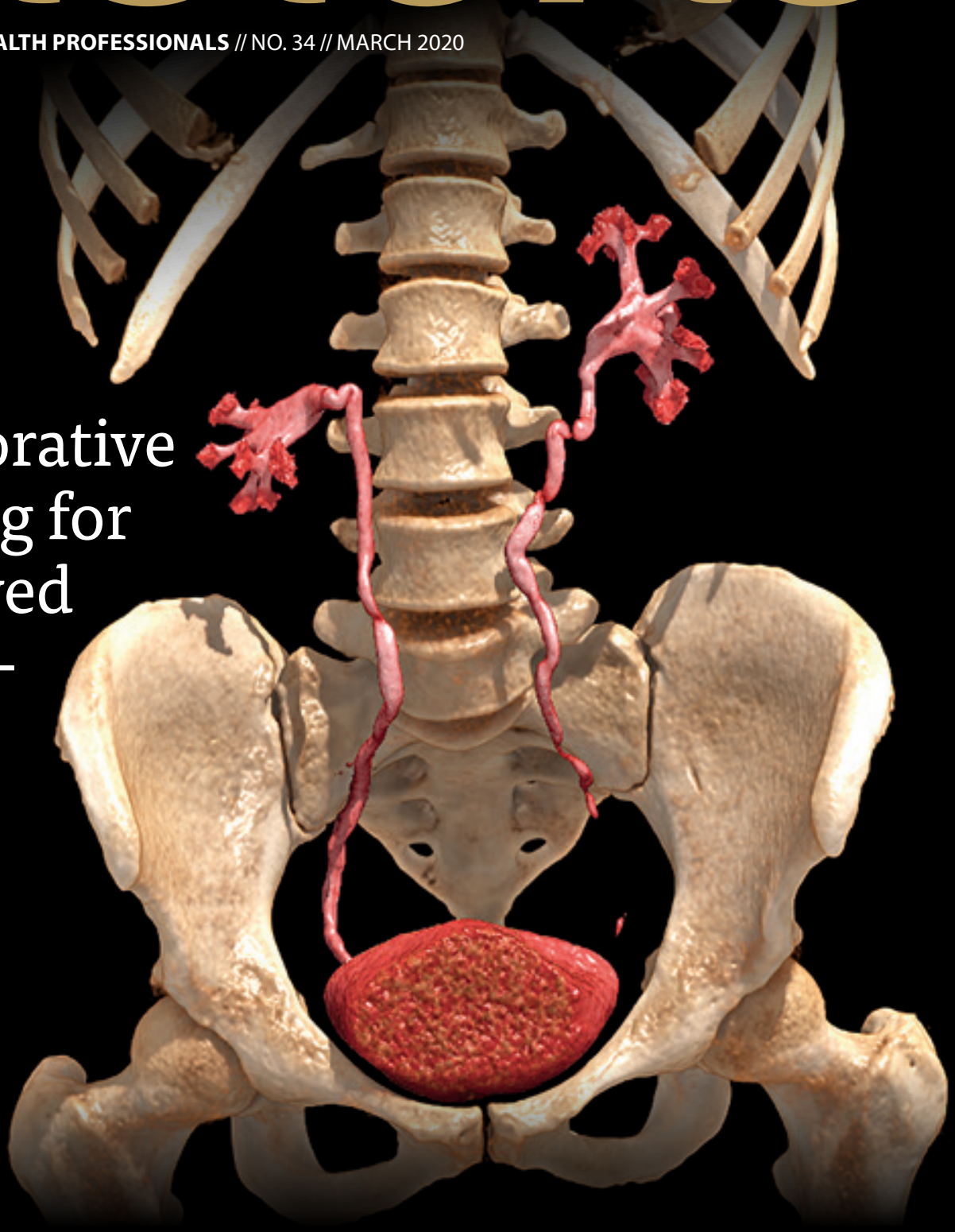
visions

MAGAZINE FOR HEALTH PROFESSIONALS // NO. 34 // MARCH 2020



Collaborative imaging for Improved Patient-Centric Care

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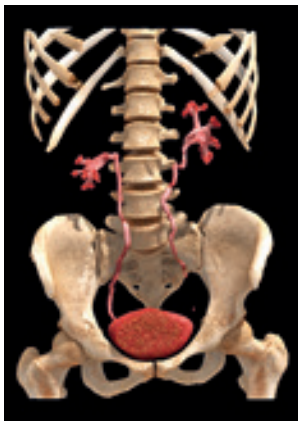
Canon



Cover Image:
Global Illumination 3D / 4D photo-realistic rendering. The urine tract with the ureters and bladder.

VISIONS magazine is a publication of Canon Medical Europe and is offered free of charge to health professionals. The magazine is published twice a year. Registration to access full, previously published, digital editions can be done via the website: https://eu.medical.canon/visions-magazine. Canon Medical stores and uses personal data of the registration to send out the magazine and inform members about new developments. Members can customize preferences or opt-out, after registration.

VISIONS magazine is covering Canon Medical'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 Canon Medical representative sales office in case of any questions.

News, articles and the full edition of VISIONS magazine are announced firstly, as pre-publication, via the dedicated VISIONS LinkedIn Group: https://www.linkedin.com/groups/3698045. In this group you can actively participate in discussions about the content and future direction of the magazine.

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 ISSN 1617-2876

// EDITORIAL

From the very beginning of this Century, it has been my passion, privilege and pleasure, as Editor-in-Chief of VISIONS Magazine - Canon Medical's Magazine for Health Professionals, to bring you news, customer and product stories, clinical examples and cases, technological progress and much more.

Supported by many colleagues and clients from all over the world, I have enjoyed working together to highlight the operational, financial and clinical benefits of our products and services portfolio, as well as our added value to today's healthcare society. Obviously, I always work with the aim of inspiring and motivating you towards putting the information and knowledge gained into practice in your daily work.

Over the years, the magazine has undergone various design and layout changes reflecting the trends and developments of the time. The most recent and clear overhaul was the transition from the Toshiba Medical brand to the Canon Medical brand.

You may have noticed that we have taken great steps to bring the magazine to a higher level. In particular, in the fields of design, photography and quality content. My long-held wish to have recognizable country editions available in addition to the international edition came true; in local language and completely customized to local needs. Currently, we have German, Austrian, United Kingdom, Dutch and bilingual Belgian editions available.

Much of this is due to the great efforts of many colleagues from the European Canon Medical office, the entire Marketing Team, local offices and partners, and the various editors of local editions. However, the driving force behind today's VISIONS editions is, to a large extent, Mrs. Jacqueline de Graaf, Senior Project Manager, in my Department. It is, therefore, that I have decided, with great confidence, to transfer my Editor-in-Chief function, as well as the actual production of the magazine, to her.

I am happy to take a step back, but will continue to be actively involved as advisor, writer and responsible manager for all Canon Medical marketing activities and programs in Europe.

In my last editorial, I would like to thank you for all the years of being a loyal reader and co-creator of VISIONS magazine, and I would like to ask you to continue your loyalty and support with the new Editor-in-Chief.

Osewa ni narimasu[1]

Kind regards,

JACK HOOGENDOORN
Senior Marketing & Brand Manager
Canon Medical Systems Europe BV

[1] *Thank you for everything.*

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Partnership with Deceuninck - Quick-Step

| Pro Cycling Team

We are proud to announce our partnership with the best Cycling Team in the world. The team was gain ranked as number 1 in 2019 at the UCI World Team Classification and had 68 victories in 2019.

"Having the Canon Medical's Viamo mobile ultrasound scanner has significantly evolved the way that we look after our riders. The nature of the sport is fast-moving and geographically challenging, making hospital visits difficult. Being able to use the scanner in a quick and efficient manner wherever we are to give an instant diagnosis of a muscle injury, can make a huge difference to a riders' recovery. As well as a valuable piece of equipment, Canon Medical have provided excellent support and it having their knowledge and expertise behind us can only enhance the care that we can offer our riders." //

University Hospital Montpellier

| France

Prof. Guiu and his team from the University Hospital in Montpellier decided to extend our Partnership with CT and Ultrasound.

Besides the Infinix-i 4D CT Prof. Guiu and his team will now also work with the Aquilion PRIME, the Aquilion ONE PRISM and the Aplio i800. //

Infinix-i 4D CT

Aquilion PRIME

Aquilion ONE PRISM

Aplio i800

Bedford Hospital

| UK

First European installation of Alphenix Sky interventional imaging system for Cardiac installed in Bedford Hospital in UK.

Pacemaker implants; Percutaneous Coronary Intervention (PCI) using Optical Coherence Tomography (OCT); Intravascular Ultrasound (IVUS); plus Fractional Flow Reserve (FFR) and instant wave-Free Ratio (iFR).

"We have received excellent after sales service from the engineers and application specialists at Canon Medical Systems UK following the installation of the Alphenix system and look forward to their ongoing guidance." //

Great Collective Cross-Modality Achievement.

Luz Saude | Portugal

Great collective cross-modality achievement in Luz Saude (Siemens install-base), one of the largest health care groups in the Portuguese market. //

3T Galan XGO

Alphenix 4D CT

Alphenix BP HD

3 x Aplio i-800

New Installations at the Helsinki University Hospital (HUS) in Finland

| Finland

Tromp Medical Oy, the official representative of Canon Medical Systems in Finland, has been chosen to provide equipment for the RAPTOR suite and trauma room for the new Bridge Hospital, Helsinki University Hospital (HUS), which is the most leading Trauma Hospital in Europe. HUS will be the first hospital in Europe with a RAPTOR* suite for trauma use.

The patients will be taken care of by a multi-disciplinary group, which will consist of experts in traumatology, vascular surgery, anaesthesiology and radiology, in addition to 3 to 4 first aid professionals in the initial phase. The suite will be equipped with the Alphenix 4D CT angiography and slide-rail operated CT system integrated into the same patient table and user interface. An additional 4D CT training unit will be installed in the HUS facilities. //

** RAPTOR is the abbreviation for Resuscitation with Angiography, Percutaneous Techniques and Operative Repair.*

Untire Gives Cancer Patients and Survivors the Tools to Reduce Fatigue

Millions of cancer patients and survivors worldwide suffer from extreme fatigue. They feel so tired that it affects all aspects of their lives. They often feel stressed and depressed as well. Sounds familiar?

The Untire App helps them cope with their specific fatigue. The app also contains a program that will help them understand their fatigue and will give tips and exercises to work on their energy level. These tips and exercises are based on proven methods in the clinical practice. The app addresses eight important themes: anxiety, worry, boundaries, sleep, nutrition, self-care, activity and of course, fatigue.

Download and use Untire for free at the AppleStore and Google Play. Read more at https://untire.me. //

Canon Donates an Aquilion Lightning to Wuhan, China, in Response to Spread of Novel Coronavirus

Canon (China) Co., Ltd., Canon Medical Systems (China) Co., Ltd. and all members of the Canon Group will donate a full-body X-ray CT diagnosis system (Aquilion Lightning) to the Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology, in the city of Wuhan.

Using this system, medical professionals can perform clinical tests for emphysema caused by the Novel Coronavirus.Through the donation of the X-ray CT diagnosis system, the Canon Group aims to support medical professionals and those in other industries working to treat patients who have contracted the Novel Coronavirus. In addition, Canon will provide needed parts and maintenance to hospitals throughout China that use the company's medical devices. //

Second Angio CT installation at University Hospital Strasbourg

Strasbourg | France

Prof. Gangi decided to invest in a second Angio CT system.

An Alphenix 4D CT based on Aquilion ONE Genesis with AiCE and Alphenix Sky + technology is now installed. It is the first site in Europe to have two Angio CT's installed. //

Specialists Explore Liver Ultrasound Capabilities in Key Event in Latvia

| Latvia

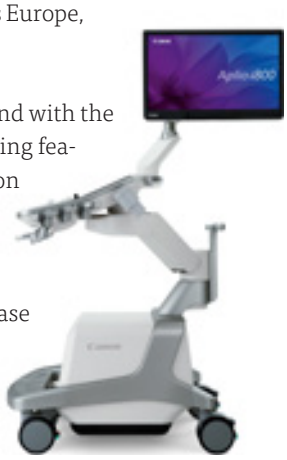
Canon Medical Systems is dedicated to bringing continuous knowledge to its customers, and so conducts regular seminars and User Days in cooperation with its official partners.

