TOSHIBA
Leading Innovation

VISIONS

Magazine for Medical & Health Professionals | July 2015

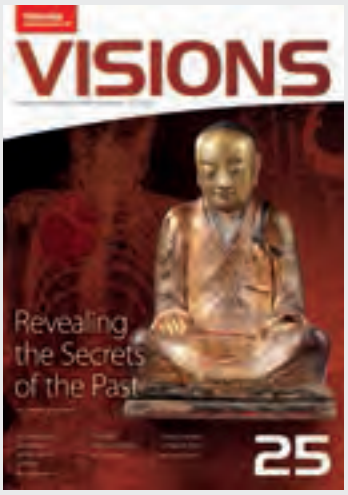
Revealing the Secrets of the Past

Providing Next Generation Healthcare in Georgia

The Aplio Platinum Edition

"Baby Andrew"; A Patient Story

25



25

A unique Chinese 'Buddha mummy' was scanned on Toshiba's Aquilion ONE™ / ViSION Edition CT system to gather new information and progress scientific research on the artefact. The scan enabled details that had previously escaped discovery to be revealed. Read more on page 14.

Imprint
VISIONS magazine is a publication of Toshiba Medical Systems Europe (Toshiba), and is offered free of charge to medical and health professionals. The magazine is published twice a year but is also available as an online portal. News items and articles are announced, pre-publication, via social media in dedicated groups. Toshiba stores data of readers and users, as far as known, of the online VISIONS portal. This data is used to send out the magazine and inform about new developments in the clinical market. Users can customize their preferences or opt-out in the online VISIONS profile at www.toshiba-medical.eu/visions.

Publisher
TOSHIBA Medical Systems Europe B.V.
Zilverstraat 1
NL-2718 RP Zoetermeer
Tel.: +31 79 368 92 22
Fax: +31 79 368 94 44
Web: www.toshiba-medical.eu
Email: info@tmse.nl

Editor-in-chief
Jack Hoogendoorn (jack.hoogendoorn@toshiba-medical.eu)

Modality coordinators
CT: Roy Irwan
UL: Joerg Schlegel
XR: Jaco Terlouw

Design & Layout
Boerma Reclame (www.boermareclame.com)

Printing
Quadraat Printmedia (www.quadraat.nl)

Text contributions
"Revealing the Secrets of the Past"
by The Creative Practice (www.thecreativepractice.com)

"Continuity, consistency and a lot more clinical power: The Aplio Platinum Edtion"
and "Virtual anatomy teaches real-world skills" by European Hospital Verlags (www.healthcare-in-europe.com)

Subscription Service
www.toshiba-medical.eu/visions

VISIONS magazine is covering Toshiba's European region and as such reflects products, technologies and services for this particular area. The mentioned products may not be available in other geographic regions. Please consult your Toshiba representative sales office in case of any questions.

ISSN 1617-2876

Follow us

Dear reader,

Earlier this year, I celebrated my 12.5 year work anniversary. In the Netherlands, this is considered to be an important milestone and a sign of loyalty, passion and commitment. In Japan they call this *Aisha Seishin* – love of company. Frankly speaking, it was not too difficult to achieve, because Toshiba is simply a great company to work for, where building and maintaining a strong sense of belonging, gaining group consensus and ensuring harmonious (work) relationships are part of the daily work ethics. This ensures that loyalty, passion and commitment are mutually beneficial and creates a feeling of pride in being part of the big, worldwide, Toshiba Family.

My personal anniversary, however, is nothing compared to the impressive milestone that Toshiba Medical Systems now celebrates - its 100th anniversary in the healthcare business[1]. Toshiba was already involved with research for manufacturing earlier, but in 1915, Japan's first domestically-produced X-ray tube was introduced and was the inspiration for many medical imaging innovations to come; such as Japan's first X-ray device in 1932, the first linear array ultrasound scanner in 1976, the world's first commercial MRI system in 1983, and world's first continuous rotating CT scanner in 1985.

Now, one hundred years later, Toshiba has become a world leader and great innovator in the healthcare industry. With a global network of local corporations and representatives in more than 135 countries, the company provides state-of-the-art products, systems and solutions that significantly improve patient safety and patient care and provides customers lasting quality with a lifetime of value. In addition, Toshiba offers the best service experience possible, by offering the most personal attention and contact in the industry. Because of this, many hospitals and clinics have chosen Toshiba as their main partner to jointly pursue the mutual goal of improving the healthcare delivery, set new goals and reach new milestones.

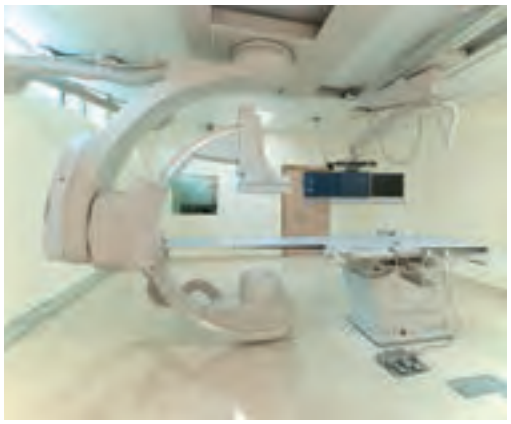
Milestones are not an end in themselves, but are a unique opportunity to reflect on. Obviously, it is of great importance to continue our journey, and I hope, alongside Toshiba, to experience many other interesting milestones that improve the quality of life for all patients worldwide. *Kanpai!*

Kind regards,

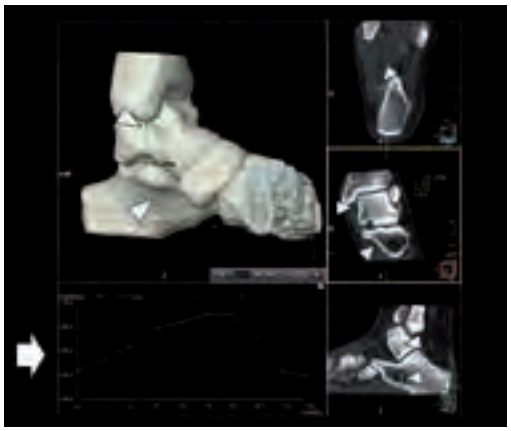
Jack Hoogendoorn
Sr. Manager Marketing Communications
Toshiba Medical Systems Europe BV

[1] Have a look at the 100th anniversary video at http://tinyurl.com/m7uyoqw

23 Reliable methods to diagnose possible complications in primary stroke prevention.



36 Lancet Medical Center works with a full range of Toshiba's medical diagnostic imaging equipment.

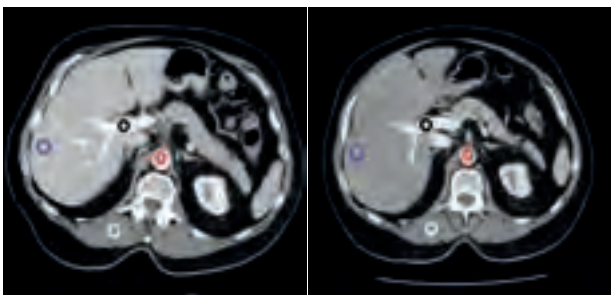


38 Wide area-detector CT is suited to dynamic study of joints, allowing volumetric study of bone and intra-articular ligaments during physiologic motion or under stress maneuvers.

CONTENT

41 The Aplio architecture enabled so many significant changes that it arrives with a new name, the Aplio Platinum Edition

54 The University of Heidelberg brought a CT scanner directly into the anatomy lab.



58 Manually selecting the kV setting is time consuming; therefore Toshiba has developed SUREkV to improve workflow.

NEWS

Long lasting quality

After 22 years of hard work and loyal services the Toshiba SSH-140A Ultrasound system of Dr Stefan Hanggi finally stopped working due to a severe defect.

Bridging time by a demo unit, a brand-new Aplio 300 could already be delivered to a him within three weeks by Mr Fritz Aeppli leaving behind a very satisfied customer for many years to come.

Dr Stefan Hanggi (left) and Mr Fritz Aeppli, Account Manager Toshiba Medical Systems Switzerland (right)

Toshiba held an event in Mitsukoshi, the department store in Japan, to encourage customers to enjoy the leading innovation technology. The video is a report of the event, featuring a communication android, a vegetable tasting booth of the plant factory, a digital signage that brings back the scenery of the Japanese Edo period (AD 1600-1868) and some other exhibitions.

Watch the video at: **http://tinyurl.com/plsfebc** (English subs)

Toshiba sponsors Water Polo League

Toshiba was National Sponsor of the Final Six Water polo Champions League held (Barcelona, Spain) showing its support to Sports in general, Water polo in particular, participants in the 'Final Six' and - last but not least, the Olympic City of Barcelona. Participants were: Szolnoki VSK (Hungary), ZF Eger (Hungary), VK Jug Dubrovnik (Croatia), VK Primorje Erste Bank (Croatia), Pro Recco Nuoto e Pallanuoto (Italy) and Club Natació Atlètic-Barceloneta (Spain).

Pro Recco achieved their eighth Champions title in history by beating Primorje in an exciting final that honored the equality that had been seen throughout the competition. Igor Milanovic´s men prevailed by 7-8 in a tight, tension-filled final and brought the Final Six to a close in Barcelona.

Toshiba also became official sponsor of Club Natació Atlètic-Barceloneta, the organizer of the tournament, by providing a portable Ultrasound Diagnostic System.

Kawasaki Tsurumi Rinko Bus Co., Ltd. recently has begun to take Toshiba's first commercial electric bus in use on its Kawasaki Municipal Hospital route (Japan). Toshiba's SCiB™ lithium-ion rechargeable battery cells, which excel in quick charging and long life, will help the electric bus reduce to CO_2 emissions by approximately 40%[1], compared to diesel buses.

[1] Result of tests conducted by Toshiba

IBA and Toshiba Sign Strategic Partnership in Particle Therapy

IBA (Ion Beam Applications S.A.) and Toshiba Corporation signed a global collaboration to expand access to advanced particle therapy worldwide. Toshiba Medical Systems Corporation will become the distributor in Japan for Proteus®ONE, IBA's compact single-room proton therapy solution, and IBA will become the agent for Toshiba's Carbon Therapy Solutions outside Japan.

IBA and Toshiba will collaborate on activities such as customer education for Proteus®ONE and Toshiba's carbon therapy solutions.

Follow us
for the latest news:

https://www.youtube.com/user/ToshibaMedicalEurope

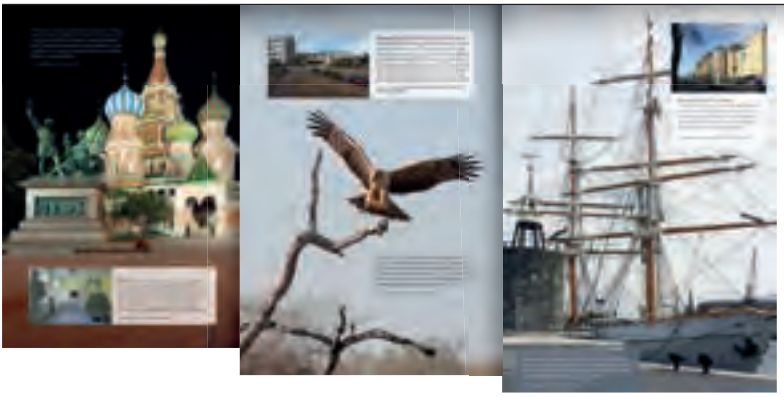
https://plus.google.com/116571489645577418994

https://twitter.com/toshiba_med

https://www.facebook.com/ToshibaMedicalSystemsEurope

http://www.linkedin.com/company/toshiba-medical-systems-europe

http://www.slideshare.net/toshibamedical



Next page is part of the VISIONS Photo Page Series reflecting an eye for the beauty of our planet, the environment and the direct surroundings where Toshiba's systems are installed by Toshiba and its customers. Not the actual imaging products but photos of sceneries, cities, countries or other cultural aspects are highlighted on this photo page.
The Photo Page is based upon an idea of Prof. Edwin van Beek.
Every reader of VISIONS can participate and get their picture published. The submitted content should include: high resolution (300dpi) image, photo of the hospital and a brief text, name of photographer and Toshiba system(s) installed. The complete result is shown on the opposite page.

Send your pictures and texts to: jhoogendoorn@tmse.nl, Subject: Photo Page

Tobata Kyoritsu Hospital (Japan) *was founded in 1912 and, as a trusted hospital, serves the Japanese community for already over 100 years. Interacting with society and with a strong emphasizing on good teamwork it continuously transforms itself to meet the ever-changing expectations of patients. Starting out with 18 bed, it now holds 218 beds and has over 125 Toshiba products and systems in use ranging from Hospital Information Systems and Bio Chemistry Analysers to CT, MR, X-ray and Ultrasound imaging systems.*

Text source and photography: www.kyoaikai.com

Tokyo Skytree℠ is a free-standing broadcasting tower with a restaurant inside the observation deck located in Sumida, Tokyo, Japan. It became the tallest structure in Japan in 2010 and reached its full height of 634.0 metres in March 2011, making it the tallest tower in the world. The two illumination patterns Iki (chic, stylish) sky blue and Miyabi (elegance, refinement) purple are used, alternating daily.

Text Source: Wikipedia – Photography: Reiko Aoki

CELEBRATING 100 YEARS
IN THE HEALTHCARE BUSINESS

Starting with Japan's first domestically produced X-ray tube in 1915, Toshiba celebrates its 100th anniversary in the healthcare business. Here you will find an overview of our rich company history and related innovations that clearly demonstrates that curiosity and passion are part of our DNA.

1915 1930s 1940s 1950s 1960s 1970s 1980s

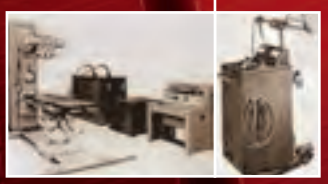
1914
Research on manufacturing X-ray tubes is started.

1915
GIBA, Japan's first domestically produced X-ray tube is introduced.

1932
The GIBA 75 X-ray device is introduced.

1946
KXO-8, the first post-war X-ray system is completed.

1955
Japan's first image intensifier is introduced to the market.



KXC-180-6 STX-20

1955
The development of an X-ray angiography system proceeds.

1966
Toshiba enters the ultrasound market.

1960
Japan's first X-ray TV devices are launched (image-scope 506 and 507).

1967
A high-energy therapeutic system is developed.

1969
Toshiba delivers the first gamma camera to National Kohnodai Hospital. It can visualize scintigrams instantaneously without the need for scanning the organs.

1976
The first linear array ultrasound scanner is introduced.

TCT-60A

1978
Japan's first whole-body CT scanner is released.

1978
The first cassette-less X-ray device is launched.

MRT-15A

1983
The world's first commercial MRI system is introduced.

TCT-900S

1985
Toshiba introduces the world's first continuously rotating CT scanner with slip-ring technology.

100th Anniversary in Healthcare

1990s 2000s 2010s 2015

Made for Life

1990
The triple-head digital gamma camera GCA-9300 A wins the Image of the Year award at the annual meeting of the U.S. Society of Nuclear Medicine.

1990
The world's first helical scan CT system is developed.

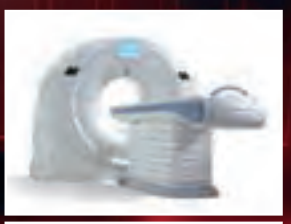
1999
Toshiba's noise reduction technology Pianissimo revolutionizes the MRI market.

Ultimax

2003
Toshiba's first digital X-ray system with flat panel detector Ultimax is launched.

2007
The world's first wide-area detector CT Aquilion ONE is launched.

2012
Iterative dose reduction becomes standard on all Toshiba CT scanners.

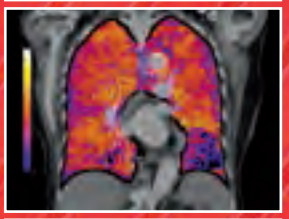


Safer imaging, clearer outcomes
Toshiba's revolutionary PUREVISION dtector makes CT imaging safer for all patients. Delivering up to 40% increased efficiency it enables superior imaging with significantly reduced radiation dose and iodine.

Making the unseen visible
Toshiba's innovative SMI ultrasound technology on the Aplio Platinum Series provides a safe and contrast-free way to examine the microvasculature, advancing diagnostic accuracy and patient outcome.

Innovating clinical pathways
Toshiba introduces Infinix 4D CT, a powerful hybrid imaging system combining the world's most flexible angio suite with the world's most advanced dynamic volume CT.

Comprehensive dose management
Toshiba's DoseRite technology is a comprehensive dose management solution. The dose Tracking System provides continuous real-time information on skin dose deliverd to the patient.



Adaptive diagnostics
To make complex exams easier, to minimize patient dose, and to improve diagnostic accuracy and reproducibility, Toshiba has introduced Adaptive Diagnostics technology to its CT systems.

Minimizing patient risk
To minimize the potential risks associated with gadolinium-based contrast agents Toshiba provides clinicians with unique, non-contrast MRA sequences that minimize risk to patients while producing exceptional images.

PRESIDENT'S MESSAGE

"We are committed to developing solutions to improve clinical work-flow, advance patient outcomes and patients' quality of life."

Throughout its 100-year history in the medical device business, Toshiba has responded to customers' needs by providing a wide range of high-value solutions. These efforts have made us the top company in our business segment in Japan, and have supported expansion of our global presence into over 135 countries around the globe.

Delivering many Japanese- and world's firsts, we have always been committed to developing solutions that help improve clinical workflow and advance patient outcomes and patients' quality of life. From corporate programs to the wide range of product features that protect patients and healthcare providers, we have made safety a top priority in everything we do.

During the second half of 2014, we introduced the following systems and technology to the market:

In X-Ray, as most of you know, we introduced the Infinix 4D CT at The Radiological Society of North America's Annual Meeting, RSNA2014. This powerful hybrid imaging system combines the world's most flexible angio suite with the world's most advanced dynamic volume CT. This outstanding image-guided solution for interventions also easily accommodates a wide range of interventional procedures from TACE (Transarterial Chemo Embolization) to Trauma, and from Neuro to Cardiac. Introducing new technology, we promoted the new XR Dose Right DTS (Dose Tracking System), a real time, peak skin dose visualization tool, which color-maps the exposure of the patient during endovascular treatment, and enables the interventionalist to better manage the dose delivered to the patients to help avoid serious, undesirable effects on the skin.

In Nuclear Medicine, we introduced the Large-Bore TOF PET-CT Celesteion.

The versatile system combines high performance PET and CT for all radiation and oncology imaging needs, including tumor-detection, treatment-evaluation and CT-simulation. It features the industry's largest bore, state-of-the-art PET- and CT technology and dose reduction.

In Computed Tomography, we introduced a new detector for the Aquilion ONETM ViSION Edition - PUREViSION. Toshiba's commitment to ALARA, while delivering 4D functional dynamic studies at conventional dose levels, was a key driver in the development of PUREViSION. Having achieved a further 40% increase in light output and a 28% decrease in electronic noise with this development, PUREViSION provides the latest generation in detector performance for clinical- and diagnostic excellence, while ensuring patient safety at all times.

In MRI, we introduced our new Saturn Gradient, software, and 16ch Flex SPEEDER coils for 3T systems to boost image quality, speed, and flexibility. This new combination has been in operation at the VU University Medical Center (VUMC) Amsterdam, the Netherlands, since January 2015.

Toshiba's Vantage Elan was welcomed by the market, with its excellent image quality, ease-of-use, compact footprint, and total lifetime value. In addition, the results of REACT (REnal Artery Contrast-free Trial) Multi-Center Study, which validated the usefulness of non-contrast enhanced MRA as a diagnostic tool for renal artery stenosis, were published in The American Journal of Roentgenology (AJR) in January 2015. An increasing awareness of the potential risks associated with Gadolinium-based contrast agents has revealed the need for alternative, contrast-free imaging techniques. We provide clinicians with unique technologies that minimize risk to patients, while producing exceptional images.

In Ultrasound, we launched the Aplio Platinum Series, a system that provides powerful clinical imaging tools for advanced visualization, quantification and intervention. We also brought new tools to clinical practice, such as BEAM (a new technique that improves needle visualization during ultrasound-guided procedures) and an advanced implementation of Shear Wave Elastography (that quickly and non-invasively measures tissue stiffness of the liver to potentially reduce requirements for expensive biopsies). Improvements to current technologies, such as Superb Micro-Vascular Imaging (SMI), have further enhanced diagnostic capabilities for day-to-day examinations, as well as for Interventionists or Specialized Radiologists.

In Vital, we introduced Version 6.7 of our Vitrea® software, with new features and enhancements to its Cardiovascular-, Neurovascular- and Oncology applications, as well as service, integration and efficiency enhancements. General and integration enhancements include improvements to Vitrea's STL export functionality, providing flexibility to export from Vitrea for use in 3D printing capabilities, such as CAD-modeling, computational-modeling and surgical-simulation. Version 6.7 also includes enhancements to partner technologies with Olea Sphere®, Visia™ CT Lung CAD, Mirada RTX and Cedars-Sinai Medical Center Cardiac Suite.

Last, but not least, let me mention the developments that have occurred within Toshiba.

In 2013, Mr. Tanaka, Toshiba's CEO and President, reshaped Toshiba's focus onto three core areas of innovation and business development – Toshiba's three pillars. Across Toshiba's many business lines, our people develop solutions, products and technologies in different ways. From lifestyle-sensing devices, designed by our Semi-Conductor Division, through to world-leading cancer treatment systems from our Power Division, these Toshiba innovations are now being brought together to better meet the needs of the total healthcare environment.

In the field of 'Big Data', Toshiba is partnering with leading institutions around the world. Together with The Johns Hopkins University in the United States (US), Toshiba is participating in work being carried out to analyze treatment pathways and outcomes in head- and neck cancer patients, towards improving outcomes for individuals in the future. Another 'Big Data' project is underway in Japan, in which Toshiba has joined forces with Tohoku University and Nihon Kohden to study life factors of more than 150,000 people from the Tohoku area in Japan. This comprehensive project, sponsored under the Japanese Government's 'Center of Innovation' (COI) Program, has already led to clinical benefits for the community and tangible business benefits for Toshiba. In December 2014, Toshiba commenced with the offer of genome testing to support the research requirements of Japanese Universities through rapid service and greatly reduced costs, thanks to knowledge developed as part of the COI Project.

While always strictly adhering to our company's well-known tradition of excellence and quality, we will continue to respond to changes in the industry and the needs of our customers, and pursue our mutual goal of improving healthcare delivery. Our products and company are dedicated to our 'Made for Life' philosophy. We deeply appreciate your continuing support and cooperation in improving human health through continually improving healthcare for all patients. Our company is the product of our employees and I am proud of our 'Toshiba Family'. I will always strive to protect our brand name and image now and in the future.

Toshio Takiguchi
President and Chief Executive Officer
Toshiba Medical Systems Corporation

Revealing the Secrets of the Past

Toshiba's motto is 'Made for Life', but a recent collaboration with a leading Dutch museum has demonstrated that its technology extends beyond this! Toshiba's Aquilion ONE™ / ViSION Edition CT system was used to scan a unique Chinese 'Buddha mummy' to gather new information and progress scientific research on the artefact. The advanced technological features of the state-of-the-art Toshiba system enabled details that had previously escaped discovery to be revealed. And the new data collected will be used for 'life-like' three-dimensional (3D) reconstruction.

The Drents Museum (www.drentsmuseum.nl) encourages visitors to discover, learn and interpret history. They do this, amongst other things, by organizing spectacular, international exhibitions that offer 'once-in-a-lifetime' experiences.

The artefact appeared to be a large, highly ornate, gilded statue of a Buddhist saint, in half-lotus position from the outside, but as work began on restoration, the mummified body of a monk, who lived around the year 1100, was discovered inside the plaster casing. The mummy is the only one of its kind known and available for scientific research outside of China. It is a truly unique exemplar and has been the star exhibit at expositions organized by the Drents Museum in Assen, the Netherlands and the Hungarian Natural History Museum in Budapest.

Initial investigations provided some information, but also raised even more questions. In the quest to find out more about this intriguing, culturally and historically significant artefact, and with the potential offered by continually advancing research technology, unravelling the mystery of the mummy has become an ongoing story.

Toshiba heard about the project through Erik Bruijn, an independent researcher, Buddhism expert and Guest Curator of the Tibet and Japan Departments of the Wereldmuseum in Rotterdam, the Netherlands, who inspired his neighbour, Dr. Ben Heggelman, Radiologist at the Meander Medical Center in Amersfoort, the Netherlands, to also become involved in the project. Toshiba offered use of its state-of-the-art Aquilion ONE to assist with the research.

"We are delighted to support scientific research that could provide fresh insights into this remarkable artefact," said Jos Ruis - Vice President Toshiba Medical Systems Europe. "Investigations like this are extremely rare. For museums, it offers the possibility to perform research that is normally beyond their means. For Toshiba, such projects are important, because we can help the scientist to better investigate and understand the subject of their research and thus demonstrate the usefulness of our imaging technology beyond regular clinical practice. New technological advances are allowing investigators to non-invasively 'look' into the subjects of their research. We can, so to speak, 'peel off' layer-after-layer, and progressively learn more and more about historically-significant specimens. By using advanced 3D reconstruction technology, we can visualize otherwise hidden features and even enable the creation of 'life-like' reconstructions in combination with 3D printing technology."

A SURPRISING DISCOVERY

In 1996, a Dutch-Asian art collector bought the statue from another Dutch collector. One year later, a skilled craftsman removed the statue's bottom wooden plate to assess the statue for restoration. He discovered a linen scroll annotated with Chinese script dating from the 1300s, along with a number of dead beetles, and realized that the statue was far more than just a piece of religious artwork. In 2013, a CT scan was made at the Mannheim Hospital in Germany with the statue-owners' approval. The result clearly revealed the skeletal remains of the mummified person inside. Subsequent research indicates that the artefact was restored in the 14th Century. Translation of the Chinese scroll text found inside the mummy, which dates from that period, suggests that the mummified remains were of a Buddhist monk, whose name is still unknown. Extensive examination of the outer casing and carbon dating confirmed that the mummy dates from the 11th or 12th Century and that the monk probably died between 1022 and 1155, as a relatively young man of around 35 to 40 years old.

The Buddhist monk would have been alive during the Song Dynasty – a time when China experienced turbulent and violent development, and Buddhism was opposed by Confucianism and Taoism, steeped as it was in corruption and decay. Its wealthy monasteries and dazzling shrines had become a heavy burden on the nation's economy. In the wars that ensued and, in particular, a revolution against mainstream Buddhism, many religious artefacts were destroyed or plundered, and as a consequence, are extremely rare finds today.

The examination was preceded by a short ceremony.

Erik Bruijn is the independent researcher and expert in Buddhism, who is leading the investigation into the mummy's significance. He explained more about the artefact:
"The monk would appear to have belonged to the Ch'an Sect of Buddhism, although we cannot implicitly verify the truth of the scroll inserted during restoration in the 1300s. Ch'an philosophy steered Buddhism back towards the values of simplicity, intuition and nature. It embraced all sorts of elements from other Buddhist traditions, and in this way appealed to many people. Ch'an Buddhism incorporated many sub sects, many of which survived the decline of mainstream Buddhism in this period. We can deduce from study of the many details on the plaster casing of the mummy that the monk was a master – for example, the positioning of the hands incorporates secret symbolism. The statue would have been a focus of worship for pilgrims in a Buddhist temple. The plaster casing was made with holes in the ears and nose so that the holy monk could 'listen' to the prayers of the pilgrims and 'smell' the incense and flowers offered by them.

UNANSWERED QUESTIONS

While the research revealed some basic information, many unanswered questions about the mummy remain. It is not clear how the Buddhist monk died, for example. The initial CT scan revealed a molar abscess in the lower, left jaw, which might have progressed to sepsis and proved fatal in a time before antibiotics existed. Or, this could be an example of 'self-mummification', which was achieved through dehydration and starvation during the end of the monk's life, as practiced by some Buddhist monks in the past. Mummification was achieved by different methods in China than in Egypt. The brain was not removed through the nose, but left intact. In the initial- and latest CT scans, the remains of former brain meninges can be seen. No other remains of internal organs exist. They could have been removed during mummification, decomposed or destroyed by insects later. Metal- and wooden rods support the spine and chin respectively, so that the mummy could assume an upright crossed-legged position.

