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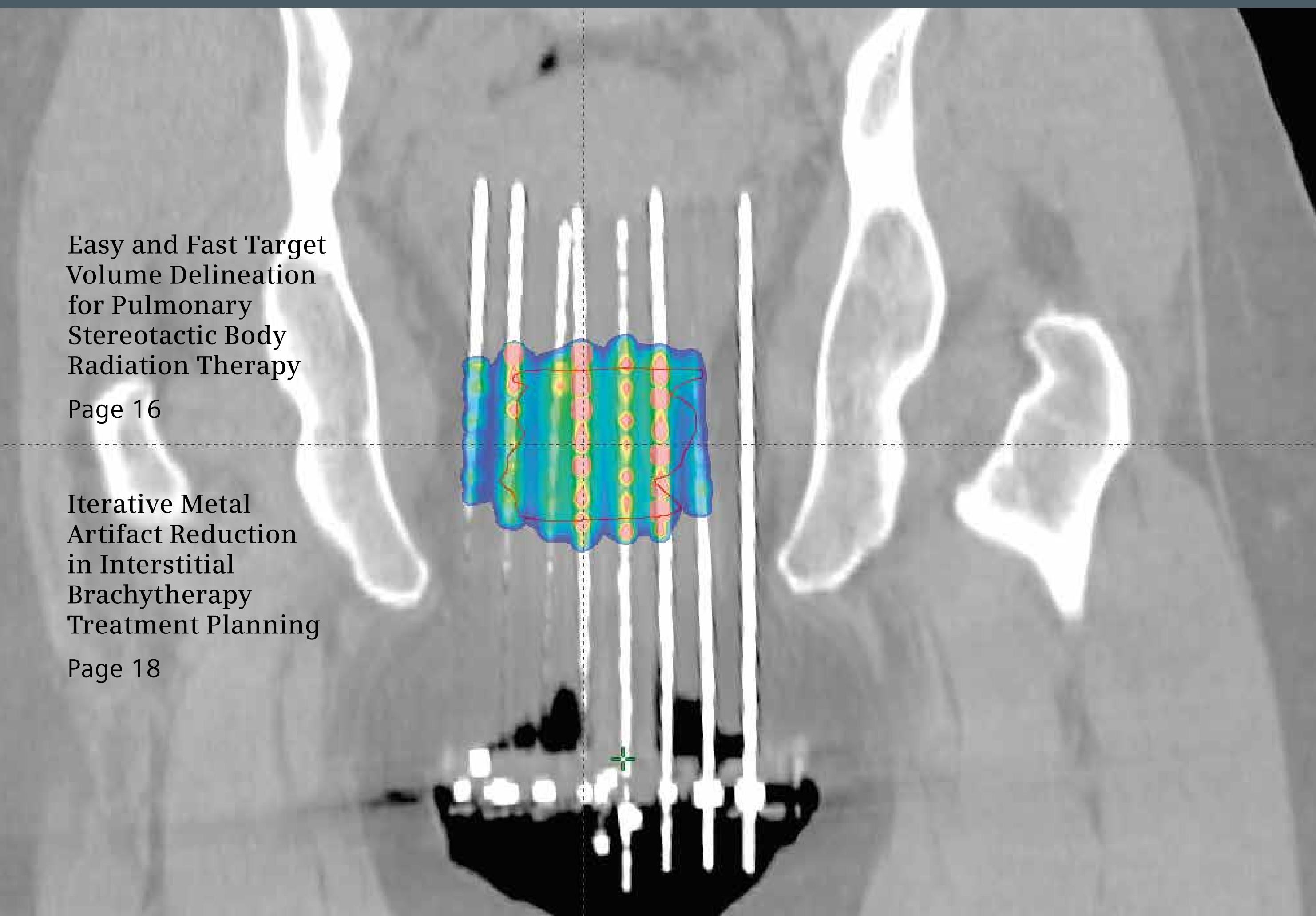
December 2015



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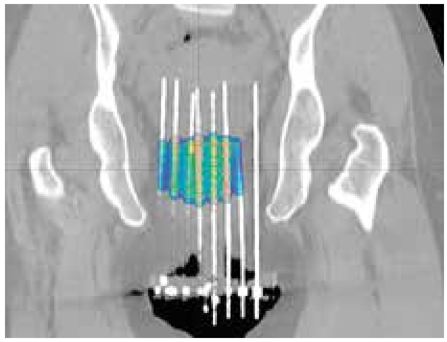
Cover



Coronal slice showing the dose distribution of the interstitial brachytherapy treatment displayed on a CT image reconstructed using iMAR.

Courtesy of Rigshospitalet, Copenhagen, Denmark

December 2015

Contents

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Dear Reader,

Imaging is becoming increasingly important to advance radiation therapy practices. As you know, technology and clinical knowledge are developing rapidly, while core challenges persist. Pressures in the healthcare sector as a whole push providers to streamline workflows and maximize the financial performance of their medical equipment. In this SOMATOM Sessions supplement, practitioners share their experiences of how imaging solutions can broaden clinical capabilities. Clinicians explain how efficiency can be driven by an excellent reputation and by attracting more patient referrals – while the priority remains improving patient outcomes and standardizing the quality of care.

Proton therapy is expanding exponentially and demands high precision – for planning as well as for positioning directly prior to treatment. At the OncoRay Center for Radiation Research in Oncology in Dresden, Germany, a key goal is to establish new methods and technologies. This includes dual energy CT directly in the bunker, allowing physicians to identify and characterize tumors for proton therapy. (page 4)

As new treatment techniques are developed, the technologies to support them also improve. Read how physicians at the PLA 301 Hospital in Beijing, China, are successfully implementing SBRT for moving tumors using images from modern CT scanners with more than 20 slices. (page 8)

Metal implants pose a growing challenge in radiation treatment planning: There is a pressing need to improve image quality and streamline the workflow by reducing metal artifacts in CT images. At Rigshospitalet in Copenhagen, Denmark, clinicians with varying levels of experience are using iMAR (iterative metal artifact reduction) to effectively reduce metal artifacts. (page 12)

Siemens is constantly striving to deliver the precision and confidence required for all types of oncology treatments – from routine brachytherapy to advanced SBRT and proton therapy. Accordingly, we offer CT imaging solutions that deliver high image quality with minimal artifacts for confident contouring and planning. Our portfolio is constantly evolving, and now includes *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 through high-quality and comprehensive multimodality viewing, easy image handling, flexible workflows, and modern delineation tools.

