters. Designed for a different age, rooms tend to be cramped. In ideal circumstances, an operation like CCGM would probably have gone for an 80 centimeter bore system. Given space limitations, however, they went for 70 centimeters. Large bore might be the global standard, but everything has worked well in Montpellier with the smaller bore size. "In the south of France, patients are not big," says Muraro. "If I were living elsewhere, maybe I would have made a different choice. But here, there is no advantage to having an 80 centimeter bore size."

With most larger patients or those who need to place extremities in certain positions, HD FoV helps, according to Muraro: “Even with a small scanner and a small tube, for us in radiotherapy the most important thing is to have the contour of the patient.” The HD FoV helps give them that.

Powerful tool

Muraro and his colleagues seem especially impressed with the iMAR, iterative metal artifact reduction, capability. “It help us compared with manual correction,” says Muraro’s colleague Geoffrey Galliano, referring to the former process of physically manipulating images to correct them. Muraro adds: “Before, it was all reconstructed by hand. The manual and visual correction led to false images and even dose errors.”

Muraro tells the story of a patient with a pacemaker he saw the day before: “You know that pacemakers and radiation do not go together well,” he says. In the past, physicians could not tell exactly where the pacemaker was, which sometimes led to confused images. “Now, with iMAR you can reduce the artifacts generated by the pacemaker,” Muraro notes.

More interaction

It might seem counterintuitive, but in terms of workflow, even as CCGM attends to more patients, the Scope and its related features have led to more interaction among technicians and physicians. iMAR reduces artifacts for patients with implants, so physicians have a better idea of what they want. And therapists can ask more intelligent questions as they prepare to get it right. The same logic goes for the HD FoV. If a patient is required to hold his or her breath to capture the right image, the therapist might also consult the physician. Again, to get it right the first time.

“The physicians now work more closely with the therapists,” Beguier agrees. “Positioning is most important. I’ll bring in physicians and radiographers to find the best position possible. Sometimes there are several possibilities.” Beguier adds: “Before, physicians would just look at an image and say what was wrong. Now they can work with the technicians to participate in the positioning,” he says.

New contouring feature

Muraro and his colleagues are looking forward to September, when they will add a new contouring feature to the scanner. This will help identify critical organs and allow for quicker scans that can move patients more promptly to treatment, he explained. “If the organs at risk are contoured for us, we waste less time,” he says.

Less wasted time, means more efficiency, and more radiation directed at tumors – these are the goals that drive CCGM. And they are hoping that the SOMATOM Scope Power will continue to support them here. ■

Iterative metal artifact reduction technology, iMAR, and high definition field of view scored particularly high marks from Muraro and everyone at CCGM.

Bill Hinchberger is a freelance writer based in Paris.

Mid-Ventilation Radiotherapy Approach for Lung Cancer: A Way To Save More Healthy Tissue?

Radiation therapy requires a delicate balance between effectively treating the tumor and limiting the damage to surrounding healthy tissue. Moving tumors like lung cancer often require larger target margins to capture the whole range of motion thus also exposing some organs to unncessary radiation. Applying the mid-ventilation approach may be a way to reduce these margins and potentially reduce the risk of toxicity.

Text: **Nils Lindstrand,** Photos: **Morten Koldby**

Mirjana Josipovic is a leading expert in radiation therapy and medical imaging at Rigshospitalet in Copenhagen.

Saving as much healthy tissue as possible, both in the lungs and in nearby organs, is critical to keep the risk of treatment-related side effects at an accepted level for lung cancer patients. "The mid-ventilation approach is a key step in this process," explains Mirjana Josipovic, senior medical physicist and PhD fellow at Rigshospitalet, Copenhagen, Denmark, and a leading expert in radiation therapy and medical imaging. Rigshospitalet specializes in the mid-ventilation approach for the treatment of moving tumors – and is one of the world's leading centers for lung cancer radiotherapy.