Of particular interest, were two previously unidentified structures found within the body cavity: what appears to be a scrolled piece of cloth inside the center of the abdominal area, and a highly layered structure in the right side of the thoracic region within the skeleton. The scroll could have been placed there at the time of mummification or during restoration in the 14th Century. The thoracic structure did not appear to be comprised of previously living tissue and could be an insect-created nest. These questions and many others prompted investigation with the advanced Aquilion ONE. In addition to

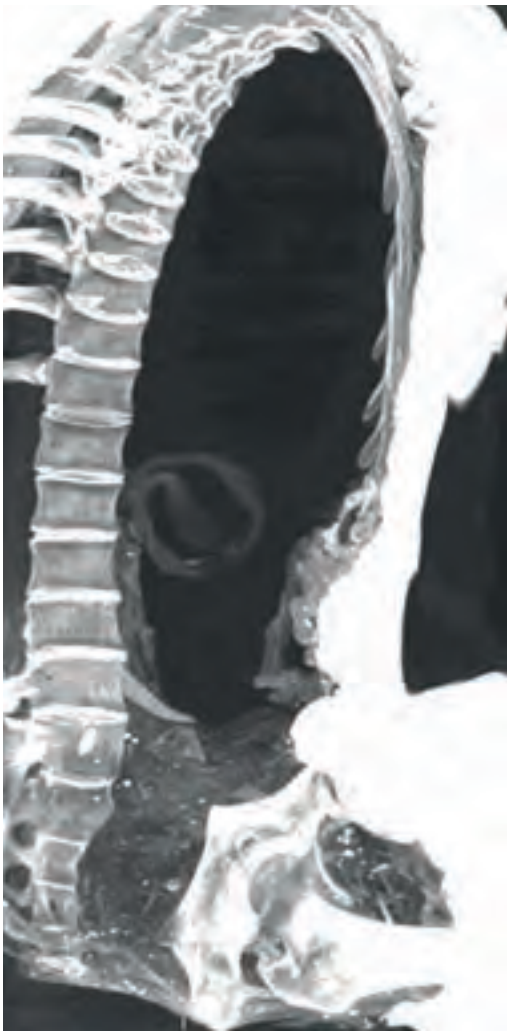


Figure 1: Maximum Intensity Projection showing a scrolled piece of cloth or paper

the CT, further scientific research was carried out with an endoscope at Meander Hospital, Amersfoort and further laboratory tests at The Rijksmuseum, in Amsterdam, the Netherlands. The endoscopic examination did confirm the presence of an as yet unidentified material in the thoracic cavity, which appeared to include scraps of rice paper covered with Chinese characters written in black ink. The endoscopic examination did confirm the presence of *corpora aliena* in the thoracic cavity.

HIGH EXPECTATIONS

Erik's neighbour, Ben Heggelman, is providing radiological and medical expertise in the current phase of research. Working in Radiology since CT was first introduced; he has seen the evolution of this modality from its very beginning and harbored high expectations for the results of the scan on the Buddha mummy.

"When I first qualified in radiology at Erasmus University, Rotterdam, in the Netherlands, CT had just been introduced. While its immediate potential was evident, technology has developed so much since then. Today's clinical practice relies on CT techniques and technology that we couldn't have imagined might even be possible then," said Ben. "The Aquilion ONE™ / ViSION Edition is considered the top of the range in the healthcare industry and we are delighted to have access to it to further our research on this unusual project. We anticipate that its advanced capabilities will provide useful additional information. The possibilities with CT now are extensive and – they are not science fiction, they are simply science fact! "

"The combination of Toshiba's innovative technology and the expertise, inventiveness and stamina of our staff can yield surprising results and insights. We demonstrated this already in our collaboration with Caspar Berger, an award-winning Dutch artist and sculptor, who created an exact copy of his own skeleton using a Toshiba Aquilion CT scanner and 3D-print technology and then incorporated this into a wide variety of creative

Skeleton / Self-portrait 20, 2012 *- by Caspar Berger*
A cast of the artists right upper arm bone (the humerus) in three kilogramme of gold.

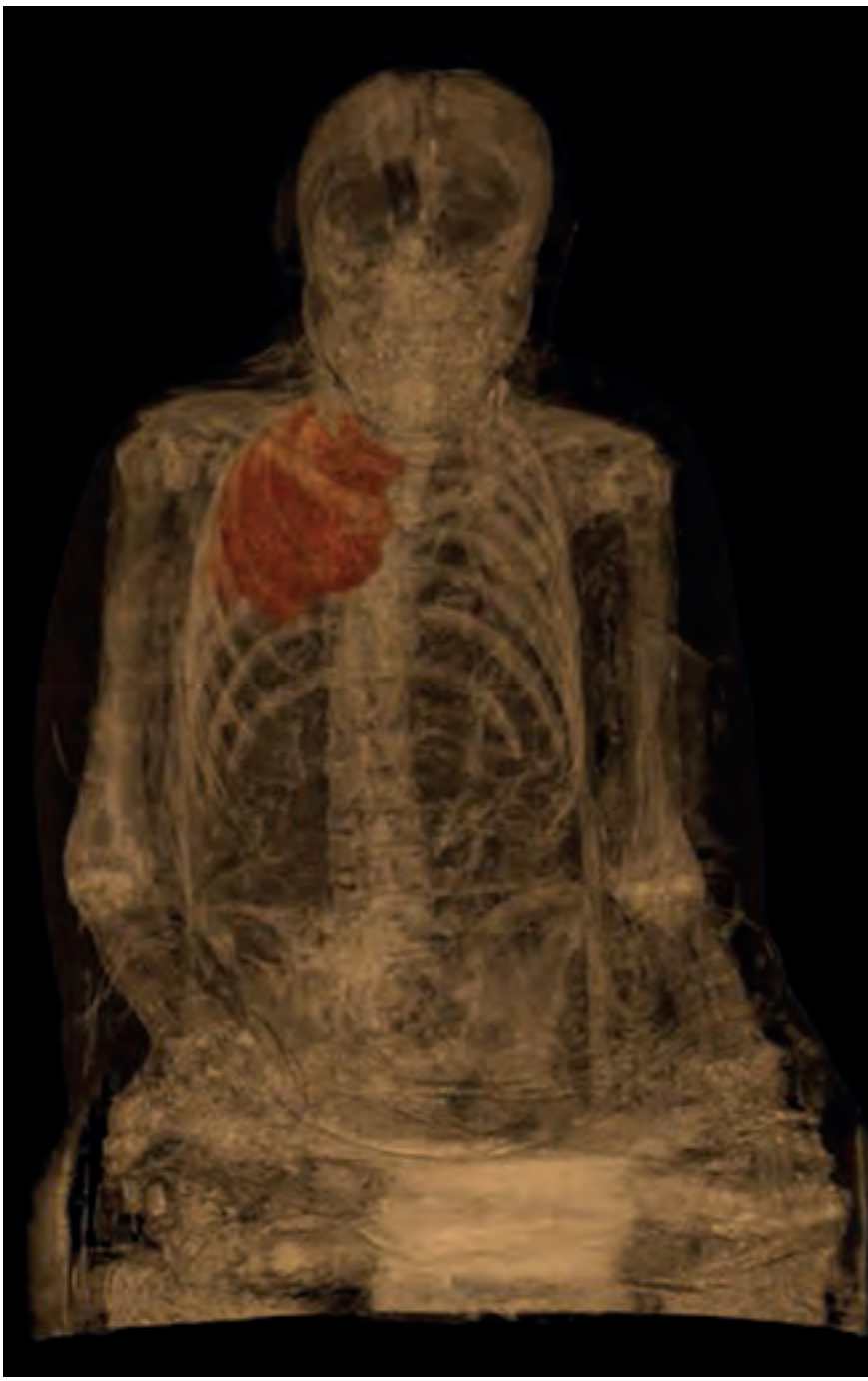
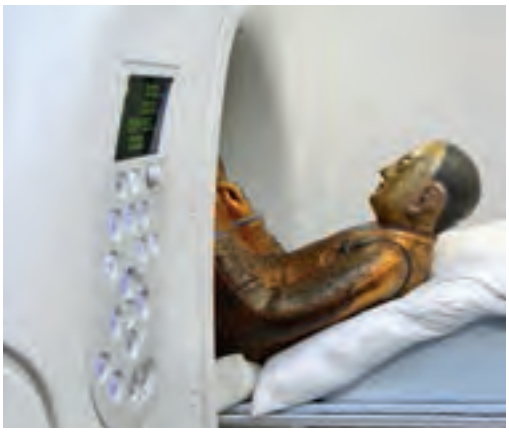


Figure 2: 3D Image displaying the layered structure in the apex of the lung

interpretations entitled 'Bone'[1]. Caspar's innovative work, which combines artistic expertise with modern techniques to creatively interpret and reflect the true qualities and beauty of the human body, was recognized with the prestigious Dutch Singer Prize in 2013," added Jos Ruis. "We hope that the same combination of technology and people can help the researchers obtain greater understanding of this intriguing story and unravel the mystery of this unknown Buddhist monk."

MEETING THE NEEDS OF THE MOST UNUSUAL 'PATIENTS'

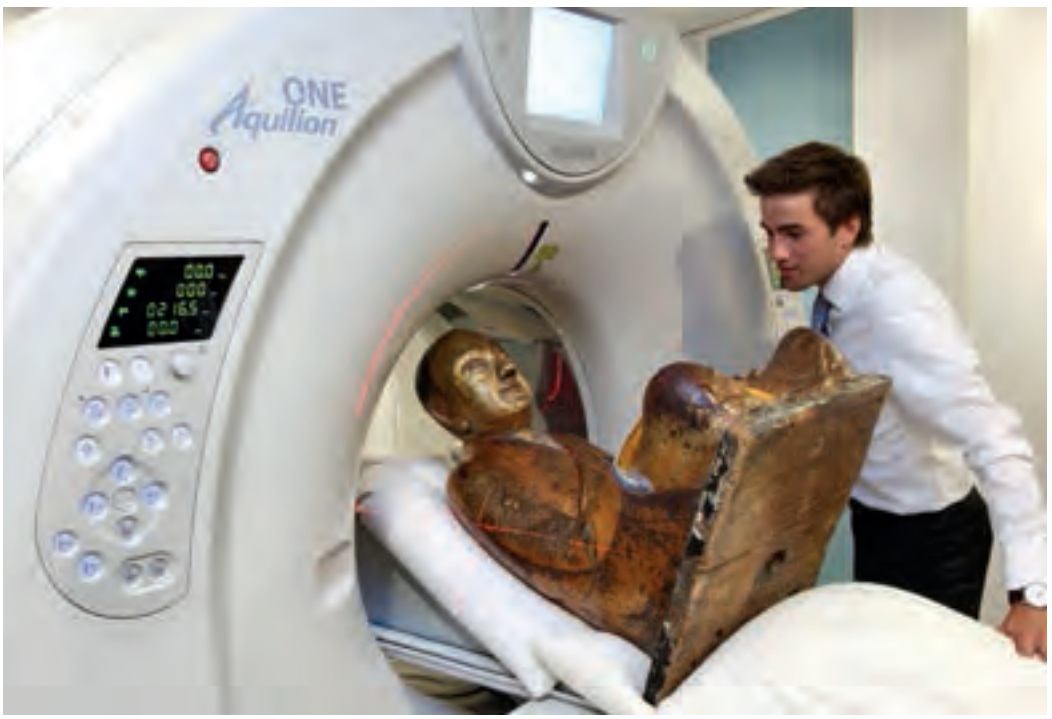
After intricate planning in agreement with the Drents museum and owners of the artefact, Toshiba's Headquarters in Zoetermeer welcomed its latest and most unusual 'patient', who was carefully transported from the Drents Museum in a custom-built, shock-protected, carrying case. A short Buddhist ceremony was held to observe religious customs. The Buddha mummy was carefully positioned for its CT by Erik. Because the statue consists of a rigid, but obviously fragile construction, very careful adjustment was required to secure and support it. The table of the Aquilion ONE features Tech Assist Lateral Slide, a unique Toshiba innovation designed to make positioning patients easy and strain-free. The artefact could be fitted safely into the scanner, thanks to its large open bore. Aquilion ONE™ / ViSION Edition has a 78cm open bore – a 10 cm wider aperture than the previous scanner used at Mannheim, providing ideal access.



Roy Verlaan, Clinical Application Specialist at Toshiba's Computed Tomography Business Group carried out the scan. Within a matter of minutes, the statue had been scanned and data collected within a single scan.

"Using Toshiba's Aquilion ONE, we anticipated that the image quality would be far superior than any CT investigation previously made of the Buddha mummy and combined with easy access, artifact reduction for metal artifacts and iterative reconstruction, we were able to contribute to further insights," he said.

"The scan indeed provided a much higher resolution; the information that we had before was better presented with far more detail, and enabled us to derive even more information," remarked Ben. "In addition, we were even able to find things that weren't apparent in the initial investigation, and through 3D reconstruction, were able to gather information on their exact shape, size and density of these 'newly discovered' structures. Extracting such information from CT is particularly important in this case, because it is unlikely that intact DNA still exists, since the mummy is around 950 years old and for a large part has been kept in a temple with temperatures of around 30°C. We may possibly be able to extract information from dental DNA in subsequent research, if this is permitted by the owner of the exhibit, but even this could prove unsuccessful."



Careful and exact positioning of the mummy in the Aquilion ONE scanner gantry

Ben will assess the results of the CT scan fully, and together with those from further research at the Meander Medical Center and Rijksmuseum, Erik will compile and publish a book, which he hopes to publish in 2016.

"It is incredible that we can gather so much new information from an image made really within a matter of seconds," said Erik. "We are confident that the latest phase of research, including today's scan, will deliver a large amount of new data, helping us to solve many of the current puzzles around the Buddha mummy."

"One word describes this day - Amazing!" concluded Roy. "This has been an absolutely unique experience. The story behind the Buddha mummy is intriguing. The artefact itself is breathtaking and the images and data we have been able to obtain with the Aquilion ONE™ / ViSION Edition have exceeded our expectations."

An illustrated book[2] with many beautiful photographs edited by Vincent van Vilsteren, the Curator of the Drents Museum, expands upon the different causes of natural mummification and provides further information on scientific research, restoration of mummies and on the medieval trade in Mumia (currently only available in Dutch).

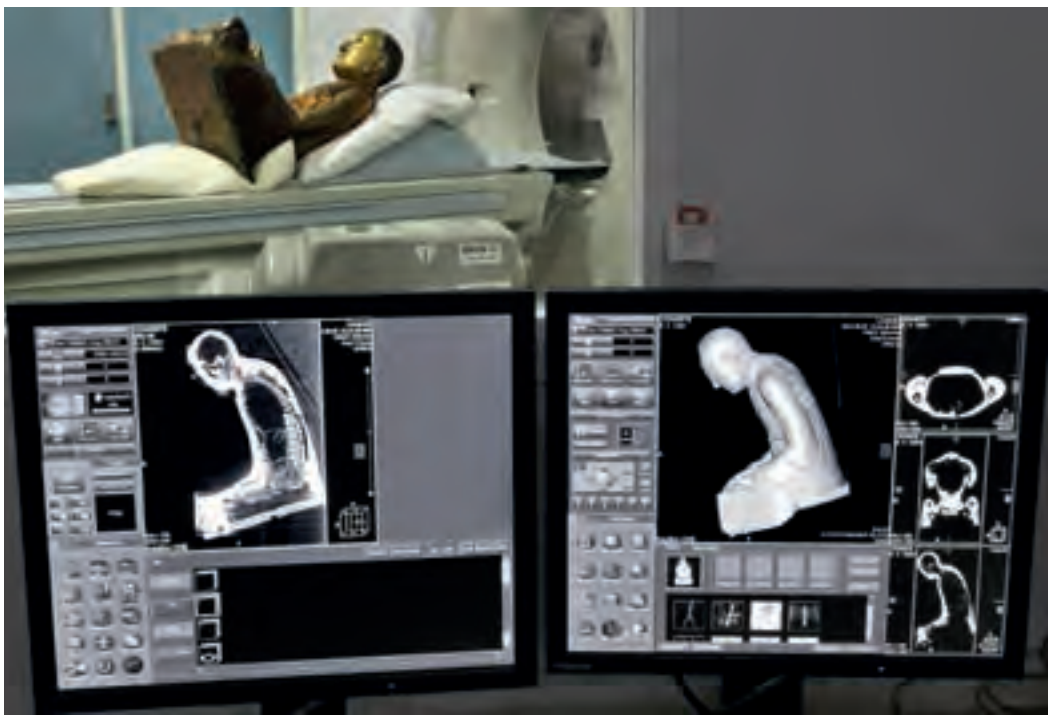
FUTURE ROLE

Advanced imaging has a clear role in helping to progress scientific research into museum artefacts and enhancing our knowledge of the past.

"New technological developments in medical imaging are, of course, implemented for the benefit of the living, however, the benefits of our discoveries could also be used for immense progress in the domain of scientific research into artefacts, like the study of this mummy," remarked Jos. "Delivering this benefit in a wider context in the future would rely on easing the access to this type of imaging technology for museums and researchers. Mobile CT and MRI scanners could play an important role in this."

Note: at the end of last year, a Toshiba CT scanner was used to study the mummy, as described in this article. The scans provided new and surprising insights that were previously unknown. Toshiba is proud to have been able to contribute to these advances in cultural and historical knowledge. Since then, and entirely unknown at the time of scanning, the ownership of the mummy has become the subject of media controversy.

References:
1. "Bone as Art – From CT scan to solid gold", VISIONS Magazine 20, p36-p39 | http://tinyurl.com/mkpnoy3
2. Vilsteren, V. van (ed.), 2014: Mummies, overleven na de dood. Zwolle. (191 pages, ISBN9789462580046)



Sagittal reconstruction (l) and 3D reconstruction (r) being displayed inside the scan room with the Chinese mummy in the background

First Clinical Results of Coronary CT Subtraction

D. Viladés-Medel MD [1,2], R. Leta MD[1,2], A. Hidalgo MD PhD [1,2], F. Carreras MD PhD [1,2], G. Pons-Lladó MD PhD [1,2], X. Alomar MD [1]

D. Viladés-Medel

Computed tomography angiography (CTA) of the coronary arteries is a useful non-invasive tool to rule out significant coronary artery disease (CAD) in many clinical situations. Recent guidelines of stable CAD[1] and non-ST segment elevation myocardial infarction[2] endorse the use of CTA in symptomatic patients with low to intermediate likelihood of the disease, given the particularly high negative predictive value of the technique. However, in patients with high pre-test likelihood of CAD, the technique is not recommended, and one of the reasons is the high probability of coronary calcification in these patients, which interferes with the analysis of the images and reduces the specificity and negative predictive value of CTA[3-6].

The introduction of Aquilion ONE™ 320-row CT scanner, and later the Aquilion ONE™/ ViSION Edition with a maximum fastest rotation time of 0.275s, have it made possible to obtain a non-invasive coronary angiography in a single heart beat and several studies have demonstrated its high diagnostic accuracy in the depiction of epicardial coronary stenotic lesions[7,8]. Despite technological advances in CT, improving both spatial and temporal resolution, there are still several limitations due to increased heart rate, presence of small stents (less than 3 mm diameter), or extensive coronary artery calcification. Recently, Toshiba has developed a new application (Coronary Subtraction) to allow the subtraction of calcium and metal stents in the coronary arteries to improve the diagnostic performance in these clinical scenarios.

Coronary subtraction CT requires two scans, one pre-contrast and one post-contrast. The subtraction of three-dimensional (3D) CTA volumes is significantly more challenging than the two-dimensional (2D) subtraction performed in X-Ray digital subtraction angiography (DSA). Subtraction in two dimensions only requires shifting of the mask image in two axes: x and y. In 3D volumes, not only manual shifting of the mask in three axes (x,y and z), but also rotational movement is required. The fact that the two studies have to be performed consecutively implies that respiratory, pulsatile and spatial motion potential changes can lead to volumes of data with somewhat different spatial relationships between bony structures and calcified or stented arteries. Coronary Subtraction can be performed in two breath-hold or in a single breath-hold (Figure 1).

The non-contrast CTA volume is then subtracted from the contrast-enhanced CTA volume, removing the calcium/metallic content of coronary arteries. To obtain an accurate registration of two volumes and minimize misregistration artefacts, the single breath-hold methodology was chosen. After pre-oxygenation with low-flow oxygen and immediately after contrast injection, a non-contrast scan and a contrast scan with

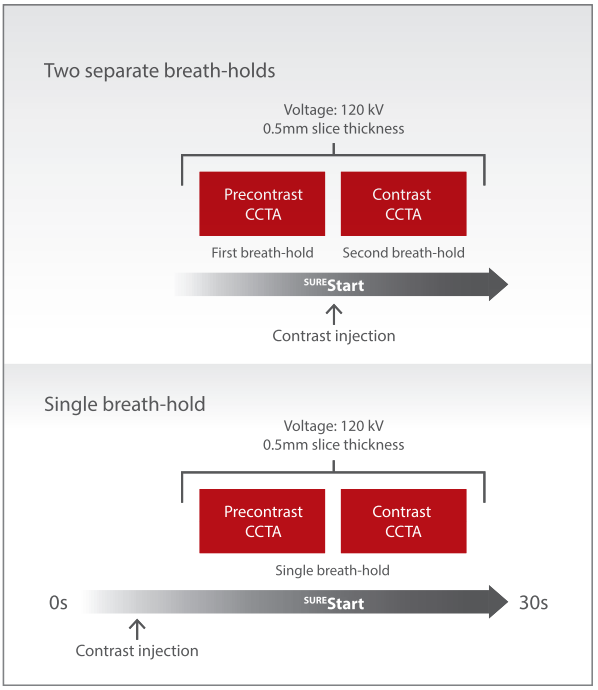
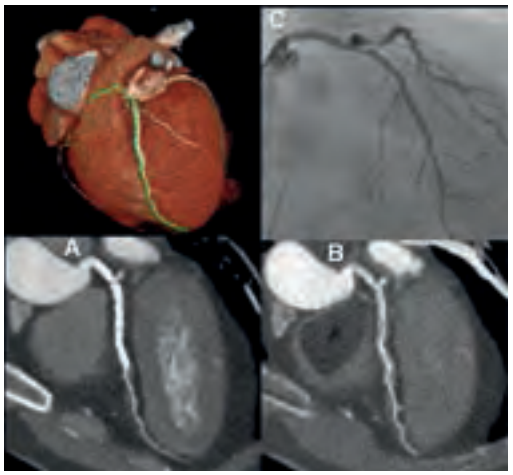


Figure 1: Image acquisition methodologies for CTA subtraction.

[1] *Clinica Creu Blanca, Barcelona*
[2] *Unitat d'Imatge Cardíaca Hospital de Sant Creu i Sant Pau Spain*

a z-coverage of up to 16cm was performed in the same breath-hold. Prospective ECG-triggering was used with a variable exposure window depending on the heart rate. Coronary CTA analysis was performed on an off-line workstation (Vitrea Fx; Vital Images).

Three clinical cases from daily practice are presented to illustrate how the Coronary Subtraction application works and its correlation with the invasive coronary anatomy seen by an invasive catheterization.

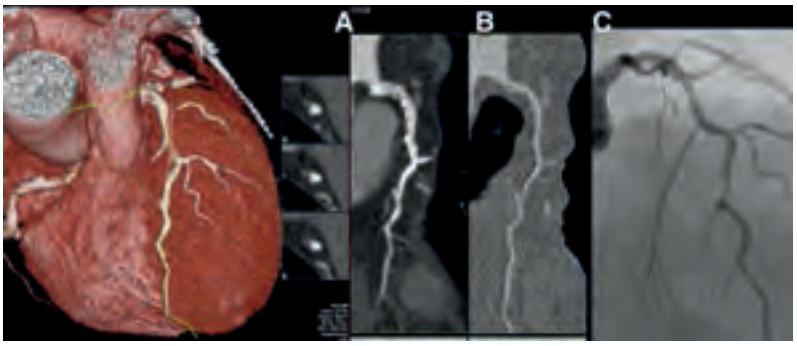


Case 1

CASE 1

51 year-old male, active smoker with hypertension, type II diabetes mellitus and hypercholesterolemia. Chronic ischemic heart disease previously revascularized with stents in left main and proximal to mid left anterior descending artery (2008). During the last month, he presented with atypical chest pain unrelated to physical effort. Baseline ECG did not show repolarization abnormalities.

Cardiac computed tomography angiography (CTA) showed previous implanted stents, with extensive metal artefact, making an assessment of neointimal hyperplasia or *de novo* atherosclerosis within the stents difficult (Figure A). After coronary subtraction, a vessel without any significant lesion could be observed (Figure B), as confirmed in a further invasive coronary angiography (Figure C).



Case 2

CASE 2

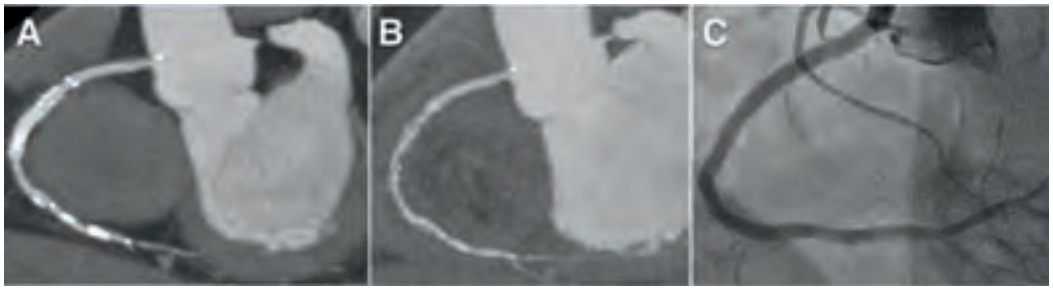
69 year-old male, past smoker with hypertension and moderate chronic renal failure with a glomerular filtration rate of 40 mL/kg/min. No previous cardiac history. During the last weeks, he presented with atypical chest pain and an inconclusive exercise ECG (subtle changes in cardiac repolarization without associated angina).

Cardiac computed tomography angiography (CTA) showed a high degree of calcification in the left anterior descending artery that impeded the assessment of the wall lumen in these segments (Agatston score 845) (Figure A). After coronary subtraction, a vessel without any significant lesion could be observed (Figure B), as confirmed in a further invasive coronary angiography (Figure C).

CASE 3

64 year-old male, past smoker with hypertension and hypercholesterolemia. Chronic ischemic heart disease with previous inferior myocardial infarction and stenting of right coronary artery (RCA). After this he presented with unstable angina in the context of a total chronic occlusion at the site of the stent. Again, he was revascularized with bioabsorbable vascular scaffold. Six months later, the patient was referred for a CTA to check this last revascularization procedure.

Cardiac computed tomography angiography (CTA) showed a patent stent in the proximal RCA and focal calcification in the distal segment of the RCA, making it impossible to rule out significant stenosis in this segment (Agaston score 530) (Figure A). After coronary subtraction, an RCA without significant stenosis was observed (Figure B), subsequently confirmed with an invasive coronary angiography (Figure C).



Case 3

CONCLUSIONS

The Toshiba Coronary Subtraction application is a promising tool to minimize calcium and metallic artefacts, as these three clinical cases have exemplified. Coronary calcium subtraction may improve the diagnostic accuracy of CTA, especially in those patients with extensive calcifications or small stents. More studies are needed to validate this diagnostic tool and find out what role this could have in clinical practice.

Refences

- Subtraction Coronary CT Angiography for the Evaluation of Severely Calcified Lesions Using a 320-Detector Row Scanner, Yoshioka K & Tanaka R, Current Cardiovascular Imaging Reports, 2011; 4(6):437-446
- Subtraction Coronary CT Angiography for Calcified Lesions, Yoshioka K, Tanaka R, Muranaka K.Y, Cardiol Clinics, 2012; 30(1):93-102
- Improved evaluation of calcified segments on coronary CT angiography: a feasibility of coronary calcium subtraction, Tanaka R, Yoshioka K, Muranaka K, Chiba T, Ueda T, Sasaki T, Fusazaki T, Ehara S, International Journal of Cardiovascular Imaging, 2013, Epub.
- Accurate Registration of Coronary Arteries for volumetric CT Digital Subtraction Angiography, M. Razeto, J. Matthews, S. Masood, J. Steel, K. Arakita, Proc. SPIE Vol. 8768, 2013.