We promise to continue to push the boundaries in CT imaging in radiation therapy so that you can be more confident in decision-making and contouring, treat more accurately, and monitor more reliably. Your cooperation drives our innovations, so we look forward to hearing your ideas and experiences.

Gabriel Haras, MD
Head of Radiation Oncology,
Advanced Therapies Division,
Siemens Healthcare, Forchheim,
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Personalized Particle Therapy Thanks to In-room Dual Energy CT

OncoRay in Dresden, Germany, is one of the first radiotherapy research institutes worldwide to use an in-room computer tomograph on rails for its proton therapy unit. Doctors and physicists alike acknowledge the benefits: Their CT scanner provides diagnostic quality right before treatment and supports personalized, adaptive planning.

Text: **Irène Dietschi,** Photos: **Detlef Schneider**

In-room CTs for image-guided therapy have shown to be highly beneficial in conventional radiotherapy. For a number of tumor types, clinical studies have suggested that patient outcome can be improved if radiotherapy sessions are preceded by immediate CTs.[1,2] This is what led the protagonists of OncoRay in Dresden, Germany, to begin this procedure at the state-of-the-art Proton Therapy Center planned at the University Hospital Dresden. Due to the experimental nature of proton therapy – which was first used in clinical practice at the beginning of the 1980s in Europe and the United States, and which is still not part of routine cancer treatment –

"Dual Energy CT imaging provides us with additional information about the tissue we want to treat. This is a major advancement to predict the range of the protons during therapy much better."

Christian Richter, PhD,
Research Group Leader OncoRay, Dresden, Germany

there are only a few studies dedicated to the impact of using an in-room CT. However, "we were convinced of the clinical advantages and believe in-room CT imaging is of immanent importance for optimal proton therapy," says Christian Richter, PhD, Research Group Leader at the center.

The doctors and physicists in Dresden are now at the very forefront of practice that is supporting the evidence. Even though the clinical benefits are yet to be proven by studies, the experts operating their in-room CT are very satisfied: "After eight months of experience, we have no doubt that the in-room CT is more than worth it," says Professor Mechthild Krause, MD, Radiation Oncologist at the University Hospital and Group Leader of OncoRay.

OncoRay in Dresden, Germany, is one of the first radiotherapy research institutes worldwide to use an in-room computer tomograph on rails for its proton therapy unit.

Personalized, adaptive treatment strategies

So what are the benefits of in-room CTs for the patient? What made the Dresden OncoRay team so determined? The first advantage is the verification of the exact position of the target volume immediately before treatment – which is even more crucial in proton therapy than in conventional radiotherapy. "Sometimes target volumes move between radiation sessions, like the prostate for example," explains Krause. "Proton therapy permits only a narrow deviation from the radiation plan, and the in-room CT enables us to control whether we are within this frame of tolerance." While the prostate is capable of moving, other organs may shrink during therapy, or certain changes in the anatomy occur. "The paranasal sinuses, for example, are usually filled with air, but due to inflammation they can temporarily fill up with fluid; applying radiation to this modified target means that the dose distribution will change," says Mechthild Krause.

This aspect of the treatment – determining whether changes, however slight, may have occurred within the patient – has been of high clinical importance for the OncoRay team right from the start. "It's essential to provide our patients with safe particle therapy treatments, because that way we know for certain that the proton beams are applied to the right volume," says Professor Krause. If the changes within the patient are found to be beyond a clearly defined security range, treatment will be interrupted in order to modify the treatment plan.

So far this interruption has meant a loss of time and additional treatment steps. In the future, however, the in-room diagnostic CT with its treatment planning quality will allow for personalized, adaptive treatment strategies, based on CT images that were acquired right before the treatment. Physicians can react to anatomical changes while the patient is in the bunker. "This option still belongs to the future and we're working on its feasibility," says physicist Christian Richter, "but current research suggests that we're swiftly heading towards real-time adaptation of radiation planning in the bunker."

The layout in the bunker in Dresden supports this claim: Since the operational start of the Proton Therapy Center in December 2014, a Siemens SOMATOM Definition AS Open with a sliding gantry – an 80 cm bore CT – has been part of the impressive facility. The Dresden team opted for Siemens mainly because of the compelling dual energy feature of its machines.

The sliding gantry of the SOMATOM Definition AS Open with its large bore means that the patient can remain in the same treatment position for the CT scan as well as for the actual particle therapy. After scanning the patient by sliding the gantry over him or her, the table simply has to be maneuvered approximately 90 degrees into the precise position for radiation.

More tissue contrast with dual energy

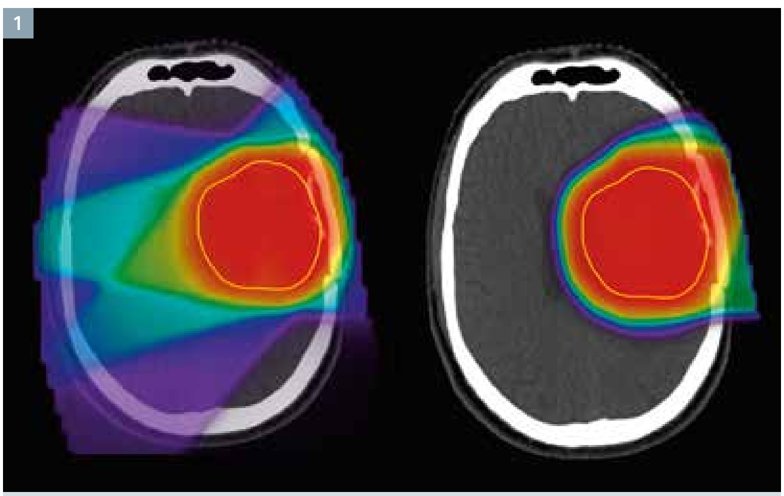
One particularly exciting feature for the OncoRay team is the dual energy option offered by

"After eight months of experience, we have no doubt that the in-room CT is more than worth it."