Reducing target margins for moving tumors

To address the uncertainties in the position of the tumor, including its respiratory movement, margins are applied around the tumor, resulting in the so-called planning target volume (PTV). While these margins ensure that the tumor is adequately covered with the prescribed radiation dose, they unavoidably contain healthy tissue that will also be exposed to radiation.

A major challenge when treating lung cancer has always been that the tumor moves as the patient breathes. Some tumors exhibit a range of motion of several centimeters. One widely used approach to take account of this motion is the internal target volume (ITV). In this approach, a volume enclosing the whole envelope of the tumor motion is defined and the PTV margin is added to this volume, and not to the tumor itself, resulting in a relatively large PTV.

Since the movement of the tumor makes it so difficult to target it, why not just let the patient hold his or her breath? "Breath-hold CT scanning and breath-hold treatment has been applied broadly for patients with breast cancer and also mediastinal lymphoma. In lung cancer it has only been investigated sparsely, due to assumption that the patients will not be able to hold their breath. However, our experience is the opposite and we are currently receiving lung cancer patients for treatment using the deep inspiration breath-hold technique (DIBH). This method has its benefits even apart from tumor motion mitigation," says Josipovic. "When you inhale and hold your breath, the lung volume increases, while the tumor remains the same. This results in a larger amount of healthy lung tissue outside the radiation treatment area."

Even though the majority of lung cancer patients can cooperate with DIBH in the experience of clinicians at Rigshospitalet, not all of them can – and, in very few, the DIBH approach is not better than free-breathing due to complex tumor geometry. Therefore, improvement of free breathing techniques is also warranted. In this area, the mid-ventilation approach offers an alternative to ITV, aiming to minimize the irradiated volume.

"We are currently receiving lung cancer patients for treatment using the deep inspiration breath-hold technique."

Mirjana Josipovic, senior medical physicist and PhD fellow, Rigshospitalet, Copenhagen, Denmark

Mirjana Josipovic has been working with the mid-ventilation approach for more than ten years.

"The mid-ventilation approach helps to tailor the irradiating volume for a particular patient, avoiding excess irradiation of healthy tissue."

The mid-ventilation approach uses the information on tumor movement from phase-based 4D CT scans to calculate the time-weighted mean position of the tumor – the so-called mid-position. The breathing phase from the 4D CT closest to the mid-position is chosen as the basis for the treatment plan. This phase is called the mid-ventilation phase and the PTV margins are then applied around the position of the tumor in this phase.

So unlike with the ITV approach, the treatment does not cover the whole range of movement of the tumor but only the area where it is most of the time, but the resulting PTV is substantially smaller.

The mid-ventilation approach was first developed at the Netherlands Cancer Institute in Amsterdam, in the early 2000s. Josipovic points out that she did not invent this approach. She has been working clinically with it for more than ten years, however. Rigshospitalet is now one of the leading centers worldwide employing this approach. "Today, the mid-ventilation approach is well known to a number of research centers and hospitals around the world. Here at Rigshospitalet, we believe this method to be useful for the treatment of moving tumors."

One step in reducing the risk of treatment side effects

So what are possible outcomes of the mid-ventilation approach? "To put numbers on potential improvements is next to impossible," Josipovic cautions. "We need to remember that we are talking about high disease burden and lung cancer patients often have more than one health problem." At present, the prognosis for NSCLC shows a five-year survival rate of approximately 15 percent.[1] "However, the mid-ventilation approach helps to tailor the irradiating volume for a particular patient, avoiding excess irradiation of healthy tissue. When it comes to improved outcomes, this is one of many steps."

"In parallel with the development of the mid-ventilation method, other improvements have been implemented clinically, as well. More efficient computers give us the possibility of more exact dose calculation, for example, and daily image guidance ensures precise positioning of the treatment target."

New software may facilitate a breakthrough

One thing that has hindered a more widespread adoption of the mid-ventilation approach is the

One thing that has hindered a more widespread adoption of the mid-ventilation approach is the need to extract the tumor motion from a 4D CT scan and then calculate the mid-position and the related mid-ventilation phase.

need to extract the tumor motion from a 4D CT scan and then calculate the mid-position and the related mid-ventilation phase. Today, these fairly complex and relatively time-consuming calculations are done either manually or with individually designed software tools.