Bibliography

1. Members TF, Montalescot G, Sechtem U, Achenbach S, Andreotti F, Arden C, et al. 2013 ESC guidelines on the management of stable coronary artery disease: The Task Force on the management of stable coronary artery disease of the European Society of Cardiology . Eur Hear J 2013;34 (38):2949–3003.
2. Hamm CW, Bassand J-P, Agewall S, Bax J, Boersma E, Bueno H, et al. ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: The Task Force for the management of acute coronary syndromes (ACS) in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC). Eur Hear J 2011;32 (23):2999–3054.
3. Stolzmann P, Scheffel H, Leschka S, Plass A, Baumüller S, Marincek B, et al. Influence of Calcifications on Diagnostic Accuracy of Coronary CT Angiography Using Prospective ECG Triggering. Am J Roentgenol. 2008;191(6):1684–9.
4. Vavere AL, Arbab-Zadeh A, Rochitte CE, Dewey M, Niinuma H, Gottlieb I, et al. Coronary Artery Stenoses: Accuracy of 64–Detector Row CT Angiography in Segments with Mild, Moderate, or Severe Calcification—A Subanalysis of the CORE-64 Trial. Radiology 2011;261(1):100–8.
5. Abdulla J, Pedersen KS, Budoff M, Kofoed KF. Influence of coronary calcification on the diagnostic accuracy of 64-slice computed tomography coronary angiography: a systematic review and meta-analysis. Int J Cardiovasc Imaging. 2012;28(4):943–53.
6. Meijboom WB, van Mieghem C a G, Mollet NR, Pugliese F, Weustink AC, van Pelt N, et al. 64-Slice Computed Tomography Coronary Angiography in Patients With High, Intermediate, or Low Pretest Probability of Significant Coronary Artery Disease. J Am Coll Cardiol. 2007;50(15):1469–75.
7. Dewey M, Zimmermann E, Deissenrieder F, Laule M, Dübel H-P, Schlattmann P, et al. Noninvasive Coronary Angiography by 320-Row Computed Tomography With Lower Radiation Exposure and Maintained Diagnostic Accuracy: Comparison of Results With Cardiac Catheterization in a Head-to-Head Pilot Investigation . Circulation 2009;120 (10):867–75.
8. De Graaf FR, Schuijf JD, van Velzen JE, Kroft LJ, de Roos A, Reiber JHC, et al. Diagnostic accuracy of 320-row multidetector computed tomography coronary angiography in the non-invasive evaluation of significant coronary artery disease. Eur Hear J 2010;31 (15):1908–15.

Toshiba's Aquilion ONE / ViSION Edition offers all patients a successful examination, with the lowest possible radiation exposure and the highest quality diagnostic outcomes - www.aquilionvision.com

Capabilities of Ultrasound Elastography in the Diagnosis of the Structure of Atherosclerotic Plaques in Carotid Arteries

A. R. Zubarev [1], I. V. Rychkova [1], M. B. Saratov [2], A. K. Demidova [1], E. L. Tumanova, V. N. Fedorova, V. Y. Panko, N. V. Krivosheeva.

The proportion of acute ischemic cerebrovascular accidents associated with carotid atherosclerosis is 68%[1]. This disease is associated with high mortality and disability rates, therefore reliable methods to diagnose possible complications in primary stroke prevention are necessary, as about 70% of strokes develop without any precursors[2].

Today there are two major mechanisms for pathogenesis of ischemic cerebrovascular disorders (CVD): hemodynamic (narrowing of the artery with insufficiency of cerebral blood flow) and embolic (destruction by atherosclerotic plaque - ASP - with ulceration of the tectum). Developed over 50 years ago, carotid endarterectomy (CEA) is still the most efficient intervention to prevent stroke in patients with carotid artery stenosis. According to A. V. Pokrovsky, the indications for CEA are determined by the presence or absence of clinical manifestations of cerebrovascular insufficiency, as well as by the extent and nature of changes in the carotid arteries: the degree of the internal carotid artery (ICA) stenosis (expressed as a percentage); structural characterization of atherosclerotic plaque; and the condition of the ASP tectum[3].

Ultrasound (US) today is the gold standard in carotid artery examination and risk assessment for CVD development in patients with carotid atherosclerosis. Being inexpensive, non-invasive, and precise, it allows the physician to explore the patency of the vessel, its diameter, vascular wall and perivascular tissue condition[4].

To characterize the echogenic properties of plaques, in most cases the A. Gray-Weale classification is used, supplemented by C. M. Steffen, G. Geroulacos, and by the Russian scientific centre of surgery (RSSS) named after acad. B. V. Petrovsky of RAMS. [Guided / Ed. by A. V. Pokrovsky]:

- **type I** - completely hypoechoic ASP with thin echogenic tectum (homogeneous);
- **type II** - predominantly hypoechoic ASP with <50% of hyperechoic areas (heterogeneous);
- **type III** - predominantly hyperechoic ASP with <50% of hypoechoic areas (heterogeneous);
- **type IV** - completely hyperechoic ASP (homogeneous);
- **type V** - ASP can not be identified due to pronounced calcification causing acoustic shadow.
- **type VI** - isoehoic ASP with echo-structure with the intensity of the reflected US signal similar to that of the vascular wall.

US enables detection of cerebrovascular embolic event risk factors, evaluation of ASP structural features and of stenosis configuration. The sources of microemboli are known[5] to be homogeneous hypoechoic ASP, heterogeneous ASP with a prevalence of hypoechoic zones, plaque

[1] *Department of ultrasonography. Russian National Research Medical University named after N.I. Pirogov. Moscow. Russia*

[2] *Department of vascular surgery. State-owned Federal State Institution "Main Clinical Military Hospital of Federal Security Service of the Russian Federation". Moscow. Russia*

with irregular contours and with "silent" areas on color Doppler mapping (CDM), as well as complicated plaques (with bleeding and / or ulceration). New US modes with enhanced quality of US images do not, unfortunately, provide any additional US criteria for interpretation of hypo- and anechoic zones forming a heterogeneous plaque[6]. The possibilities of US in assessing the ASP structure in case of pronounced calcification in the examined area are also limited due to the fact that the acoustic shadow makes it impossible to reliably estimate the structure of ASP, creating the illusion of a "hypoechoic component."

To date, the most accurate non-invasive technique in the diagnosis of atherosclerotic plaque instability is MRI16-18. However, the procedure is quite expensive and time consuming. Ultrasonic elastography (USEG) is an inexpensive technique, implemented in many modern devices, allowing determination of the mechanical properties of tissue that can be used in addition to a standard US exam13-15. The method is based on an objective assessment of the degree of displacement of the tissue, depending on its stiffness in response to outside pressure. Given that the mechanical properties of tissues are directly dependent on their structural organization, we assumed that the various components of ASP being coded in B-mode as a hypoechoic component of ASP may differ on elastograms7. Thus, the aim of our study was to assess the ability of USEG to diagnose various components of ASP and its instability. The results of USEG were compared with morphological and histological data obtained after separation of ASP by CEA.

MATERIALS AND METHODS

To achieve the goal of the study, to evaluate the ability of USEG to determine the components and stability of atherosclerotic plaque, and given the novelty of the methodology and the lack of sufficient data on its use in clinical practice at the time of beginning the study, we had to perform several preliminary stages.

At the beginning of the study the methodology was tested on a specially designed gel phantom. At this stage the best machine settings were revealed, and repeatable results were achieved by the doctors involved in the project.

In the second stage the methodology was tested on healthy volunteers. At this stage, two variants of the methodology showed similar results: performed with own tissue pulsation and during compression; several machine settings were adjusted for optimal visualization against the background of own pulsation.

At the next stage a study was conducted on volunteers with carotid atherosclerosis. To confirm the safety of the procedure we carried out an emboli detection procedure in the medial cerebral arteries (MCA) on both sides simultaneously with the US and elastography. First the patients signed informed consent notices, which described the essence of the procedure and possible risks.

At the fourth stage, all patients with indications for CEA received a standard US in combination with USEG and transcranial microemboli detection. The visualization results obtained were detailed for the operating surgeon and sketched on the scheme developed. The obtained results of complex US and elastography exams were compared with intraoperative results and the histopathological examination data. Subsequently, all the data were recorded in the database and processed. All the methods were compared with each other, and also differences and possible reasons for the discrepancies were assessed.
The standard US and elastographic exams were conducted on a Toshiba Aplio XG, supplied with a high frequency linear transducer, using the dynamic flow technique.

The study was conducted with the patient in the normal position. At the stage of standard US in longitudinal and transverse scanning of arteries the following were evaluated: patency, diameter, and geometry of the vessel, vascular wall along its entire length, surface and internal structure of the atherosclerotic plaque (ASP). Using Doppler technology, the blood flow was quantitatively determined. Using CDI, power Doppler mapping, and dynamic-flow techniques allowed us to identify and assess the nature of hypoechoic areas, and to assess the surface of the plaque.

Then the targeted elastography of the ASP identified was conducted. Given the need to compress the study area to obtain an elastogram and the high risk of complications developing during compression in patients with severe carotid atherosclerosis, the study was conducted with extreme caution, in the presence of a treating physician. Use of the own pulsation of arteries to develop elastograms, as in the case of normal unaffected arteries, appeared impossible; which is likely to be due to the severe rigidity of the walls of the affected vessels. After several cycles of compression-decompression the device started the qualitative and quantitative elastography mode, and data processing was performed in off-line mode.

RESULTS AND DISCUSSION

We obtained data from five patients.

Patient 1

An US examination of the carotid arteries revealed circular prolonged heterogeneous ASP, calcified with a predominance of hypoechoic component, of the left CCA with transition to the ICA. Maximum stenosis on the cross-sectional area of the vessel reached 65-70% (Fig. 1a, 1b).

In the USEG mode the ASP region is colored heterogeneously. In the distal segment of plaque an area of marked soft-elastic consistency was found, followed by a tight area and a small soft-elastic component of the plaque with green staining of the tectum zone in the proximal segment (Fig. 1c).

It should be noted that in this case USEG identified differences between these ASP areas, while in B-mode they appeared as areas of lowered echogenicity.

Examination of ASP macropreparation, obtained by endarterectomy, showed a dense fragment of the tissue tube wall. In cross-section the tissue deep in the fragment is heterogeneous - with yellow, grey, and brown areas (Fig. 1d).

Pathohistological study revealed three zones, similar to the elastography data. In the distal fragment of the ASP the thinning of the fibrous tectum was revealed in conjunction with the accumulation of foam cells and structureless masses containing erythrocytes (zone of hemorrhage), white blood cells, and macrophages, which corresponded to the soft component of the plaque on the elastogram (red color). The medium fragment represented a necrotic core, consisting of detritus, deposits of lipids and cholesterol, with a small amount of foam cells, and contained a dissection zone in the middle. No data for active inflammatory process were obtained. An elastogram of this area corresponded to the blue staining, i.e. to the relatively dense consistency area. The proximal zone of the ASP had a similar composition, but on the periphery of the core a significant accumulation of foam cells and fibrous tissue infiltration of adjacent cells and macrophages were noted (Fig. 1e), which is consistent with green staining on the elastogram.

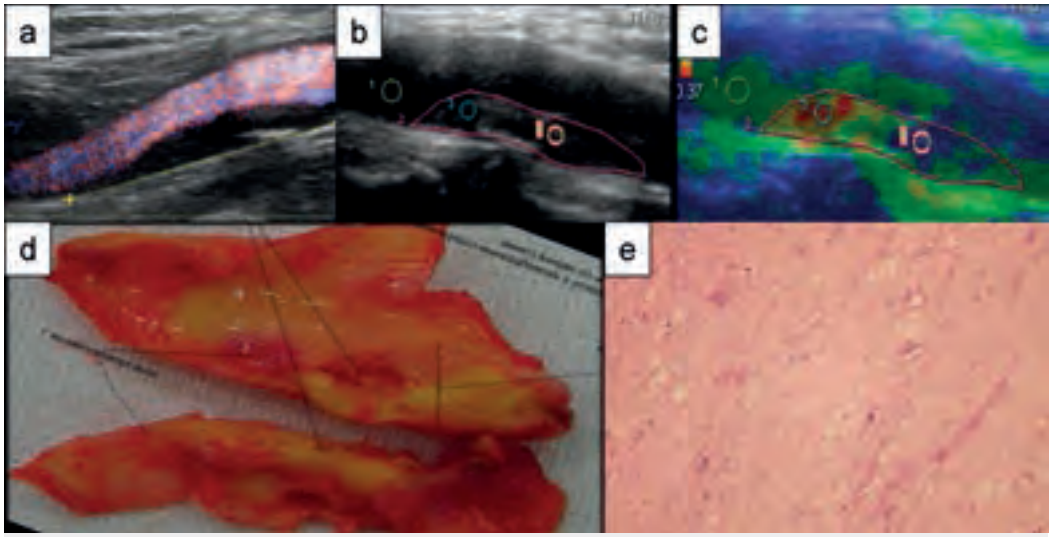


Figure 1: Patient 1
1a and 1b - grey-scale image of the circular prolonged heterogeneous calcified atherosclerotic plaque with a predominance of hypoechoic component.
1c - elastogram of atherosclerotic plaque in the lumen of the left CCA. Heterogeneous staining of ASP is noted. Left to right: area of pronounced soft consistency, colored predominantly red, area of more dense consistency, colored blue, and a small area of moderately reduced elasticity, colored green. Noteworthy green staining along the ASP tectum that probably reflects active inflammation with macrophagal infiltration of ASP tissue.
1d - photo of macropreparations obtained by endarterectomy. ASP is dissected along the back wall. In the interior of the plaque a cavity with gelatinous contents is noted. In the distal region an area raising suspicions of haemorrhage is found.
1e - micropreparation of tectum area, accumulation of macrophages in fibrous tissue adjacent to the centre of the plaque.
Thus the data obtained in the B-mode exam did not allow us to accurately determine the structure of the plaque examined. The hypoechoic component in this case could be a lipid core, as well as a manifestation of hemorrhage into the depth of the atherosclerotic plaque. Elastography data confirmed by the histopathological study, enable differentiation of the differences in the structure of atherosclerotic plaque. An active inflammatory component, presented as active tissue infiltration by leukocytes, was also reflected on the elastogram.

Patient 2

An US examination of the carotid arteries revealed a heterogeneous prolonged plaque from CCA bifurcation to the proximal third of the ICA, with a hypoechoic component and irregular contour. A detailed study of the tectum area in the hypoechoic inclusion area (fig. 2c - marked with an asterisk) gives the impression of its thinning.

According to the USEG, the plaque area is relatively homogeneously stained, excluding the area in the ASP tectum projection, colored green and detectable in transverse scan, indicating a local increase in the elasticity of the tissue in this area (fig. 2d, 2e).

The ASP macropreparation, obtained by endarterectomy, consists of two fragments, one of which is the dense inner contents of the plaque, with greyish-brown color on the outside and brown on the cross section, and the second is the dense tubular vascular cast (fig. 2f, 2g). On the surface of the plaque facing the inside of the vessel the damaged ASP tectum is visible.

During pathological examination of the greyish-brown fragment corresponding to the internal content of plaque was shown to be decaying detritus with foam cells and an accumulation of red blood cells. ASP cavity walls are formed by fibrous tissue with fibrous areas of infiltration by lymphocytes and macrophages in small quantities, and with edema and pulping fibrous tissue area.

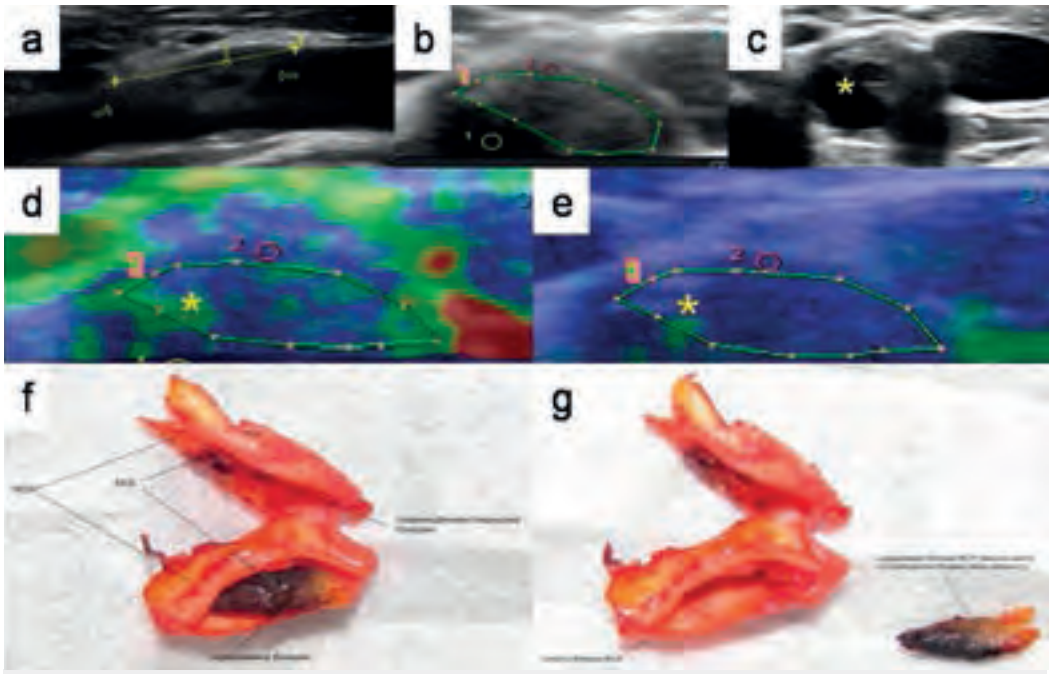


Figure 2: Patient 2
2a (longitudinal scan), 2b, and 2c (transverse scan) - a heterogeneous prolonged atherosclerotic plaque from the CCA bifurcation to the proximal third of the ICA area, with hypoechoic component and irregular contour. Arrows highlight areas, where the structure should be clarified. An asterisk denotes a zone of expressed thinning / interruption of the ASP tectum.
2d, 2e - elastography image of atherosclerotic plaque in the lumen of the ICA (magnified). 2d - cycle before compression, 2e - cycle of maximum compression. Homogeneous blue staining area of the plaque, which indicates a relatively hard consistency of the structure, except for the area in the ASP tectum projection, which is colored green and is detectable on transverse scan (indicated by asterisk) and corresponds to the hypoechoic area in the B-mode exam.
2f, 2g - ASP fragments, obtained by endarterectomy, one of which represents dense inner contents of the plaque of greyish-brown color on the outside and brown on the cross section, and the second is the dense tubular vascular cast. Thus, the standard US data do not provide a clear answer about the structure of the hypoechoic inclusion, but they were supplemented by the USEG results, which provided additional information on the damage of the ASP tectum and presence of an active inflammatory process.

Patient 3

Standard US revealed a heterogeneous circular prolonged ASP in the right ICA, with a predominant hyperechoic component, calcium inclusion, and irregular contour. Transverse scan showed a hypoechoic area, communicating with the vessel lumen, which may be a manifestation of atherosclerotic plaque contour irregularities, and we cannot rule out the presence of complicated ASP (Fig. 3a, 3b, 3c).

USEG showed homogeneous ASP staining in longitudinal scan, and a heterogeneous one with predominantly blue staining of the ASP area in transverse scan, which may indicate the hard consistency of the ASP. (fig. 3d, 3e). In the projection of hypoechoic zone, visually communicating with the lumen of the vessel, which was detected in B-mode (indicated by an asterisk), no relative difference with the surrounding tissues in elasticity was noted.

The study of ASP macropreparations, obtained by endarterectomy, showed a dense-elastic fragment in the form of a tissue tube wall portion, with non-uniform tissue of yellow-grey color (fig. 3f, 3g).

The pathohistological pattern is typical for atherosclerosis in the atherocalcification stage: a sufficiently dense fibrous tectum covers the necrotizing centre (atheroma) of the plaque, presented by a large accumulation of lipids and cholesterol, moderate deposits of fine particles of lime, a small amount of foam cells, and cell-free masses. In the adjacent fibrous tissue one notes deposits of calcium salts, focal lympho-macrophagal infiltration. Elements of plaque are presented predominantly as fibrous tissue and fibrous matrix with sufficiently large lime deposits in the interior. The fibrous tectum contains small cluster of foam cells and some scattered lymphocytes (fig. 3h).

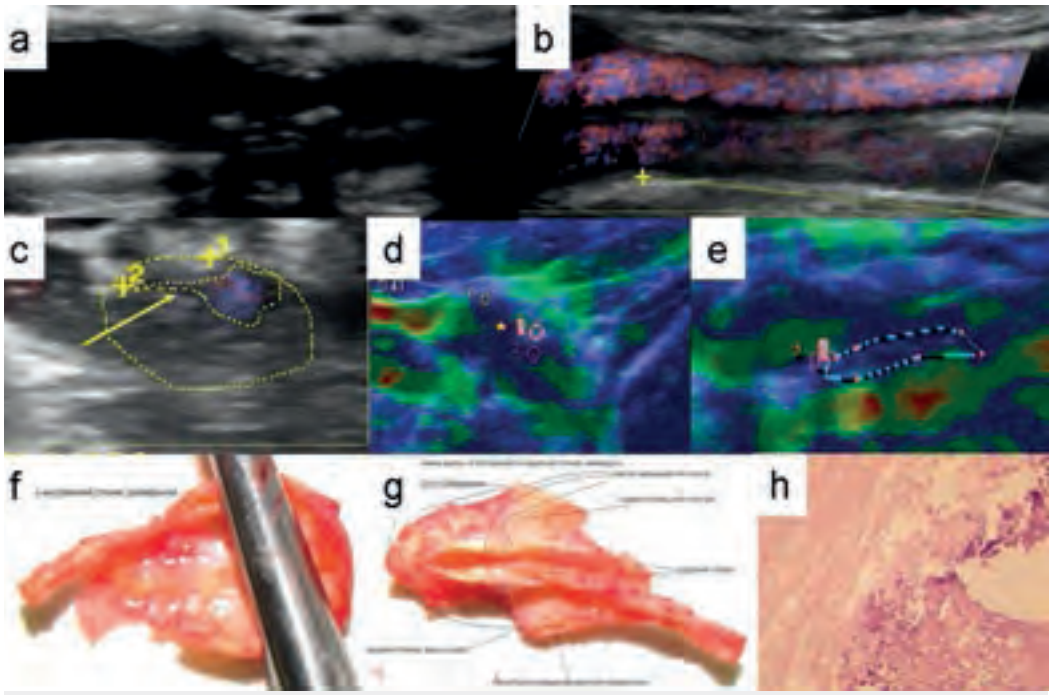


Figure 3: Patient 3
3a and 3b (longitudinal scan), 3c (transverse scan) - US exam of the right ICA. Spotted circular prolonged heterogeneous ASP is noted with predominant hyperechoic component, inclusion of calcium, and irregular contour. Transverse scan shows hypoechoic area, communicated with the lumen of the vessel (arrow).
3d - transverse, and 3e - longitudinal scans in ultrasound elastography mode. Heterogeneous, predominantly blue colored ASP, showing the hard consistency of the structure under study. In the projection of the hypoechoic zone, visually communicating with the lumen of the vessel that was detected in B-mode (fig. 3d, indicated by an asterisk) no relative difference in elasticity with the surrounding tissues was noted.
3f, 3g - nonhomogeneous dense fragment as a portion of the tissue tube wall, of yellow-grey color, obtained by endarterectomy.
3h - microscopic image of the plaque fragment: under the dense fibrous tectum is noted the atheroma of the plaque, presented as an accumulation of lipids and cholesterol, moderate deposits of fine particles of lime, a small amount of foam cells, and cell-free masses.
Thus the suspicious hypoechoic area, identified in the B-mode during transverse scanning, is a reflection of the inner contour of the ASP. Elastography in this case helped us to identify atherosclerotic plaque as relatively stable, without threatened complications in the near future.

Patient 4

Standard US revealed a heterogeneous circular prolonged ASP in the right ICA, with a hypoechoic component. This hypoechoic component may in part be an illusion, due to the presence of the acoustic shadow of hyperechoic inclusions. It should be noted that these standard US data in this case do not provide a clear picture of the ASP structure. The hypoechoic area revealed could be a manifestation of an acoustic shadow artefact as well as a true hypoechoic component of the ASP, and therefore the ASP can be assumed to be unstable.

Cross-sectional USEG showed green color in the projection area of the studied ASP tectum. No acoustic shadow, detectable in B-mode, was found on the elastograms.

The study of ASP macropreparations revealed heterogeneous tissue with areas of bone density, with crumbling grey-yellow masses, and yellow area.

According to the histological study, the structure of the plaque at the level of ultrasound and elastography studies is non-uniform. In the centre it contains a cavity containing detritus. The walls of the cavity contain focal accumulations of foam cells. A significant portion of the plaque is filled with fibrous tissue with a marked fibrillary component. There are small deposits of brown pigment (most likely due to recent small hemorrhage).

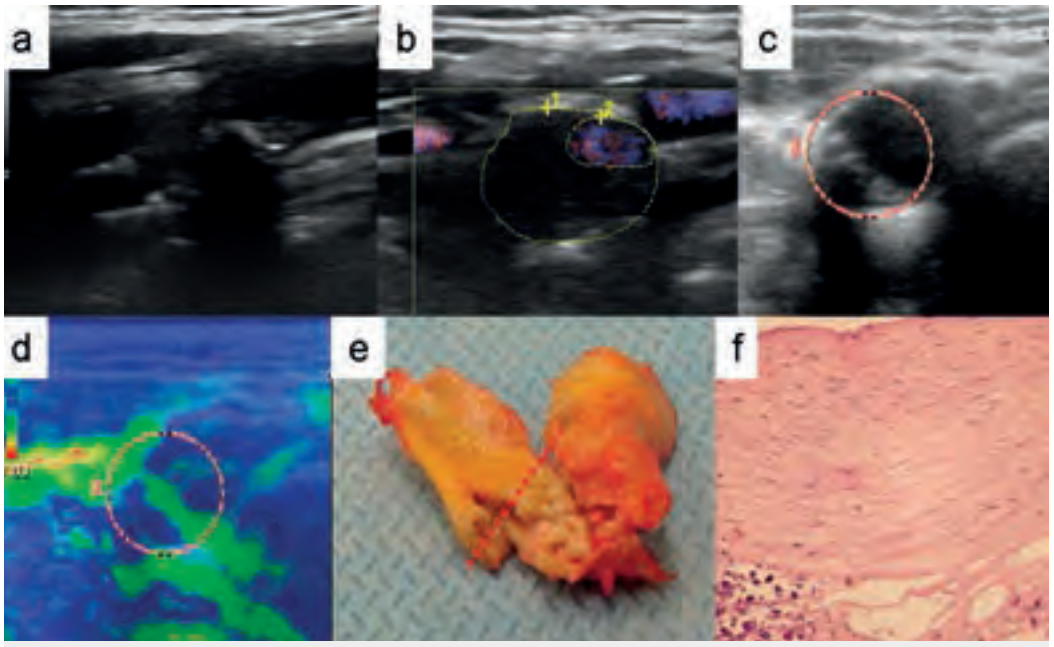


Figure 4: Patient 4
4a, 4b - US of the right ICA. Prolonged heterogeneous ASP of the right ICA with a hypoechoic component is found.
4c and 4d - elastogram and the corresponding B-mode image (4c). Green color is identified above the ASP tectum projection, which could indicate the softer consistency of the area.
4e - photo of macropreparation, obtained by endarterectomy. Dashed line indicates the approximate direction of the scan during USEG.
4f - microscopic image of a dense fibrous plaque.
Thus, in this case the elastogram reflected dense consistency of ASP core and walls. However, the reason for the clear green staining in the projection of plaque tectum is not completely clear. While assessing the location of the green stained area its shift toward the vessel lumen is noteworthy. It is possible that this pattern may be a manifestation of slow blood flow and turbulence near the wall.

Patient 5

US of the carotid arteries revealed circular heterogeneous ASP in the left CCA, with a predominant hypoechoic component. Maximum stenosis reaches 65-70% (fig. 5). B-mode revealed in this case a predominance of hypoechoic component of the ASP, which may be related to the peculiarities of the internal ASP structure, as well as to poor visualization due to acoustic shadowing.

USEG identified two areas of ASP, differing in elasticity (fig. 5b).

The study of macropreparation revealed an area raising suspicions of local necrosis (fig. 5c).

The data obtained were confirmed by histopathological study, which evaluated the structure of the two ASP fragments. The first fragment (on elastogram corresponds to the blue staining) consists of predominantly fibrillary fibrous tissue with areas of calcified detritus. The second segment, having a green color on the elastogram, is represented by fibrillary fibrous tissue with lipoidosis portions, accumulation of cholesterol crystals, and accumulation of macrophages.