Mechthild Krause, MD,
Radiation Oncologist at the University Hospital and Group Leader of OncoRay, Dresden, Germany

SOMATOM Definition AS Open. "This is a major advancement for proton therapy treatment," says Richter. "Dual energy provides us with additional information about the tissue we want to treat, which is crucial for radiation planning. If we have precise knowledge of the composition of the tissue in the beam path, we can predict the range of the protons during therapy much better." This helps to optimize the radiation plan by reducing the safety margins: The protons unfold their impact exactly where the physicians want them to, while healthy tissue remains unaffected. Contouring the target volume and contrasting it from risky organs appears to be more effective with dual energy. "We clearly see these advantages in the imaging process," says Christian Richter, "and we are now carrying out a contouring study to find out if this also has a clinical effect, and whether it can be quantified."

Moreover, not only is dual energy able to improve tissue contrast, but it also reduces artifacts. "For example, if we have a patient who has metal parts in his body, let's say an artificial hip joint or even dentures, this can cause terrible artifacts in conventional CT imaging," says Christian Richter. "With dual energy, we can diminish those artifacts considerably, which is a key benefit enabled by physics." Now the team in Dresden wants to find out how many of these imaging advantages are actually transmitted to the patient; Richter estimates that they will have enough data in a few months to provide more evidence.



1 Comparison between a photon (left) and proton (right) treatment plan for the same target volume. The protons unfold their impact exactly where the physicians want them to, while healthy tissue remains unaffected.
Courtesy of OncoRay, Dresden, Germany

Every patient is part of a study

In the first eight months since going operational, the OncoRay team has treated about 70 adults and children with proton therapy. They expect to treat between 100 and 110 patients before the end of 2015. Every patient has to agree to be part of an observational study if he or she wants to undergo the procedure, and a further prerequisite is that the tumor is at a curable stage. Professor Krause and her team are recruiting patients from their own department at the Clinic for Radiation Therapy and Radiation Oncology at Dresden University Hospital. "Many cancer patients call the OncoRay's public telephone number of their own accord because they have high hopes regarding the new procedure. However, only some of them are candidates for proton therapy. Proton radiotherapy can be helpful in patients where the tumor is still growing locally and can therefore be treated by using localized radiotherapy. Here, proton radiotherapy may help to better protect sensitive normal tissues that is situated closed to the tumor," says Mechthild Krause. Patients whose tumor has spread in their body need medical treatment as a priority, for example.

So far, the proton therapy team in Dresden has been focusing on tumors located in the brain, at the base of the skull, in the posterior abdomen, and in the pelvis. “We are gradually adding more organs to our protocols, such as the lungs,” Krause explains. The facility allows for a maximum capacity of 400 to 500 patients per year, but the team is taking it slowly at these early stages, gaining experience with the powerful machines as well as carefully examining the effects of the treatment.

An important part of the learning curve is gathering evidence on how the in-room CT-on-rails and its dual energy capability can help provide better treatments – and ultimately improved outcomes – for the patients. ■

Irène Dietschi, is an award-winning science and medical journalist based in Switzerland. She works for the public media such as *Neue Zürcher Zeitung NZZ* and for private institutions. She has published several books, the latest about the 600-year history of the Swiss hospital in Biel.

Further Information

www.siemens.com/imaging-for-RT

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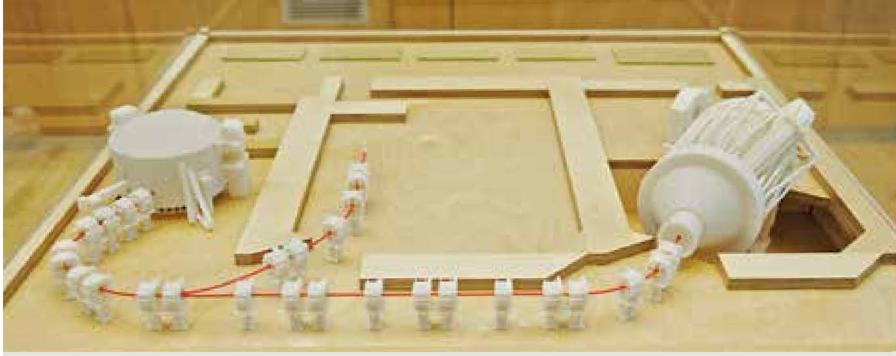
CT must be switched off during treatment.



OncoRay operates the first proton therapy facility in eastern Germany. Construction took only three years from start to completion in 2014.

A pioneer in Germany

Dresden’s cancer research institution OncoRay was founded in 2005 and is a pioneer in the field of proton therapy and other research areas. OncoRay works in close collaboration with the Heidelberg Institute for Radiation Oncology (HIRO), another groundbreaking German institution for radiotherapy research. The two research clusters, OncoRay in Dresden and HIRO in Heidelberg, form a joint research center called the National Center for Radiation Research in Oncology (Germany). OncoRay is mainly funded by the German Helmholtz Association and by institutional grants from the German Federal Ministry of Education and Research. The several million euro investment in the proton facility and the OncoRay research building was achieved as part of the Excellence Initiative of the State of Saxony, the University Hospital Dresden, and the Helmholtz-Zentrum Dresden-Rossendorf.

OncoRay operates the first proton therapy facility in eastern Germany. Construction took only three years from start to completion in summer 2014. Half a year later, in mid-December 2014, the first cancer patients began their radiation cycles in the proton therapy unit. Christian Richter recalls: “It was a huge effort to organize everything so we could go operational, technically as well as administratively, but compared to other proton therapy facilities around the globe everything went very fast and smoothly.”