Josipovic is supporting work to develop a commercially available software product that would make the calculations easier to handle. "A more automatic and standardized calculation would certainly be welcome. It would save time, obviously, but it would also mean that calculations would be made in the same way every time. Today, there is an element of individual assessment and estimation, which means that results may be observer dependent."

The mid-ventilation approach may help to better spare healthy tissue during radiation therapy. A new software solution might help to speed up the adoption of this method in more cancer centers. ■

Nils Lindstrand has been working as a science, business, and technology writer for more than 30 years. He is based in Stockholm, but has worked in more than 20 countries so far. His academic background is in chemistry, natural sciences, and technology.

Reference

[1] NORDCAN: Cancer 2/2014. Engholm G, Ferlay J, Christensen N, Johannesen TB, Khan S., Køtlum JE, Milter MC, Ólafsdóttir E, Pukkala E, Storm HH

Rigshospitalet in Copenhagen, Denmark specializes in the mid-ventilation approach for the treatment of moving tumors – and is one of the world's leading centers for lung cancer radiotherapy.

Case 1

RT Planning for a Large Patient with Breast Carcinoma and Cardiac Implant

By Stéphane Muraro and Geoffrey Galliano, MD

Department of Radiation Therapy, Centre de Cancérologie du Grand Montpellier (CCGM), France

History

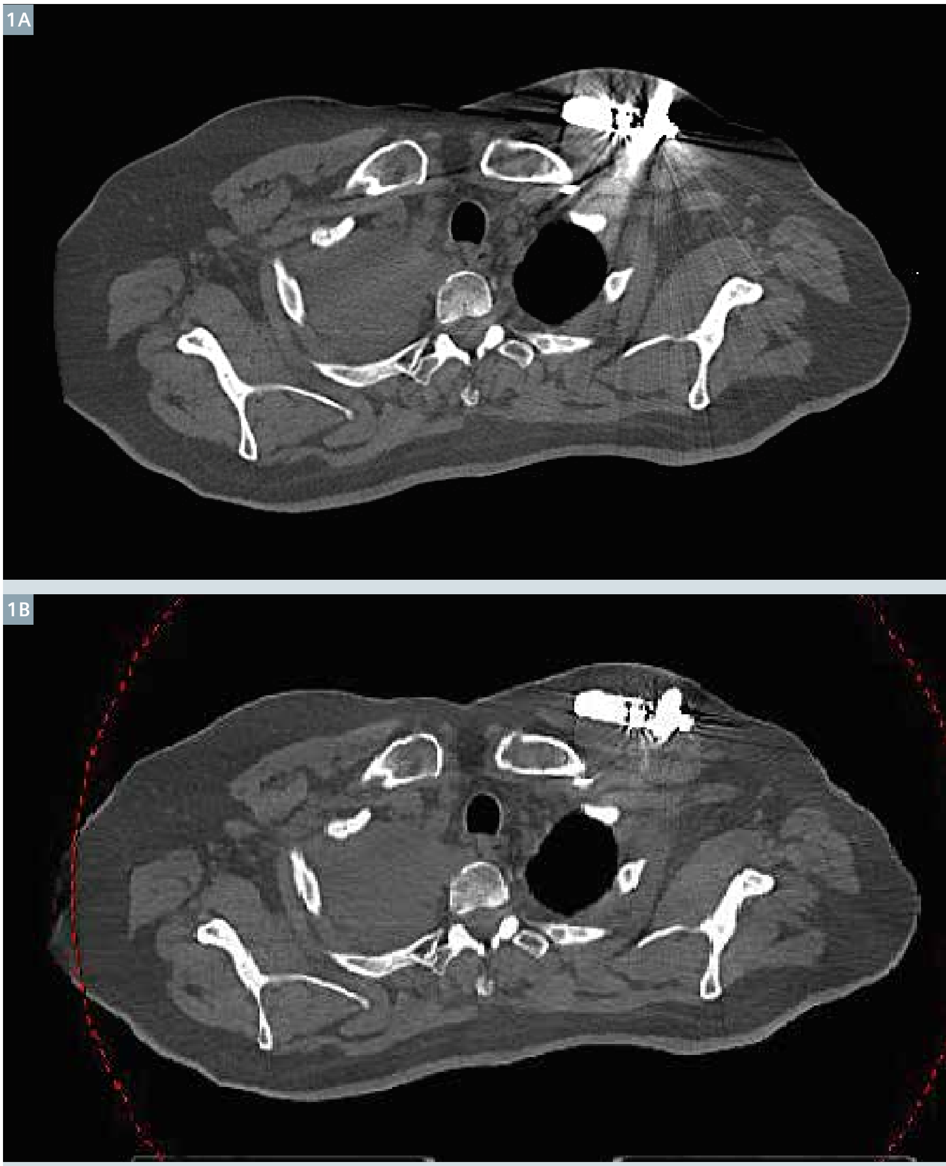
A 59-year-old male weighing 115 kg presented to the CCGM for treatment of a carcinoma of the breast. His specific diagnosis was a slightly differentiated (stage 3) ductal carcinoma locally advanced of the retro-areolar region of the left breast.