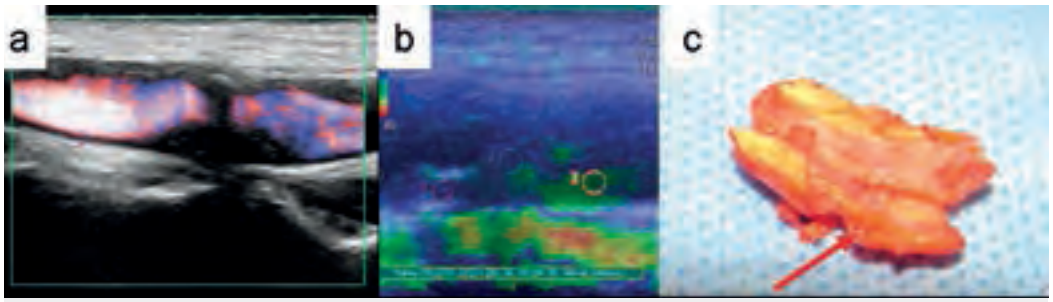


Figure 5: Patient 5
5a - US of ASP in the left CCA. The prevalence of hypoechoic component in ASP is noteworthy.
5b - US elastography mode. Heterogeneous staining is revealed: the two ASP areas differ in elasticity, with the left which is harder, and the right one having a soft component.
5c - the study of macropreparation revealed an area raising suspicions of local necrosis (arrow).
Thus, the USEG data allowed us to allocate a site of active inflammation in the studied ASP.

DISCUSSION

So, as mentioned earlier, the classification of different types of atherosclerotic plaques is based on the assessment of echo-structural ASP features, and a reliable judgement on the ASP structure is not always possible based on the standard US scanning using Doppler and other advanced technologies. Our study showed the possibility of USEG to differentiate the biomechanical properties of the various ASP components. All of our patients had heterogeneous plaques with a marked hypoechoic component, which could be a reflection of the lipid component of the plaque[8], but also of recent hemorrhage in the interior of the plaque, or of thrombotic surface depositions[9]. Usage of USEG enabled us to obtain additional data on the structure of the atherosclerotic plaques studied. The fibrillary component and necrotic core of plaques consisted of cholesterol, cellular debris and lime, and naturally had a more dense structure. A soft consistency is noted in structures that are a reflection of plaque destabilization: pronounced leukocyte infiltration, haemorrhage in the interior of the plaque, and a region of tectum rupture (Table 1). These data are common with earlier studies, which showed that the fibrous acellular component of ASP has a greater stiffness as compared with the components of plaque, containing a large number of cellular elements, as well as higher stiffness values of calcified and fibrous plaque components, as compared with non-fibrous components[20,21].

Morphology	Standard ultrasound	Ultrasonic elastography
Necrosis	Hypoechoic component	Blue color - tight-elastic component
Detritus	Hypoechoic component	Blue color - tight-elastic component
Lipid core	Hypoechoic component	Blue color - tight-elastic component
Thinning of the plaque tectum	Hypoechoic component, interruption of the structure	Green color - soft-elastic component
Calcium deposition	Hyperechoic component	Blue color - tight-elastic component
Hemorrhage	Hypoechoic component	Red and green color - soft-elastic component
Inflammation	Hypoechoic component	Green color - soft-elastic component
Fibrotic component	Hyperechoic component	Blue color - tight-elastic component

CONCLUSION

Based on our data it is too early to discuss the identification of criteria for plaque destabilization. More in-depth research is undoubtedly required, but now it can be assumed that the use of a combination of standard ultrasound and USEG will improve the quality of noninvasive diagnosis of atherosclerotic lesion of carotid arteries, and perhaps in the future give reasons for the revision of current indications for carotid endarterectomy. Perhaps in the future, based on the data on the rigidity of the various ASP components, the course of atherosclerosis can be monitored and the degree of the ASP structural instability can be established.

Bibliography

1. Z. A. Suslina, N. V. Vereshchagin, M. A. Piradov. Subtypes of Ischemic Cerebrovascular Events: Diagnosis and Treatment. Cons. Med. 2001; 3 (5).
2. American Heart Association. Heart Disease and Stroke Statistics-2004 Update. Dallas, Tex: American Heart Association; 2003.
3. Clinical Angiology: Guided / Ed. by A. V. Pokrovsky. In two volumes. "Medicine" Publishers, JSC, 2004. V.1. p. 758.
4. Davies M. J., Richardson P., Woolf N., Katz D., Mann J.. Risk of thrombosis in human atherosclerotic plaque: role of extracellular lipid, macrophages and smooth muscle cell content. Br Heart J 1993;69:377–381.
5. Orlandi G., Parenti G., Bertolucci A. Carotid plaque fetures on angiography and asymtomatic cerebral microembolism. Acta Neurol Scand 1997; 96: 183–6
6. I. E. Thymina, E. A. Burceva, N. D. Scuba, A. V. Pokrovsky, G. I. Kuntcevich. A comparison of the structure of atherosclerotic plaques in the carotid artery by complex ultrasound and histological studies. Ultrasound and functional diagnostics. No. 3, 200. p. 81-87. Ultrasound and Functional Diagnostics. Number 3, 200.81-87.
7. A. R. Zubarev, V. N. Fedorova, A. K. Demidova, etc. Ultrasound elastography as a new step in the differential diagnosis of thyroid nodules: Literature review and preliminary clinical data. //Medical Imaging 2010. v.1. p. 11.
8. Mazzone A. M., Urbani M. P., Picano E. et al. In vivo ultrasonic parametric imaging of carotid atherosclerotic plaque by videodensitometric technique // Angiology. 1995. V. 46. № 8. P. 663–672.
9. Schulte_Altedorneburg G., Droste D. W., Haas N. et al. Preoperative B_mode ultrasound plaque appearance compared with carotid endarterectomy specimen histology // Acta Neurol. Scand. 2000. V. 101. № 3. P. 188–194.
10. Ophir, J., Alam, S. K., Garra, B. S., Kallel, F., Konofagou, E. E., Krouskop, T., Merritt, C. R. B., Righetti, R., Souchon, R., Srinivasan, S. and Varghese, T.: Elastography: Imaging the Elastic Properties of Soft Tissues with Ultrasound. Journal of Med Ultrasound, Vol. 29, Winter, pp. 155-171, 2002. Invited Review Article.
11. Fung Y. C.: Biomechanical properties of living tissues, Ch. 7, Springer Verlag, NY, 1981
12. Biomechanics: Mechanical Properties of Living Tissues (2nd) (Hardcover) Author: Y. C. Fung, 2nd (1993-06-18), Publisher: Springer, 568 pages
13. de Korte C. L., van der Steen A. F., Cépedes E. I., Pasterkamp G., Carlier S. G., Mastik F., Schoneveld A. H., Serruys P. W., Bom N. Characterization of plaque components and vulnerability with intravascular ultrasound elastography. Phys Med Biol. 2000 Jun;45(6):1465-75.
14. Carlier S. G., de Korte C. L., Brusseau E., Schaar J. A., Serruys P. W., van der Steen A. F. Imaging of atherosclerosis. Elastography. J Cardiovasc Risk. 2002 Oct;9(5):237-45.
15. Reza Karimi, Ting Zhu, Brett E. Bouma, and Mohammad R. Kaazempur Mofrad. Estimation of Nonlinear Mechanical Properties of Vascular Tissues via Elastography Cardiovasc Eng. 2008 December; 8(4): 191–202.
16. Cai J., Hatsukami T. S., Ferguson M. S. et al (2005) In vivo quantitative measurement of intact fibrous cap and lipid-rich necrotic core size in atherosclerotic carotid plaque: comparison of highresolution, contrast-enhanced magnetic resonance imaging and histology. Circulation 112:3437–3444
17. Cappendijk V. C., Cleutjens K. B. J. M., Kessels A. G. H. et al (2005) Assessment of human atherosclerotic carotid plaque components with multisequence MR imaging: initial experience. Radiology 234:487–492
18. Takaya N., Yuan C., Chu B. et al (2006) Association between carotid plaque characteristics and subsequent ischemic cerebrovascular events: a prospective assessment with MRI—initial results. Stroke 37:818–823
19. Maurice R. L., Soulez G., Giroux M. F., Cloutier G. (2008) Noninvasive vascular elastography for carotid artery characterization on subjects without previous history of atherosclerosis. Med Phys 35:3436–3443
20. H. M. Loree, B. J. Tobias, L. J. Gibson, R. D. Kamm, D M Small and R T Lee. Mechanical properties of model atherosclerotic lesion lipid pools. Arteriosclerosis, Thrombosis, and Vascular Biology.1994; 14: 230-234
21. Lee R. T., Grodzinsky A. J., Frank E. H., Kamm R. D., Schoen F. J. Structure-dependent dynamic mechanical behavior of fibrous caps from human atherosclerotic plaques. Circulation. 1991;83:1764-1770.

Getting it right!

Optimizing scan protocol, contrast administration and patient instruction for CT pulmonary angiography

Matthew Benbow [1], Cees Verlooij [2]

After myocardial infarction and cerebral stroke, pulmonary embolism (PE) is the third most common acute cardiovascular disease. In the United States 650,000 cases are reported per year and pulmonary embolism is responsible for 200,000 deaths per year. Blood can clot in vessels and form a thrombus. When a thrombus breaks off and travels with the bloodstream, it is called a thromboembolism.

Matthew Benbow

Cees Verlooij

Blood in the veins is more likely to clot, because of the slower flow and lower pressure compared to arteries. Usually a blood clot is formed in a deep vein in the legs, called DVT or Deep Venous Thrombosis. When a clot breaks free, it may enter the Inferior Vena Cava through the right heart and lodge in a pulmonary artery. There it can block the flow of blood to the lung tissue causing an infarction. The symptoms of PE are sudden chest pain and breathlessness. Large emboli may be lethal, particularly if left untreated. Risk factors include smoking, pregnancy, recent surgery, long bed rest, and long haul flights.

DIAGNOSTIC TESTS

Originally invasive catheter pulmonary angiography was the gold standard to diagnose PE. In search of noninvasive methods to evaluate patients with suspected PE, the results of the PIOPED (Prospective Investigation of Pulmonary Embolism Diagnosis) were published in 1990. The conclusion was that the Ventilation Q lung scan was an effective, noninvasive way to diagnose or exclude the presence of acute PE. In 2006 the PIOPED II study was published, a prospective, multicenter study to investigate the diagnostic accuracy of CT Angiography for diagnosing acute PE. This study showed that CTPA had a high sensitivity and specificity making it the preferred diagnostic test for acute PE. The development of the multislice in general and in particular over 64 row helical scanners has increased this high sensitivity and specificity even more. The Wells Score is a series of clinical tests that clinicians can use at the bedside to suggest the increased likelihood of symptoms being as a result of a PE.

Symptons	Points
Clinical signs and symptoms of DVT (min. swelling and pain when palpated)	3
PE more likely than alternative diagnosis	3
Heart rate > 100 bpm	1.5
Immobilization (at least 3 days) or surgery in previous 4 weeks	1.5
DTV or PE in history	1.5
Hemoptysis	1
Malignancy (till 6 months after last treatments or palliative)	1

Review: ≤ 4 points – PE unlikely;
> 4 points – PE likely (Wells, 2000)

Also, there is a blood test to diagnose thrombosis which is based on finding the D-dimer concentration. D-dimer is a fibrin degradation product (FDP), a protein in the blood when a blood clot is degraded by fibrinolysis. The D-dimer test can have false positive and false negative readings and the final diagnosis or exclusion of PE can therefore not be based on this test alone. Thus, patients presenting with suspected PE, the clinical probability of PE is first assessed using the Wells clinical prediction rule. If based on this prediction rule the presence of PE is unlikely, the D-dimer test is used for final rule out of PE. In case of a higher probability of PE (or a positive D-dimer test), a CTPA scan is typically performed.

CT TECHNIQUE

Once it has been decided that the patient should have a CT scan as a test to detect PE, it is essential that all the parameters are chosen in such a way that the results are optimal and at the lowest possible dose. The patient is placed supine, feet first on the couch. An 18 gauge cannula is placed in the ante-cubital vein, preferably on the right side because of the shorter route. The scan direction is cranio-caudal. The majority of emboli are located in the lower lobes and because of this phenomenon it is often recommended to scan in the caudo-cranial direction.

[1] *Royal Bournemouth Hospital, UK*

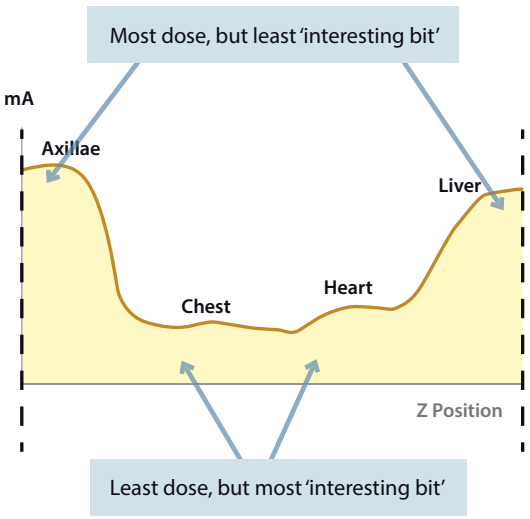
[2] *TMSE, Zoetermeer, Netherlands*

This was also done to prevent image quality issues when the patient started breathing at the end of the scan. The very fast scan times and an optimal contrast timing justify the cranio-caudal scan direction. The images are reconstructed with three different WW/WL defaults: 400/50 for mediastinum; 1300/-500 for lung parenchyma and 700/150 for detecting emboli. The Aquilion ONE allows scanning in a helical mode and a Wide Volume mode. The Wide Volume mode does not give direct benefits unless dual or triple rule out imaging is desired. Therefore helical scan using 80 rows of 0.5 mm is the best option in terms of scan time and patient dose. Routinely patients are scanned with 100 kVp and patients with a low BMI can be scanned with 80 kVp. Iterative reconstruction (AIDR 3D) is integrated in the automatic exposure control (SUREExposure) and used for all patients. The scan is performed with 0.5 s rotation speed and a fast pitch (1:1.39) resulting in a total scan time of app. 3 seconds.

DOSE CONSIDERATIONS

The use of 80 kVp and 100 kVp results in lower CTDIvol values and lower patient doses. SUREExposure is optimized to obtain sufficient image quality to evaluate the CTPA examination. A target SD value of 20 for 5 mm reconstructions is a good choice. Based on the attenuation values of the two scanograms, the target SD and the fact that the system knows iterative reconstruction is used, the mA will drop to low values. Minimizing the scan range is an efficient way of reducing the total DLP. According to Dr. N.S. Paul limiting the range from the aortic arch to the base of the right ventricle 'results in a significant saving in radiation dose and does not miss any significant findings'. (Paul, 2012)

The benefit of this technique is that the areas of the chest not exposed are also those that would require the highest doses, i.e. through the shoulders to image the lung apices, or through the upper abdomen to image the lung bases.



CONTRAST TIMING

The ideal examination will have optimal filling of the pulmonary circulation with not too much enhancement in the superior vena cava, because of high density streak artefacts. The left atrium and the left ventricle should be slightly enhanced to know for certain that the contrast has passed the entire pulmonary system. The nephrotoxicity should also be taken into account so the amount of contrast should be as low as possible. SUREStart is Toshiba's bolus triggering software that will measure the HU until the set threshold is reached, starting the helical scan. To save dose the measurement can be set to intermittent, choosing the delay. For CTPA intermittent 1 second intervals are selected. Because of this method the uncertain factor of cardiac output of the patient is accounted for. A ROI is set in the pulmonary trunk and a target of 150 HU, absolute value. Accurate timing like this can generate problems. Since we are dealing with the small circulation here the following scenario is a realistic possibility: the contrast arrives, the threshold is reached, the breathing command is given (4 seconds), the table moves and the scan is done. In the meanwhile the contrast is in the aorta and the pulmonary circulation is empty. To prevent this scenario it is not uncommon that hospitals prolong the injection duration by administration of 100 ml contrast agent or even more. Since the goal is to decrease the amount of contrast another approach is clearly needed. A part of SUREStart is the voice delay. This is set to 5 seconds resulting in the breathing command already given 5 second after injection start and during SUREStart. Once the threshold is reached the scan will start within 1 second while the patient is already holding his breath. The voice delay is also helping to avoid Valsalva which is covered elsewhere in this article.

WHAT CAN GO WRONG?

Valsalva is one of the main reasons of a failed CT Angio examination. It is named after the Italian physician and anatomist Antonio Maria Valsalva (1666-1723). He described the method to test the patency of the Eustachian tube or to expel pus from the middle ear. The maneuver is to force expiration while the nose is pinched resulting in a blocked airway. This is the same method performed in an airplane to clear the ears when the pressure changes. Patients will do this when they take a (too) deep breath. In an attempt to endure intra-thoracic pressure will build up preventing the contrast to flow into the right atrium. There will be enough contrast in the pulmonary trunk to let the bolus triggering start the actual scan, but the rest of the contrast will be stuck in the Superior Vena Cava and the pulmonary system will be empty.
Another pitfall can be the so-called 'transient interruption of contrast'. When the patient breathes in as deep as possible, the diaphragm will cause a decreased intra-thoracic pressure and simultaneously an increased abdominal pressure. This pressure drags the blood

from the Superior Vena Cava, filled with contrast, but also blood without contrast from the Inferior Vena Cava, diluting the contrast. The larger the inspiration, the larger the influence of the dilution will become. (Gosselin MV, 2004). To avoid Valsalva we utilize the Voice Timing Tool in the SUREStart software and set the delay time to 2-5 seconds. This means that 2-5 seconds after the start of the bolus triggering and the start of contrast injection the patient is already asked to hold his breath. Meanwhile the bolus triggering is still measuring the HU in the pulmonary trunk. As soon as the threshold is reached (the pulmonary trunk is filled with contrast) the Helical scan will start immediately. To prevent Valsalva even further the patient is asked to take a breath in with an open mouth, because doing so it is very difficult to build up pressure in the thoracic cavity. To avoid 'transient interruption of contrast' a voice command is recorded, asking the patient to take a small breath in.

THE CONTRAST INJECTION

Nephrotoxicity is a major concern in all CT Angio procedures and it is directly related to increasing volumes of contrast agent. The total amount of contrast should be lower than 50 ml. The use of Iterative reconstruction (AIDR 3D) allows 80 kV and 100 kV scanning in the majority of examinations. The use of 80 kV and 100 kV results in a much higher contrast enhancement in the vessels. Simply said: with the same amount and flow of contrast, much brighter enhancement of the arteries is obtained. Or to get the same enhancement, the total amount of contrast and flow can be reduced. If an Iodine Flux of 1.5 gI/s is maintained the volume and flow can be adjusted according to the patient weight. The concentration of the contrast in mgI/ml is also important. For CTA we advise a concentration of 350 mgI/ml. Higher is possible, but not really needed. Viscosity plays a role in nephrotoxicity and therefore contrast agents with a low viscosity should be used. The total scan time is around 3 seconds and combined with the breath hold in the bolus triggering and the fast start of the scan when reaching the threshold a contrast injection of 30 ml is sufficient. This is enough to fill the right side of the heart and the pulmonary arteries. The left atrium has just minor enhancement as proof that the contrast has passed the small circulation. The saline flush will take care that the enhancement in the vena cava superior is not so high that streak artefacts will obscure the evaluation of the pulmonary arteries. A saline flush (25 ml at the same flow as the contrast) will ensure that the contrast bolus is tight resulting in maximum enhancement.

WHAT ABOUT REALLY CHALLENGING SITUATIONS?

Breath-holding issues

For a significant number of CTPA studies there can be problems to overcome that can raise the risk of an under enhanced and therefore non-diagnostic study. Patients may for example be extremely breathless and unable to hold their breath. In this situation the effort of them trying to hold may raise the likelihood of Valsalva. Also, during the scan they may fail the breath-hold resulting in detrimental movement. Other patients may not be able to hold due to lack of understanding. Confusion, dementia, learning disabilities, children or patients unable to communicate due to language barriers could all be in this category.

Poor cardiac output

For some patients their circulation is poor and their hearts are enlarged. The result of this can be slow transit of contrast through the lungs, with the bolus getting lengthened and weakened. Contrast may stagnate in the superior vena cava and right heart and therefore not cause optimal enhancement in the pulmonary arteries.

Poor renal function

Contrast Induced Nephropathy (CIN) is a risk to patients undergoing CTPA who have reduced renal function (*The Royal College of Radiologists, 2015*). However, the seriousness of the condition cannot be ignored and often the test needs to go ahead regardless. Reducing the contrast volume used is certainly beneficial in these situations and shorter scan times allow this to happen. Occasionally it is necessary to rule out a PE in a pregnant patient and the contrast load is of course shared by the fetus, so keeping it low is again advantageous.

THE SOLUTION

The Aquilion ONE offers a technique that can address all of the above issues and thereby increase the success rate of CTPA in these difficult situations. It involves using a free-breathing, fast rotation, low kVp single rotation technique. A single volume (usually 16cm for an adult) is positioned from above the arch to below the heart. The bolus triggering SUREStart slice is positioned mid-volume, i.e. through the level of the main pulmonary arteries. The patient is informed that they should lie still and breathe gently. All automatic breathing instructions are switched off. An injection protocol with a saline chase is used, particularly important where a poor cardiac output is suspected. A breathless patient with a large heart seen on the scanogram may raise this suspicion. The saline will help to push the contrast bolus through the right heart and limit it from diluting. The scanner rotation time should be at the minimum which is 0.35 seconds for the Aquilion ONE and 0.275 for the Aquilion ONE ViSION. The kVp should be kept as low as the scanner will allow whilst still achieving enough mAs for the desired SUREExposure image quality. For most patients this will be 80 kVp, but 100 kVp on larger patients. 120 kVp should never be needed. Due to the increased enhancement offered at lower kVps, the contrast volume should be kVp dependent. For 350 strength contrast media, this needs only to be 30 ml for 80 kVp. The increased enhancement at lower kVp

also allows the flow rates to be kept at only 3 ml/sec. This allows narrower gauge cannulae to be used in patients with problematic veins.

The scan is triggered manually with a 1 second intermittent SUREStart slice acquisition when contrast is seen to fill the pulmonary arteries. As there are no breathing instructions the single rotation scan will occur almost instantaneously. The result is an examination with perfect contrast timing. The whole examination requires just one rotation of the tube so detrimental patient movement is unlikely. If however the patient coughs just at the wrong time, a further option is always available. The acquired dataset can be retrospectively reconstructed with 180° of data, i.e. half reconstruction. In this way the temporal resolution will be halved, reducing unwanted patient movement. The temporal resolution of the whole examination is reduced to just 175 ms for the Aquilion ONE and 137.5 ms for the Aquilion ViSION, though there will be a small increase in image noise.

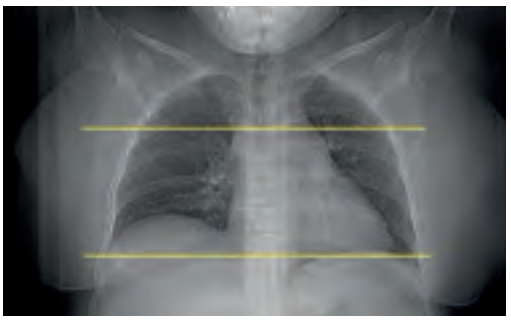
This technique can also be used when the examinations fails due to reasons mentioned before. Repeating the scan without knowing the cause might fail again. The free-breathing-one-rotation scan will eliminate all the elements jeopardizing the scan and will lead to a successful result.

Clinical example (Case 1: courtesy Royal Bournemouth Hospital)

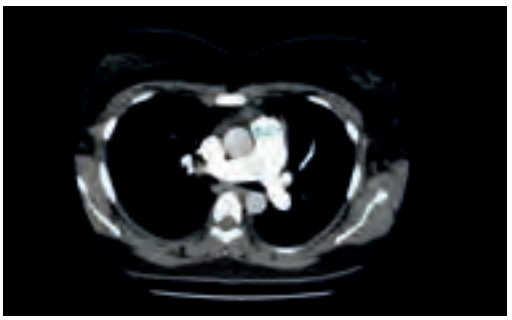
Relatively large 36 year old female with pleuritic chest pain, shortness of breath and a positive Wells score and D-dimer. Due to her age and breathlessness a decision was made to perform a free-breathing volume CTPA. It was performed at 80 kVp, 0.275 second rotation with 30 ml contrast media. Images of the coverage obtained and a selection of the resultant scans are shown below. The enhancement of the pulmonary arteries was measured at 565 HU. The dose for the volume scan was 99.2 mGy.cm DLP

Scan Mode	Collimation	Pitch	kVp	mAs	Rotation Time (s)	Scan Range (mm)	Dose Reduction	CTDIvol (mGy)	DLP (mGy.cm)	Effective Dose (mSv)	k
Volume	0.5 mm x 320	N/A	80	SUREExposure	0.275	160	AIDR 3D Standard	6.2	99.2	1.39	0.014

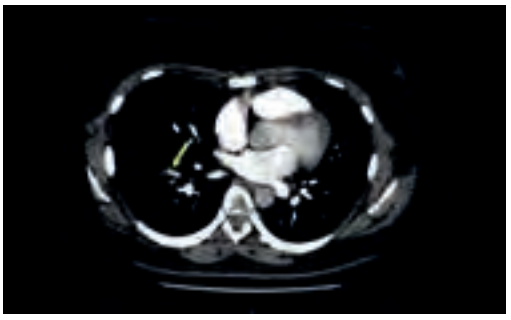
Contrast	Concentration (mgI/ml)	Volume (ml)	Injection speed (ml/s)	Iodine Flux (gI/s)	Injection Time (s)	Iodine Dose (g)
Niopam	370	30	3.0	1.1	10.0	11

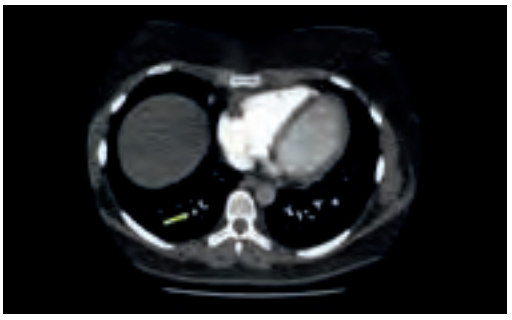


16 cm coverage achieved



>560 HU measured in the PAs





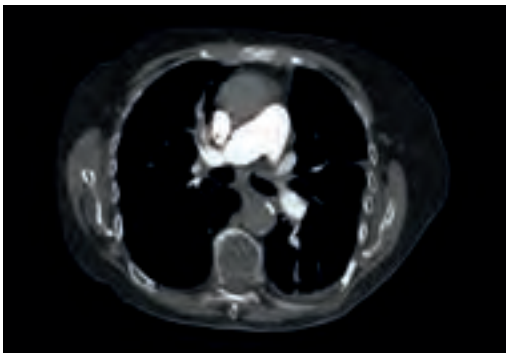
Report: "There are segmental emboli within the lower lobe of the right lung"

Clinical Example (Case 2: Courtesy Danderyd Sjukhus, Sweden)

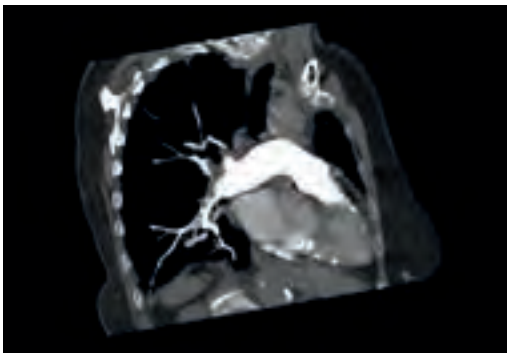
Average built 85 year old female with clinical suspicion of pulmonary embolism. Despite her age she was capable to lay on her back and hold her breath. The patient was scanned using a Helical acquisition with a high pitch. Only 30 ml of low density contrast was given. The voice timing was set to 5 seconds after the start of the injection, resulting in the patient holding her breath already before the start of the Helical scan. Measured enhancement in the pulmonary arteries was 575 HU. The total dose –including bolus triggering- was 177.2 mGy.cm

Scan Mode	Collimation	Pitch	kVp	mAs	Rotation Time (s)	Scan Range (mm)	Dose Reduction	CTDIvol (mGy)	DLP (mGy.cm)	Effective Dose (mSv)	k
Volume	0.5 mm x 80	Fast	100	SUREExposure	0.5	228	AIDR 3D Standard	5.6	164	2.29	0.014

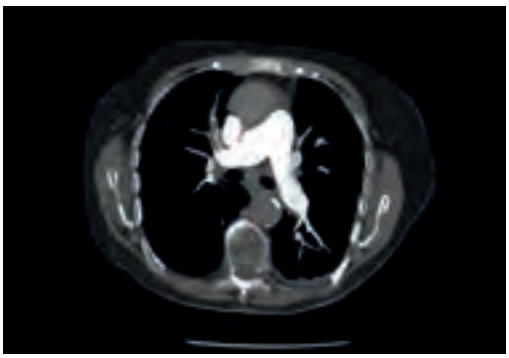
Contrast	Concentration (mgI/ml)	Volume (ml)	Injection speed (ml/s)	Iodine Flux (gI/s)	Injection Time (s)	Iodine Dose (g)
Iomeron	300	30	5.0	1.5	6.0	9



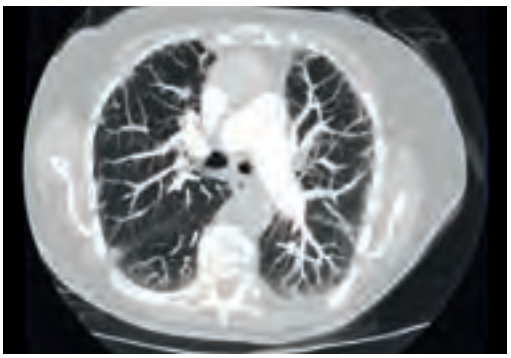
Axial 3 mm MIP with emboli



Curved 7 mm MIP showing extend of PE



Axial 7 mm MIP overview



10 mm axial MIP in lung setting

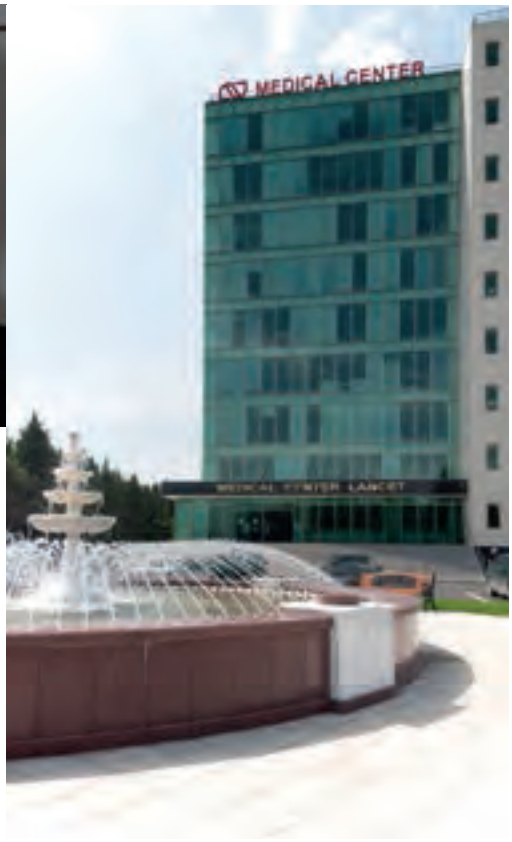
References

- Bae, K. (2010). Intravenous contrast medium administration and scan timing at CT: considerations and approaches . Radiology, 32-61.
- Daniel F. Worsley, A. A. (1995). Comprehensive Analysis of the Results of the PIOPED study. J Nucl Med, 2380-2387.
- Gosselin MV, R. U. (2004). Contrast dynamics during CT pulmonary angiogram: analysis of an inspiration associated artifact. J thorac Imaging, 1-7.
- Mortimer AM, S. R. (2011). Use of expiratory CT pulmonary angiogrpahy to reduce inspiration and breath-hold assosiated artefact: contrast dynamics and implications for scan protocol. Clin Radiology, 1159-1166.
- Paul, N. (2012). Dose reduction in CT pulmonary angiography: is it safe to limit scan coverage? ECR Scientific session B-0277. Vienna.
- Prokop, M. G. (2002). Spiral and Multislice Computed Tomography of the Body. Thieme Medical Publishers, Inc.
- The Royal College of Radiologists. Standards for intravascular contrast agent administration to adult patients, third edition. London: The Royal College of Radiologists, 2015
- Wells, P. (2000). Derivation of a simple clinical model to categorize patients probability of pulmonary embolism: increasing the models utility with the SimpliRED D-dimer. Thomb Haemost, 416-20.
- Wittram, C. (2004). CT Angiography of Pulmonary Embolism: Diagnostic Criteria and Causes of Misdiagnosis. Radiographics, 1219-1238.
- Wittram, C. Y. (2007). Transient interruption of contrast on CT pulmonary angiography: proof of mechanism. J Thorac Imaging, 125-129.
- Wolf SJ, M. T. (2004). Prospective validation of Wells Criteria in the evaluation of patients with suspected pumonary embolism. Ann Emerg Med, 503-10.