One fifth of patients will benefit from proton therapy

25 years after proton therapy was first introduced in a clinical environment at the Loma Linda University Medical Center (USA), this treatment method is still regarded as experimental. “There are only a few tumors where we know, based on evidence, that proton therapy is more effective than conventional photon therapy,” says Professor Mechthild Krause, Radiation Oncologist and Vice Chair of the clinical department and Section Head for Translational Radiooncology of OncoRay. However, there are certain tumor types where only protons are capable of applying the dose necessary to kill the malignant cells. “This is the case for certain tumors at the base of the skull or for eye tumors,” she says. For these types of cancer, proton therapy is increasingly regarded as the clinical standard. The same is true for brain tumors in children. Mechthild Krause asserts that “proton therapy is less likely to damage the developing brain than conventional radiotherapy; thus, children suffer fewer side effects and have better chances of recovering from treatment.” For the majority of tumors, however, there are no clinical studies yet which would prove the superiority of one method over the other. Like other experts, Professor Krause believes that around one fifth of all radiation patients will ultimately benefit from proton therapy over conventional radiotherapy.

For Professor Qu and his team, the quality of their CT equipment is crucial to the precision with which SBRT treatment can be administered.

Precise CT Imaging for Advanced Radiation Therapy

Stereotactic body radiation therapy (SBRT) can benefit both cancer patients and hospitals, says Professor Qu Baolin, Director of Radiation Oncology at one of China's leading institution, the 301 People's Liberation Army Hospital in Beijing. During an interview, Professor Qu explains why accuracy is of the essence. He emphasizes that precise imaging is key to safe SBRT and explains what this means for his hospital – and his patients.

Text: **Justus Krüger,** Photos: **Tang Ting**

A hospital's place in national rankings can depend on many criteria. In China, the 301 People's Liberation Army Hospital is believed to be one of the best hospitals in the country. Situated in the Haidian district in the west of the city, the hospital, is the preferred address for the upper echelons of the Chinese leadership – and also fulfills its public function. One characteristic of the institution that reflects its role as a place of treatment for high-ranking officials is the large number of older patients. Naturally, a patient's age is a factor in the kind of cancer treatment to which he or she can be exposed, so the 301 PLA Hospital has some special requirements in this respect.

Therapeutic flexibility

Stereotactic body radiation therapy (SBTR) is a case in point. "In many cases, you might want to insert a gold marker into the body in order to track the tumor," says Professor

"With a state-of-the-art CT scanner, we have the necessary precision and can manage the respiratory motion. If we couldn't handle the motion, we wouldn't dare to administer a high treatment dose."

Professor Qu Baolin, MD, Director of Radiation Oncology, 301 People's Liberation Army Hospital, Bejing, China

Qu, Director of the Radiation Oncology Department at the 301 Hospital. "With older patients, however, this form of intervention, whereby a fiducial marker is implanted, is often not advisable" – because of its invasive nature. In this case, the imaging quality achieved by the CT scanner becomes even more important for planning the therapy than it would otherwise be. "In these cases," Qu adds, "speed and excellent imaging quality are especially important."

The 301 Hospital – together with its neighbor, the 302 People's Liberation Army Hospital – is one of China's leading centers for cancer treatment.

Qu and his colleagues provide a range of SBRT treatment options: When appropriate, they implant fiducial markers under CT guidance and treat using tracking – and when not, they utilize high-performance CT capabilities in order to maximize the accuracy of tumor contouring. Whatever the treatment approach, the quality of the CT equipment is crucial to the precision with which the SBRT treatment can be administered. And to provide this flexibility in treatments, the hospitals have decided to extend their set of modern SOMATOM Definition AS 40 and 64 slices.

Moving targets

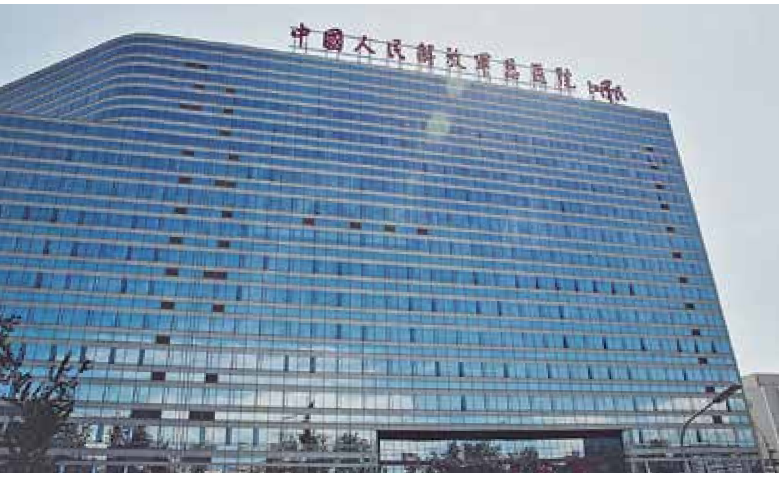
Precision is especially pertinent when planning SBRT treatment of the most common cancers in China, where the tumor is moving. Sadly, the habit of smoking tobacco is still very widespread, and therefore lung cancer is still the most frequently encountered form of the disease in the 301 and 302 Hospitals. Liver malignancies are another form of cancer that the two hospitals frequently encounter. It is unusually prevalent in Asian countries, and the liver, just as the lung does, moves with respiration. As the scan speed is crucial for all "moving targets," the quality of the CT scanners is central to the accuracy of planning and subsequently to delivering the best possible treatment.

Speed and precision

"In the past, we used CT scanners with 16 slices," says Professor Qu's colleague Xu Shouping, Chief Physician of the Radiation Oncology Department. "But this brings with it a number of limitations when planning SBRT treatment," he explains. "Sixteen slices means that the scanning process is relatively slow."

The implication is that when planning treatment for lung cancer patients, for example, a scan of the complete region of interest is not possible with one deep breath-hold. "But with a modern, faster CT, we can ask the patient to hold

Wth a high number of slices, a CT scan can be conducted in one deep breath-hold which means great precision when determining tumor volume.



Speed and accuracy of the imaging equipment are central to the planning of any form of SBRT, and the 301 Hospital employs a variety of treatment delivery systems to provide such therapies.

his or her breath and finish the scan in one inspiration," says Xu. This is, of course, crucial for the treatment. "Immobility during the scan means greater precision when determining the tumor volume. This in turn means better treatment and, therefore, better outcomes for the patients."

The number of slices of a CT scanner when planning SBRT is also important for another reason. Since stereotactic treatments are suitable for smaller tumors, the thickness of the slices is essential. "With a 16-slice scanner, the slices are rather thick," says Xu. "So if you have a small tumor, it may be sitting right in the part that you don't see very well. This is especially problematic when you do the contour. It simply isn't very accurate. When you scan with a higher number of slices, though, you can really see the details."