A cardiac defibrillator was implanted in August 2015 for a dilated cardiomyopathy. This heart condition is a contraindication for chemotherapy. Therefore, a decision to apply radiation therapy was reached at the multidisciplinary meeting.

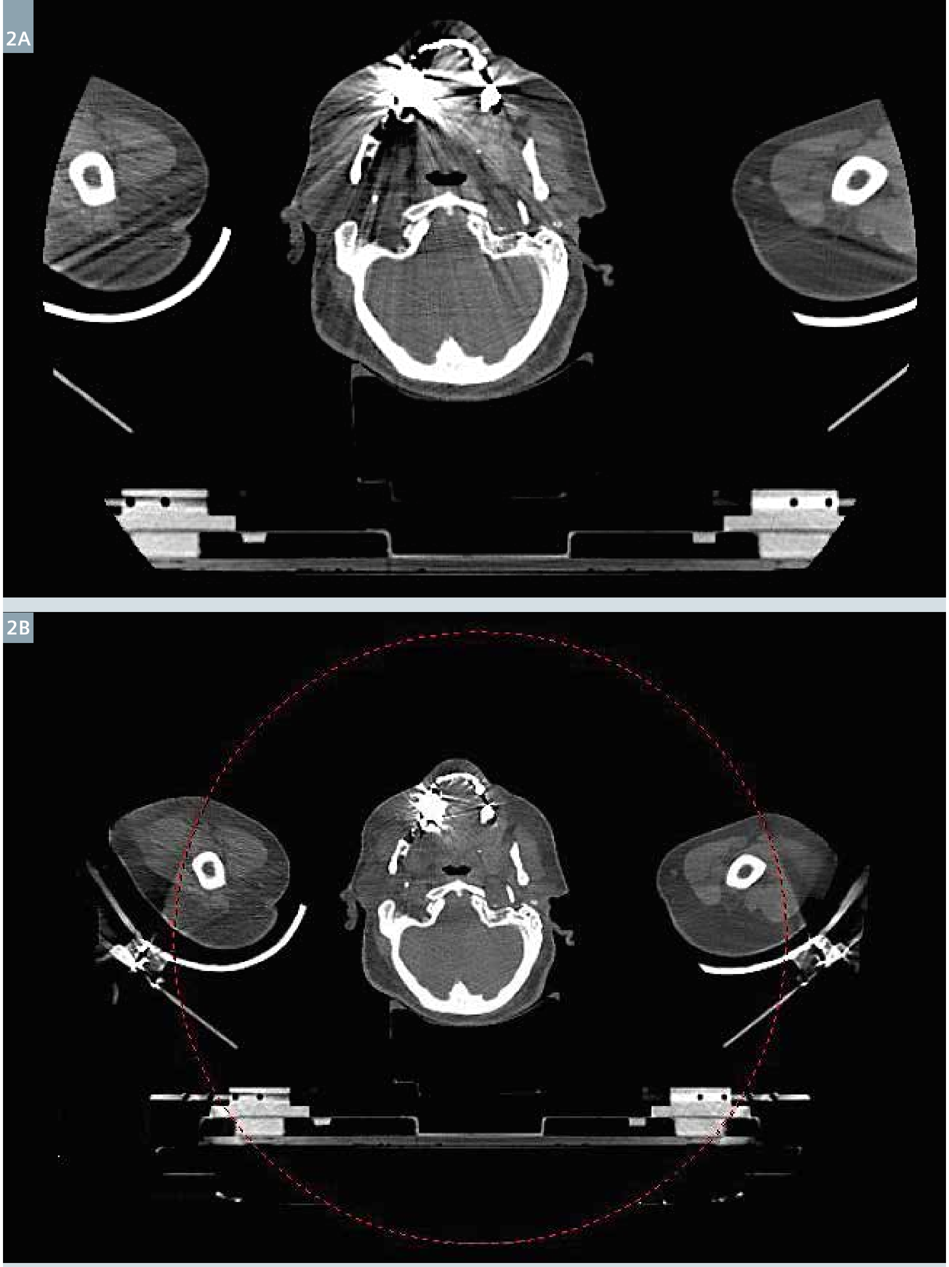
Before the start of the treatment, the patient underwent a dosimetric CT scan to support treatment planning.