On October 31st, 2019, Latvia's second User Day was organized by A-Medical (official distributor of Canon Medical Systems Europe in Latvia) and Canon Medical Systems Europe, with the aim of delivering information on the latest developments in Ultrasound.

With the theme, 'Advanced diagnosis in Liver', the event was well attended and attracted around 40 physicians, who appreciated the high-level speakers, as well as the live scanning with real patients.

Presentations and demonstrations were given by outmost renowned speakers from Latvia and other countries, including:

- Prof. Adrian Lim, Charing Cross Hospital, Hammersmith Hospital, London, United Kingdom.
- MD, PhD Maija Radzina, President of the Latvian Association of Radiologists, and President of the Latvian Society of Ultrasound, Radiologist, Diagnostic Radiology Institute in Paula Stradina Clinical University Hospital, Riga, Latvia.
- Dr. Kaspars Stepanovs, Radiologist, Head of Radiology department of Health center 4, Riga, Latvia
- Nadim Kaafarani, International Clinical Market Manager Ultrasound, Canon Medical Systems Europe, The Netherlands.



Canon Medical's Aplio i800 Ultrasound with the latest software package on liver imaging featured heavily in the event. Attenuation Imaging - the first Ultrasound imaging technique able to quantify liver steatosis, amongst other conditions – was also demonstrated. The ease of use, outstanding image quality and unique liver diagnose package, impressed both new and existing customers in attendance. //

North Estonia Medical Center (NEMC) Chooses Aplio i800

| Estonia

The North Estonia Medical Center (NEMC) – the biggest medical center in Estonia- selected Canon Medical's Aplio i800 Ultrasound for an upgrade that would meet their high-end requirements for now and in the future.

The higher specs and features of the Canon system provided the extraordinary performance that the NEMC was looking for.

An offer and demonstrations were organized by Semetron (official distributor of Canon Medical Systems Europe in Estonia), with the support of Canon Medical Systems Europe.

During an 18-month trial period, the NEMC tested and compared the Aplio i800 system with other vendors and concluded that Canon Medical's offer was the most convincing.

The installation of six Aplio i800 Ultrasound systems at the NEMC was completed in September 2019. //

Collaboration with CMCiB for R&D in Neurology, Cardiology & Oncology

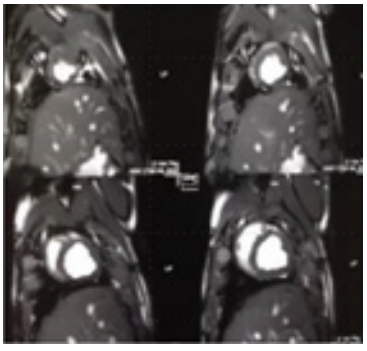
Badalona | Spain

The Comparative Medicine and Bioimage Center of Catalonia (CMCiB) is anv unique new facility for research and training in Europe.

The latest technology and tailor-made facilities are available for a full range of biomedical examinations, from pre-clinical models to new surgical techniques, all conforming to European standards for responsible research.

The CMCiB has setup a real Imaging environment with the Vantage Galan XGO and the Alphenix Core +, with Vital & Olea post-process.

The CMCiB is a facility of the German Trias i Pujol Research Institute (IGTP), located on the Can Ruti Campus, in the Barcelona region, Spain. //



Vantage Galan XGO

First Alphenix Biplane HD in Europe

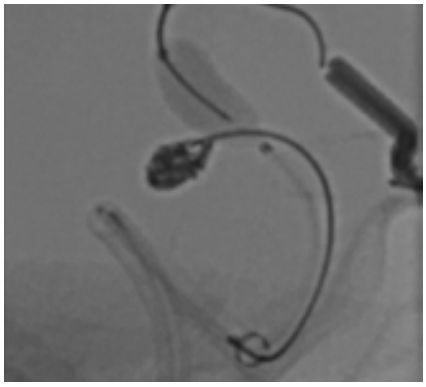
| Sweden

Since 2011 Akademiska University Hospital in Uppsala has been a customer to Canon Medical Systems. Their first installation of an Infinix-i Biplane system marked the start of a close collaboration.

Over the years several scientific publications regarding our technology has been produced here. Akademiska University Hospital has also largely contributed to the development of the Alphenix platform.

Early 2019, the decision was made to replace the current system with a brand new Alphenix Biplane with HD.

During the grand opening on November 4th 2019, the hospitals managing director Mr. Eric Wahlberg and chief of the radiology department Mr. Adel Shalabi cut the ribbon together marking the continuum of a great and prospering cooperation between Akademiska University Hospital and Canon Medical systems. //

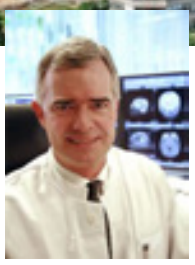


Alphenix BP HD

CT Installation in One of the Biggest and Most Leading University Hospitals

| Germany

In 2019, the Aquilion ONE GENESIS Edition, Volume-CT in combination with Deep-Learning-Reconstruction AiCE, was installed at the Medical University Hannover, Germany in the department of Prof. Dr. Lanfermann. //



Prof. Dr. Lanfermann
Head of Neuroradiology.

AiCE
Integrated Intelligence

Canon
CANON MEDICAL

Healthcare solutions

Made possible.

Made For life

Working together to understand your needs and challenges drives valuable outcomes that positively impact you and your patients' future.

Canon Medical's vision and commitment to improving life for all, lies at the heart of everything we do. By partnering to focus on what matters, together we can deliver intelligent, high quality solutions.

With Canon Medical, true innovation is **made possible**.

"The future of Medical Imaging"

We would like to express our gratitude to our valued customers. Thank you for your continued support and for using our products and services.

This is the Year of the Rat, which is the first year in the Chinese zodiac cycle. In the Chinese zodiac, the Year of the Rat symbolizes new luck or taking new challenges. Canon Medical Systems restructured its business globally last year and started off under a new structure this January. As "One Canon", we are determined to provide products and services that are more customer-focused than ever before.

In the last year, we have adopted denoising technology using AI (which is already installed in our CT systems) in our MR systems. We also offer a wide lineup of products. CT systems that allow high-resolution imaging with low exposure dose and MRI systems that allow high-resolution imaging using shorter scan times have been highly evaluated not only for their clinical value but also for their contribution to reducing the physical and mental burden on the patient during examination. In addition, our image interpretation solutions using AI algorithms are expected to improve workflow for physicians and technologists involved in diagnostic imaging and imaging examinations, and contribute to provision of efficient healthcare.

In 2020, as in previous years, with the aim of achieving more efficient healthcare and optimizing patient outcomes, Canon Medical Systems will continue striving to be a company that moves forward with our customers based on our management philosophy "Made for Life".

TOSHIO TAKIGUCHI
President and Chief Executive Officer
Canon Medical Systems Corporation

AiCE
Integrated Intelligence

The Power of the New Aquilion ONE / PRISM Edition

Since its global launch in December 2019, the Aquilion ONE / PRISM Edition has been making waves all around the world particularly with its Advanced intelligent Clear-IQ Engine (AiCE), Deep Learning Spectral and CT fluoroscopy capabilities. To find out more about what our customers think, we sat down with leading clinicians from two-prestigious institutions, Radboud University Medical Center (the Netherlands) and Strasbourg University Hospital (France), for an in-depth review of the CT system that's designed for deep intelligence.

One of the most exciting features of the PRISM is our Advanced intelligent Clear-IQ Engine (AiCE), a cutting-edge Deep Learning Reconstruction technology that's been trained to reduce noise and boost signal to deliver sharp, clear and distinct images at speed.

Can you tell us a bit about how your teams have adopted AiCE?

Prof. Ohana: *We weren't sure in the beginning whether to use AiCE for specific applications or as an additional reconstruction, so we tried it with the first patients. The difference with AIDR 3D was so immense that we decided, ok, let's use it for every patient.*

Prof. Prokop: *Our people accepted AiCE extremely quickly and have used it immediately for most applications.*

Watch here the promo video of Aquilion PRISM.

Radiology Team Strasbourg University Hospital, France

Watch here the full video testimonial of Prof. Roy.

"The image quality is excellent with the new PRISM Edition."

Prof. Catherine Roy, Radiologist, Strasbourg University Hospital, France.

"AiCE lets us obtain thinner images at high quality, which helps us make a more confident diagnosis."

Prof. Mathias Prokop, Head of Radiology, Radboud University Medical Center, the Netherlands.

Watch here the full video testimonial of Prof. Prokop.

- Part 1 - **- Part 2 -**

Prof. Catherine Roy and Prof. Mickaël Ohana at Strasbourg University Hospital, France.

Watch here the full video testimonial of Prof. Ohana.

- Part 1 -

- Part 2 -

"With Spectral Imaging, we are more confident."

Prof. Mickaël Ohana, Radiologist, Strasbourg University Hospital, France.

What's the most significant difference that AiCE has made to your practice?

Prof. Prokop: *AiCE lets us obtain thinner images at high quality, which helps us make a more confident diagnosis. When you're looking at complex cases in which you have to focus on detail, your confidence goes up.*

Dr. Smit: *I really like AiCE because of its low contrast detectability, especially with liver lesions or peritoneal metastases. Also, the contours are much sharper, which helps with the delineation of bowels, to assess fat stranding, or to see if a tumour is infiltrating another tissue.*

What about dose, have you seen any benefits there?

Dr. Smit: *Because AiCE in integrated in the automatic exposure controle, there's no guessing on how low the dose should be. It's just about switching on the button for dose reduction. I generally check the dose report for every scan, and I'm often surprised at how low the dose is.*

Prof. Prokop: *We wanted to move on from using morphological information, like in the past, to using more functional information, and we wanted to do that using the lowest possible dose and in a repeatable, reproducible fashion. AiCE lets us do that.*

Spectral Imaging: Improved quality and workflow

In addition to AiCE, the new Aquilion ONE / PRISM Edition features advanced spectral imaging to improve workflow and help reduce patient iodine load. Images can be analysed directly at the workstation with a range of new Vitrea applications.

Have you seen an overall reduction in iodine load?

Prof. Roy: *That's the main application in our department and all around the world. Spectral imaging means that we're now able to use a contrast agent of 270 mg I/mL instead of staying in the 400 mg I/mL range. Plus, you can still see everything perfectly, with all the tiny details. This is a user-point that still amazes me.*

Watch here the full video testimonial of Dr. Smit.

"I really like AiCE because of its low contrast detectability and the much sharper contours."

Dr. Ewoud Smit, Radiologist, Radboud University Medical Center, the Netherlands.

"I really like working with the new console. It's faster and I can stay more focused for a more efficient and safe procedure."

Dr. Sjoerd Jenniskens, Radiologist, Radboud University Medical Center, the Netherlands.

Watch here the full video testimonial of Dr. Jenniskens.

Have you noticed an improvement in tissue classification?

Prof. Ohana: *In oncology imaging, we sometimes have subtle lesions. With spectral imaging, we are more confident and can see if there is or isn't contrast uptake in these lesions. Spectral imaging is also more specific, mostly for gout or kidney stones. We are able to characterize the tissue and give more specific answers to the clinician.*

What about workflow, is that better?

Prof. Ohana: *Acquisition time is the same as a single energy examination; there's no difference in terms of timing. But also, speed of reconstruction is almost the same.*

CT Fluoroscopy: More control where you need it

The new Aquilion ONE / PRISM Edition features a hybrid CT Fluoroscopy interface that enables one-handed operation with ergonomically designed controls and a versatile touchscreen tablet.

Has the new CT Fluoroscopy panel made things easier for your team?