CT performance for SBRT

Speed and accuracy of the imaging equipment are central to the planning of any SBRT, and the 301 Hospital employs a variety of treatment delivery systems to provide such therapies.

"We used to think of SBRT primarily as a form of treatment connected with specific equipment," says Professor Qu. "For instance, in the past we used the Gammaknife, or nowadays the Cyberknife, and our belief would be that this is the proper specialized equipment to deliver SBRT." But the hospital now has a whole range of linear accelerators, and utilizes several of them for SBRT: "This is because we no longer think of SBRT as equipment-specific, but rather as a technique that can be delivered from different platforms. So how should we classify it? If the dose you administer each time is sufficiently high – no matter from which device – this can be classified as SBRT."

According to Qu, seeing it this way sets the bar for the performance of the CT scanner even higher. "For

Precision is especially pertinent when planning SBRT treatment of the most common cancers in China, such as lung or liver, where the tumor is moving.

example, when we treat lung cancer with the Cyberknife, we deliver ten beams, five times. Now, how do we even dare to administer this dose? Well, the Cyberknife uses gold markers as a tracking system. But we also use equipment that doesn't utilize fiducial markers, yet we deliver the same dose," he adds. "How can we do this? With a state-of-the-art CT scanner, we have the necessary precision and can manage the respiratory motion. If we couldn't handle the motion, we wouldn't dare to administer a high treatment dose."

Beneficial for all

One significant implication of the therapeutic flexibility is that the hospital has been able to increase the degree to which it can utilize SBRT. This offers a range of benefits for the patients, for the hospital, and for society at large.

"We have patients coming to us from all over the country," says Professor Qu. "Many of them really prefer non-invasive treatment. This rules out the insertion of fiducial markers." In such cases, the hospital can apply other forms of SBRT.

More importantly perhaps, the duration of the treatment is much shorter with SBRT, which delivers high dose in fewer fractions than conventional external beam delivery. "Treatment takes about a week – compared to the six to seven weeks we had before," says Qu. This greatly reduces costs for the patients, because patients from out of town do not have to stay in Beijing for very long. By Chinese standards, Beijing is a very expensive city, and reducing these auxiliary costs for the patients really makes a difference that matters to Professor Qu.

By the same token, SBRT treatments increase patient throughput. "As a doctor, the patient's benefit is my main concern. But there's no doubt that the increased speed is also economically advantageous for the hospital," says Qu. "Above all, we have shorter waiting lists, and can treat more people." This means that in cases like these, benefits for the patients and the hospital's economic sustainability are not at odds – they go hand-in-hand. "The patients profit from this, the hospital does, and so does society at large," says Professor Qu. "It's good for everyone." ■

Justus Krüger has worked as a China correspondent in Hong Kong and Beijing for ten years, contributing to *CNN*, *Neue Zürcher Zeitung*, *Berliner Zeitung* and *Deutschlandradio*, among others.

Further Information

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Patients come to the 301 People's Liberation Army Hospital in Beijing from all over the country.

Tackling the Challenge of Metal Artifacts

Today's image-guided radiation therapy can be applied with great precision. One growing challenge is the increasing amount of metal in patients' bodies, which leads to artifacts in CT images and obscures vital information. Laura Ann Rechner, Medical Physicist at the Rigshospitalet Department of Oncology, Section of Radiotherapy in Copenhagen, Denmark, is exploring how to solve this challenge using the iMAR algorithm.

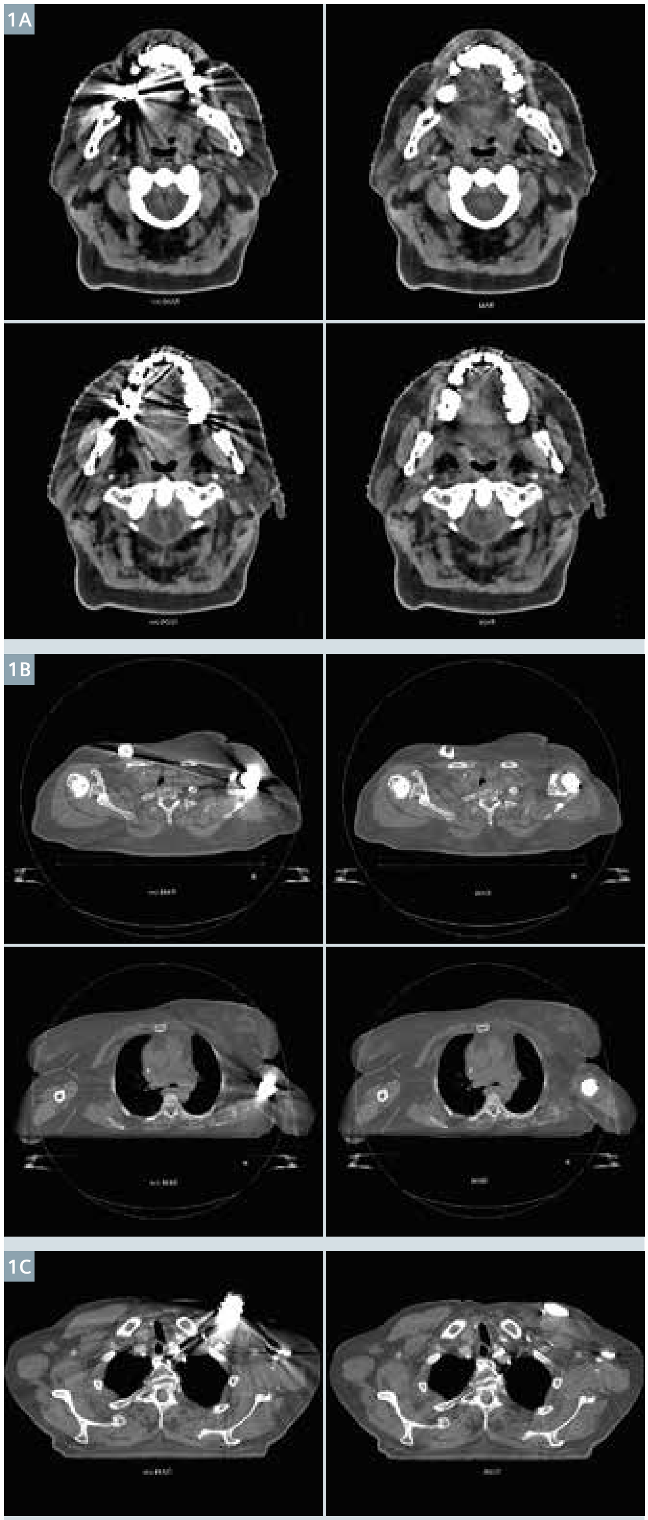
Text: **Wiebke Kathmann, PhD,** Photos: **Morten Koldby**