Comments

The patient was overweight and had metal implants (defibrillator and dental implants). For successful radiation therapy, it is necessary to see the full external outline of the patient. In this case, the external patient outline was truncated (> 500 mm of the standard FoV). Furthermore, the defibrillator caused several metal artifacts leading to uncertainty in contouring and reduced image quality. Algorithms on SOMATOM Scope Power, such as HD FoV and iMAR, can overcome these limitations by reconstructing missing data. ■



1 Metal artifacts caused by defribrillator are reduced with iMAR.



2 Artifacts caused by metal dental implants are reduced (iMAR) and data are recovered outside the standard FoV (> 500 mm) (HD FoV).

The outcomes 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.

Examination Protocol

Scanner	SOMATOM Scope Power		
Scan area	ORL	DLP	826.65 mGy cm
Scan length	510 mm	Rotation time	1 s
Scan direction	Cranio-caudal	Pitch	0.8
Scan time	34.86 s	Slice collimation	16 × 1.2 mm
Tube voltage	130 kV	Slice width	2 mm
Tube current	151 mAs	Reconstruction increment	700 mm
Dose modulation	CARE Dose4D	Reconstruction kernel	I30S
$CTDI_{vol}$	15.40 mGy		

Case 2

Monitoring Response to Stereotactic Ablative Radiotherapy for UICC Stage I NSCLC using Dual Energy Dual Source CT

Chukwuka Eze, MD;[1] Olarn Roengvoraphoj, MD;[1] Julien Dinkel, MD, PhD;[2] Barbara Wieser,[2] and Farkhad Manapov, MD[1]

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[2] Department of Clinical Radiology, LMU Munich, Munich, Germany