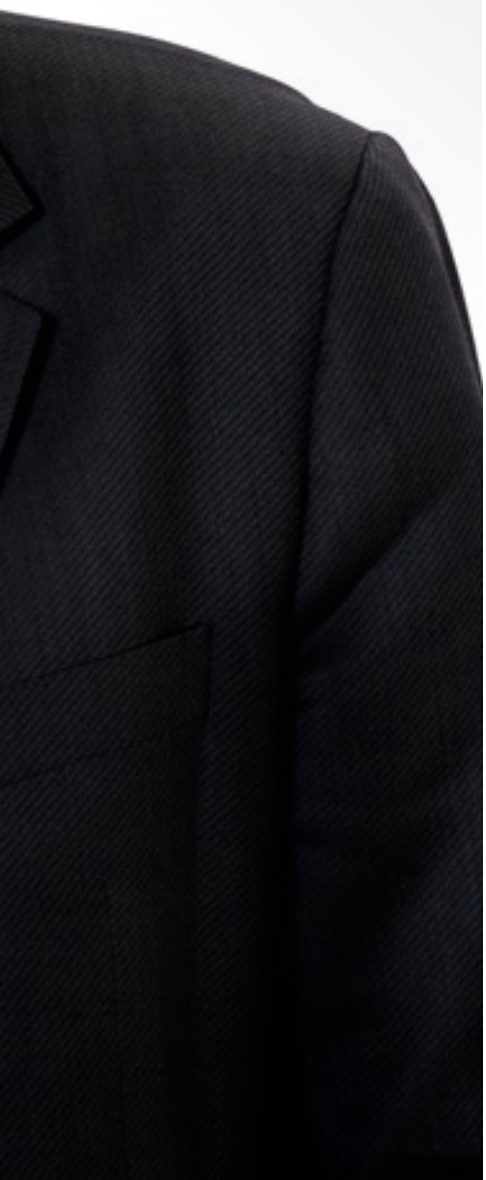
Dr. Jenniskens: *I really like working with the new console because it's faster and I have everything under my control. I have an overview of the whole process and can stay more focused for a more efficient and safe procedure.*

Prof. Prokop: *It's important to control the system from inside to do what you want quickly and without too much hassle. The Aquilion ONE PRISM Edition offers more flexibility for improved control and safety during the procedure.*

Are there any benefits for the patient?

Dr. Jenniskens: *Absolutely. You can now stay close to the patient, which is more comfortable for everyone. Patients also benefit from the new console because the procedure can be expedited, and they can be out of the room earlier. //*

Find out more about Aquilion ONE / PRISM edition on our website: https://eu.medical.canon/product-solutions/computed-tomography/aquilion-one-prism-edition/



VISIONS spoke with
Thierry Munier, Senior Manager
for the European MR Business Unit,
Canon Medical Systems Europe.

Understand our Customers and Anticipate their Needs

With the recent introduction of Deep Learning Reconstruction and new systems in the pipeline, Canon Medical is completing its impressive portfolio and confirming its leading role in MRI innovation. And with the nomination of Thierry Munier as Senior Manager for the European MR Business Unit last summer, the group is all set to answer and anticipate the end users' needs.

Thierry Munier started his career caring for patients directly, by manipulating the imaging equipment as a radiographer. This experience has given him invaluable insight of what customers need from equipment manufacturers, and a unique opportunity to witness all the technological advances in the field.

"I started as a radiographer in 1987, the same year MRI became widely implemented in clinical practice. So I sort of grew with MRI and had time to assimilate the developments. This knowledge became very useful when I switched to the industry 15 years later," he said.

Thierry is now responsible for Canon Medical's MR business in 50 countries, a mission that is both complex and exciting. "We're dealing with different organisations and distributors in many countries, languages, cultures and various healthcare systems. Our partners also have different levels of maturity in medical imaging, so we have to adapt our offer to each and every scenario while matching the needs of every end user. It's exhilarating," he said.

A leader in patient comfort

To match the wide disparity in its customer base, Canon Medical Systems Europe has developed a set of solutions based on efficiency, with an emphasis on patient comfort.

"MRI examinations are known to be long and noisy, so we must offer appropriate strategies to make the patients feel as much as possible at ease. They must overall have a positive experience and be calm during the examination," Thierry said.

The quality of images acquired with MR heavily depends on patient cooperation. To augment patient well being, Canon Medical's MR systems all feature ultra-short open bores and feet-first imaging.

A few years ago, Canon Medical introduced the MR Theater, an immersive entertainment system that helps patients focus their attention on elements other than the examination. The MR Theater uses sounds and videos of peaceful surroundings that are being projected on a screen and onto the bore's walls to soothe any potential patient anxiety.

Canon Medical has also pioneered and patented the Pianissimo™ technology to reduce the level of noise in and around the MRI environment and improve comfort. Users have reported high levels of satisfaction and quiet with this unrivalled solution, which uses space at the heart of hardware. "Pianissimo has made our reputation. It has 0 impact on workflow and it's unique on the market. It's deeply rooted inside the equipment," Thierry explained.

Canon Medical is also increasingly equipping its new MR scanners with wider bores (71 cm vs. 60 cm), as these can improve patient experience and accommodate larger patients.

Different customers/ users, different offer

Canon Medical's MR systems offer wide field of view and extensive range of standard and specialty coils, to ensure accurate diagnosis in a variety of clinical and research scenarios.

The 1.5T Vantage Elan provides standard, high quality imaging. It's easy to install and useful in many settings including paediatric, cardiac, vascular, breast and quantitative imaging. But this market segment is continuously dropping for the past few years in Europe because buyers focus more on wide bore scanners which increase comfort and patient acceptance during the examination.

"The market demands more efficient and faster systems, which reflect the evolution in MR in terms of resolution, scanning time and diagnosis accuracy/ reliability, but also comfort and ease-of-use. So we now have the 1.5 T Vantage Orian, which offers much more technical possibilities with a 71 cm-wide bore," Thierry said.

The Vantage Galan 3T enables to expedite examinations with cutting edge acquisition techniques such as DTI or fMRI. Recent technological advances in 3T MRI have enabled its wider adoption in clinical practise. "With 3T we can now have very versatile equipment and well known 3T artefacts are now far away," he said.

Our strategy is to match the end users' needs, as the current trend is to decrement, with the majority of healthcare systems experiencing budget cuts. Strategies that help to do more with less have therefore been explored.

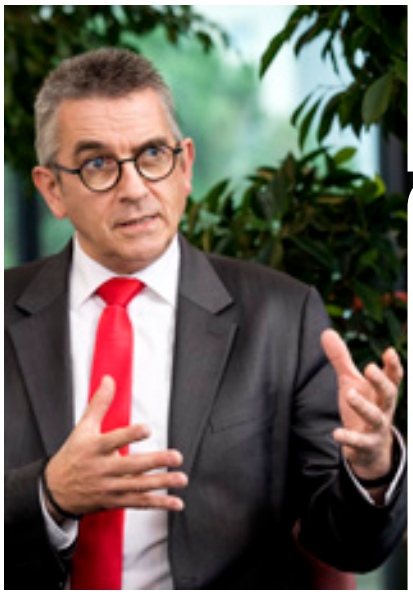
A precursor with DLR and vendor versatility

Artificial intelligence (AI) has emerged as a potential solution in many applications that could enable to save costs in the future. Canon Medical has taken the lead with the recent launch of a Deep Learning Reconstruction (DLR) solution, the Advanced intelligent Clear-IQ Engine (AiCE) software, which helps to 'see through the noise' combined with the Vantage Galan 3T and Vantage Orian.

"We are the first on the market to offer a validated tool that enables to reconstruct and eliminate noise from an image, even a very noisy one. This is called denoising; we're just taking the noise away, not the useful information. Some preliminary users have even noticed that images acquired with 3T and AiCE look similar to those acquired with 7T."

AI will continue to play a leading role in MR workflow and help stabilize image quality, an ever challenging task with MR. "AI will enable to anticipate these situations and correct an image whenever necessary, in order to obtain optimal quality and reproducibility. Manufacturers will help a lot in this regard," he said.

To improve reproducibility between exams, Canon Medical has developed EasyTech, a machine learning-fed software which positions slices according to patient's anatomy using automatic detection. The solution enables to obtain the same slice positioning in different examinations, which can be useful for radiologists doing follow-up imaging but also for radiographers, by providing easy, automatic and reproducible slice positioning for every patient.



"We have a very complete portfolio to help our users take MR to the best of its abilities."

Thierry Munier, Senior Manager for the European MR Business Unit , Canon Medical Systems Europe.

In spite of the tremendous possibilities, many hospitals are still reluctant to use AI because of vendor dependence issues. There is still a trend for manufacturers to only enable to run algorithms that have been purchased with their equipment, which limits the widespread use of AI technology in clinical practise.

Canon Medical has already addressed the problem during RSNA 2018, by launching, Collaborative imaging, an initiative to allow a transversal and multi solution-based approach in the management of particular anatomies or pathological scenarios, from diagnosis to treatment, analysis and information sharing.

"It's one of the main questions right now: what is the place for AI? We think it will be everywhere. We already use the Collaborative imaging approach on our different modalities, but we could also do it in image post processing, analysis and reporting. Unleashing the power of AI regardless of the acquisition modality will be paramount and we need a global solution," Thierry said.

Canon Medical works with Vital and Olea Medical on post processing solutions that can easily be shaped depending on customers' needs - a single stand-alone console, a light server, a larger server for major institutions with many users for image analysis and reporting - regardless of the manufacturer.

"Compatibility is often an obstacle, however, you need to be able to work with others to grow. We therefore offer a post processing solution that can adapt to any system or setting."

Future directions

Canon Medical Systems Europe aims for 15-20% of the MRI market share and is actively working towards that goal, by taking part in impacting research projects at Bordeaux University and Sainte Anne Hospital, Paris Descartes University in France.

The Vantage Galan 3T is instrumental in setting future clinical practise and offers two versions of magnetic fields gradients to step up cardiac and oncology imaging quality, by notably working with acquired and synthetic images, which help speed up acquisition times.

The Vantage Galan 3T is the technology used by the medical teams of prestigious football clubs such as Manchester United, Real Madrid and FC Barcelona. "These partnerships already demonstrated our strength in matching high image quality expectations in MSK imaging of professional players, anytime clinicians need immediate diagnosis for: acute injury or long term follow-up for physical load programme during training," Thierry said.

Canon Medical's MR product line also helps improve breast MRI, a fast developing field with major on-going screening campaigns. In dense breast mammography, this technology can be a complementary solution, especially in difficult cases, as recent studies highlighted.

One machine in the pipeline that should obtain CE mark early 2020 is the 3T Vantage Centurian, which will be deployed in the research setting. The technology has the most performing gradients available on the market and is currently being implemented at Bordeaux University.

Be it for general or high-end MR systems, Canon Medical continues to invest massively to provide the fastest and easiest user experience, and match a common expectation: make MRI simple, fast and reliable, regardless of the operator's knowledge and skills.

Customer satisfaction is reportedly very high on all devices and Canon Medical wants to set the bar higher.

"For us, it's all about placing healthcare professionals and patients at the centre of our activity. We cater to our end users' needs; be they in daily practice workflow, post treatment, analysis or system optimisation. We have a very complete portfolio, with guaranteed ease of use, to help our users take MR to the best of its abilities, " Thierry concluded. //

EasyTech Solutions
Increase throughput in MR

Frédéric Martin , Dr. Marie Dominique Boespflug, Patrick Andres

The EasyTech functions guide the operator through the scan process, from beginning until end. This reduces idle-time between the sequences, improves the workflow and enhances reproducibility for longitudinal follow-up examinations.

EasyTech Knee Package

The EasyTech Knee Package consists of the SUREVOI Knee and KneeLine+ applications and supports the operator in automatically centering the volume of interest (VOI) and position slices for knee examinations. The application also detects when the knee is incorrectly placed in the RF coil. It enables a knee examination with just one mouse click.