Laura Ann Rechner, Medical Physicist at the Rigshospitalet Department of Oncology, Section of Radiotherapy, explored the potential of the iterative metal artifact reduction (iMAR) algorithm in comparative studies with patient cases and phantoms.

Setting up a treatment plan for cancer patients with metal implants has so far required physicians to manually correct metal artifacts in the area of interest. Information about the tumor extension can be lost, and surrounding soft tissue needing protection from the radiation may remain undetected. In order to avoid the consequences of corrupted pictures, images must be manually corrected and contouring structures partially created using guesswork – this is a time-consuming and laborious task, and may result in inter-observer variability. In turn, this could jeopardize the levels of precision that today's radiation therapy can achieve.

This challenge is becoming more of an issue as metal implants are on the rise in most countries. Almost all head and neck patients have metal in the form of dental fillings, which obscure parts of the CT images. In pelvis and spine tumor cases, the situation is similar since spinal and hip implants are becoming increasingly common.

"So far, we override such a region by calculating it as water or air as our best guess, knowing that this is not correct," explains Rechner. "The precise contouring can be very time-consuming and difficult in these cases." Up to now, there was no better way to deal with the effects of metal implants. None of the techniques currently proposed for metal artifact reduction are in widespread clinical use, as some add artifacts or remove valuable information. This is why Laura Ann Rechner began exploring the potential of the iMAR (iterative metal artifact reduction) algorithm last fall. She was able to address these critical issues in comparative studies with patient cases and phantoms.



1 In patients with metal implants, such as dental fillings (Fig. 1A), shoulder and hip implants (Fig. 1B), and pacemakers (Fig. 1C), using the metal artifact reduction algorithm iMAR (right column) can make it easier to reconstruct images accurately.

Rechner tested the accuracy of iMAR in patient and phantom studies. One case that she found particularly convincing was that of a patient with cervical cancer who was treated with interstitial (MUPIT-type) pulsed dose rate (PDR) brachytherapy. "In this case, we lost a little information in the center due to the numerous metal implants, which resulted in somewhat blurred CT HUs (Hounsfield units) in the middle. But we decided that it was more useful to see the needles clearly," Rechner explained. "This case convinced us to use iMAR as standard on all of our scanners in order to better serve our patients with metal implants."

In her phantom study based on a tongue tumor, Rechner first performed contouring in the usual way. She then added the implant to the phantom and took the image with and without iMAR. Applying the algorithm, she was able to reduce the metal artifacts for a better image. The same was true for a pelvic phantom of a hip implant.

Reduction of streak artifacts

Another case with impressive results using iMAR involved a patient with a bladder tumor and two metal hip implants. For most patients with hip implants, the artifact would be an irritation that one would have to draw over in contouring, but in this case the target was very much affected by the artifact. On the regular image, there was no information on the key region of interest, making it difficult to decide where to treat. The algorithm helped to reduce the artifacts, according to Rechner.

She tested multiple iMAR algorithm reconstruction kernels, each relating to a different metal density, size, and degree of artifact, and making sure that the HU were all correct. After comparing the different delineations and dose calculations with the usual procedure when drawing in water, the dose was roughly equivalent.

According to Rechner, those patients scheduled for stereotactic radiation in particular may benefit. In these cases, small lesions need to be treated with a high degree of accuracy and with high doses, and therefore require images with reduced metal artifacts.

Great flexibility

Overall, iMAR reduces metal artifacts by combining three successful approaches: beam hardening correction in sinogram regions that have less severe metal attenuation; normalized sinogram inpainting in sinogram regions that have high metal attenuation; and frequency split to mix back noise texture and sharp details that are potentially lost during inpainting. The correction process is iteratively refined by repeating the normalized sinogram inpainting and the mixing steps up to six times. In turn, this leads to fewer artifacts, as an evaluation of artifact quantification using gold markers revealed. The risk of new artifacts is reduced thanks to Adaptive Sinogram Mixing, which flexibly combines normalized interpolation and a soft reduction metal artifact algorithm depending on the severity of the artifacts.

Radiologist Anne Kill Berthelsen, MD, works in the radiation therapy department and believes that iMAR has great potential. "We are pretty convinced that it will reduce metal artifacts – mainly from dental fillings or from hip implants – in gynecological tumors. This will be a big improvement, as we don't know in advance which metal implants will lead to metal artifacts for which patients. We mostly hope to use it for head and neck patients where there are big holes in the scan. The radiation oncologists demand images with less and less metal artifacts as they want to make their radiation therapy more and more precise."

"We are pretty convinced that iMAR will reduce metal artifacts. So radiation therapy can be provided more and more precisely."

Anne Kiil Berthelsen, MD,
Chief Radiologist at Rigshospitalet, University of Copenhagen

"iMAR saves us time, by reducing metal artifacts."

Laura Ann Rechner, Medical Physicist at the Rigshospitalet Department of Oncology, Section of Radiotherapy in Copenhagen, Denmark

Reconstruction with iMAR is fast. It takes one to two minutes with a choice of eight different reconstruction modes (neuro coils, dental fillings, spine implants, shoulder implants, pacemaker, thoracic coils, hip implants, extremity implants). Rechner recommends trying multiple types of reconstruction modes and devising the best strategy for each new type of metal implant.