Providing Next Generation Healthcare in Georgia

Lancet Medical Center is a multidisciplinary hospital that offers high-level medical facilities from a brand new campus in Tbilisi, Georgia. The hospital is located in a ten storey building and has a capacity of 200 beds. Its design meets all European standards, but is also tailored to the needs and comfort of patients and staff. Furthermore it provides high-level care throughout the Caucasus Region and has developed a healthcare model which extends its competence and capacity to surrounding regions. The Medical Center works with a full range of Toshiba's medical diagnostic imaging equipment.

Joe Cavanaugh, Director of the Representative Office of Toshiba Medical Systems in Georgia



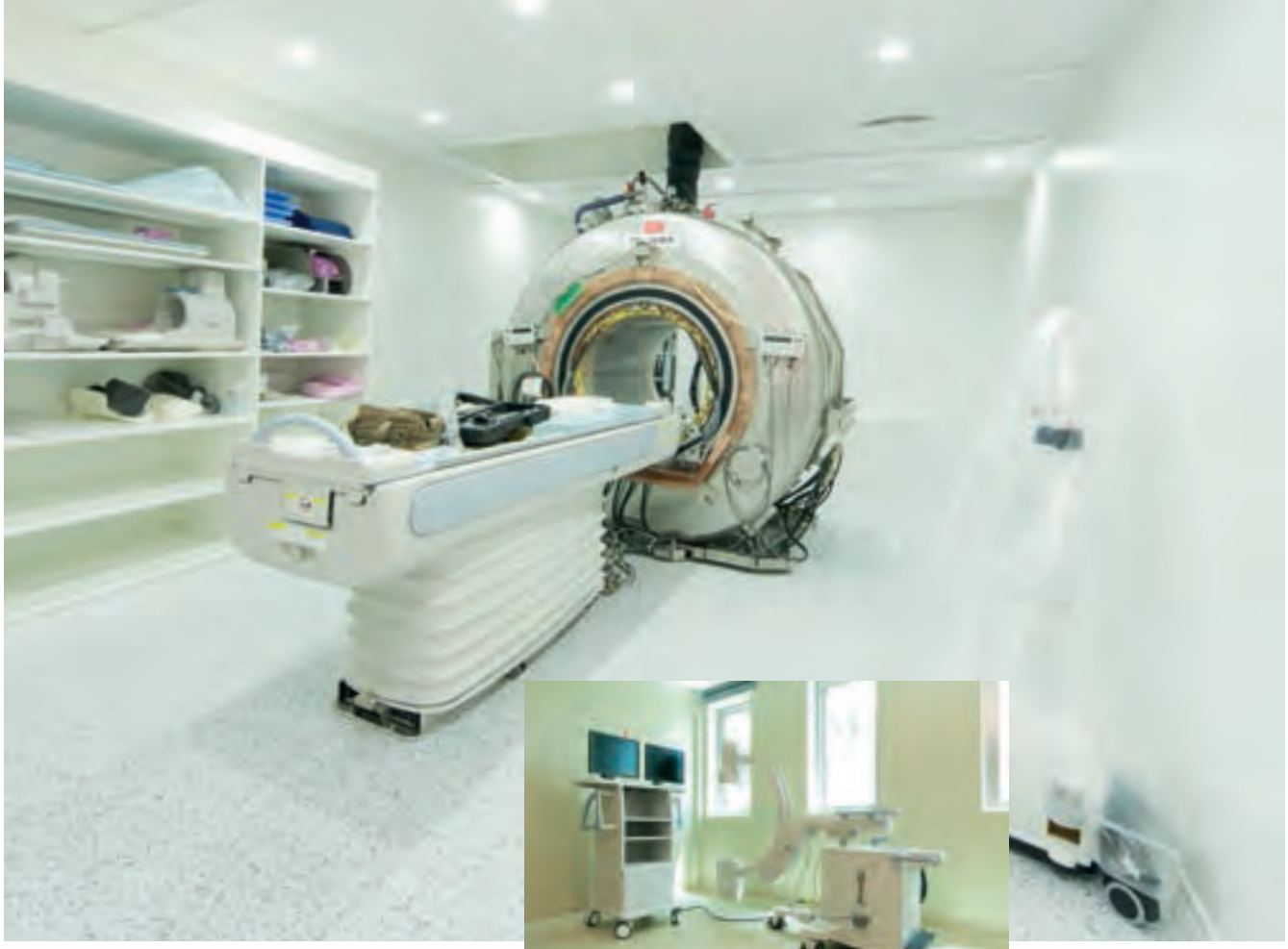
Lancet Medical Center

A healthcare project of this size is unprecedented in the Caucasus Region and an excellent example of the professional collaboration between Toshiba and the local distributor, TMD. TMD was awarded the contract to provide all medical diagnostic imaging equipment for the Medical Center, including CT, MR, Ultrasound and X-Ray equipment following a public tender process. TMD was involved from an early stage in the development of the new facility.

"Toshiba's state-of-the-art technology was a major advantage in equipping the Lancet Medical Center," remarked Joe Cavanaugh. "We were able to provide the Medical Center with the latest technology available on the market. In addition, Toshiba's outstanding reputation in reliability and maintenance contributed to establishing an excellent relationship with the hospital. The support of our colleagues in the European Head Office of Toshiba Medical Systems was invaluable."

Tekla Gvantseladze, co-director at TMD, explains the benefits of the Toshiba systems.
"Toshiba's Infinix-i angiography system enables the cardiologists at the Medical Center to visualize the heart and surrounding anatomical structures with an image quality that they have never been able to achieve before," she said. "Toshiba's flexible Raffine remote-controlled DRF system provides general radiographic and fluoroscopic imaging for the hospital."

Tekla Gvantseladze and Mariam Kavtuashvili



Installation of Toshiba's Titan MRI system

Besides the X-ray systems, the hospital also has a Toshiba Aquilion PRIME volume CT scanner and Toshiba's Titan MRI system.

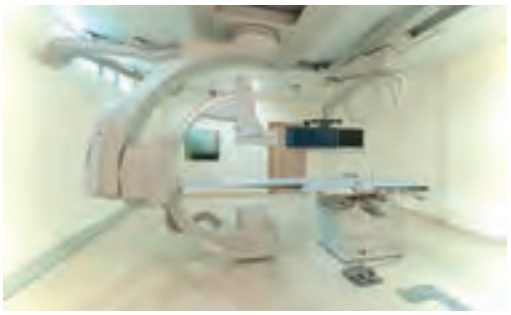
"AIDR 3D, Toshiba's innovative dose saving feature, ensures that high-quality images are routinely acquired with lowest possible patient dose, enabling the best possible diagnosis," explained Tekla. "This makes the Aquilion PRIME a perfect volume CT scanner in this modern and dose-conscious hospital. The large 60 cm bore in combination with the brilliant image quality of the Toshiba Vantage Titan make this the system of choice for the Lancet Medical Center. Many patients aren't familiar with MRI examinations. The large bore virtually eliminates claustrophobia, but there is no compromise in image quality."

Mariam Kavtuashvili, further explains how Toshiba's ultrasound systems complete the Medical Center's range of Toshiba products, systems and technologies to provide optimal diagnostic capabilities.

"The ultrasound systems in the Lancet Medical Center cover all anatomical regions," she said. "The Toshiba Xario, Aplio and Viamo systems are located in specialized departments. This decentralized approach contributes to the comfort of patients and staff. The different configurations offer great mobility if required, but guarantee at the same time maximum diagnostic possibilities."

According to Joe, this Medical Center will serve as a great tool in advancing the quality of medical practices in Georgia and the region and thereby improving the quality of life of the people.

The Toshiba Clearscope mobile C-arm bring excellent fluoroscopy to the surgery theatre in the facilities of Medical Center Lancet



Interventional angiography procedures will be carried out by using the state-of-the-art Toshiba Infinix VC-i with 30 x 40 cm FPD

Radiography & fluoroscopy examinations are performed on the Toshiba Raffine remote controlled digital RF system with integrated FPD and a portable FPD in the vertical Bucky stand

Clinical Experience with 4D Ortho Application

Dynamic CT Post Processing of the Musculoskeletal System

Pedro Augusto Gondim Teixeira MD, PhD [1], Alain Blum MD, PhD [1]

Pedro Augusto Gondim Teixeira MD

Alain Blum MD

[1] Service d'Imagerie Guilloz, CHU-Nancy, France

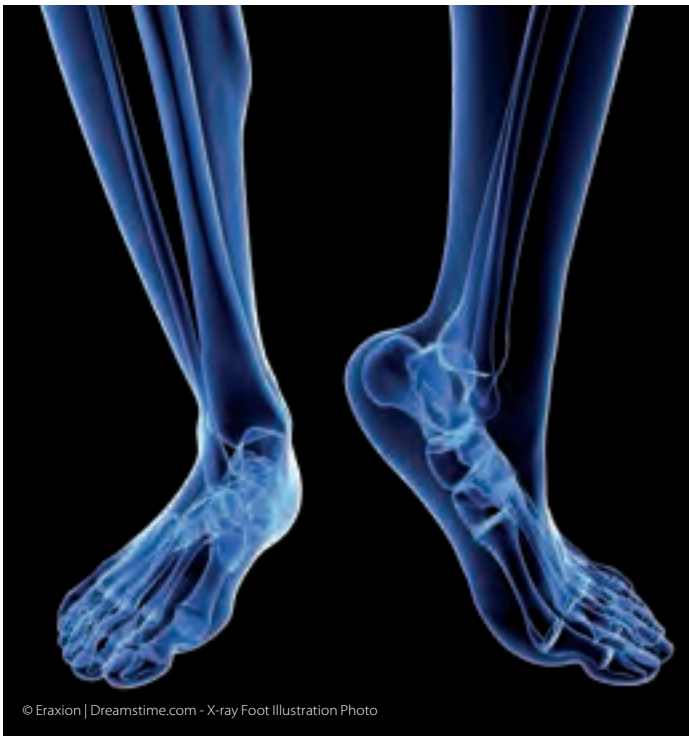
Motion is frequently involved in the pathogenesis of musculoskeletal diseases. With static imaging methods, the diagnosis of dynamic pathology (e.g. friction and impingement syndromes) is based on secondary findings only[1]. This fact and the frequency of these conditions underscore the importance of dynamic imaging modalities in the evaluation of musculoskeletal diseases. Wide area-detector CT is suited to dynamic study of joints, allowing volumetric study of bone and intra-articular ligaments during physiologic motion or under stress maneuvers.

Dynamic CT is complementary to other dynamic methods, helping overcome some of their limitations, such as evaluation of bony and intra-articular structures with ultrasound or superimposition of structures on fluoroscopy[2]. Dynamic CT is most frequently used for the evaluation of the wrist, but can be used on various joints (shoulder, hip, elbow, knee, and ankle)[3-5].

Up until now, the analysis of dynamic CT images was mostly subjective. Without specific tools quantitative analysis is time consuming and poorly reproducible, since measurement points must be selected manually on each acquisition volume (e.g. eight to ten per maneuver). Although subjective analysis of dynamic data is helpful in individual cases, developing general diagnostic criteria and scientific evaluation of the diagnostic performance with this method are hampered by the absence of quantitative data.

When performing musculoskeletal dynamic studies, a single motion or maneuver should be imaged per acquisition to avoid parasite motion (e.g. accessory motion distinct from target motion), which can complicate image interpretation. Parasite motion can be reduced by patient training and appropriate immobilization during acquisition, but complete suppression is difficult to achieve. When significant parasite motion is present, motion of one bone has to be evaluated relative to other moving structures, which may lead to diagnostic errors and makes the learning curve for the analysis of dynamic CT studies particularly long.

The 4D-Ortho application has two features that greatly improve analysis of dynamic joint studies by limiting the impact of subjectivity and parasite motion. Firstly, distance and angular measurements throughout



© Eraxion | Dreamstime.com - X-ray Foot Illustration Photo

the motion cycle can be obtained semi-automatically. Secondly, all motion can be displayed with respect to a given bone, which remains fixed or locked. Preliminary clinical testing of the 4D-Ortho tool is presented below.

BASIC PRINCIPLES

Musculoskeletal dynamic CT is performed by acquiring multiple, low-dose volumes of the target zone during motion. The 4D-Ortho application is based on the

registration of each individual bone of the body part examined in all the acquired volumes. This is possible because, regardless of their respective position, bones are non-deformable structures. Once this process is completed, any point of any bone can be found automatically in all acquisition volumes.

4D-Ortho works as follows: All the volumes of a given dynamic acquisition are loaded. Multiplanar and a 3-D volume rendered images are displayed. Time controls allow the examiner to browse the images from all the volumes acquired. The examiner may then select a bone to be locked by placing a seed point anywhere within its medullary cavity (Fig. 1). Any bone can be selected - the target bone may vary depending on the evaluated pathology or the maneuver performed. After processing, all motion is displayed with respect to the locked bone, greatly reducing the influence of parasite motion.
Independently of the bone locking procedure, distances and angles can be measured with 4D-Ortho. The points selected for the measurement are plotted automatically to all volumes, increasing measurement reproducibility and greatly reducing post-processing time. To measure a distance, the volume that depicts the greatest distance between the points to be measured must be selected. Then, using multiplanar and/or volume rendered reformats, the points to be measured are selected. The selected point must be placed in the cortical bone near the bone surface, as opposed to the medullary cavity. Processing is launched, and once completed, the distances between the selected points throughout the motion cycle are displayed in a graphic (Fig. 2). The same procedure is applicable for angular measurements. By selecting two points within a bone and two points in another, two lines are created. The angle between these two lines can be measured automatically in all acquisition volumes (Fig. 3).

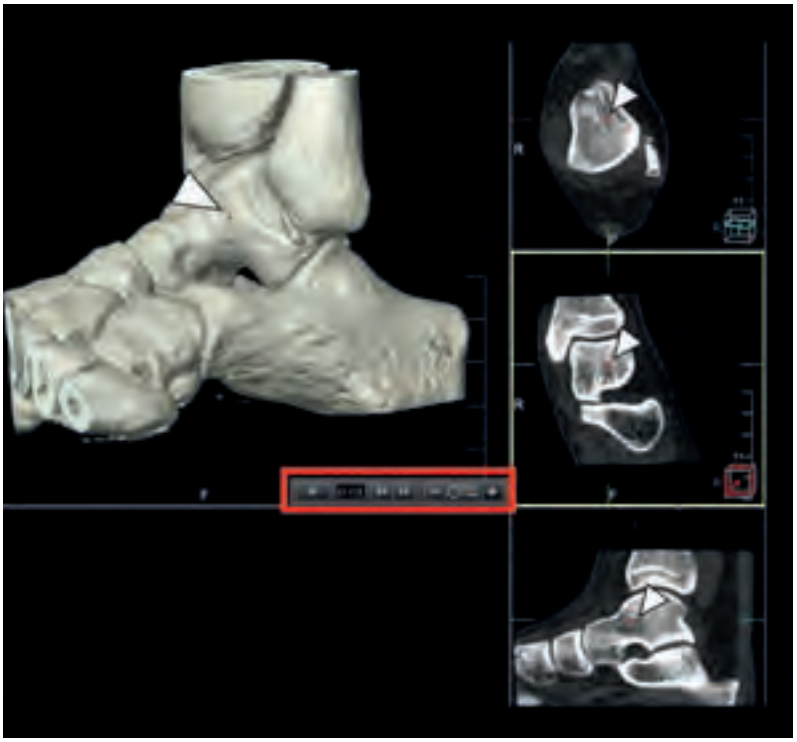


Figure 1: Bone locking procedure. A seed is placed in the medullary cavity of the bone to be locked (arrowheads). Position can be checked in both volume rendered and multiplanar images. Note the time controls (red square) allow browsing through all the volumes loaded.

CLINICAL EXPERIENCE

Since 2008, dynamic CT has been performed in our institution for the evaluation of musculoskeletal diseases. Wrist and ankle dynamic CT studies performed routinely were post-processed using the 4D-Ortho application. A total of ten studies were included in this analysis. All studies were performed with a 320 detector-row CT scanner (Aquilion ONE™, Toshiba Medical Systems, Otawara, Japan) using intermittent acquisition mode with a one second inter-volume interval. Acquisition lasted 8 to 12 seconds. Tube output parameters were adapted to patient anatomy[2]. In the wrist, radio-ulnar deviation was performed and in the ankle, prono-supination of the foot.

Bone locking was possible in all cases and improved visual analysis markedly, by reducing the influence of through-plane motion. In our opinion, the use of a static reference for motion analysis allows a better appreciation of the amplitude of the target motion and improves the analysis of each individual moving bone.

Distance and angular measurements were feasible in all patients allowing quantitative analysis of clinical data. Measurement post processing may fail if the selected points are within areas of prominent motion artefacts, which should be avoided by optimal patient training and immobilization.

DISCUSSION AND CONCLUSION

4D-Ortho was successfully used in the evaluation of clinical data, offering reproducible, semi-automatic measurements of distances and angles. Musculoskeletal dynamic CT is a relatively new technique and its clinical application is just beginning. Quantitative analysis is of great importance for the dissemination of this technique, since it facilitates the establishment of general diagnostic criteria that currently remain absent in literature. Clinical studies are currently being performed with the aid of 4D-ortho application in normal and pathologic patients, to assess normal and pathologic variation of distances and angles during different types of motion and in different joints.

Despite the importance of quantification in musculoskeletal dynamic CT, subjective analysis remains paramount for the interpretation of these studies. Visual understanding of motion paths and bone relations is important for diagnosis and may shed new light into the physiopathology of musculoskeletal diseases. In complex joints, such as the wrist, multiple carpal bones move with

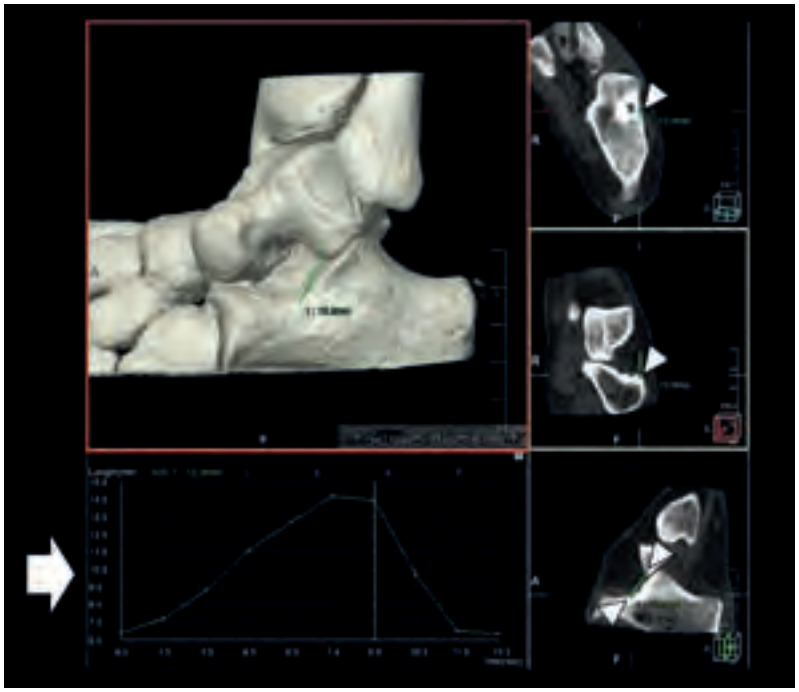


Figure 2: Two-point distance measurement with 4D-Ortho application during subtalar joint prono-supination. Two points are placed in the volume that shows the largest distance between the points to be evaluated (red square). The exact location of the selected points is displayed on the multiplanar images (arrowheads). Note that the points are located in the cortical bone and not in the medullary cavity. After post processing, the graphic on the lower right shows the distance variation (arrow).

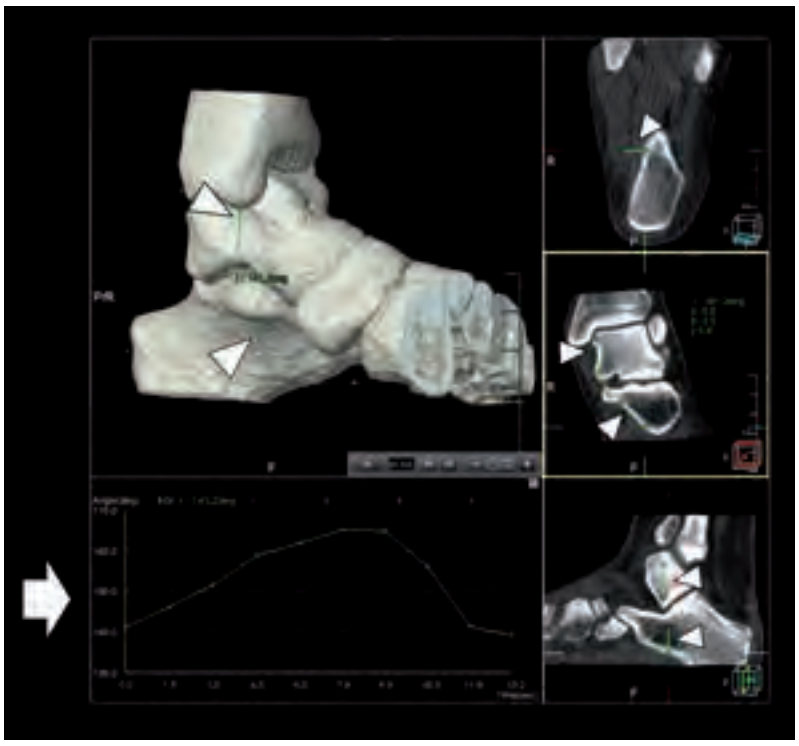


Figure 3: Four-point angular measurement with 4D-Ortho application during subtalar joint prono-supination. Two points are placed in two different bones, in this case the talus and the calcaneus. The selected points are shown both in the volume rendered and multiplanar images. Two lines intersecting the selected points are seen (arrowheads). After post processing, the graphic on the lower right shows the variation in the angle between these two lines (arrow).

respect to each other, adding to the complexity of the analysis. Bone locking improves visual analysis of dynamic data, making it easier to appreciate fine motion and bone displacement.

In conclusion, 4D-Ortho represents a major development in the post processing of musculoskeletal dynamic CT. This application has the potential to improve diagnostic performance and reproducibility of musculoskeletal dynamic CT, playing an important role in the clinical application of this technique.

CT FUNCTIONAL SUITE - CAPTURE HUMAN MOTION

The wide 16 cm z-axis coverage provided by the Aquilion ONE™ and Aquilion ONE /ViSION Edition makes these systems ideal for capturing motion and flow with true dynamic volume acquisition. Toshiba offers a wide range of advanced applications to facilitate both qualitative and quantitative functional analysis for more accurate diagnosis and treatment planning.

4D ORTHOPEDIC ANALYSIS

Patients who suffer from pain during movement in a variety of everyday activities often have no obvious structural abnormalities. Dynamic volume scanning is able to capture the often complex mechanical abnormalities responsible for the patient's symptoms. The 4D Orthopedic Analysis application enables superior visualization and quantification of joint motion to more accurately identify any abnormalities.

Bibliography

1. Guillin R, Marchand AJ, Roux A, Niederberger E, Duvauferrier R. Imaging of snapping phenomena. Br J Radiol. 2012 Oct;85(1018):1343–53.
2. Gondim Teixeira PA, Gervaise A, Louis M, Lecocq S, Raymond A, Aptel S. Musculoskeletal Wide detector CT: Principles, Techniques and Applications in Clinical Practice and Research. European Journal of Radiology. 2015 (in press);
3. Wassilew GI, Janz V, Heller MO, Tohtz S, Rogalla P, Hein P, et al. Real time visualization of femoroacetabular impingement and subluxation using 320-slice computed tomography. J Orthop Res. 2013 Feb;31(2):275–81.
4. Totterman S, Tamez-Pena J, Kwok E, Strang J, Smith J, Rubens D, et al. 3D visual presentation of shoulder joint motion. Stud Health Technol Inform. 1998;50:27–33.
5. Edirisinghe Y, Troupis JM, Patel M, Smith J, Crossett M. Dynamic motion analysis of dart throwers motion visualized through computerized tomography and calculation of the axis of rotation. J Hand Surg Eur Vol. 2014 May;39(4):364–72.