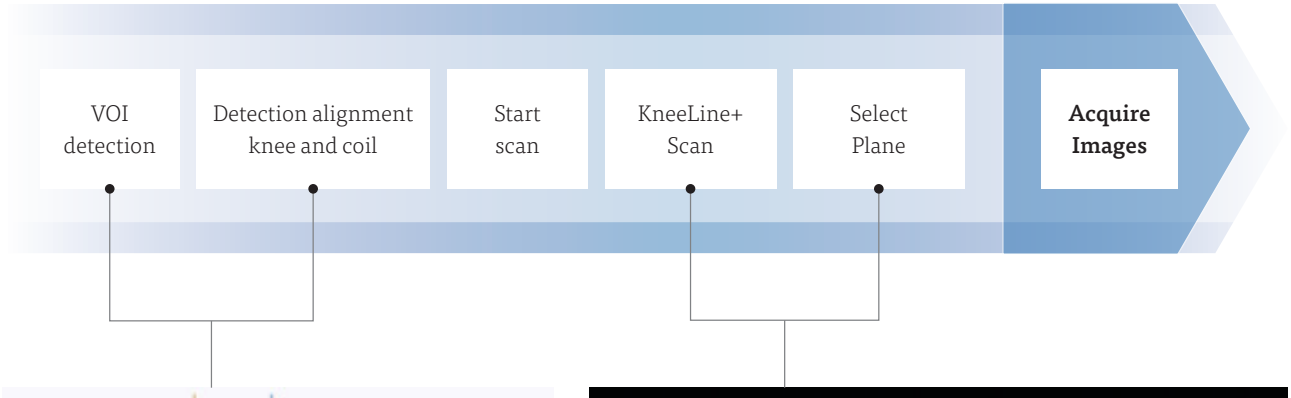
SUREVOI Knee

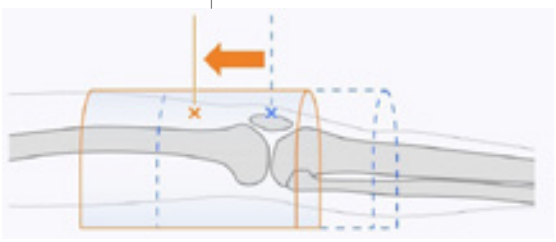
SUREVOI Knee is a positioning support function that automatically detects the knee and places the VOI and pre-saturation zones (if necessary) to eliminate wrap-around and flow artifacts. Using anatomical recognition, SUREVOI detects if the center of the knee and the center of the RF coil are aligned, and instructs the operator if repositioning is needed.

KneeLine+

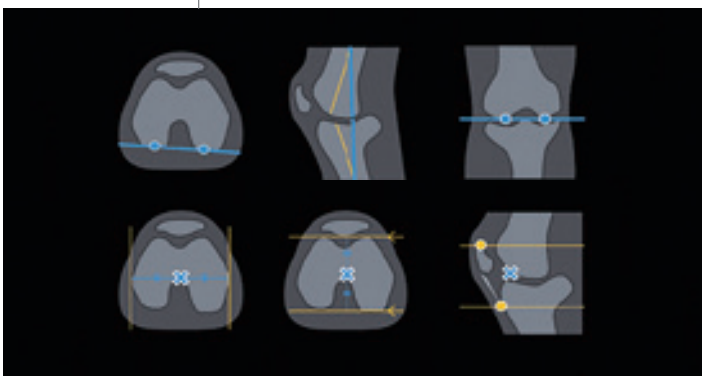
KneeLine+ automatically defines the standard scan planes of the knee (axial, sagittal and coronal). If necessary, the orientation and position of the standard planes can be adjusted.

Workflow EasyTech Knee Package:

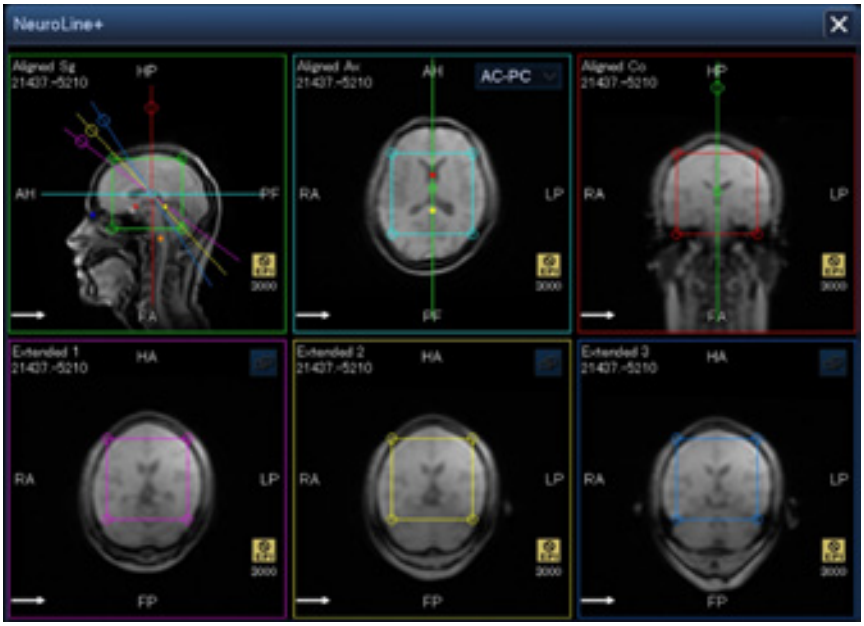




SUREVOI Knee



KneeLine+.



NeuroLine+ window.

The G.I.E VAR OUEST private center in Ollioules, France, has a Vantage Orian with M-Power V4.5. Most of the center's work is based on musculoskeletal- (frequently of the knee) and neurological examinations (of the brain).

Using the EasyTech Knee Package, the sequences follow each other automatically without wasting time. The operator can register and prepare the next patient. Looking for musculoskeletal examinations, the EasyTech Knee Package enables an increase in efficiency and scanning of an additional 1.5 patients extra per day on average.

"After 2 to 3 days of adaptation, the team acquired the utmost confidence in the AI automatic positioning techniques, which allow them to concentrate on other, more rewarding tasks, such as post-processing tasks. Examination time is optimized, and no time is wasted. Today, 85% of knee exams are performed using this technique.", explained Mr Martin.

NeuroLine+

The NeuroLine+ application is used to automatically plan brain scans. The three standard planes are detected: (1) the mid-sagittal plane, (2) the axial plane (either parallel to the anterior commissure - posterior commissure (AC-PC) line, or to the orbitomeatal (OM) line) and (3) the coronal plane. Alongside these planes, the user can define his/her own scan planes.

Initial results from G.I.E VAR OUEST demonstrate the efficiency of this technique, both from the point of view of reproducibility of longitudinal lesion follow-up and from a smooth workflow. Regarding the time taken to perform neurological examinations, they have increased efficiency by one more patient a day on average. In patients suffering from Multiple Sclerosis, the radiologist will not only be able to count the number of plaques, but will also be able to compare their sizes, because the follow-up examination is acquired in exactly the same plane. The same applies for the follow-up of patients with 'tumor-like' lesions, enabling better treatment adjustment.

"Using this technique allows us to carry out a real follow-up of patients with Multiple Sclerosis and brain tumors. The reproducibility of the scan planes enables us to compare both the number of macrophages and their size. Measurements can also be replicated in the case of brain tumor treatment, and we can judge the effectiveness of the treatment. Today, 97% of exams for MS and tumors are carried out using this technique.", explained Dr. Boespflug. //

Frédéric Martin
Referring MRI Radiographer, G.I.E VAR OUEST, Ollioules, France.

Dr. Marie Dominique Boespflug
Radiologist and Doctor, G.I.E VAR OUEST, Ollioules, France.

Patrick Andres
MRI Clinical Application Specialist, Canon Medical Systems France.

VISIONS spoke with Prof. Franco Orsi, from the European Institute of Oncology (IEO), Milan, Italy

Expanding Interventional Radiology with the Highest Image Quality

The Alphenix 4D CT helps considerably improve minimally invasive treatments, by facilitating workflow, reducing surgery time and improving image quality, according to a leading interventional radiologist at a prestigious cancer centre in Italy.

The European Institute of Oncology (IEO) in Milan is the fastest growing comprehensive cancer centre in Europe. The team at IEO tackles cancer on all fronts, from prevention, diagnosis, and treatment to training and basic and translational research.

At the institute, Interventional Radiology (IR) is truly the fourth pillar of oncology, next to clinical oncology, surgical oncology and radiation therapy. In 2010, IR became a clinical department of its own, completely separated from the rest of radiology.

Prof. Franco Orsi has been involved with the IEO ever since its iconic founder Prof. Umberto Veronesi was hiring young specialists to build a new concept of clinical oncology management, mainly based on minimally invasive therapy.

The Radiology Team at IEO, Milan, Italy

Prof. Orsi is Chairman of the Interventional Radiology department, with a team of seven interventional radiologists, two or three residents, six anaesthesiologists, seven nurses and eight technicians.

The team performs a wide range of activities from invasive diagnosis, with around 1,500 CT and Ultrasound guided biopsies per year, to highly sophisticated interventions, such as liver chemoperfusion during Extra Corporeal Circulation (ECC) and percutaneous ablation during single lung ventilation.

"The huge experience we've accumulated within the last twenty-five years and our close collaboration with other specialists enable us to constantly update our approaches, with the aim to increase the indications for IR, always within the boundaries of minimal invasiveness," Prof. Orsi said.

To match the growing demand for less invasive procedures, the IEO decided to add Canon Medical's Angio CT Suite, the Alphenix 4D CT in 2018.

Canon's experience with the technology is a specific guarantee for the functionality of the system, according to Prof. Orsi. "It is of the utmost importance when reliability and efficiency of this technology are the basis of an adequate and safe daily clinical activity. Regarding the specific features of the system, of course the connection between Fluoro and CT provided by the system is unique on the market," he said.

The IR team uses the Angio CT Suite routinely, and with Canon Medical's help, has learned how to use the system to the best of its abilities.

Boosting workflow

The core business of IR clinical activity is mainly represented by those interventions that are performed under general anaesthesia. Since 2008, the IEO had been equipped with a CT room, with a mobile digital C-arm fully dedicated to IR procedures performed under general anaesthesia.

This combination of CT and fluoroscopy in one room enhanced the safety, precision and efficacy of these interventions. But many important issues were affecting the workflow. Due to the indirect interaction between acquired fluoro and CT images the procedure times were long.

"The procedures took longer because of the time needed for post processing the imaging data sets. This challenge has been completely overcome thanks to the Alphenix 4D CT system. CT, Fluoro and Ultrasound images are integrated and sent to a large screen directly in the room, for faster and more efficient imaging interpretation. Reducing the length of the intervention is of critical importance, especially since patients are under general anaesthesia," he explained.

Imaging data sets coming from different sources can be processed in real time by the system and fused, if needed, to improve the visibility of the area where the intervention is being carried out.

Having the patient lying on an angio table rather than on a CT couch, has also improved patient accessibility.

Thanks to the rails on which it is mounted, the CT scanner can be positioned close to the patient and in parking position, positioned far from the patient. "That's a great feature, allowing the IR room to host the many indispensable technologies for modern IR activity," Prof. Orsi said.

A wide variety of procedures made possible

The Alphenix 4D CT is of great support to perform intra-arterial embolisation (TAE), chemo-embolisation (TACE) and radio-embolisation (TARE) procedures of liver tumours. These procedures particularly benefit from a technology like the Alphenix 4D CT because of the integration of vascular images and CT.

Intra-arterial liver chemosaturation during Extra Corporeal Circulation (ECC) is safer and faster with the system, which also enables us to increase the number of percutaneous ablations to around 500 ablations per year at the IEO.

Renal and lung liver are routinely performed with fusion imaging software integrating Ultrasound and CT imaging. The Alphenix 4D CT also enables us to treat emergencies, for example, when bleeding is suspected. "The patient is usually sent to the the Alphenix 4D CT instead of the CT room for initial diagnosis, in order to save time and start the embolisation immediately after bleeding is detected," he said.

The Alphenix 4D CT also offers plenty of new unexplored possibilities, and as the technology improves, intra-arterial procedures for treating tumours will increase indication and efficacy, he believes. "The concept of treating tumours through their vascular feeders is winning, but the main limitation is the detection of all the right feeders, and it is a matter of imaging quality," he said.

The IEO changed their clinical pathways thanks to the new system. For instance, during hepatic angiography performed as simulation for TARE, the volume CT acquisition during the selective intra-arterial injection allows us to precisely define volumetric assessment of the involved liver parenchyma, facilitating the process of treatment planning.

Collaboration with Canon Medical Systems has been fruitful from day one and the team is looking forward to more exchange to improve an already amazing system.

"After a few months of IR activity with the new Alphenix 4D CT, I cannot think how to treat my patients without it. The system is really addictive and once you start to use it for clinical practice, you will never want to stop to use it."

The new Alphenix 4D CT means being able to "navigate" virtually within the volumes of the organs. It means targeting quickly and accurately the tumour lesions to be eliminated. To feel confident to have eliminated the pathological tissue without complications, immediately at the end of the treatment and without other instrumental checks." Prof. Orsi concluded.

"The system is really addictive. I cannot think how to treat my patients without the Alphenix 4D CT."

Prof. Franco Orsi, Head of the Interventional Radiology department, IEO, Milan, Italy.