Easy to use on all tailored scanners

At the Rigshospitalet of the University of Copenhagen – an institution with over 10,000 employees, more than 1,600 beds, and around 100,000 inpatients and 650,000 outpatients – about 70 doctors, 16 physicists, and 25 radiographers work at the Department of Oncology. Altogether, 500 employees take care of approximately 4,000 patients per year. Until now, iMAR has been running on a SOMATOM Definition AS Open – RT Pro edition. Soon it will be running on all scanners as standard.

Based on her experience so far, Rechner sees the application for iMAR mostly in head and neck patients, as well as for pelvic patients.

Rechner underscores the two main advantages of iMAR: Firstly, "iMAR saves us time, which we love." Secondly, according to the medical physicist, "iMAR helps the patient, as the main objective of our treatment planning is to optimize the balance between efficiently treating the tumor and sparing the surrounding tissue. The reduction of metal artifacts that is possible with iMAR helps us do our job."

She is curious about combining iMAR with 4D CT in patients with thoracic tumors and dental fillings. The team already tried combining Dual Energy CT and iMAR. When using 130 kV Dual Energy CT and iMAR, they were quite happy with the metal artifact reduction from iMAR alone. Since soft tissue contrast is presumed to be better at 70 kV, they now hope to achieve better metal artifact reduction together with better soft tissue contrast and lower energy.

With regard to the workflow, it is too soon to tell. "In the beginning, incorporating iMAR added a little time to the process, as we compared the image and HU values to our standard of care. But in the long run, it will save us time. Besides, patient outcome might be better, as we can target what we want to treat and protect, what we want to spare." ■

Wiebke Kathmann, PhD, is a frequent contributor to medical publications. She holds a Master's in Biology and a PhD in Theoretical Medicine, and was employed as an editor for a number years before going freelance in 1999. She is based in Munich and Karlsruhe, Germany.

Further Information

www.siemens.com/imaging-for-RT

Case 1

Easy and Fast Target Volume Delineation for Pulmonary Stereotactic Body Radiation Therapy

By Julia Sudmann, MD

Department of Radiation Oncology, Radiologische Allianz Hamburg, Germany

History

A 68-year-old patient initially received lung cancer surgery. At follow-up, he was diagnosed with a contralateral pulmonary tumor using PET/CT, which corresponded to either a second primary tumor or a solitary contralateral pulmonary metastasis. Due to the low grade, stereotactic radiation treatment was chosen as a potentially curative treatment approach.

Comments

For dose planning purposes, three non-contrast thorax CTs were acquired (inhale, exhale, free-breathing). This enabled assessment of the maximum extent of tumor movement. Together with the FDG PET/CT, the three CT datasets available in the *syngo*.via database were concurrently loaded into *syngo*.via RT Image Suite and could be easily accessed there. All four datasets were registered semi-automatically and the PET/CT registration was adjusted according to the best anatomical match. In *syngo*.via RT Image Suite, the target volume was contoured concurrently in the three CT phases and the PET/CT using parallel contouring.

With parallel contouring, a contour belonging to one image series can be modified while superimposed over any other image series. In this way, it is possible to contour directly on any image series and mirror that volume to all other images. Contours can be drawn in any orientation (axial, sagittal, and coronal).

It was possible to load all required image series concurrently rather than sequentially as in other systems. This facilitated our workflow and allowed us to contour a composite perform in one step based on the free-breathing CT as well as on the inhale, exhale, and PET image series.

Using *syngo*.via RT Image Suite, the internal target volume (ITV) can be generated in one step without the need to repeatedly load and unload image series, and with the advantage of being able to compare different image series. In contrast to most commercially available contouring software, there is no need to fade the corresponding image in or out. In conclusion, *syngo*.via RT Image Suite enabled easy integration of all relevant clinical images and efficient contouring of the target volume of this lung SBRT patient. ■

Examination Protocol

Scanner	SOMATOM Definition AS Open 20 – RT Pro edition		
Scan length	350 mm	Rotation time	0.5 s
Scan direction	Cranio-caudal	Pitch	1.2
Scan time	8.35 s	Slice collimation	1.2 mm
Tube voltage	120 kV	Slice width	2 mm
Tube current	195 mAs	Reconstruction increment	2 mm
Dose modulation	CARE Dose4D	Reconstruction kernel	B 31f

1 *syngo*.via RT Image Suite enables smooth drag and drop loading of the images. The visualization capabilities support easy side-by-side display of CT acquired in different phases of the respiratory cycle as well as PET/CT images. Parallel contouring – delineation on one image series while contours are immediately visualized on others – supported the incorporation of all relevant imaging information easily in this SBRT lung cancer patient.

Case 2

Iterative Metal Artifact Reduction in Interstitial Brachytherapy Treatment Planning

By Laura Ann Rechner, MD; Jens Peter Bangsgaard, PhD; Henrik Roed, MD

Department of Oncology, Section of Radiotherapy, Rigshospitalet, Copenhagen, Denmark

History

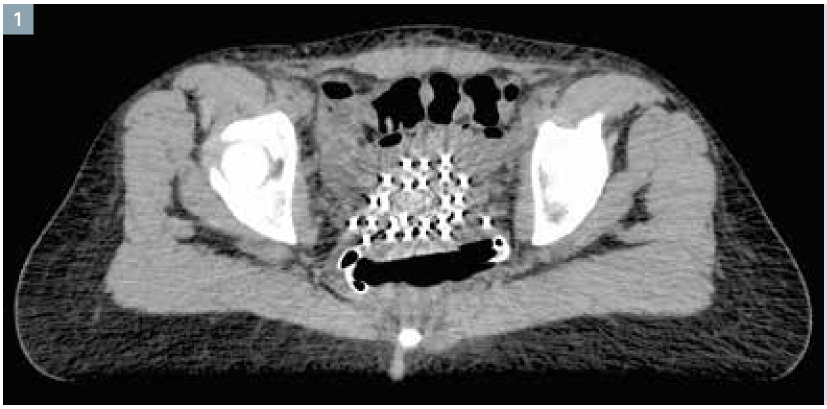
A 46-year-old woman was diagnosed with cancer of the vagina in 2015. A vaginal adenocarcinoma 2–3 cm in diameter that extended to the bladder was found on a clinical exam, and a PET scan revealed multiple positive lymph nodes. External beam radiation therapy was administered using volumetric-modulated arc therapy (RapidArc, Varian Medical Systems) to the pelvis of 50 Gy with an integrated boost to the PET positive lymph nodes of 64 Gy. Following external beam radiation therapy, an interstitial brachytherapy boost of 30 Gy to the gross tumor volume was applied. An MRI was performed with a vaginal obturator in place prior to needle insertion. After needle insertion, a CT scan was performed and fused with the MRI. Both the MRI and the CT were used during brachytherapy treatment planning.