TOSHIBA
Leading Innovation

VISIONS

SPECIAL

Continuity, consistency and a lot more clinical power

The Aplio Platinum Edition

Continuity, consistency and a lot more clinical power *The Aplio Platinum Edition*

Increasing the speed and capacity of the core Aplio architecture enabled so many significant changes on this premium ultrasound platform that it arrives with a new name, the Aplio Platinum Edition. The new Aplio improves the existing functionalities of the high-end systems, dramatically enhances image quality, increases diagnostic confidence and further streamlines workflow. With the new hardware come new capabilities as Toshiba introduces an advanced Doppler algorithm called Superb Microvascular Imaging (SMI) and expands its suite for elastography with the addition of Shear Wave Elastography (SWE).

High Density Beamforming

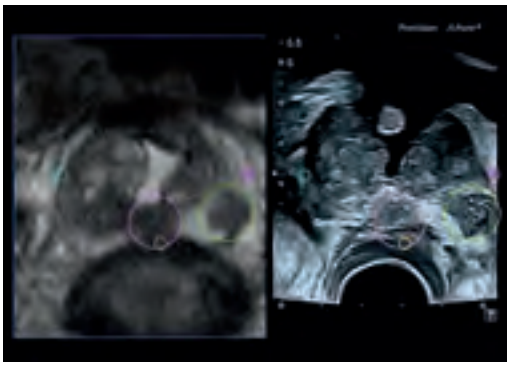

Realtime Aplication


iStyle

HD Rendering

"The Aplio Platinum Series is an evolution within the Aplio family, consistent with the revolutionary architecture and continues Toshiba's legacy of innovative solutions," said Dr. Joerg Schlegel, Senior Manager, Product Marketing at Toshiba Medical Systems.

"With the Premium Edition we are expanding the power of the Aplio in particular into innovative and growing fields of ultrasound applications such as comprehensive liver diagnostics with our unique SWE Smart Map approach, advanced prostate diagnostics with our



MR-US fusion of the prostate with marked targets

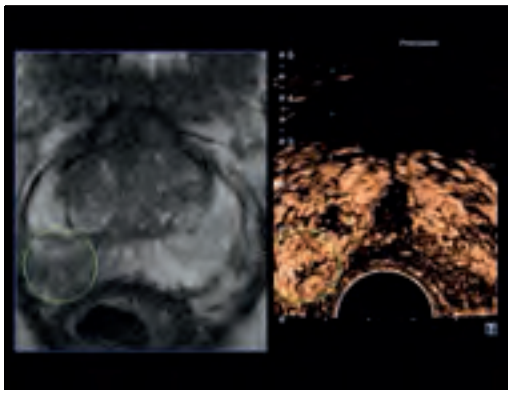
Smart Fusion for MR-US fusion-guided biopsy solutions, gynecological diagnostics with our Fly Thru technology for ultrasound hysteroscopy and musculoskeletal diagnostics with our SMI for assessing inflammation, just to give some examples," explains Dr. Christoph Simm,

Prof. Dr. Thomas Fischer
Radiological Institute at Charité Hospital, Berlin

"In summary SMI constitutes a novel and promising technique for visualizing microcirculation. In particular, SMI provided relevant information that allowed the evaluation of small lesions, subcutaneous masses and structure in the region of the scar."

Adrian Lim, M.D.,
Consultant Radiologist and Adjunct Professor at Imperial College and Chief of Ultrasound at Charing Cross Hospital, London

"The innovative features of the new Aplio bring significant changes. Grayscale imaging particularly stands out with very nice homogenous images and crisp margins."



MR-CEUS fusion of the prostate: rapid enhancement of suspected tumor area

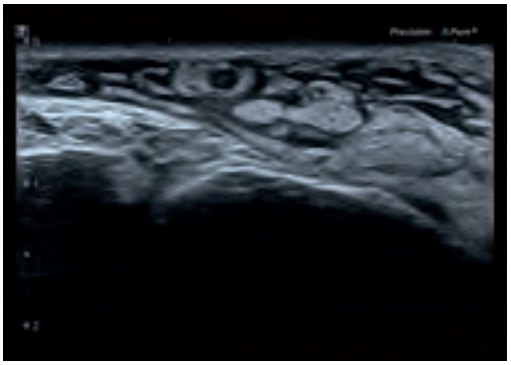
Toshiba's Senior Manager of the European Ultrasound Group, "These developments with clear focus on clinical outcomes will drive the continuation of the great success of the Aplio platform in the market."

Along with the release of the new Aplio, Toshiba has also introduced four new probes, including the world's first wideband single crystal transducer created with a new composition of piezoelectric crystals and tissue matching technology to provide an increased bandwidth, a better signal-to-noise ratio and improved axial resolution and penetration.

The first experiences with Aplio Platinum won praise from a cohort of leading clinicians who applied the new capabilities to advanced investigations as well as clinical routine. Six leading physicians presented their findings on the impact of enhanced features of the new platform through a series of case studies for specific clinical applications, as well as during a roundtable discussion where they shared experiences.

Prof. Dr. Thomas Fischer from the Radiological Institute at Charité Hospital in Berlin said, "The dramatic increase in image quality, Doppler sensitivity and Fly Thru rendering accuracy and speed lead to the question of whether there are clinical advantages with all the new tools of this very advanced system. Having worked with the system for almost a year I can say that this new technology helps us in many, many ways to enhance confidence and throughput."

According to Adrian Lim, M.D., Consultant Radiologist and Adjunct Professor at Imperial College and Chief of Ultrasound at Charing Cross Hospital, both in London, "Every time a new technique or technology comes along one needs to ask if it is something useful or just a toy. The innovative features of the new Aplio bring significant changes. Grayscale imaging particularly stands out with very nice homogenous images and crisp margins."



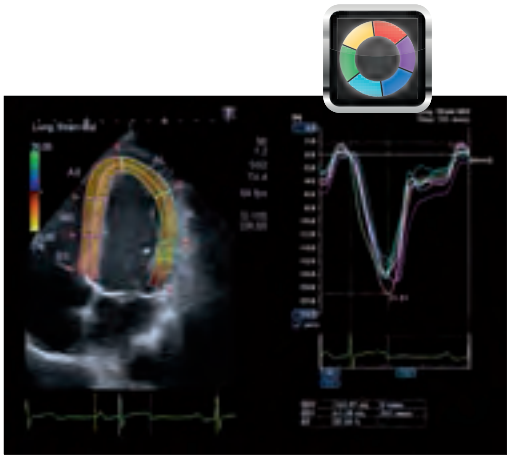
Cobblestone oedema

An author on 142 published papers, Leopoldo Peréz de Isla, M.D., explores advanced echocardiographic measures to establish reference values at the Cardiovascular Institute of the Hospital Clínico San Carlos in Madrid, Spain.

"I need a system with a very high temporal resolution and I need a fast system," he said. "I can't use a system where I have to push a lot of buttons and wait a long time. This is the first system that works very fast to analyze a complete left ventricle using Wall Motion Tracking in a very accurate way."

Accelerated processing across the Aplio architecture was seen to deliver a variety of clinical benefits, speeding up the responsiveness of functionalities and thereby improving productivity and workflow.

Toshiba's unique Fly Thru technology is just that much faster in rendering large data volumes. Smart Fusion now manages multiple data sets from CT and MRI. Differential



Left ventricle

Tissue Harmonics Imaging has stepped up to a new generation while 3D multi-planar reconstruction has been refined. Thanks to boosted processing, Toshiba Precision Imaging and Precision+ have entered a new dimension with 3D volume capabilities.

All clinicians shared an appreciation of the enhanced image quality, citing outstandingly smooth images with significantly sharpened outlines, enhanced uniformity and reduced clutter.

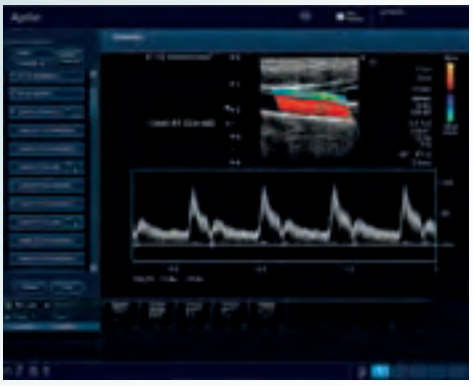
Delivering more information with accelerated processing in an intuitive, easy to understand display, Aplio Platinum builds diagnostic confidence and helps physicians avoid the need for supplementary exams.

Leopoldo Peréz de Isla, M.D., Cardiovascular Institute of the Hospital Clínico San Carlos, Madrid

"This is the first system that works very fast to analyze a complete left ventricle using Wall Motion Tracking in a very accurate way."

Aplio's fully programmable console adjusts to your needs.

Quick Start adjusts all clinical settings at the touch of a button.



Quick Assist protocols help you ensure consistency.

Ergonomic with a fully customizable console, this advanced system saves time and expense, enhancing departmental productivity.

SIMPLY SUPERB MICROVASCULAR IMAGING

One of the most stunning additions to the Aplio platform that was introduced with the new release is the enhanced Superb Microvascular Imaging (SMI) capability. An intelligent imaging tool, SMI moves beyond conventional color Doppler technology by applying a unique algorithm allowing visualization of small vessels with low velocity, while maintaining high resolution, minimal motion artefacts and high frame rates.

"SMI ensures vascular imaging with outstanding detectability for low-velocity blood flows, even in studies performed without the use of a contrast medium," said Jiro Hata, Ph.D., MD, from the Clinical Pathology and Laboratory Medicine Department and Professor at the Kawasaki Medical School in Okayama, Japan. "This technique is of great value for early diagnosis and treatment planning in patients with cancer, tumors, rheumatoid arthritis and many other medical conditions."

The principle underlying SMI is a powerful and intelligent algorithm that effectively separates flow signals from overlaying tissue motion artefacts, preserving even the subtlest low-flow components with unmatched detail and definition. SMI analyzes clutter motion and uses a new adaptive algorithm to identify and remove tissue motion and reveal true blood flow.

SMI is available in two modes, grayscale and color. The color mode displays B-mode and color information simultaneously, while the grayscale mode focuses only on the vasculature by subtracting the background information, improving sensitivity.

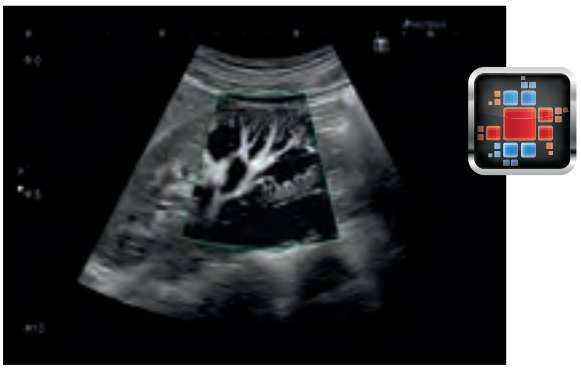
According to Dr. Hata, SMI has demonstrated significant clinical value in the evaluation of the density and shape of tumor vessels, and the visualization of blood flow within superficial lesions is an excellent application of SMI.

In his investigation of the clinical utility of SMI for assessing musculoskeletal inflammation, Prof. Lim stated, "Our early experience with SMI shows that it has excellent depiction and fine detail of the microvasculature not seen with routine Doppler technology. With significantly increased sensitivity SMI has great potential to identify low-grade inflammation which was not possible previously. The improved diagnostic confidence with this technology would have a significant clinical impact and influence clinical management of patients."

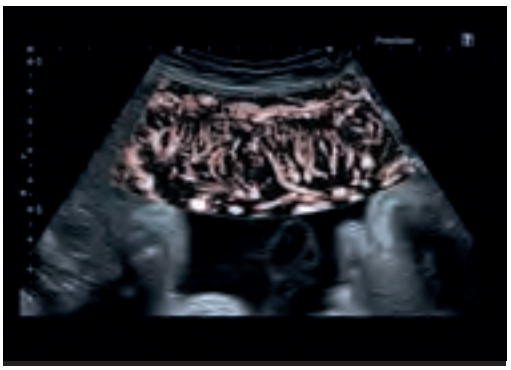
Comparing power Doppler to SMI in a study of 29 patients with low-grade inflammation of joints and tendons, Dr. Lim reported there were 16 patients where vascularity was only seen using SMI and the ability to assess the microvascularity led to a change in treatment management for 12 of those patients.

Applying SMI to an analysis of the microvascular tree in reactive and suspected malignant lymphadenopathy in advanced stages of malignant melanoma, Prof. Fischer wrote, "In summary SMI, which can be used with or without contrast agents, constitutes a novel and promising technique for visualizing microcirculation. In particular, SMI provided relevant information that allowed the evaluation of small lesions, subcutaneous masses and structure in the region of the scar." He underlined SMI's potential for assessing carcinomas and scanning lymph nodes.

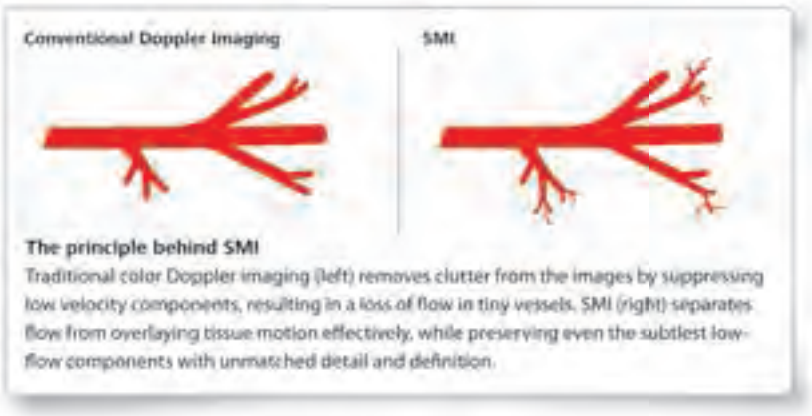
SMI can be used in combination with contrast-enhanced ultrasound (CEUS) to further enhance sensitivity and accuracy in examinations. Yet a significant clinical contribution would be the possibility for diagnostic assessments using SMI without CEUS.

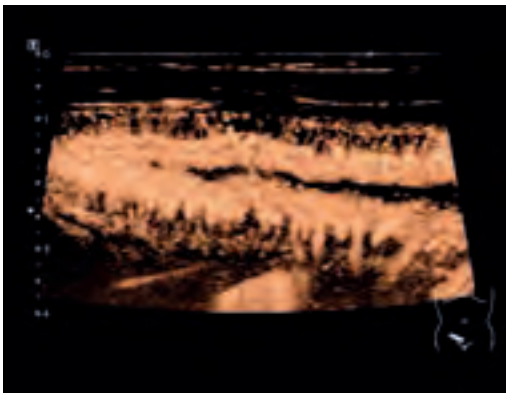


Kidney perfusion

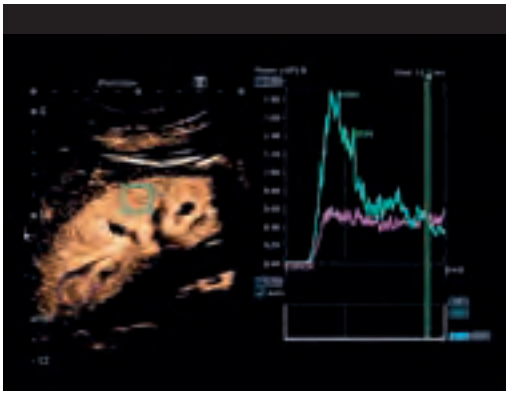


Placenta at 15 weeks





Crohn's disease



Renal cell carcinoma

In a roundtable discussion, Prof. Lim told colleagues, "The combination of SMI with contrast is very powerful. Yet many times we have asked in clinical routine if we can avoid using contrast, because of the time and expense. And we are finding occasions where we really can do so, using SMI with images that are not distorted, that are normal and patterned. I would very much like to see this as a comparative study."

While contrast-enhanced ultrasound increases the detectability of blood flow, it does have a number of drawbacks in that CEUS is not readily available everywhere, it is subject to certain restrictions regarding contrast agent use and it places an additional cost burden. SMI is a perfect tool helping clinicians to overcome these drawbacks.

NEW CHAPTER IN VASCULAR STUDIES

After delivering their conclusions on diverse applications for Superb Microvascular Imaging (SMI) with the Aplio Platinum Series, three physicians arrived at a similar opinion regarding the potential this new capability presents for expanding an understanding of blood circulation in microvessels.

The Head of Ultrasound at the Academic Teaching Hospital in Düren, Germany, Dr. Horst Kinkel, utilized SMI in conjunction with several probes, including a new laparoscopic transducer.

In an assessment of the liver, he stated, "When I switch on SMI, I can be very sure of my diagnosis. Even without contrast there is a better result than with conventional Doppler. With SMI I can see small vessels that were not visible before, so we will probably have to write a new chapter in the book."

In presenting his findings from studies, Prof. Fischer came to a similar conclusion and added "Because we see much, much more of vascularity with SMI, such high, brilliant contrast with edges like we have never seen before, we actually have to learn how to interpret these images in order to understand."

Dr. Horst Kinkel,
Head of Ultrasound at the Academic Teaching Hospital, Düren

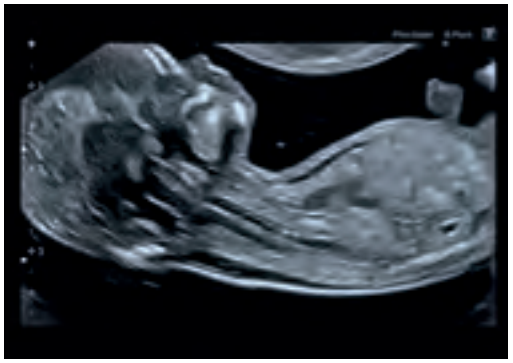
"When I switch on SMI, I can be very sure of my diagnosis. Even without contrast there is a better result than with conventional Doppler. With SMI I can see small vessels that were not visible before, so we will probably have to write a new chapter in the book."

Jader Cruz, M.D.,
leading specialist in fetal medicine and obstetrician at Centro Hospitalar, Lisbon

"Normally you cannot see the heart of a fetus very well with 2D ultrasound, but now with SMI I can see the structures, a view of the four chambers, the vessels, everything. I can see the filling of the chambers, even the crossing of the vessels. Most impressive for me is to see the septum clearly, and as I sweep down I can see the aorta coming out. This is amazing."

Jader Cruz, M.D., agrees. An obstetrician with the Centro Hospitalar in Lisbon and a leading authority in fetal medicine, Dr. Cruz said that with SMI, "We can see things we are not used to seeing. We are learning how to look at the images, to interpret them and asking how we can apply these assessments in the future."

In a unique application of Superb Microvascular Imaging, Dr. Cruz examined the microcirculation in the tiny hearts of fetuses at 12 weeks, saying he found the monochrome mode the most effective in this assessment. "While SMI was not developed for this exam, it works very well here because it removes the clutter in the ultrasound image. You cannot see these hearts very well with 2D ultrasound, but now with SMI I can see very well the structures, a view of the four chambers, the vessels, everything. I can see the filling of the chambers, even the crossing of the vessels. Most impressive for me is to see the septum clearly, and as I sweep down I can see the aorta coming out. This is amazing."



Fetus at 12 weeks

FLEXIBILITY WITH DUAL MODES FOR ELASTOGRAPHY

With the new Aplio Platinum Series Toshiba has created a veritable suite of tools and technologies for elastography, the assessment of tissue stiffness. The first module is the industry-leading technology for strain elastography offered on this platform, while the second module is Shear Wave Elastography (SWE).

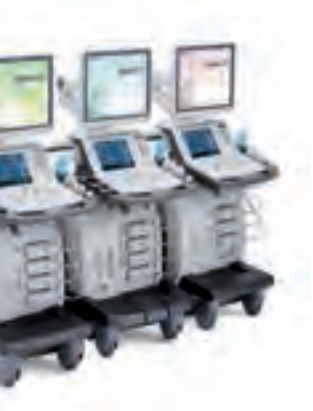
As the name implies, strain elastography depends on tissue compression to create a distortion that is measured as a ratio to calculate the stiffness of a suspected structure such as a lesion or a tumor. With SWE an acoustic impulse is generated by the transducer and sent into the tissue. The resulting shear waves travel at varying speeds through tissue, faster when the tissue is stiff, more slowly through softer tissue.

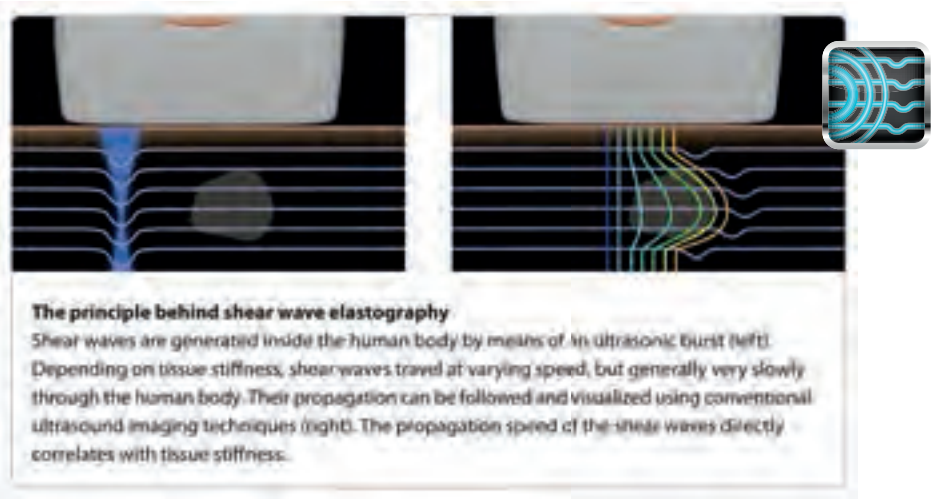
Uniquely on the Aplio Platinum Series clinicians can now choose between two modes for shear wave generation, utilizing either a single-shot mode or a multishot live mode.

The propagation of the waves can be both quantified and visualized. One display maps the speed of the shear wave in meters per second while a second display quantifies the stiffness of the targeted tissue in kilopascals. Unique to Toshiba is a third display that maps shear wave propagation.

According to Fuminori Moriyasu, M.D., Professor of Internal Medicine at Tokyo Medical University Hospital, Toshiba's SWE "allows the propagation velocities of shear waves to be quantified and mapped by including a display mode in which the shear waves' arrival times are shown as contour lines permitting the reliability of the acquired elastography information to be verified. For example, if distorted contour lines are observed in deep regions, it indicates reliable information cannot be obtained. By setting regions of interest of the desired size in the color map, the shear wave propagation velocity can be measured quantitatively."

"The Aplio Platinium Series is consistent with the revolutionary architecture and continues Toshiba's legacy of innovative solutions."

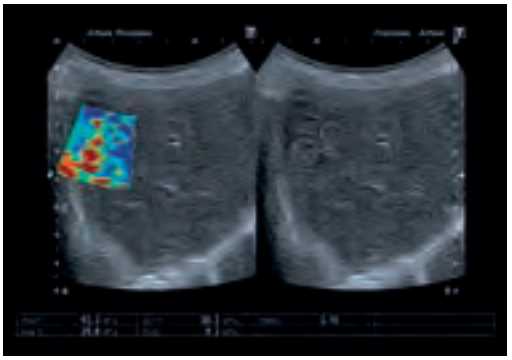




The principle behind shear wave elastography
Shear waves are generated inside the human body by means of an ultrasonic burst (left). Depending on tissue stiffness, shear waves travel at varying speed, but generally very slowly through the human body. Their propagation can be followed and visualized using conventional ultrasound imaging techniques (right). The propagation speed of the shear waves directly correlates with tissue stiffness.

The propagation map becomes a powerful and intuitive tool to visually assess the quality of an elastogram, said Christoph Simm, "Giving clinicians the ability to verify the quality of the acquisition can help them avoid unnecessary acquisitions and can lead to faster, more precise results."

Dr. Joerg Schlegel said the Toshiba elastography suite presents an optimal configuration for tissue and tumor assessments. SWE is ideal for evaluating liver disease, providing an operator-independent, non-invasive technique to monitor changes to tissue stiffness and assess a larger area of that organ, compared to invasive biopsies. Meanwhile strain elastography is the preferred choice for assessments of the breast and thyroid, in keeping with Guidelines and Recommendations by the European Federation of Societies for Ultrasound in Medicine and Biology (EFSUMB) on the Clinical Use of Ultrasound Elastography.



Liver metastasis

Fuminori Moriyasu, M.D.,
Professor of Internal Medicine at Tokyo Medical University Hospital, Tokyo

"Toshiba's Shear Wave Elastography allows the propagation velocities of shear waves to be quantified and mapped by including a display mode in which the shear waves' arrival times are shown as contour lines permitting the reliability of the acquired elastography information to be verified. By setting regions of interest of the desired size in the color map, the shear wave propagation velocity can be measured quantitatively."

As the Aplio will likely be a system used for shared services in hospitals and clinics the combination of both strain ratio and shear wave capabilities on a single system responds to the preferences of different operators, their respective experience, and the requirements of the pathology being examined.

REAL-TIME VERIFICATION OF PROBE CONTROL FOR STRAIN ELASTOGRAPHY

The strain elastography system has also been improved with the enhancements to the processing architecture on the new Aplio with a greater stability, higher resolution, a graphic quality indicator as well as more intuitive measurement displays at the user interface.

"In breast exams elastography has proven to be a very good tool to build diagnostic confidence and especially to upgrade the severity of lesions," notes Vito Cantisani, M.D., with the Department of Radiology at the hospital Umberto I in Rome and Professor of Radiology at the University of Rome, La Sapienza. He is also a key contributor on the use of strain elastography to assess thyroid lesions for EFSUMB recommendations for the Clinical Use of Ultrasound Elastography.

Vito Cantisani, M.D., Department of Radiology, hospital Umberto I, Rome, and Professor of Radiology at the University of Rome, La Sapienza

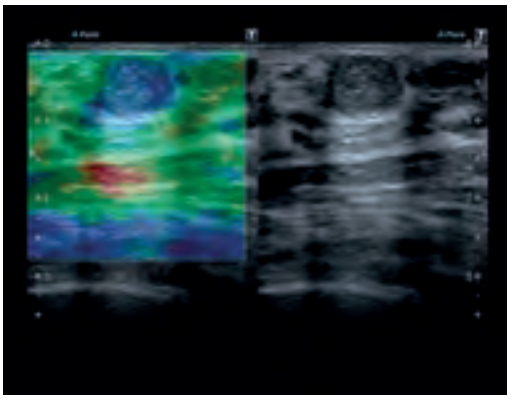
"Now we can check real time that we are doing a good compression with color values on the screen representing different aspects of probe control, and especially a linear red value verifying if you are applying the probe homogeneously."

In 2011 Prof. Cantisani noted that while elastography enables differentiation of thyroid lesions, the possibility to obtain quantitative data such as strain ratio and velocity ratio may help to achieve objective results.

"We were lacking something to indicate online that we are doing the right compression, a number that permits us to be more objective and to reduce intra- and interobserver variability," he said, adding that thyroid assessments with strain elastography can vary depending on the neck of the patient, the patient positioning during the exam and that patient's cooperation.

Throughout the summer Prof. Cantisani worked with new software developed for the Aplio 500 that enables verification of the strain compression.

" Now we can verify the compression in real-time with color values on the screen representing different aspects of probe control, and especially a linear red value verifying if you are applying the probe homogeneously."



Malignant breast lesion

According to Prof. Casani, at his hospital quantification of the compression parameters offers an additional benefit as teachng tool.

FLY THRU SOARS TO NEW HEIGHTS

Fly Thru is a stunning technology from Toshiba that lets a physician virtually dive into a volume data set to explore cavities, ducts and vessels from the inside and in three dimensions. Comparable to virtual endoscopy, Fly Thru adds cross-sectional ultrasound information to the plain surface data, making it an expert tool for exploring lesions and in-growing masses, as well as to assist in planning and follow-up of interventions such as placing stents or grafts.

Fly Thru technology is processing-intensive for the reconstruction and display of the complex 3D data acquisitions. On the Aplio 500 platform improvements include accelerated response speed and an immediate start-up with the touch of a button.

Bill Smith, M.D.
Head of Ultrasound Services at the privately-owned Clinical Diagnostic Services in London

"Toshiba offers a refinement in this area to assess the maturity of an egg and increase the likelihood of a pregnancy. With 4D Fly Thru we can see the cumulus mass, the fluffy material surrounding those eggs attached to the follicle, and then we can clearly see the mature, free-floating egg shedding the granulosa cells."

The Head of Ultrasound Services at the privately-owned Clinical Diagnostic Services in London, Bill Smith, M.D., said the diagnostic value and clinical impact of Fly Thru has made this technology an integral part of a gynecological ultrasound examination.

"Multi-planar reconstruction in four dimensions allows us to see adhesions far better, bringing a particular value for patient management," he said. "Fly Thru enables views of a polyp from different directions, clearly delineating further structures, such as a smaller polyp adjacent to the suspect polyp, emphasizing the degree of resolution obtained by this advanced technology."