Prof. Franco Orsi (right) and Dr. Della Vigna (left).

The added value of the Embolisation Planning Software

Imaging is the backbone of Interventional Oncology and its quality and precision will affect the outcome of any image-guided interventions. In the field of intra-arterial therapy, such as liver chemo-embolisation and radio-embolisation, the quality and the amount of imaging information regarding the target, are directly affecting the whole procedure itself: precision, complexity, safety, length and results, are essential values, depending by the quality of the facilities used for treating the patient.

The fact that we have both real CT images and angiography images in the same room is obviously a great advantage if compared with a regular angiography system or C-arm for maintaining a high level of precision in targeting a liver tumour during the embolisation. Aquiring CT images during selective arterial contrast injections allows us to confirm the correct position of the catheter tip prior to the treatment. Moreover, by changing the position of the catheter, according to the vascular anatomy (provided by DSA) and the CT imaging, it will be possible to save unaffected liver parenchyma or to find more feeders for the same tumour, to be targeted for a more effective treatment. Unfortunately, when the imaging information is coming from different sources, such as CT, DSA and US, the management of this huge amount of information is usually up to the Interventional Radiologist.

That's the real benefit provided by the Alphenix 4D CT: images are integrated by the system, because the sources are connected, to each other. One of the helpful features provided by this unique integration, is the Embolisation Plan software package. It is a dedicated software tool for quickly finding the correct feeders to be targeted for a super selective embolisation of (liver) tumours or arterial bleedings.

It usually reduces procedure time and also x ray dose because it helps to avoid unnecessary catheterization of arteries which are not feeders of the tumour.

The Flexibility

The amount of Interventional procedures are rapidly increasing and are also becoming more and more complex. The strength of an Angio CT concept is bringing the best of 3 worlds together in one room to optimize flexibility, minimise risks and improve patient outcome.

The system allows to give flexible space for collaborating with colleagues such as Anesthesiologists or Surgeons who are present in the room during some interventions. The Alphenix 4D CT positioning is very flexible to avoid interference with those people and their equipment.

Moreover, an advanced IO activity cannot avoid to use different devices for treating different tumours in different organs. There is more often the need to change the position of the many devices around the patient and it can be done only when the system has flexibility, which allows the C-arm and the CT scanner to move out from the patient very fast and easily, by only pushing couple of buttons. And using its auto-positioning possibility where pre-defined positions of CT and C-arm can be programmed and recalled.

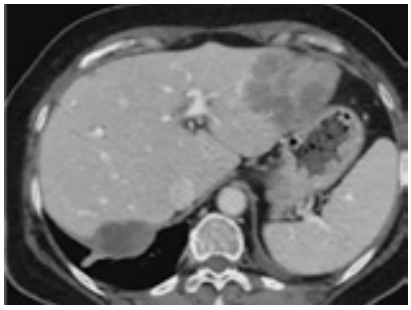
A one room solution

The availability of all of the most useful imaging sources into the same room, as previously mentioned, allows for better disease definition and target identification. Moreover, all these facilities will also provide a better and earlier feedback of the treatment. It is of crucial value, certainly when the patient is under general anesthesia during an IO intervention.

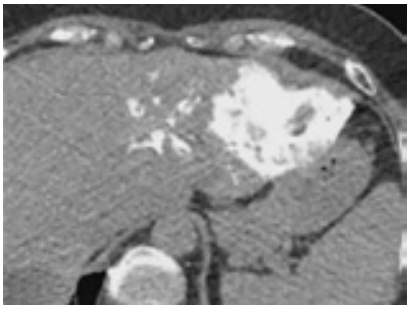
Before waking up the patient, the success of the treatment can be verified directly and it can be decided right away if the treatment needs to be continued instead of assessing the outcome a day after when the procedure is already finished. //

Clinical case 1:

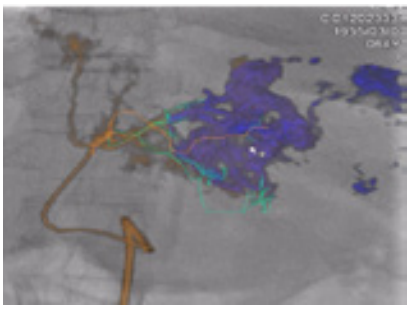
Liver metastasis from CRC progressed after to 2 lines of chemo:
indication for Irinotecan-DEB-TACE.



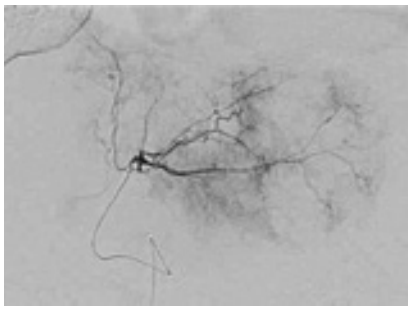
CT scan shows the huge liver metastasis in the left lobe.



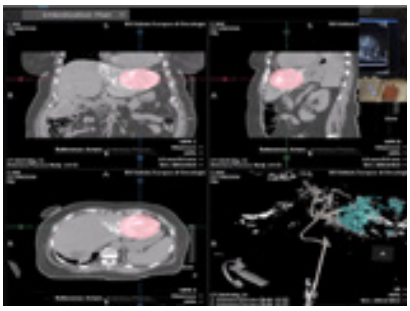
CT during arterial selective injection of c.m., shows the enhancement of the tumor.



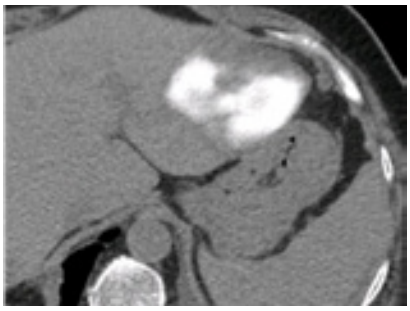
3D roadmap is used to overlay the CT volume to fluoroscopy for guiding the treatment.



DSA of the left hepatic artery shows the possible feeders to be used for chemoembolisation.



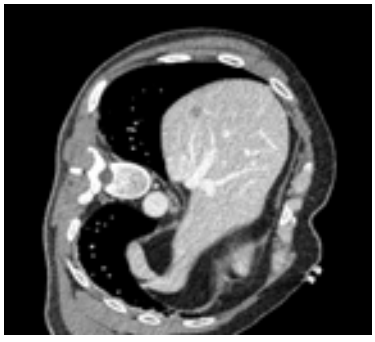
DSA and CT imaging are integrated by the system, which will provide a 3D Roadmap and the routes for treating selectively the mass.



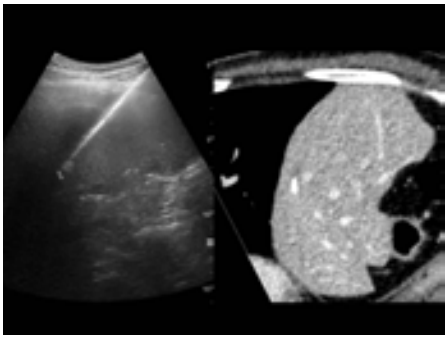
Native CT after the procedure, shows the embolic material concentrated within the tumour.

Clinical case 2:

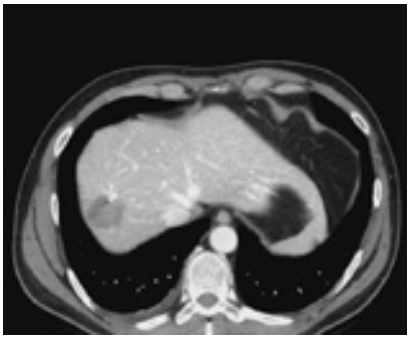
Post-surgical relapse of a liver metastasis from CRC:
indication for percutaneous ablation.



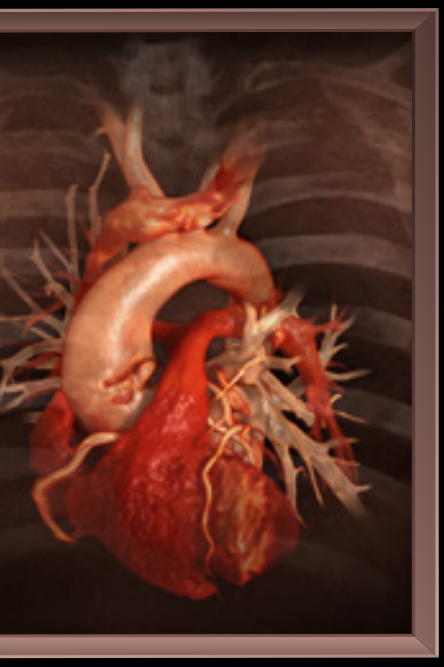
CT performed with the patient in lateral position, ready for the ablation, shows the small liver relapse after liver resection.



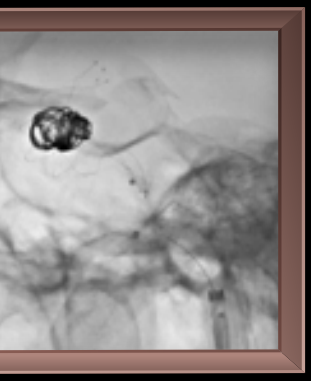
Fusion imaging (Ultrasound and CT) was used to target the liver lesion and guiding the MWA-needle to the target.



CT scan shows the large ablation zone after the procedure. The surgical clip of previous resection is also visible.



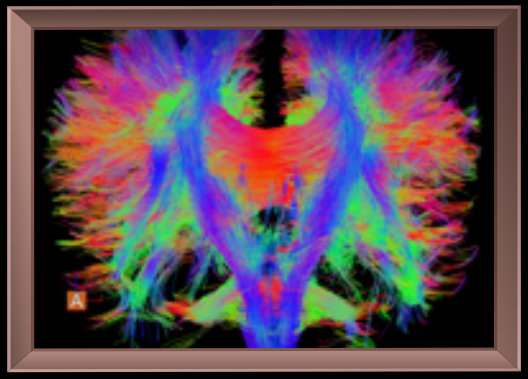
Collaborative imaging for Improved Patient-Centric Care



At Canon Medical Systems, we recognize that the healthcare landscape is rapidly changing and understand that you face many challenges with each patient encounter. Collaborative imaging, our novel approach to healthcare, unites multiple modalities and innovative clinical applications with integrated imaging intelligence at the center of a patient's journey – enabling you to deliver better patient-centric care.

Collaborative imaging helps to make sense of the complexity, by simplifying and streamlining workflows through the integration of Artificial Intelligence (AI). It allows you to organize and orchestrate all pieces of the care-cycle puzzle and optimize collaboration between all departments within your institute.

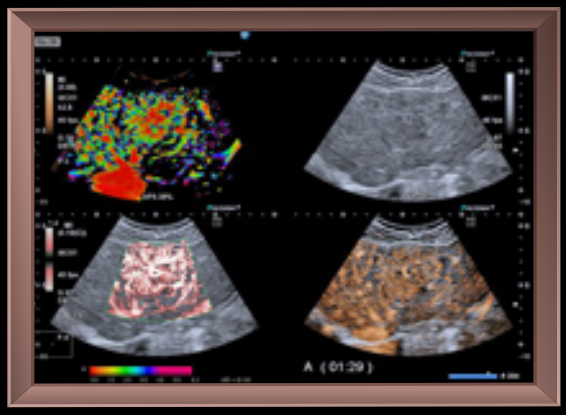
Born from our "Made for Life Philosophy" and our unwavering commitment to innovation and improving the quality of life, Collaborative imaging enables you to improve clinical-, operational- and financial outcomes, while effectively managing and reducing risks.

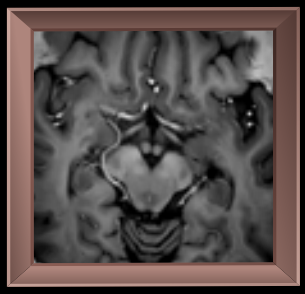


Improve **clinical outcomes** by seamlessly combining multiple imaging modalities and the extensive portfolio of systems and applications with leading-edge AI-assisted technologies to help you deliver high-quality care with confidence. From scan, to diagnosis, to treatment delivery, you'll have all the insight you need to optimize outcomes for every patient, at every stage of their clinical journey.