Comments

The CT scan used for interstitial brachytherapy treatment planning was reconstructed using the iMAR (iterative metal artifact reduction) algorithm, which reduced the artifacts around the stainless steel needles. An important and time-consuming part of interstitial brachytherapy treatment planning is the definition of all the needles that can be used through which to send a radioactive source to irradiate the tumor from the inside. The reduction in artifacts made defining the needles in the treatment planning system faster, especially where needles crossed or were close together. One type of iMAR reconstruction (for spine implants) reduced many of the artifacts and retained the soft tissue contrast in the region. A stronger type of iMAR (with neuro coils) reduced more artifacts but also removed some of the soft tissue contrast near the needles. We elected to use the neuro coil iMAR reconstruction for this type of treatment due to the clear definition of the needles and because the soft tissue information was obtained through the fused MRI scan. In conclusion, iMAR reconstruction improved the speed and confidence of needle definition for interstitial brachytherapy treatment planning. ■

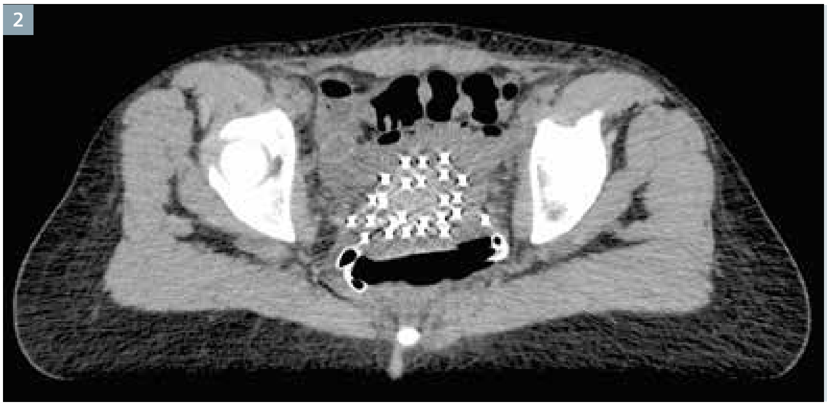
Examination Protocol

Scanner	SOMATOM Definition AS Open – RT Pro edition
Scan area	Pelvis
Scan length	19.2 mm
Scan direction	Cranio-caudal
Scan time	12 S
Tube voltage	100 kV
Tube current	335 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	12.74 mGy
DLP	453.83 mGy cm
Effective dose	9.1 mSv
Rotation time	0.5 S
Pitch	0.8
Slice collimation	1.2 mm
Slice width	2 mm
Reconstruction increment	2 mm
Reconstruction kernel	B31f



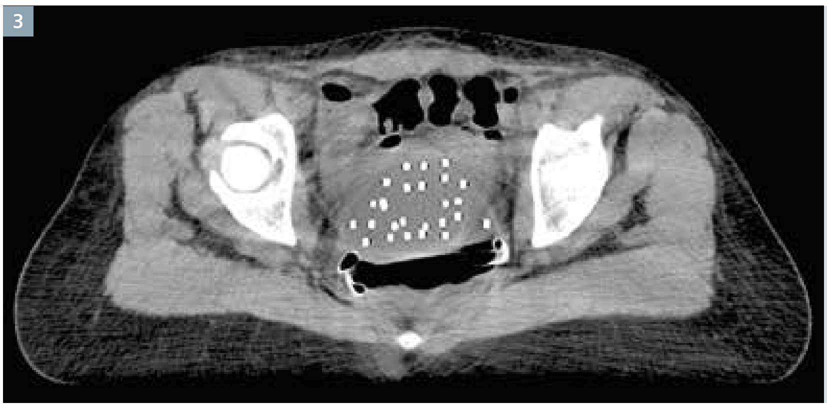
1

Interstitial brachytherapy treatment with no iMAR reconstruction.



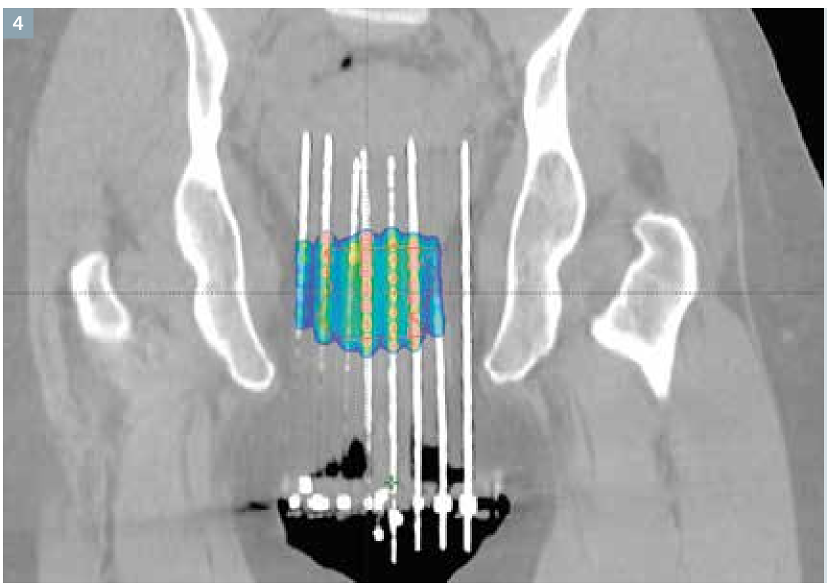
2

Interstitial brachytherapy treatment with spine implant iMAR reconstruction.



3

Interstitial brachytherapy treatment with neuro coil iMAR reconstruction.



4

Coronal slice showing the dose distribution of the interstitial brachytherapy treatment displayed on a CT image reconstructed using iMAR.

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