A pioneer of the now well established clinical exam called saline infusion sonohysterography (SIS) to assess abnormal uterine bleedings, Smith said that 4D Fly Thru brings considerable credence to the technique, with obvious clinical benefits. It is now common practice to include SIS as a pre-requisite to in vitro fertilization (IVF) in order to exclude female infertility.

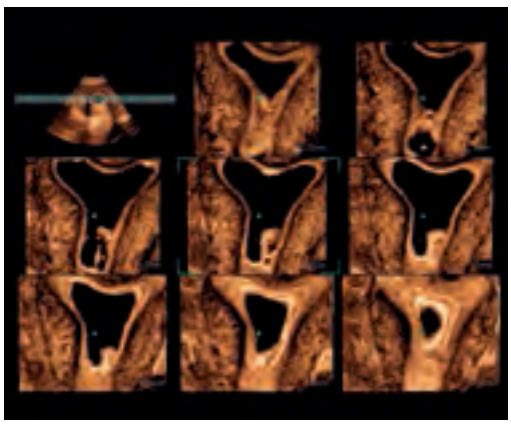
IVF is an important part of the work at Clinical Diagnostic Services, he said, and here as well the Aplio 500 is making a significant contribution, this time for assessing the potential for successful pregnancies.

"With the high resolution of the grayscale image, we can see the eggs in a follicle, but we can't be certain which egg is mature. Toshiba offers a refinement in this area to assess the maturity of an egg and increase the likelihood of a pregnancy. With 4D Fly Thru we can see the cumulus mass, the fluffy material surrounding those eggs attached to the follicle, and then we can clearly see the mature, free-floating egg shedding the granulosa cells."

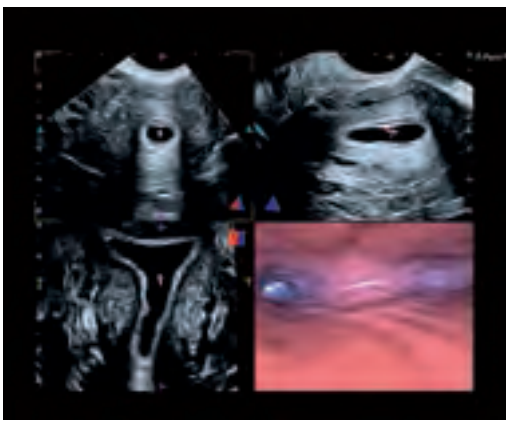
EXPANDED CAPABILITIES FOR SMART FUSION

Synchronizing real-time ultrasound imaging side-by-side with static views of anatomy from either CT or MR, Smart Fusion enables physicians to reliably locate hard-to-find lesions and improves confidence during ultrasound-guided interventional procedures.

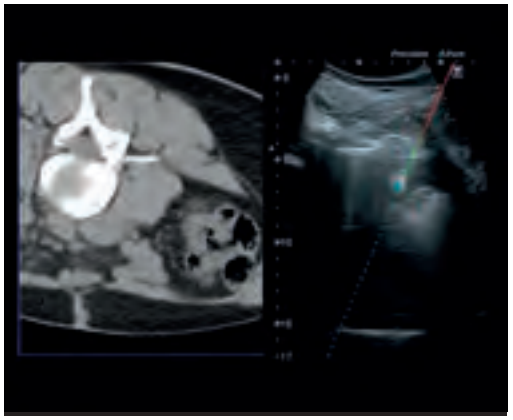
With its intuitive set-up, Smart Fusion from Toshiba is the easiest to use fusion on the market with a simple and



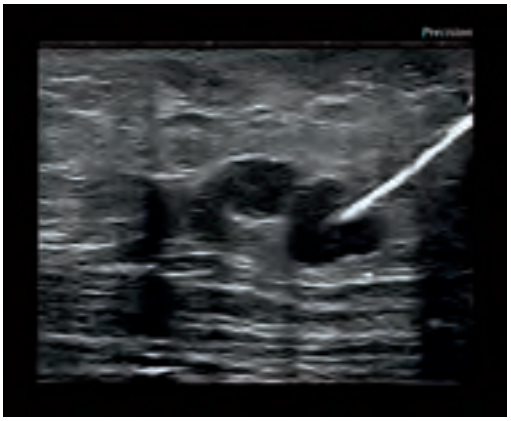
Uterine polyp



Interstitial tubal occlusion



Smart Navigation in liver lesion



Lymph node biopsy with BEAM

quick two-step process reading 3D DICOM data sets from all major imaging modalities. For a comprehensive pre- and post-interventional evaluation Toshiba's Smart Fusion works in many ultrasound imaging modes including color Doppler and contrast-enhanced ultrasound.

On the Aplio Platinum, enhancements to Smart Fusion include a capability to manage processing of multiple data sets from CT or MRI and improvements to image quality. For prostate exams, angle changes to the initial orientation of images are now easily made using an intuitive interface. Smart Fusion supports acquisitions from multiple transducers, now including the linear probe PLT-1005BT.

Significantly, multiple phase CT and MRI can be loaded without requiring a re-registration for the additional data sets. Clinicians also have full flexibility for sending image sets, utilizing an auto-send function, or specifying image sets of still images and video clips to be shared with researchers.

Moving beyond abdominal examinations, Dr. Fischer applied this innovative technology in a new technique combining contrast-enhanced ultrasound with 3D data sets acquired with computed tomography angiography (CTA) in following up patients with aortic dissection.

"Fly Thru reconstruction with the 3D CTA dataset provides an elegant alternative to CTA and magnetic resonance angiography of the aorta that is less invasive and more patient-friendly," he found, suggesting, "A potential positive consequence of utilizing CEUS with fusion technology is the possible cost efficiency when used as long-term follow-up on patients."

Dual Energy

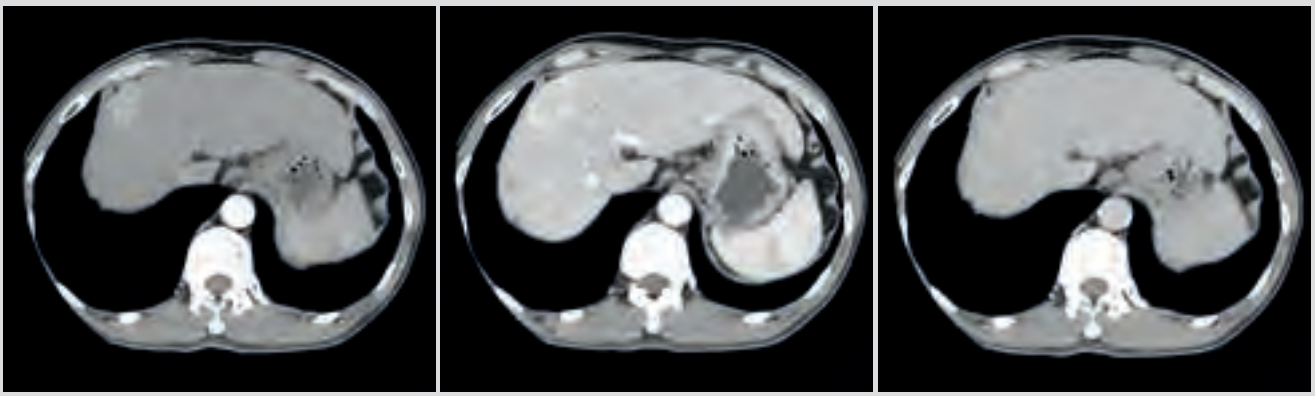
Dr S. Dong Cao [1)]

Dr. Shao Dong Coa

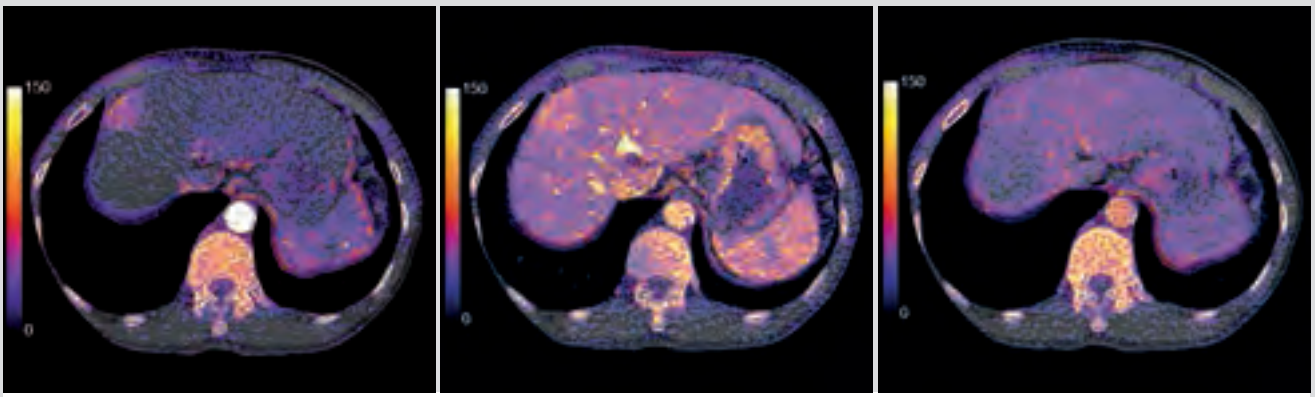
This 58 year old male presented with a liver lesion seen on prior imaging. A dual energy scan was performed to further characterize the lesion. Volumetric Dual Energy scans were performed following the injection of 80mls of contrast. Scans were performed during Arterial Phase, early Portal Phase and Delayed at 3mins. Monochromatic images, iodine maps and virtual non contrast images were generated for review.

	Scan Mode	Collimation	kVp	mAs	Rotation Time (s)	Scan Range (mm)	Dose Reduction	CTDIvol (mGy)	DLP (mGy.cm)	Effective Dose (mSv)	k
Arterial	Dual Energy	0.5mm x 320	80/135	SUREExposure 3D	0.5	160	AIDR 3D Standard	10.5	167.9	2.52	0.015
Early Portal	Dual Energy	0.5mm x 320	80/135	SUREExposure 3D	0.5	160	AIDR 3D Standard	10.5	167.9	2.52	0.015
3 min Delay	Dual Energy	0.5mm x 320	80/135	SUREExposure 3D	0.5	160	AIDR 3D Standard	10.5	167.9	2.52	0.015

Arterial Phase | Early Portal Phase | 3min Delay Phase

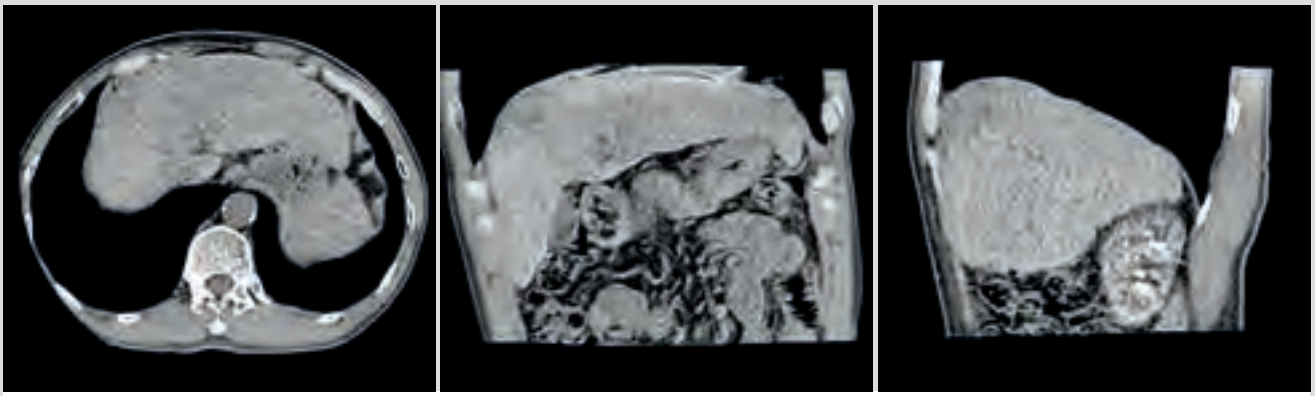


70keV Monochromatic Image



Iodine Map

[1)] *Harbin No 4 Hospital, China*



Virtual Non Contrast images generated in the early venous phase demonstrate lesion homogeneity

SUMMARY

The lesion demonstrates characteristics consistent with a Hepato-Cellular Carcinoma (HCC). These lesions have intense arterial enhancement, fast washout and then become homogeneous with normal liver. Raw data based dual energy provides high quality monochromatic images at 70keV which correspond to a routine 120kVp image allowing adjacent structures to be reviewed as usual. The iodine maps provide easy visualization and quantification of the lesion.

This case demonstrates that volumetric dual energy can be implemented into dedicated liver imaging protocols with good image quality in multiple phases at a reasonable radiation dose. Additional information is provided by the iodine maps.

What is dual energy?

CT imaging is based on the principle that various anatomical structures within the body attenuate X-rays differently. Unfortunately, structures with similar Hounsfield units (i.e. CT numbers) remain very difficult to differentiate from each other. However, structures that produce similar Hounsfield units at one beam energy may respond differently at a different beam energy. Dual energy scanning can increase the amount of information available from CT imaging. Iodine maps can be generated by analyzing images acquired at both high kVp and low kVp, providing functional information about tissue.

As said Dual-energy helical scanning alternates between high and low kV with each gantry rotation. Also the mA is automatically adjusted for the two different energies to ensure a matched signal-to- noise ratio which increases the accuracy of dual energy analysis. Also the tube exposure can be manually turned OFF in the upper 180 degree of the gantry rotation that would expose the ventral side of the patient and potentially more radiation sensitive areas such as breast tissue in females.

Virtual anatomy teaches real-world skills

Prof. Dr. F. Giesel [1)]

Prof. Dr. Frederik Giesel

Introducing medical students to 3D views of anatomy significantly increases diagnostic skills. To better prepare the next generation of physicians for practicing medicine in the Digital Age, the University of Heidelberg brought a CT scanner directly into the anatomy lab.

Now as first-year medical students explore a human body with surgical tools, they can look up to a 3D image of the same cadaver they are about to dissect. It is a real-time marriage of the physical specimen with its digital counterpart.

Increasingly, a radiology exam is the starting point for patient care in any healthcare system. And medical imaging plays an equally important role in monitoring patient treatment and predicting the outcome of that treatment. Skill and experience in evaluating radiology images is now part of the clinical routine for physicians. As the next-generation of students leave medical school to enter their chosen area of practice, they need to be able to correctly interpret radiological images.

Yet for most medical students there is a disconnect between the lab course where they handle human anatomy for dissection, and the radiology course where they learn to visualize the human body using flat, two-dimensional case studies.

In Heidelberg the idea of integrating the anatomy course with radiology instruction was proposed by Radiologist and Nuclear Medicine Physician Professor Doctor Frederik Giesel, M.D. and Dr. Sara Doll from the Department of Anatomy. "First-year student have no idea of how to begin a dissection or where they are going," he said. "Usually they learn by standing over a cadaver and opening it at certain sites. This is the way things have been done for 100 years. Now that CT imaging has moved into the class we can take a completely different approach. While the students begins at the surface and move through the muscle to the bones or the organs, they now have an anatomy map, a 3D image side-by-side. This changes this workflow. It allows them to better see and to enhance their understanding of the structures," said Frederik Giesel.

The introduction last year of a 16-slice Toshiba Aquilion CT scanner is the latest advance at the University of Heidelberg Medical School in its effort to bring clinical practice closer to students. Where traditionally students

[1)] *University Hospital Heidelberg, Germany*

are taught the basics and progressively build up their learning until they show they are ready to enter a real clinical setting, Dr Giesel said today the border between the pre-clinical setting and the clinic is become blurred. "We should not draw a line between the basic skills and the clinic," he stated. "More and more we need to introduce students to clinical experiences from the first year of studies. We need to connect the basics with the clinical implications of what we are teaching."

Beginning in 2007 the university offered to first- and second year students a course that combined studies of physical anatomy and with interactive, three dimensional (3D) radiology images, thanks to advanced post-processing capabilities. The software at this point was in-house developed by Dr Roland Unterhinninghofen, PhD from the Karlsruhe Institute of Technology.

A more advanced course is offered to students in their fourth and fifth years to improve their radiological diagnostic skills, specifically with a focus on visual-spatial ability, a key skill for correctly interpreting radiological images and successfully relating the findings to physical anatomy.*

In the first published study to evaluate the effectiveness for medical students of this advanced, hands-on radiology course, Doctor Fabian Rengier, M.D., and colleagues from the Radiology group at the Heidelberg University Hospital found an improvement of almost 40% in students' diagnostic skills.

While the study did not make a direct comparison with a control group of students, it is known that in the conventional approach of teaching interpretation skills by case-based learning using preselected 2D Images improved such skills by around 15%. According to the study authors, "the integration of interactive 3D image post-processing software into undergraduate radiology education effectively improves radiological reasoning, diagnostic skills and confidence as well as visual-spatial ability." Learning how to view the same anatomical information from multiple perspectives and correlating 2D with 3D information is a skill students retain beyond the course work.

The authors noted that the improved ability to understand the spatial relations among structures shown in 3D was also associated with improving diagnostic skills across all radiology modalities, including those not taught in the seminars. As a result, medical students felt better prepared for every day clinical practice. In an earlier study, the same authors gathered self-evaluations from students of the benefit of the first-year introductory course for virtual anatomy. Originally a pilot program, the course has since become mandatory.

An improved appreciation of 3D spatial relations and the possibility to correlate anatomical knowledge from the gross anatomy lab with radiological imaging were most often mentioned advantages of the course. As future physicians entering an increasingly digital age of medicine, the students appreciated the interactivity features of the software and the degree of independence they found in the work of combining axial source data with multiplanar two- and three-dimensional visualizations.

The Heidelberg faculty is unique in Europe for offering virtual anatomy, noting that the increasing availability of web-based software for 3D volume imaging may help to expand this type of training. They believe that such courses, most especially focused on improving visual-spatial skills would be of benefit throughout a student's education, from undergraduate to post-graduate levels.

* The course and the software development of AnatomyMap has been generously supported by Klaus-Tschira-Stiftung, Heidelberg

https://www.youtube.com/watch?v=7XRj1dJUwwU

PUREViSION in Clinical Practice

Dr R. Bull [1)]

Dr R. Bull

The first clinical Aquilion ONE Next Generation was installed at our institution in November 2013. This incorporated a completely new detector system: the PUREViSION. The PUREViSION detector is now installed as standard on all new Toshiba Aquilion CT systems from 16 detector rows upwards.

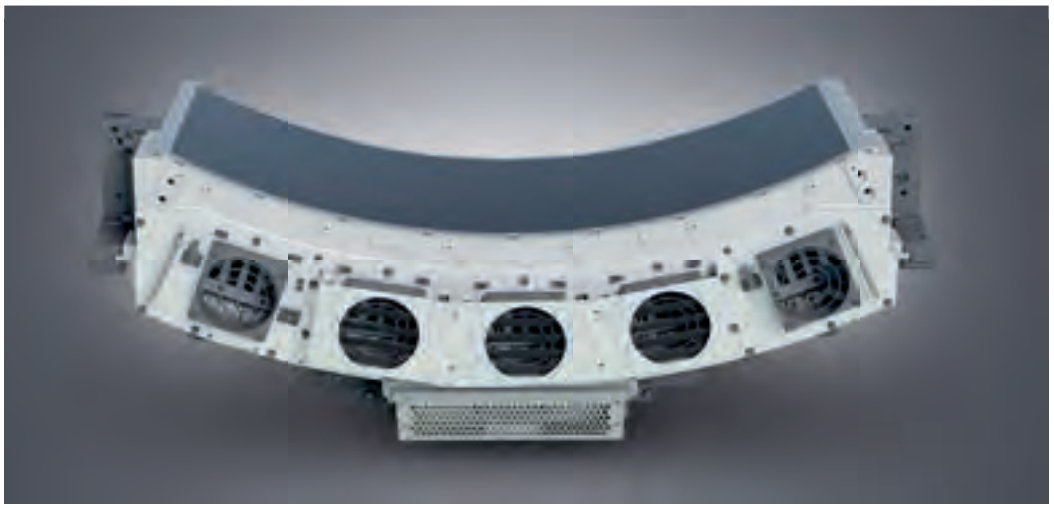


Figure 1: PUREViSION Detector with Praeseodymium activated scintillator (superior luminescent properties), 40% increase in light transmission to the photodiode, and 28% decrease in DAS noise (miniaturization of integrated circuit board).

PUREVISION REDUCES RADIATION DOSE

Two independent audits were performed at our institution in summer 2013 and autumn 2014 as part of National British Society of Cardiovascular Imaging (BSCI) cardiac CT dose audits (Fig. 2).

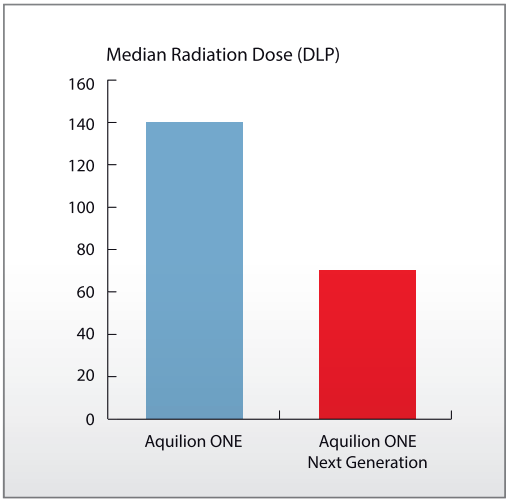


Figure 2: Median Radiation Doses for Aquilion ONE and Aquilion ONE Next Generation with PUREViSION detector.

Our scanners involved in these dose audits were the Aquilion ONE™ and the Aquilion ONE Next Generation, respectively. All consecutive patients were included for both audits with no exclusions. Rotation time (0.35s), median BMI (27), median acquisition heart rate (56bpm) and image noise were identical in both groups. Iterative reconstruction (AIDR 3D) was used in all patients. Median DLP on the Aquilion ONE Next Generation with PUREViSION (Fig. 1) was 77.5 (1.08mSv) compared with a median DLP of 98.8 (1.38mSv) on our previous Aquilion ONE. This represents an impressive 44% radiation dose reduction due to the improved efficiency of the PUREViSION detector. Typical patients now receive sub-millisievert radiation doses with excellent image quality (Fig. 3). The very high efficiency of the PUREViSION detector now also allows us to scan extreme bariatric patients with good image quality using low doses of radiation (Fig. 4).

PUREVISION REDUCES IODINE DOSE

Low kVp scanning generates low energy photos which are intensely absorbed by iodine due to the 'k' edge effect. This allows for equivalent enhancement to be obtained using much lower doses of iodine compared with conventional 120 kVp scanning. Low kVp scanning

[1)] *Royal Bournemouth Hospital, United Kingdom*

Figure 3: CT Coronary Angiogram. BMI 26. Critical LAD stenosis (arrowed). Dose 0.8 mSv

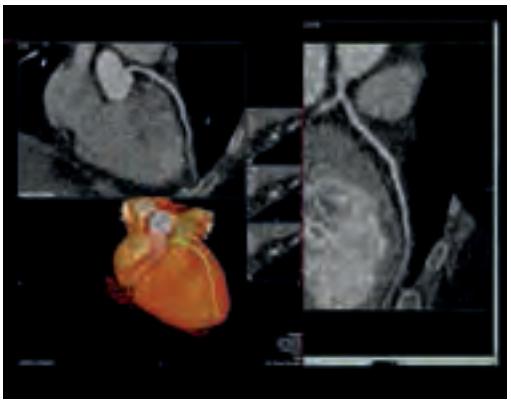


Figure 4: CT Coronary Angiogram. BMI 74. Normal coronaries. Dose 4.8 mSv

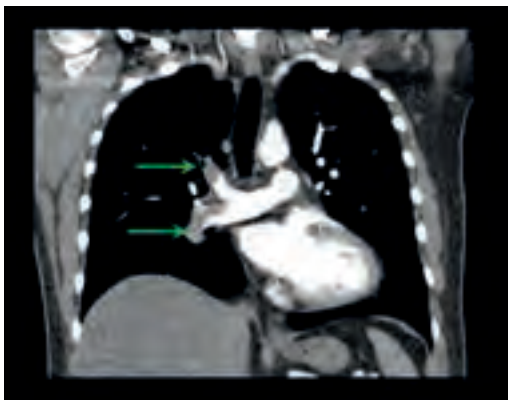


Figure 5: Routine Helical CTPA – BMI 26. 80kVp. 45ml Niopam 370@ 3ml/s. Dose 1.3 mSv. Multiple right-sided pulmonary emboli (arrowed)

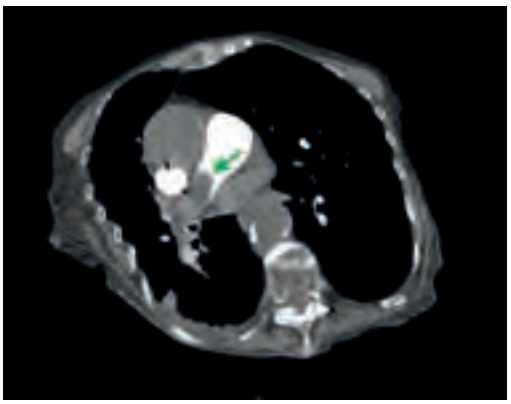


Figure 6: Free breathing single-rotation CTPA – 80 kVp. 30ml Niopam 370 @ 3 ml/s. Dose 0.5 mSv. Large pulmonary embolus obstructing right pulmonary artery (arrowed)

generates fewer photons for a given tube current and has been traditionally limited to patients with low BMI due to poor signal to noise ratios in larger patients with conventional detector systems. The greatly increased efficiency and reduced electronic noise of the PUREViSION detector allows us to use 80kVp scanning in a much wider group of patients and it is now our standard technique for angiography in patients with BMIs of up to approximately 35. This reduction in iodine doses of up to 40% reduces the risk of contrast induced nephropathy (CIN) and allows patients with impaired renal function to be scanned much more safely (Figs. 5 and 6).

PUREVISION REDUCES COST

The efficiency of the PUREViSION detector has enabled us to reduce contrast doses for all body parts, including for all cancer staging studies. Almost all patients can now be scanned at 80-100kVp resulting in substantial contrast dose reduction (Table 1) whilst maintaining or increasing organ enhancement. This has resulted in an overall 25% reduction in contrast usage with estimated savings of approximately £ 15,000 per year.

Patient Weight	80 kVp	100 kVp	120 kVp
Up to 50 kg	50 ml	50 ml	60 ml
50 to 60 kg	50 ml	60 ml	70 ml
60 to 70 kg	60 ml	70 ml	80 ml
70 to 80 kg	70 ml	80 ml	90 ml
80 to 90 kg	80 ml	90 ml	100 ml
90 to 100 kg	90 ml	100 ml	110 ml
100 to 120 kg	100 ml	110 ml	120 ml
120 to 150 kg	110 ml	120 ml	150 ml
Over 150 kg	120 ml	150 ml	180 ml
NB: Chart based on use of 370 mgI/ml contrast media.			

Table 1: Royal Bournemouth Hospital Contrast Injections Protocols for body imaging

CONCLUSION

The Aquilion ONE Next Generation with PUREViSION detector allows us to scan all patients with exceptional image quality with reductions in radiation and iodine doses of up to 40%. This improves diagnostic confidence, improves patient safety and reduces costs.

SUREkV - total patient protection

W.J. van der Woude [1)]

W.J. van der Woude

Lowering radiation and contrast dose is one of the priorities at RUMC to provide superior care and safety to our patients. Toshiba technology such as the new PUREVision Detector, AIDR 3D and SUREExposure 3D allow us to use low kVp settings in a wide range of patients. Manually selecting the kV setting is time consuming; therefore Toshiba has developed SUREkV to improve workflow.

At our institution low kV scanning has been employed in combination with SUREExposure and AIDR 3D and already resulted in better CNR and lower patient dose, however manually changing the tube voltage based on body weight or BMI has been time consuming. SUREkV is an automated kV selection tool which works with SUREExposure 3D. By using the attenuation information from the scanograms, tube voltage (kV) and tube current (mA) are automatically determined to maintain a desired level of image quality (Fig. 1).

Setting up SUREkV is easy; the SUREkV settings can be applied to different categories: adults/children, non-contrast/contrast and ECG gating ON/OFF protocols (Fig. 2).

Within each category the user can set which tube voltages can be selected by SUREkV. For example the system can be set up to select only 80 and 100kV for child protocols or select only 100,120 or 135kV for Adult non contrast protocols. Once these settings have been implemented, SUREkV is then turned on in each individual protocol.