Improve **financial outcomes** by safeguarding your investments through our strong and premium service program that leads to better uptime and keeps equipment running at peak performance. Optimize system usage by analytics and dashboards that put relevant information at your fingertips and, if the need arises, we can help you create custom dashboards that reveal specific details about your business. Last but not least by addressing your educational needs, which are a cornerstone to our business. Our approach is well-known and unique in the industry. We customize programs to fit your needs depending upon the base knowledge and the ability to learn. The simple fact is that when your staff know-how to fully operate your Canon Medical equipment, workflows are enhanced, and outcomes are improved.

Improve **operational outcomes** through our AI-based Automation Platform – an advanced AI-solution – that receives images directly from scanners and intelligently processes relevant patient data and delivers zero-click automated clinical results to the relevant clinical team. Additionally, Canon Medical's AiCE (Advanced intelligent Clear-IQ Engine) and DLR (Deep Learning Reconstruction) technology, available for both CT and MR, transforms images that were once noisy or seemed to have poor signal, into sharp clear images. Image sharing is made simpler with Vitrea Connection, while Vitrea View allows for fast access to this data with diagnostic quality images providing physicians the ability to review patient-related information, even at bedside and on a wide variety of platforms. Cyber security is also inherently integrated into the Collaborative imaging story. We understand that threats are hard to see and can come at a great expense when they occur. This is why we offer multiple solutions, adding multiple layers of security that can alert and stop cyber-attacks before they can cause serious harm.





In conclusion, Collaborative imaging helps you putting patients at the center of care. It improves outcomes and reduces and manages risks with integrated intelligence every step of the way.

The ultimate goal of Collaborative imaging is to improve every individual patient outcome.

Canon Medical is debuting Collaborative imaging at this year's European Congress of Radiology. //

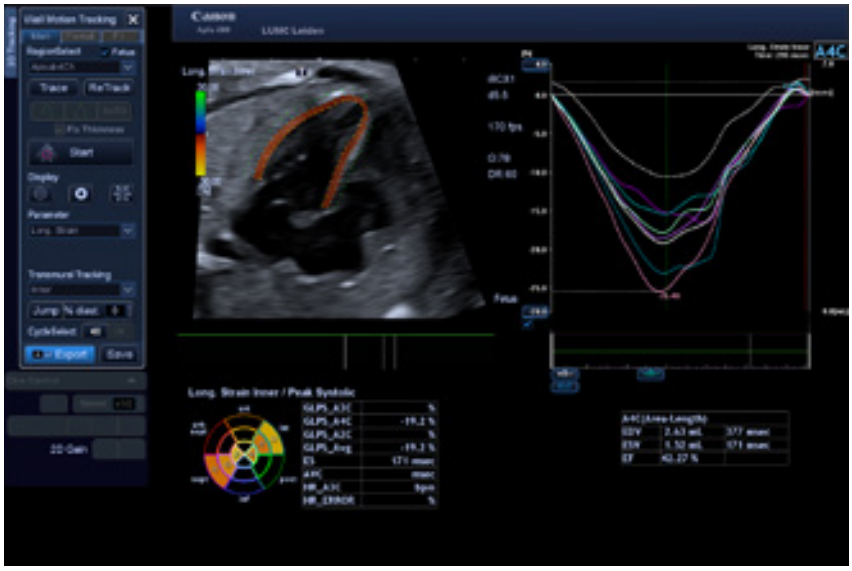
VISIONS spoke with Dr. M.C. Haak, from LUMC, Leiden, the Netherlands.

Detecting Congenital Heart Defects in the Womb

Canon Medical's Aplio i-series delivers outstanding clinical precision and helps clinicians get diagnostic answers quickly and reliably. Monique C. Haak, MD, PhD, fetal-maternal medicine consultant, fetal surgeon and head of obstetric ultrasound at Leiden University Medical Centre in the Netherlands, explained how the system's image quality and options such as speckle tracking have helped her improve her diagnostic confidence when detecting fetal abnormalities.

Challenges in fetal imaging

Leiden University Medical Centre (LUMC) is a referral centre and performs all fetal procedures in the country. Dr. Haak's team includes fetal medicine specialists, prenatal nurses, five sonographers and physicians specialising in ultrasonography, residents in training, fellows and administrative and social workers.



"My daily work is to care for fetuses with congenital abnormality. A big part of my work is to sort out what is wrong in unborn babies," Dr. Haak said.

"With the advancement of technology and improved visibility of the machines, we can detect more and more abnormalities, but we do not always know what they really mean for the life of the fetus, yet it is very important to make a proper prognosis," she said.

This gap is especially true for fetal brain imaging, where researchers have made huge strides in the past 15 years, but still struggle to get good long-term outcome studies in sufficiently high numbers.

"Follow-up studies are difficult to do, you need parent consent for everything. Your data is sometimes three years old. So you gather a lot on a particular abnormality, but can't connect it to the outcome. However you need that if you want to do proper parent counselling," she explained.

LUMC has a very good follow-up programme for fetal surgery and the largest service in the world for Twin-to-Twin Transfusion Syndrome (TTTS), a serious disorder that occurs in identical twins and higher order multiples who share a placenta. Each year, the hospital carries out around 50 to 60 laser surgeries for TTTS as well as ten fetal shunts and 60 fetal blood transfusions.

Image quality, speckle tracking and other cutting edge technologies

Ultrasound is of course the first choice modality in fetal imaging and good equipment with the latest technology available is key. Dr. Haak and her team have been working with three Aplio i800 systems for the past three years, a decision they have never regretted.

"The system's image quality is superb, especially in challenging patients, for example obese mothers-to-be. We typically obtain less clear images in these patients. The Aplio i-series is the best system at the moment. I am surprised on a daily basis how good the images are in these patients," she said.

With the Aplio i-series, Dr. Haak can examine more patients in a reduced time, a clear benefit in fetal surgery. "If you have to put a shunt or needle in the chest of an unborn baby, image quality during the procedure is crucial and will determine how long the procedure will take," Dr. Haak said.

Dr. Haak is coordinator of the Fetal Heart Programme, with around 100 new patients with congenital fetal heart defects each year. To detect heart defects, she increasingly relies on new technologies like speckle tracking, in addition to standard 2D and Doppler ultrasound.

"The system's image quality is superb."

Dr. M.C. Haak, Fetal-maternal medicine consultant, Fetal surgeon and head of obstetric ultrasound LUMC, Leiden, the Netherlands.

From left to right: Dr. Katinka Teunissen, Dr. Manon Gijtenbeek, Annemarie de Veld (Fetal therapy nurse), Dr. Monique Haak (Fetal-maternal medicine consultant, surgeon and head of obstetric ultrasound).

"Innovation in ultrasound is very welcome. Canon was one of the first to offer excellent speckle tracking, enabling us to check strength of the heart, if contractility is reduced or not. It is a challenge to look if modalities that are suitable and important in adults can have a role in fetal cardiology. I expect a lot from these new technologies for our youngest patients," she said.

Other features that will be interesting to explore are Myocardial Performance Index (MPI) and Wall Motion Tracking (WMT), especially in fetuses with conditions that affect one chamber of the heart. "Sometimes you see progressive valve stenosis, and at 20 weeks, you don't know yet if that will progress to, for example, fibrotic heart disease. MPI and WMT may be able to predict which fetuses will develop this condition and which will end up with preserved left ventricle of the heart," she explained.

Another useful technique on the Aplio i-series is Superb Micro-vascular, which expands the range of visible blood flow and provides visualisation of low micro-vascular flow. Benefits compared to conventional Doppler technologies are high frame rates, high resolution, high sensitivity and fewer motion artefacts, offering clinicians new means to reveal minute vessels when evaluating fetal brain, kidneys or any other tiny vessels.

The future will be automated

These new modalities have convinced Dr. Haak. "Ten years ago, I could not have foreseen that image quality would improve that much. It's pretty remarkable."

In the future, she expects 3D technology to help make bigger strides with ultrasound, just as it did with MRI. Another area she believes will peak is automation of image analysis, to help determine which patients need referral and not.

"Automation could help to look at the volume of anatomical structure to detect whether a specific organ is abnormal or if it's too small or too big. We still need someone to measure this manually now, but within a decade, that kind of technology will be available. However we still need proper research if this is really beneficial or not," Dr. Haak said.

Genetic innovation will have a great impact on daily practice. Image quality will be the corner stone in fetal dismorphology and brain imaging.

There is a huge psychological impact when reporting fetal abnormalities and technology that helps provide more accuracy is essential. "You have to be absolutely sure of your diagnosis, because it may lead to pregnancy termination. You have to be very accurate."

"The Aplio i-series has not failed to deliver and the unmatched support from Canon Medical Systems has been equally flawless", Dr. Haak concluded. "I am really grateful to Canon and their service. They're reactive and can fix a problem within just a few hours." //

What is Synthetic MRI?
Olea Nova+ is the future

Thiele Kobus

Synthetic MR images are generated through calculation from acquired images and this MRI technology is gaining increasing interest. While the technique was already described in the 1980s, the high computational powers of current PCs make it possible to generate Synthetic MR images in real-time, extending its potential for clinical applications tremendously. Canon Medical together with Olea Medical offer a complete package for Synthetic MRI: Olea Nova+. VISIONS explains the technical background behind this.

Relaxation: The basis for MR contrast

To make an MR image, differences in magnetic properties between tissues are leveraged. Two important magnetic properties are the longitudinal (T1) relaxation time and transverse (T2) relaxation time.

Transverse relaxation time

T2-relaxation time is related to transverse magnetization. When no excitation pulse is applied, there is no transverse magnetization. By applying an excitation pulse, transverse magnetization is created. This transverse magnetization decays again over time. The speed at which the transverse magnetization decays defines the T2-relaxation time (Figure 1).

Longitudinal relaxation time

Although there is no transverse magnetization without excitation pulses, there always is longitudinal magnetization. The longitudinal magnetization is in 'thermal equilibrium'. By applying a 90-degree excitation pulse, the longitudinal magnetization is temporarily lost. After the pulse, the longitudinal magnetization will regrow to thermal equilibrium at a speed known as T1-relaxation time (Figure 1).

Tissue differences = contrast

Following a certain time after the excitation pulse, a difference in longitudinal and transverse magnetization occurs for tissues with short- and long T1 and T2 relaxation times. This tissue property is utilized to obtain contrast in MR images (Table 1).

Imaging parameters

As well as differences in the relaxation times, imaging parameters contribute to MR contrast. Echo time (TE) and repetition time (TR) have the biggest influence. With these parameters, the time between the excitation pulse and the

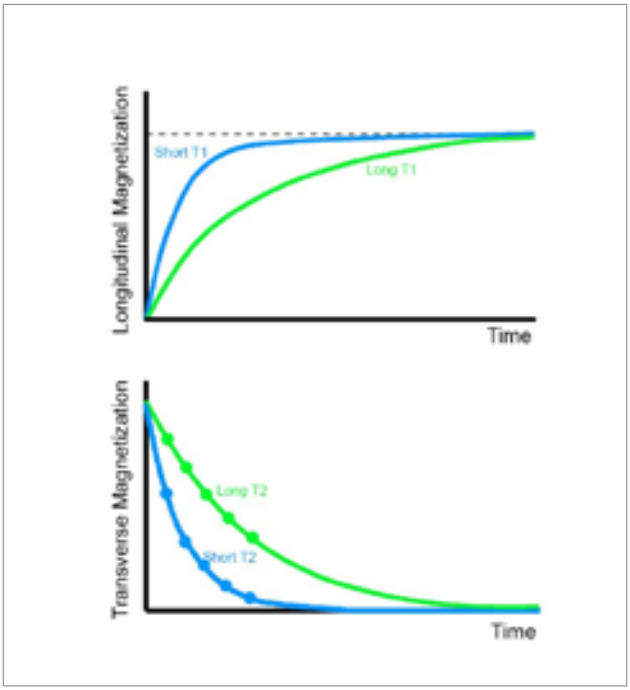


Figure 1, A fast return or magnetization drop means a short T1 or T2 relaxation time (blue lines) and the slow return or slow magnetization decay has a long T1 or T2 relaxation time (green lines).

Tissue	T1 (ms)	T2 (ms)
Water/CSF	4000	2000
Grey matter	900	90
Muscle	900	50
Fat	250	70

Table 1, Approximate relaxation times for different tissues at a field strength of 1.5T.