History

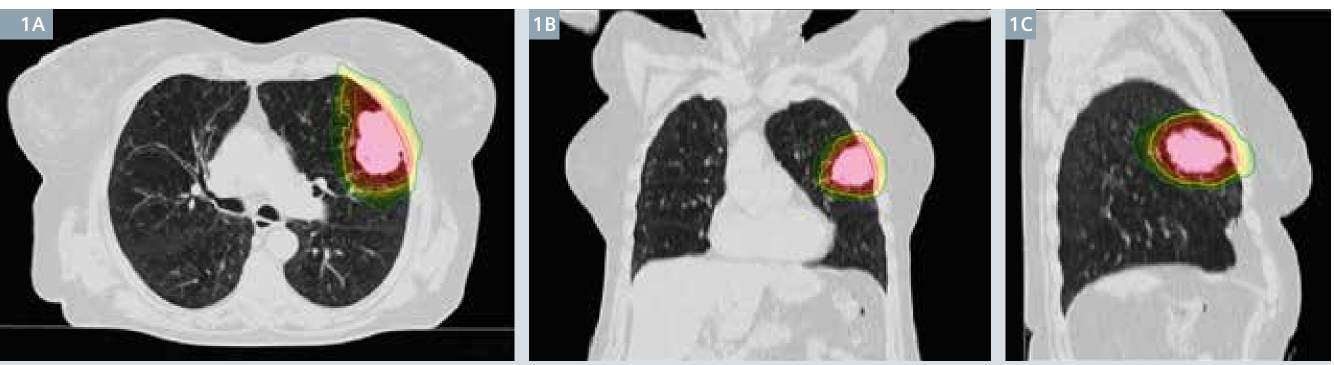
A 69-year-old female was presented with acute exacerbation of the COPD. A left upper lobe lung lesion (49 × 38 × 34 mm) was detected incidentally on computed tomography (CT). A transbronchial biopsy confirmed a moderately differentiated squamous cell carcinoma (SCC). Endobronchial ultrasound transbronchial needle aspiration (EBUS-TBNA) of the thoracic lymph nodes showed an absence of regional lymph node involvement resulting in a UICC Stage IB classification. Initial pulmonary function yielded a forced expiratory volume in 1 second (FEV1) of 1.0 liter and a diffusion capacity (DLCO) of 32%. The case was discussed by the thoracic multidisciplinary tumor board. Due to severe emphysema and limited lung function, the patient did not meet the criteria for tolerance of definitive surgical therapy. Stereotactic radiotherapy was therefore recommended.

The patient underwent stereotactic ablative radiotherapy (SABR) to the lung lesion with a total dose of 60.0 Gy in 8 daily fractions. The dose was calculated using the collapsed cone algorithm and prescribed to the 80% isodose line encompassing the planning target volume (PTV) (Fig. 1).

Comments

The patient underwent 18F FDG PET/CT and 4D CT (10 sequential scans in all respiratory phases) in the treatment position (with vacuum pillow and alpha-cradle). A combination of 4D CT and PET/CT was used to achieve better definition of the target volume. The gross tumor volume (GTV) included the primary tumor. An internal target volume (ITV) was defined by the overlap of the GTVs delineated on 10 phases of 4D CT. A clinical target volume (CTV) was not generated. An isotropic margin of 5 mm was added to the ITV to generate a PTV.

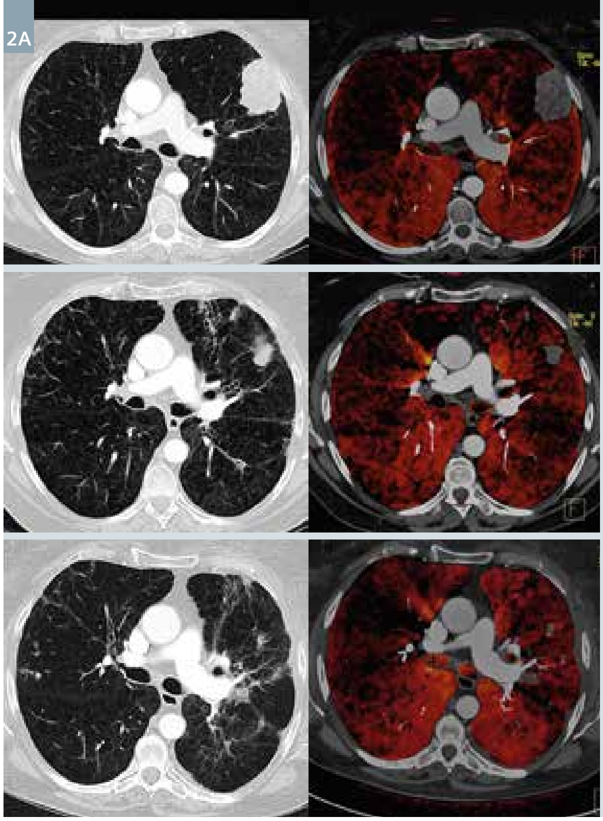
The PTV was calculated at 133.8 cm^3. Maximum, minimum and mean point doses to the tumor target: 76.92 Gy (Dmax), 43.68 Gy (Dmin), and 67.34 Gy (Dmean). The treatment was tolerated well without any relevant toxicity. Follow-up CT scans using dual energy dual source at 3, 6, and 9 months showed a