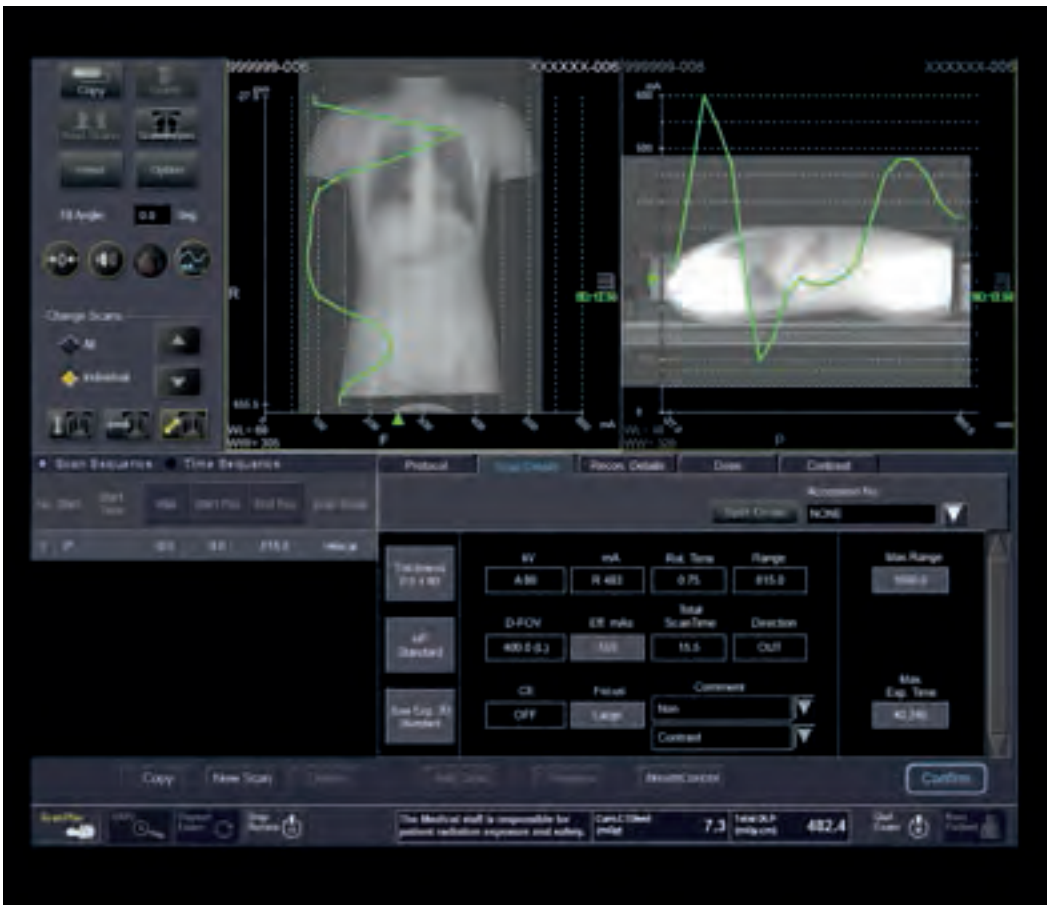


Figure 1: SUREkV and SUREExposure automatically determined the kV and mA for this patient.

[1)] *Radboud University Medical Center, Nijmegen, The Netherlands*

The use of low kV imaging is useful in CTA studies where the high HU values of iodine at 80 and 100kVp can be used to reduce the volume of contrast. Figure 3 shows the difference in CNR between 100kV on the left image and 120kV on the right image in a 70kg patient with a follow up scan after 8 weeks. In this case SUREkV automatically selected 100kV and the 120kV image was performed following our criteria for only lowering kV for patients below 70kg. All other parameters such as SD for SUREExposure 3D, iterative reconstruction parameters and the amount of contrast were the same. The HU values in the aorta, portal vein, latissimus dorsi muscle and liver, show significantly higher CNR in the 100kV scan with lower CTDIvol, resulting in a lower patient dose for the same exam. The measurements are shown in Table 1.

ROI	100kV	120kV
Aorta (Red)	159.4 HU	130.0 HU
Portal Vein (Black)	202.5 HU	186.4 HU
Latissimus dorsi muscle (White)	55.06 HU	43.52 HU
Liver (Blue)	128.9 HU	61.06 HU

Tabel 1: CNR measurements

Figure 2: SUREkV setup in Protocol Preset.

CONCLUSION

SUREkV in conjunction with SUREExposure automatically determines the lowest kVp setting to maintain the desired image quality while maximizing the attenuation of iodine and therefore allowing reduced contrast volumes for CTA examinations.

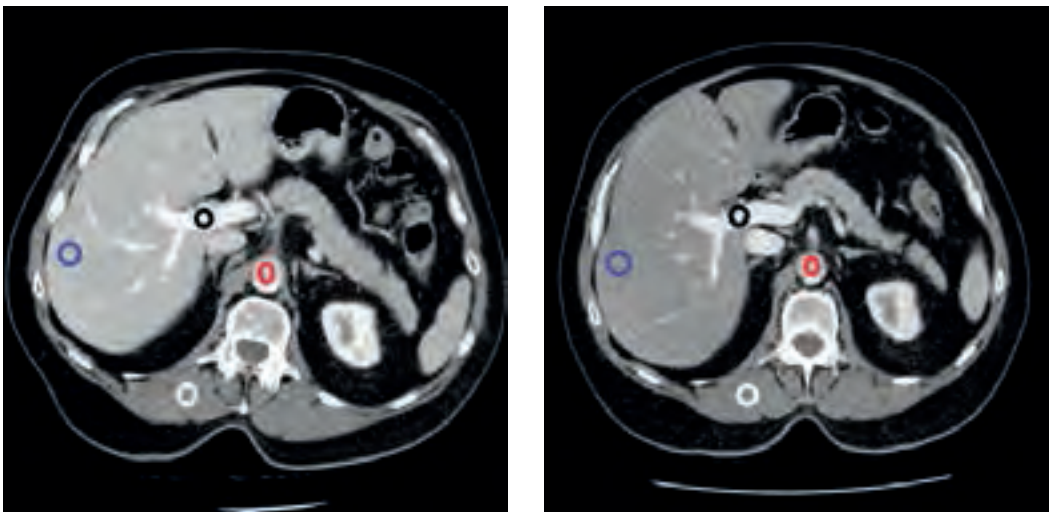


Figure 3: 100 kV image (left) and 120 kV (right) of same patient. SUREkV demonstrates higher CNR and lower dose.

360 SAFETY

Toshiba's "360 degree safety" patient protection is about making sure your patient's overall safety is assured, from minimizing dose, minimizing use of contrast and maximizing the comfort of your patients' CT experience, no matter their age or size – at all times.

Andrew's story

HIS STORY

The beginning of Andrew's story started several years ago when his mother, Megan, was a teenager. She was diagnosed with a rare form of ovarian cancer at the age of 17. Megan, now in her 30s, is married to Michael, and they are the parents of three young children. In 2013, Megan joined the International Ovarian and Testicular Stromal Registry. Through the registry, she learned that she carries a marker to the DICER1 gene. Megan was pregnant with their third child, Andrew, at the time. Doctors recommended that they test their children for a childhood cancer called pleuropulmonary blastoma, or PPB. It is so rare that only about 50 children globally are diagnosed with it each year.

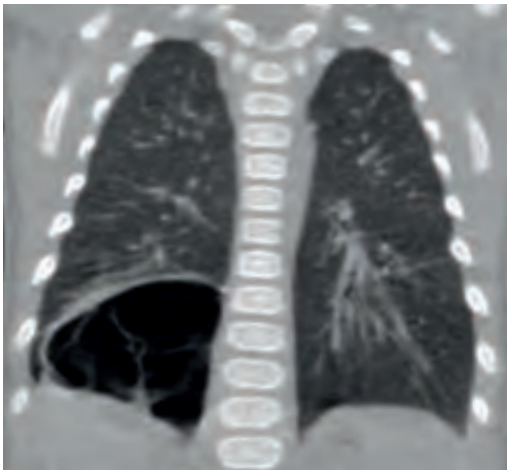
THE DIAGNOSIS

After Andrew was born, a CT scan was performed at Children's Hospitals and Clinics of Minnesota to take a closer look at him. Doctors confirmed that he had a cystic mass that looked like a growing bubble in his right lung. Andrew's care team used Vitrea® software to visualize the tumor in his lung. The surgical team performed a 4-hour surgery to remove a golf-ball sized tumor from Andrew's lung. They used a plastic bag to remove the entire tumor to ensure all cells were carefully contained. After the surgery, doctors confirmed it was PPB, a rare tumor associated with the same DICER1 genetic marker.

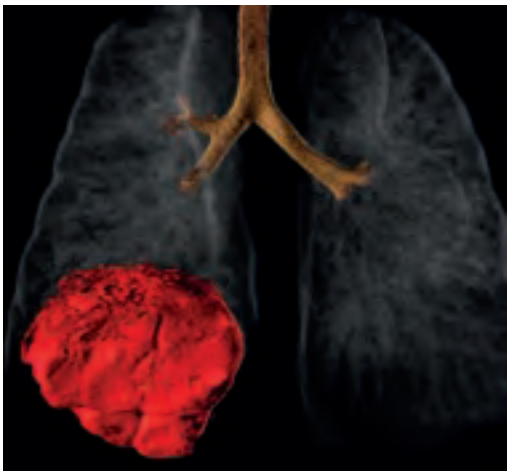
ANDREW TODAY

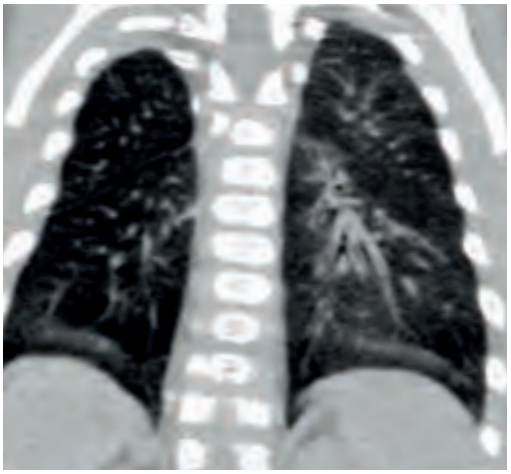
Andrew is a healthy little boy and enjoys playing with his siblings. He will continue to have routine follow-up scans and his care team will monitor his health closely over the next five years.

Watch the video at: http://tinyurl.com/p4rkwy9



Pre-Op





Post-Op

VITAL
A Toshiba Medical Systems Group Company

Vital Images, Inc., a Toshiba Medical Systems Group Company, is a leading provider of health imaging informatics solutions, including: advanced visualization, enterprise image viewing solutions and business intelligence technology designed to help healthcare organizations deliver exceptional care while optimizing resources across multi-facility organizations.

www.vitalimages.com

Images made with a Toshiba Aquilion CT system

CTEU150096

Julie Ratkovich/Simply Bliss Photography / Courtesy of Megan Flynn

VITAL

A Toshiba Medical Systems Group Company

Advanced imaging tools enhance diagnostic confidence and improve patient outcomes

Giving Radiologists a voice by expanding imaging beyond traditional boundaries.

Advanced visualization tools that deliver actionable insights across the care continuum

Sight to Insight

www.vitalimages.com

Coronary Artery Adaptive Motion Correction Software

Martina Chantal de Knegt, MD [1)]

Motion artifacts can have detrimental effects on cardiac CT image quality. This has led to new innovative strategies such as Toshiba's Adaptive Motion Correction (AMC) software. In this paper we discuss current developments and challenges.

Dr. Martina Chantal de Knegt

Coronary artery disease (CAD) is a leading cause of mortality and morbidity worldwide[1]. Reliable methods for the correct determination of CAD are, therefore, of paramount importance. Conventional invasive coronary angiography has been the golden standard for the assessment of obstructive CAD for decades. More recently, however, coronary computed tomography angiography (CTA) has been investigated as a potential alternative to the current golden standard: CTA has a high sensitivity and negative predictive value, i.e. identifies individuals with and without CAD with high accuracy[2]; CTA has a milder risk profile than the current golden standard which is associated with potentially serious adverse effects[3]; CTA may prove more cost-effective than its current invasive counterpart[4]. In order for CTA to gain a firm position within the clinical world, good image quality is a vital prerequisite for the correct assessment of the coronary tree for the presence of disease.

The utility of CTA has been greatly aided with advances in multidetector computed tomography (MDCT) technology. Increased temporal resolution, growing number of detectors, faster gantry speed, dual energy, and iterative reconstruction techniques have all resulted in marked improvements in image quality. Despite these aforementioned developments, there are still artifacts which result in degraded image quality and therefore, the potential for misinterpretation, that remain to be addressed.

One of the most commonly occurring artifacts in CTA is blurring caused by motion. Motion artifacts can be attributed to cardiac, pulmonary, or other body motion. Artifacts due to cardiac motion are caused by high heart rates that exceed the speed of image acquisition and irregular heart rates due to arrhythmia and/or the acceleration of heart rate at the end of breath hold (5). Any of these causes of motion may result in motion artifacts so severe that they can render segments or the coronary tree unevaluable. Often, image quality of the right coronary artery (RCA) is affected by motion as this artery exhibits the highest velocity movement and greatest positional changes, followed by the circumflex branch of the left coronary artery, the left main coronary artery, and the left anterior descending artery[5].

A variety of methods for the reduction of motion exist: Respirational movement is combated using breath hold techniques and cardiac motion is reduced with β-blockers to maintain optimal heart rate during scanning and the selection of an appropriate reconstruction window, often in diastole at low heart rates and in systole at high heart rates. The use of β-blockers has proven to be a safe and reliable first line method for reducing cardiac motion in correctly screened patients[6,7].

Despite optimal preparation and instruction of patients, motion artifacts continue to effect image quality. This has led to new innovative strategies such as Toshiba's Adaptive Motion Correction (AMC) software:

AMC reconstruction is a two-step process; motion estimation (ME) followed by motion compensated reconstruction. Toshiba's AMC algorithm utilizes two methods to perform motion estimation, a local ME using coronary artery information and position matching; and global ME to calculate the motion of the entire heart. A backproject and warp method is then used to perform the motion compensated reconstruction[8]. Data is reconstructed either side of the selected best phase. These data are used to perform global ME. The coronary arteries are automatically extracted to perform local ME followed by motion compensated reconstruction[8]. Other vendors have also developed motion correction software, some employing tracking of the vessel. This may not, however, produce a high success rate as tracking a coronary artery with severe motion may be difficult.

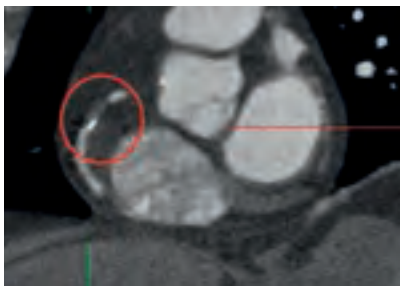
CASE

The patient is a 69 year old woman admitted to hospital with unstable angina pectoris. The patient had no prior admissions with CAD but had two CAD risk factors: hypertension and type 2 diabetes mellitus. The patient had a body mass index of 27, blood pressure 122/73 mmHg, pulse 67 BPM, and sinus rhythm at the time of scanning. The patient was not pre-treated with β-blockers.

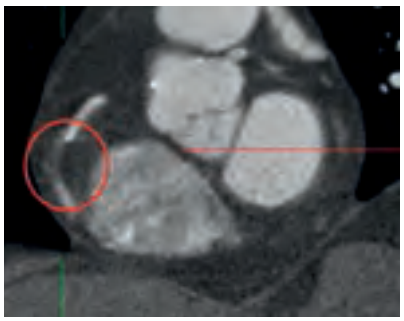
Image acquisition was performed prospectively using a 320-row CT (Aquilion ONE, ViSION Edition). A CTA was performed with the following settings: 320 x 0.5 mm detector collimation, 120 kV tube voltage, 470 mA tube

[1)] *Rigshospitalet, Copenhagen, Denmark*

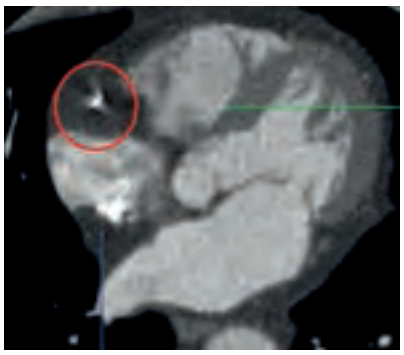
Before Adaptive Motion Correction



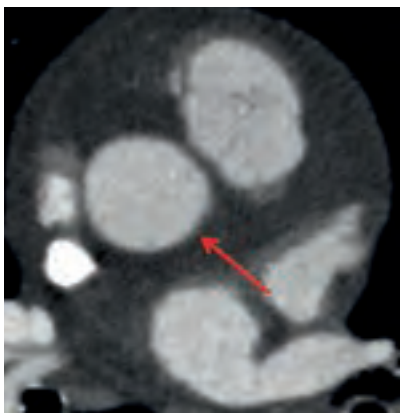
A



B

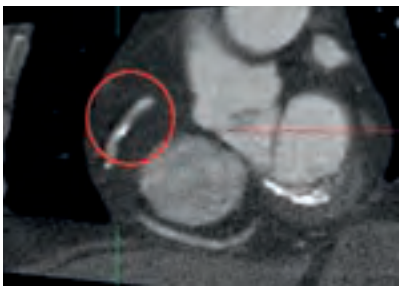


C

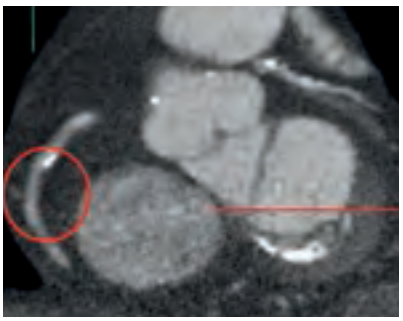


D

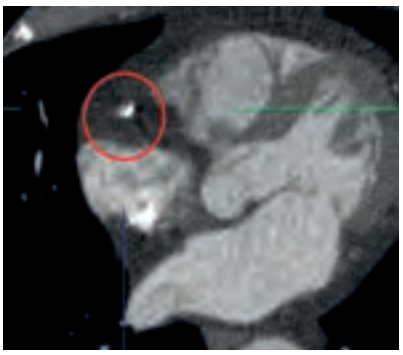
After Adaptive Motion Correction



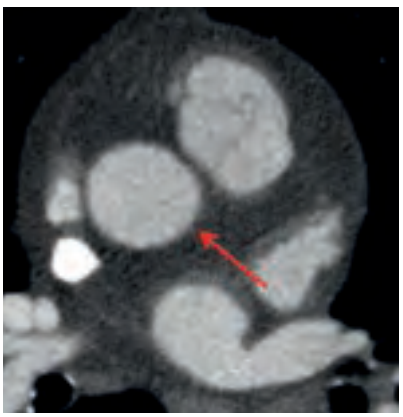
a



b



c



d

*Figure **A-D** displays images before AMC application. One can ascertain from figure **A-B** that the proximal/mid RCA segments are difficult to evaluate with certainty due to blurring which, in this case, could be mistaken for a potentially occluding predominantly non-calcified mixed plaque. In figure **C**, the characteristic halo artifact caused by movement of the proximal RCA segment combined with a blooming artefact cause by the presence of calcium in the vessel wall results in significant blurring of the vessel wall. Figure **D** allows for the appreciation of motion in the image as a whole as one is able to assess the sharpness/blurriness of the ascending aortic wall. A slight fuzziness of the ascending aortic wall can be appreciated.*

*Figure **a-d** displays images after AMC application. Figure **a-b** depicts the areas of the RCA that were difficult to assess prior to AMC. One can now see the contours of the RCA vessel wall sharply and can, with more certainty, rule out the presence of obstructive CAD in these segments. In figure **d**, there is a clear reduction of the halo artifact and, while blooming still persists, one can more easily assess the degree of stenosis caused by the calcified plaque. Figure **d** is the counterpart to figure **D**, and when comparing the two, there is a greater sharpness of the image, as a whole, after AMC.*

current, and 0.275 s gantry rotation time. Intravenous contrast media (Visipaque 320, GE Healthcare, Chalfont St. Giles, United Kingdom) was infused with a flow rate of 5 ml/s with a biphasic injection protocol followed by a saline chaser. The automatic bolus triggering technique was used for initiating image acquisition. Images were obtained over 1 segment. Reconstructions at 75% of the R-R interval were performed. Images were reconstructed with 0.5 mm slice thickness and increments of 0.25 mm. Image data was transferred to an external workstation (Vitrea 2, version 6.9, Vital Images Inc., Plymouth, Minnesota). Noise was calculated using a 200 mm^2 region of interest placed in the ascending aorta just proximal to the aortic valve and was found to be 410 ± 30 HU.

Toshiba's Adaptive Motion Correction (AMC) software was applied to this study due to significant blurring of the proximal/mid RCA segments caused by motion. Definitive evaluation of these segments for the presence of disease was deemed difficult prior to AMC application.

Based on this case, AMC was a helpful tool in the assessment of significant CAD in CTAs that are otherwise unevaluable due to motion artifacts. There are, however, some limitations to AMC that have to be addressed: Firstly, AMC can only be applied to images obtained over one segment. If a CTA is obtained over two or more segments, the scan must be reconstructed to one segment. This results in reduced image quality and the incremental value of applying AMC is presumably less under such conditions. Secondly, AMC, in its current form, is a somewhat computational lengthy process. It takes approximately 15 min to apply AMC and the procedure should therefore be reserved for difficult cases in which motion artifacts hamper a definitive clinical conclusion.

CONCLUSION AND FUTURE PERSPECTIVES

AMC software is a helpful tool in the assessment of significant CAD in CTAs that are otherwise unevaluable due to motion artifacts. Some limitations inhibit the general application of AMC to all CTAs. Once processing time is reduced and segment limitations are overcome, however, AMC software may be beneficial in providing excellent image quality, reduced radiation doses, and incremental information in the assessment of coronary artery disease in all CTAs.

References:

1. WHO | Cardiovascular diseases (CVDs) [Internet]. WHO. [cited 2013 Jan 22]. Available from: http://www.who.int/mediacentre/factsheets/fs317/en/index.html
2. Miller JM, Rochitte CE, Dewey M, Arbab-Zadeh A, Niinuma H, Gottlieb I, et al. Diagnostic performance of coronary angiography by 64-row CT. N Engl J Med. 2008 Nov 27;359(22):2324–36.
3. Scanlon PJ, Faxon DP, Audet AM, Carabello B, Dehmer GJ, Eagle KA, et al. ACC/AHA guidelines for coronary angiography: executive summary and recommendations. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Coronary Angiography) developed in collaboration with the Society for Cardiac Angiography and Interventions. Circulation. 1999 May 4;99(17):2345–57.
4. Darlington M, Gueret P, Laissy J-P, Pierucci AF, Maoulida H, Quelen C, et al. Cost-effectiveness of computed tomography coronary angiography versus conventional invasive coronary angiography. Eur J Health Econ HEPAC Health Econ Prev Care. 2014 Jul 3;
5. Choi HS, Choi BW, Choe KO, Choi D, Yoo K-J, Kim M-I, et al. Pitfalls, artifacts, and remedies in multi- detector row CT coronary angiography. Radiogr Rev Publ Radiol Soc N Am Inc. 2004 Jun;24(3):787–800.
6. Mahabadi AA, Achenbach S, Burgstahler C, Dill T, Fischbach R, Knez A, et al. Safety, efficacy, and indications of beta-adrenergic receptor blockade to reduce heart rate prior to coronary CT angiography. Radiology. 2010 Dec;257(3):614–23.
7. Kassamali RH, Kim DH, Patel H, Raichura N, Hoey ETD, Hodson J, et al. Safety of an i.v. β-adrenergic blockade protocol for heart rate optimization before coronary CT angiography. AJR Am J Roentgenol. 2014 Oct;203(4):759–62.
8. Qiulin Tang, Beshan Chiang, Akinola Akinyemi, Alexander Zamyatin, Bibo Shi, Satoru Nakanishi. A combined local and global motion estimation and compensation method for cardiac CT. SPIE 2014.

General guidelines for authors

Works are generally classified into two categories: Full length articles (e.g. clinical added value of new/special applications & technologies) and Short contributions (e.g. system testimonials, case reports, technical notes).

All articles should be double-spaced.

FULL LENGTH ARTICLES:

Full length articles should generally include the following:
- Author's full name and highest academic degree, employer medical institution
- Author's biography (150 words)
- Author's passport-size photograph (suitable for publication); (image of 300 dpi)
- 200-word abstract
- Text including headline, sub-title, introduction and sections like: materials & methods (which should include a full description of equipment used), results, discussion and references
- Text approx 4 to 5 pages or 12.000 to 14.000 characters (not including figures, tables and photographs)
- Correspondence address
- Literature (no more than 10 references)
- Separate, continuous numbered image- and table captions

SHORT CONTRIBUTIONS:

Short contributions should generally include the following:
- Author's full name and highest academic degree
- Author's employer medical institution
- Author's biography (150 words)
- Author's passport-size photograph (suitable for publication); (image of 300 dpi)
- Text including headline, sub-title, introduction and full description of methods & materials/equipment used
- Case Report or description of system improvements (Technical Notes)
- Correspondence address
- Literature (no more than 10 references)
- Separate, continuous numbered image- and table captions

TEXT

The article should be saved in Microsoft Word (PC format) if possible, and, if not, in text only.

Please indicate the software program and version used (Microsoft Word 2007, etc.) and whether it is a PC or Macintosh formatted document. If e-mailing, make sure to send it as an attachment, rather than embedded in the e-mail message.

SYMBOLS, FORMULAS AND ABBREVIATIONS

Symbols, Greek letters superscripts/Subscripts must to be identified clearly. Furthermore, the figure 1 (one) and the letter l (el) as well as the capital letter 0 and the figure 0 (zero) should be easy to differentiate.

All abbreviations including units of measure, chemical names, technical or medical acronyms, names of organisations or institutions should be defined when they first appear in the text (e.g. congestive heart failure (CHF). Please refrain from using unfamiliar abbreviations, clinical slang or jargon.

IMAGES, ART AND TABLES

Cite all figures and tables in text, preferably in consecutive order. Please include a caption for each figure. All captions for each figure, should be separate from the text, at the end of the manuscript on a separate page. Captions should avoid duplication of text material. Credit lines for artwork can appear at the end of the corresponding caption by stating: (Provided by first initial, last name). Black out (or give clear instructions which parts should be blackened out) of the images to not violate any data protection regulations (e.g. patient data)

Do not embed figures, charts, or graphs into your document file. Please provide them as a separate file, as well as hard copy/correct .pdf file. Please use one the following formats: EPS , TIFF or JPEG.

Arrows stuck onto images for purposes of delineation should be clearly visible and reproducible.

Authors should indicate if they would like to have artwork returned.

Each table should have a title, and all abbreviations should be spelled out or explained in a footnote.

STYLE

Title page should include full names, degrees and titles of authors, and affiliations (name of institution, city and state) for use in a by-line, as well as phone and fax numbers to facilitate sending edited copy back to author for approval.

Define all symbols, abbreviations and acronyms on first reference.

All manuscripts should be written in a third-person style, unless the article is specifically an editorial or first-hand review.

REFERENCES

A maximum of 10 references is suggested. Complete references should be listed in order of citation in text, NOT alphabetically. Up to four authors will be listed; if there are five or more authors, only the first three will be listed, followed by et al. Within the text, reference numbers should appear as footnotes in parentheses or in superscript text at the end of each appropriate citation. Please do not use Microsoft Words endnote feature, as this causes major problems in the editing phase.

In addition, if the reference is not in English, please indicate the language of publication.

Journal example:
Oberhaensli RD, Galloway GJ, Hilton-Jones D, et al. The study of human organs by phosphorus-31 topical magnetic resonance spectroscopy. Br J Radiol 1987;60:367-373

Book example:
Welch KMA, Barkley GL. Biochemistry and pharmacology of cerebral ischemia. In: Barnett JHM, Stein BM, Mohr JP, Yatsu FM, eds. Stroke: pathophysiology, diagnosis and management. New York: Churchill Livingstone, 1986;75-90.

healthcare-in-europe.com

Trends & innovations in the healthcare market.

25 YEARS of European healthcare communication: **print & online.**

Online Portal | Newspaper | Product Guides | Newsletter

Stay tuned on all channels.

published by

EUROPEAN HOSPITAL

European Hospital Verlags GmbH | Theodor-Althoff-Straße 45 | 45133 Essen
follow us on | visit us on
www.healthcare-in-europe.com