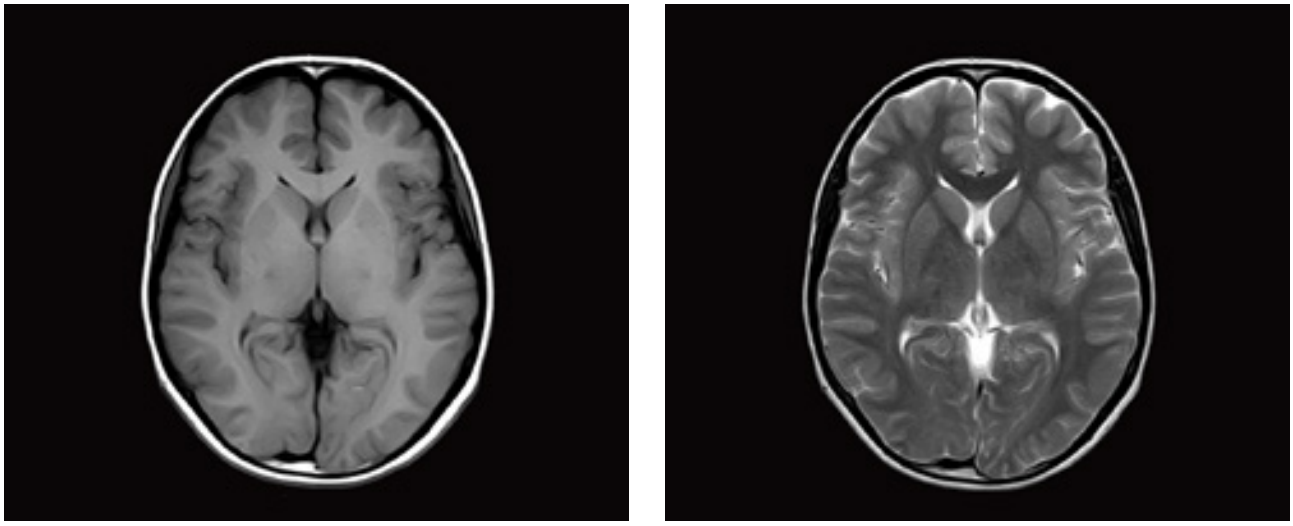


Figure 2, Axial MRIs of the brain. Left: T1-weighted image (short TE and TR). Right: T2-weighted image (long TE and TR).

sampling (TE) or time till the next excitation pulse (TR) is set. The operator can select these imaging parameters to give optimal contrast between two or more tissues.

Figure 2 shows differences in T1 and T2 relaxation times. For a T1-weighted image, we choose a short TE and TR, while for the T2-weighted images, both TE and TR are long. Many combinations in TE and TR are possible; however, to acquire many different contrasts, MR examinations can become very lengthy. Furthermore, different pathologies can alter the relaxation times of the tissue, which could lead to a sub-optimal image contrast for diagnosis. To overcome this, it would be desirable if the imaging parameters could be altered retrospectively. This is possible if you know the actual T1 and T2 relaxation times. Based on these values, you can calculate how the tissues would behave under different imaging conditions. The method to create new images from these calculations is called Synthetic MRI.

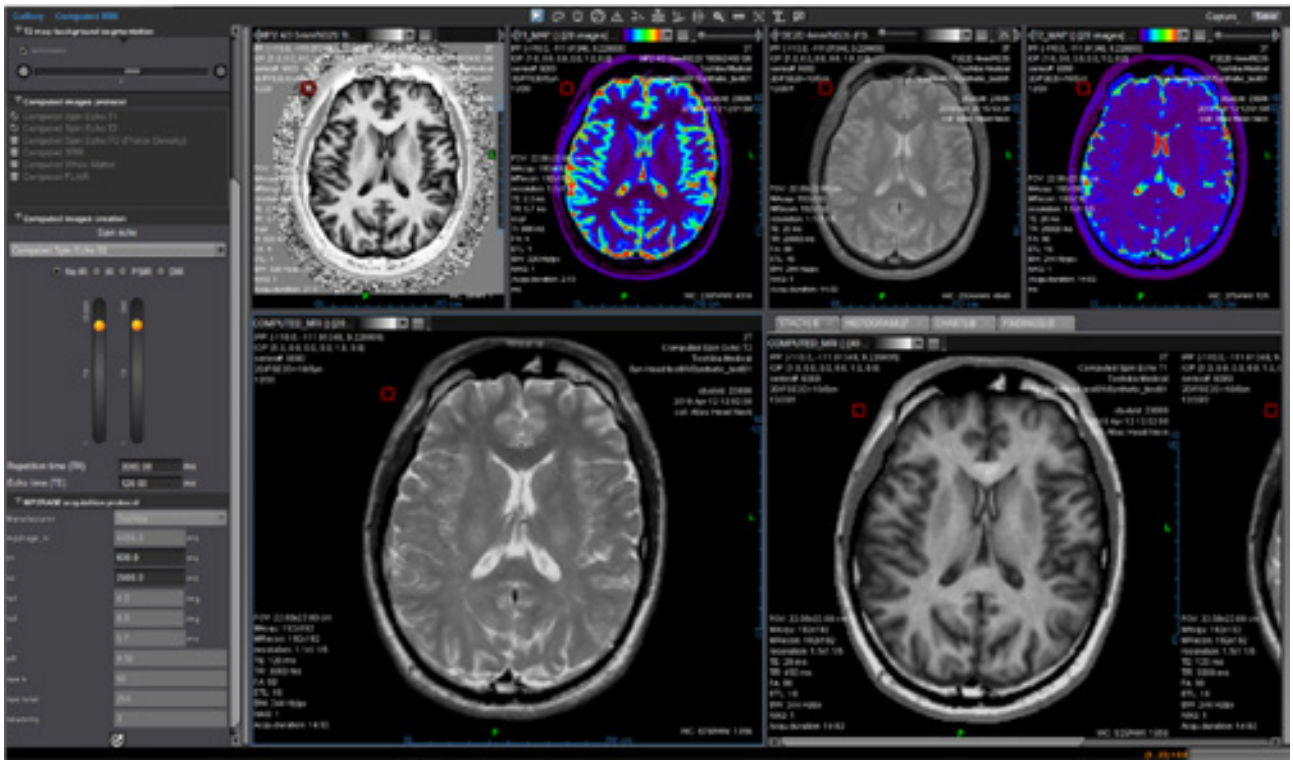


Figure 3, Olea Nova + software. Top row: MP2RAGE images from which the T1-map is calculated and FSE mEcho images used to calculate the T2-map. Bottom row: Two synthetic images with different imaging parameters.

How we do it?

Canon Medical MR systems require two sequences to be able to calculate T1 and T2 relaxation times. To measure the T2-relaxation time, we use a 2D FSE mEcho (2D Fast Spin Echo Multi-Echo) sequence. This sequence acquires the signal multiple times after an excitation pulse (illustrated by dots in the T2-relaxation graph in Figure 1). The longer the time between the excitation and the signal acquisition (TE), the smaller the transverse magnetization becomes. This is an exponential process and the Olea software fits the data points to obtain the T2-relaxation time (Figure 3 – top right).

For the computation of the T1 relaxation time, we use a MP2RAGE sequence (Magnetization Prepared 2 RApid Gradient Echo). This sequence starts with inverting the longitudinal magnetization of all tissues and samples the regrowth of the magnetization at two different time points after this inversion. In the Olea software, the signal intensity at these two time points is fitted and the T1 relaxation time is determined at each voxel (Figure 3 – top middle). Before the fitting process of both the T1 and T2 relaxation times, motion correction is applied.

Now that the T1 and T2 relaxation time is known at every position in the image, the software can synthesize new contrasts using signal equations that describe the signal intensity based on the T1, T2, TE, TR and TIs (inversion times). To create a T1-weighted image, a short TE and TR can be selected. The software then calculates the contrast obtained with these settings, presenting the result immediately. This new synthetic image can be saved and exported. To change the contrast again, the parameters can be altered (Figure 4) and a new image is created, without the patient needing to be present.

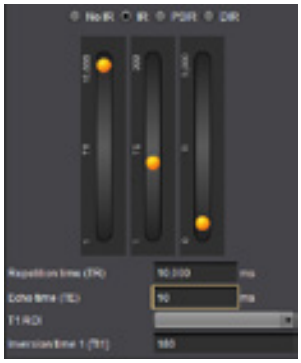


Figure 4, Selection of the imaging parameters.

Advantages and challenges

Synthetic MRI could alter the way MR images are acquired and interpreted. In a typical MR examination, several different contrasts are acquired. Many could be replaced by Synthetic MR images. This could significantly decrease scan time. Much greater flexibility is possible. The radiologist can alter the contrast after the MR examination and make additional contrast images without time penalties. The radiologist can access quantitative images of T1 and T2 relaxation times. This information could be very beneficial for follow-up examinations, as tissue changes can be compared quantitatively. Alongside this, contrasts that are difficult to obtain in vivo can be calculated , (e.g. examinations with long TEs or double inversion recovery (DIR) sequences). When acquired on the scanner, these sequences may have low signal-to-noise ratios, due to decayed magnetization.

A bonus is that the effect of metal artifacts is reduced in synthetic images cf. acquired images, which can improve image interpretation in e.g. MSK exams of patients with implants.

Despite these advantages, routine clinical use of Synthetic MRI will take some time. Radiologists are used to reading weighted images displayed in black-and-white, so it takes time to get a feeling for the quantitative (colored) maps of relaxation time (Figure 3). Furthermore, the contrast of a synthetic image with a certain TE and TR may look different to acquired images with the same settings.

A potential issue are the small partial volume artifacts that can occur at the edge of structures. However, these are easy to recognize by radiologists aware of their existence. Due to the endless contrast options available, radiologists might see structures that they are not as familiar with, requiring a return to their books! //

Thiele Kobus
Product Manager MRI
Canon Medical
Systems Europe.

Towards a Quantitative Era in MRI

Prof. Luca Saba

Professor Luca Saba, Head of the Radiology Department of the University Hospital of Cagliari, Sardinia, Italy, is an established and award-winning international radiology research professional. Enthusiastic about the advantages of Synthetic MRI, he shares his views on this new technique and his experience with Canon Medical's new Olea Nova+ with VISIONS.

Why are you particularly interested in Synthetic MRI?

"There are two levels of interest in Synthetic MRI; research and clinical. I think that the technique could have a significant impact in both."

"Firstly, for research, it is a cutting-edge technology with many advantages. It is easy to define a new hypothesis by using this technique in research, as everything remains to be proven. This is an important point. It's like writing a new book - Right now, we only know the letters, but we are starting to use them to write words, sentences, chapters, and so on.

Secondly, on a more technical basis, is that we can explore the intrinsic properties of the tissues. We can obtain pieces of information that do not depend upon the sequences or the magnetic fields but are intrinsic properties.

In the past, it was not possible to assign a unique number to a specific tissue. This was one of the limiting factors in MRI. When we conduct a study and demonstrate something based on signal intensity, we currently do not use a number, but say that it is brighter, or darker, compared to the muscle, for example.

These are obvious limitations compared to CT, in which we can assess that water is zero and fat is below -80 Hounsfield units. Previously, MRI, has been lacking a quantitative approach. Now, we are moving towards phenotypic and quantitative values - This is a concept of biomarkers. Synthetic MRI is allowing us to move towards a quantitative era of MRI.

With this, thirdly, we can move towards standardization of MRI interpretation. If we can assert that a tissue under examination has a value of 800 signal intensity, and we know that 800 is the normal value of the grey matter, we can conclude that there is no epilepsy for example, because the grey matter in that region is normal. This means that standardization in interpretation could be applied and a new database in terms of T1 and T2 values of tissues could be created. It is a new language!"

"As mentioned, there is also a clinical impact. With synthetic MRI , we could theoretically reduce acquisition time. As other sequences can be created from only two originals, we can show that the acquisition time could decrease by acquiring both original sequences and comparing the generation time.

Also, the aim of our next studies is to determine if conventional and Synthetic MRI series qualities are similar; if they are, then we can demonstrate that images obtained with Synthetic MRI could, therefore, potentially replace conventional sequences.

In addition, with Synthetic MRI post-processing, it is possible to obtain missing sequences. This is not possible with a conventional approach. After performing a study with the general protocol, we can read the examination 24 hours later, for example.