1 Distribution of isodose lines in selected CT slices for planning.

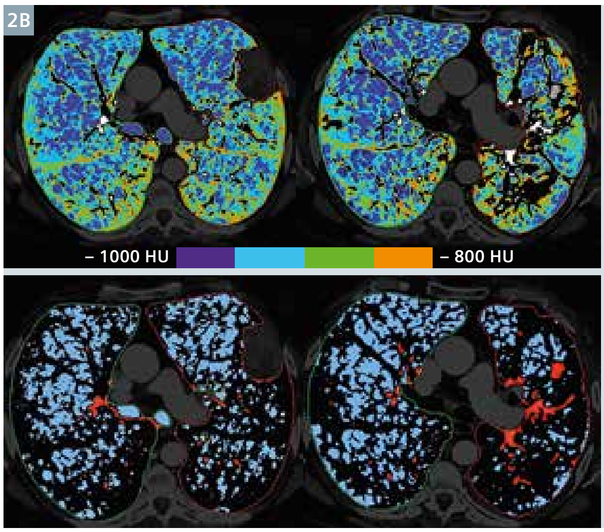
continued decrease in the size of the lesion (Fig. 2). Additional tin filtration on the high kV tube enables a dual energy scan at doses similar to a single energy CT scan. An iodine map of the lung parenchyma was inhomogeneous due to centrilobular emphysema. The patient did not suffer from radiation pneumonitis (RP). Minimal retraction dystelectasis and some radiation-induced fibrotic changes were noted in the follow-up scans.

In conclusion, dual energy dual source CT imaging supports improved monitoring of lung function (lung perfusion) following SABR. If a patient were to develop RP following treatment, symptoms and radiographic changes usually occur 2 to 6 months following SABR. This would typically constitute ground-glass opacities and/or airspace consolidation in and around the irradiation field. The typical changes in pulmonary function parameters consist of a significant decrease in DLCO. Early detection of RP is important as early application of steroids can reduce the severity, hence preventing the progression to irreversible pulmonary fibrosis. ■



2A

Baseline CT (upper row), 3-month follow-up (middle row) and 9-month follow-up (lower row): Tumor size significantly decreases over time. Please note the surrounding minimal fibrotic changes. The iodine map is fairly inhomogeneous due to centrilobular emphysema. The perfusion map for lung parenchyma is slightly impaired in the vicinity of fibrotic changes.



2B

The 9-month follow-up shows no significant changes in lung density (upper row). The lower row shows the area of the lung with attenuation values below -950 HU (blue clusters). Note the minimal shrinkage of the left lung after radiation therapy (right).

Examination Protocol

Scanner	SOMATOM Definition Flash		
Scan area	Thorax	Slice collimation	64 × 0.6 mm
Scan length	ca. 40 cm	Slice width	1.5 mm
Scan direction	Caudo-cranial	Spatial Resolution	0.33 mm
Scan time	8 s	Reconstruction increment	1 mm
Tube voltage	100 kV / Sn140 kV	Reconstruction kernel	Q30f, I26f
Tube current	Ref mAs 165 mAs (Tube A)	**Contrast**	
Dose modulation	CARE Dose4D	Rotation time	0.28 s
Rotation time	0.28 s	Flow rate	5 mL/s
Pitch	0.55	Start delay	8 s with bolus tracking, pulm

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