If, at that time, we realize that one sequence is missing, we can still obtain it if Synthetic MRI sequences have been acquired. This is a strong point from a clinical point of view, and we have already performed this in reality. In one case, a specific sequence was missing, because of a particular approach, but, with Synthetic MRI, we were able to reconstruct it afterwards. It is really useful!

Finally, Synthetic MRI allows standardization of workflow. In the future, if this approach is confirmed as robust, we could only have Synthetic MRI, diffusion and something

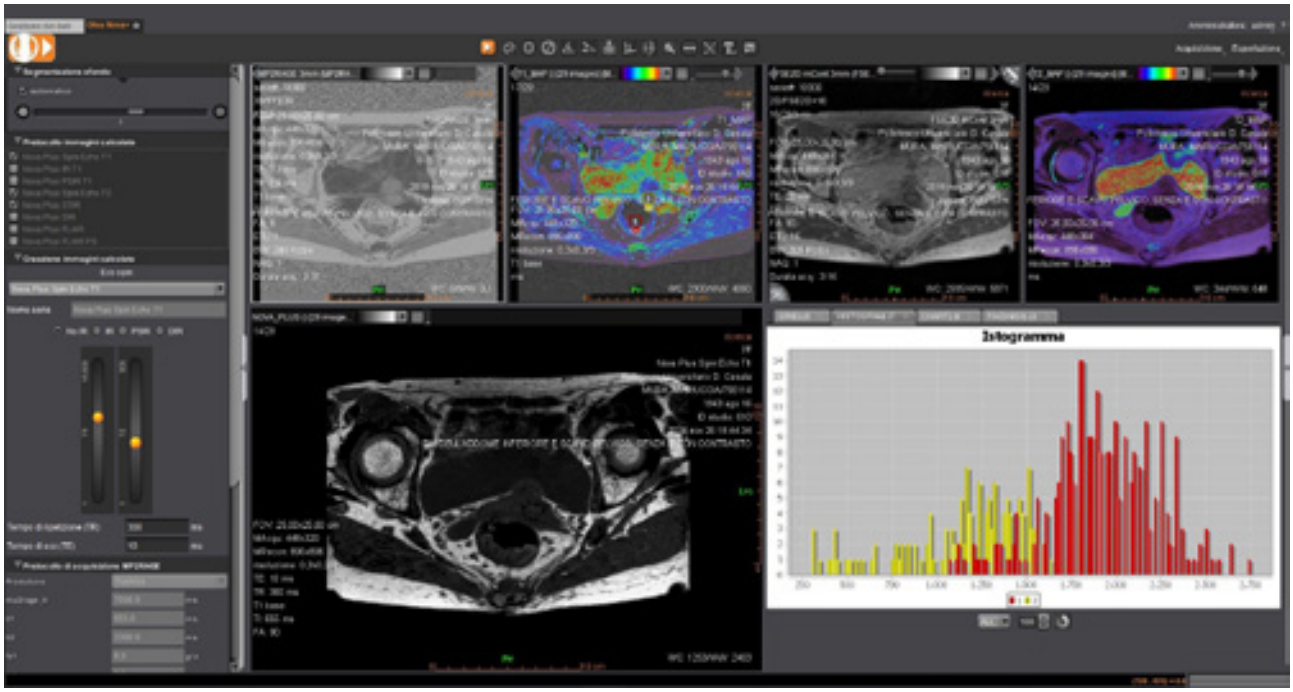


Figure 5, Olea Nova+ application in rectum. First row: MP2RAGE with T1 map and 2D FSE mEcho with T2 map. Second row: synthetic T1w image, histogram shows T1 values of neoplasm (red) and healthy tissue (yellow).

else, which gives us a very simple approach, but provides all the information we need. Moreover, this could avoid errors in the acquisition protocol. Most institutes have a high personnel turnover, however, working with MRI requires time to improve skills and understand techniques. With a simplified approach, we can avoid mistakes."

What is your experience so far with Olea Nova+?

"We are currently using Olea Nova+ in different organs: brain, rectum, prostate and musculoskeletal (MSK) imaging. For prostate, what is interesting is that we have patients who have undergone biopsy or prostatectomy, so their Gleason score is available.

The protocol is very simple; so, when we have time to perform it, we do so in a general clinical setting. For brain, there are cases with some types of pathologies where we always use Synthetic MRI. Therefore, we have a data bank with control subjects and some groups of patients with pathologies.

That is very important, because if we want to create a database of T1 and T2 values in normal brain – this has not been done yet, we need normal brains.

Ongoing studies concern validation among readers and acquisitions on the reproducibility of the sequences obtained from Synthetic MRI, compared to the conventional sequences in clinical practice of brain MRI. We have made presentations to the European Congress of Radiology (ECR) 2019, in which we demonstrated the flow charts and the advantage with regard to time, since it theoretically removes about six to seven minutes.

That is important, because compared to the 22 minutes conventional protocol, we could move to 15 minutes for a high throughput center."

The sequences required for Olea Nova+ provide quantitative information about T1 and T2 relaxation times. Does it bring new relevant information compared to qualitative MRI images?

"Of course, we have also studied the contribution of the quantitative analysis. For example, in rectal and prostate cancers, we analyzed the differences in T1 and T2 values between healthy tissues and tumors and found a significant difference in the distribution of these quantitative values between normal and pathological areas (Figure 5).

This is the future, and it is simple.

What could also be interesting is to combine Olea Nova+ with Olea Texture analysis. The massive approach implies that we use all the available features. If we have 120 features, we should use 120 and test to identify which feature has the best performance. So, we could say at the end: the best thing is to perform MRI with the two sequences required for Synthetic MRI, add the quantitative analysis and use the convolutional matrix inverse feature, for example. There are so many opportunities."

Prof. Saba graduated in Medicine from the University of Cagliari in 2002. His research interests focus on Multi-Detector-Row Computed Tomography, Magnetic Resonance, Ultrasound, Neuroradiology and Diagnostics in Vascular Sciences.

His work is embodied in more than 250 papers published in high impact scientific journals, including Lancet Neurology, Radiology, the American Journal of Neuroradiology, Atherosclerosis and European Radiology. Prof. Saba's work has been recognized by 18 scientific- and extracurricular awards during his career. He has presented more than 500 lectures, papers and posters in National- and International Congresses (RSNA, ESGAR, ECR, ISR, AOCR, AINR, JRS, SIRM, AINR); has written 21 book-chapters; is the Editor of 10 books; and reviews more than 60 scientific journals.

Prof. Saba is member of the Italian Society of Radiology (SIRM), European Society of Radiology (ESR), Radiological Society of North America (RSNA), American Roentgen Ray Society (ARRS), and the European Society of Neuroradiology (ESNR).

Synthetic MRI was the first project jointly led by Canon Medical and Olea Medical® teams. What do you think about collaborative imaging?

"I completely share the view that joining forces creates more strength. So, if we can create a connection, a cooperation between different experiences, we will create a greater product. I believe that the best thing I have done in the past was to create connections with my colleagues by identifying the people who could collaborate with different points of view.

This fosters the creation of bigger things. Not alone. Alone, I can do nothing, or not as much. I like this philosophy; it is also mine. I have always thought that it is better to win a game with people than to lose alone." //

Prof. Luca Saba
Head of the Radiology Department at the University Hospital of Cagliari, Sardinia, Italy.

Heart Disease in Small Animals

Canon Medical's High-end Ultrasound technology supports the Veterinary specialist Dr. Andreas Kosztolich (Vienna, Austria) in diagnosing the real, but sometimes hidden reason behind heart disease in small animals.

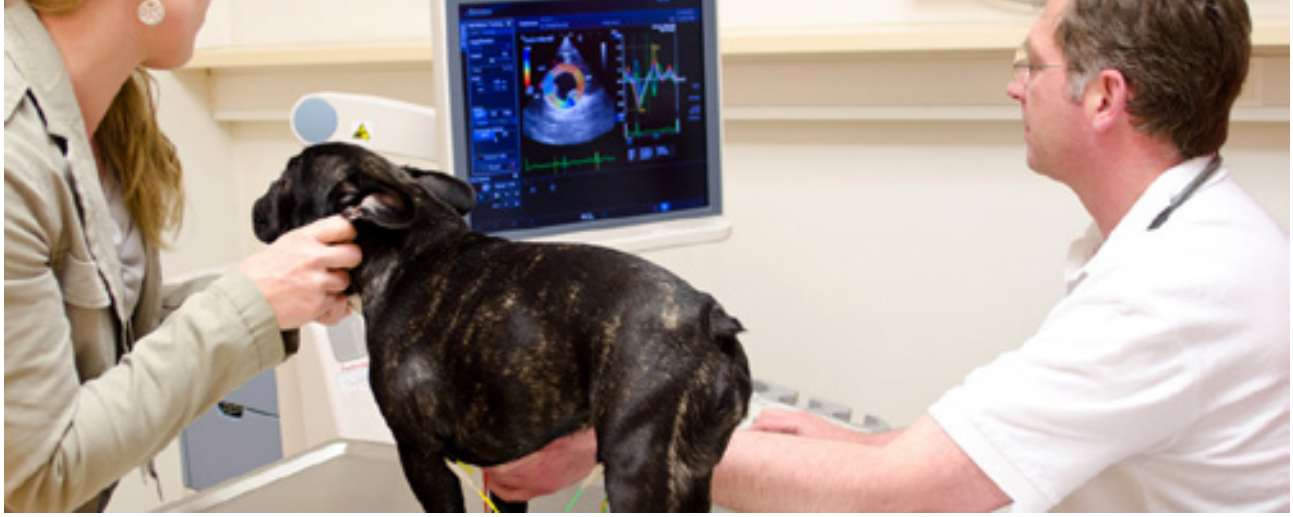
Diagnosis and treatment of cardiovascular diseases have long been of secondary importance in veterinary medicine. Very few patients appeared to suffer from such often life-threatening illnesses. The technical development of diagnostic options has shown that heart and circulatory diseases in dogs and cats as well as in many other small animals such as rats, ferrets or rabbits are quite common, as originally thought. With the aid of modern diagnostic methods, it is possible to track down congenital and acquired diseases and, if necessary, to initiate efficient therapy. How best to do this is described by Dr. Kosztolich.

You operate a cardiology practice for small animals in Vienna. What is a typical day in your practice like from a clinical point of view?
I work on the basis of referrals from veterinarians, whereby a substantial proportion comes to us by recommendations. The cardiological examination methods consist of clinical examinations as well as specialised examinations such as ECG, blood pressure, laboratory examination, ultrasound and Holter ECG. Advanced imaging techniques, such as classic chest x-ray or thoracic CT / MRI examination, are performed by the referring physician or specialist clinics. All examinations are carried out in accordance with internationally valid, standardised guidelines for the diagnosis and treatment of heart disease in small animals (European College of Veterinary Medicine, American College of Veterinary Medicine, Internat. Guidelines for Veterinary Cardiology). The therapy is then taken over again by the referring physician and we keep a check on the illness at regular intervals.

What kind of patients are referred to you?
Small animals, especially dogs and cats, are suspected of having heart disease. This is particularly necessary for cardiac sounds, signs of impaired performance, respiratory problems, discoloration of the mucous membranes, circulatory problems / history of collapse or classical breeding examinations that exclude congenital heart disease. In addition, we are involved in drug monitoring when it comes to monitoring therapeutic success.

How common are heart problems with dogs?
Very common! There are breed dispositions for heart diseases, such as the Great Dane, the Irish Wolf, the Doberman, or the Cavalier King Charles Spaniel. Purebred cats are presented to us just like normal domestic cats. We can now diagnose a heart problem very well, but it is still a chronic disease process, the clinical course of which is not always "straightforward" because of additional illnesses such as, orthopedic complaints and neurological or internal problems in the aging patient.

What was your objective to choose the Artida high-end Ultrasound system from Canon Medical?
My main concern was my need for a robust volume calculation in the heart before and during therapy. Canon Medical's Speckle Tracking Technology is the only one that provides direct visual and quantitative access to 2D regional myocardial motion and provides a high quality 2-DE resolution.



Dr. Andreas Kosztolich (Vienna, Austria).

You were the first Veterinary specialist using this high-end technology in a clinical environment for small animals. What is the advantage compared to other systems?
The referring physicians call for precise diagnostics and a therapeutic roadmap as a guideline for implementation. They do not want technical details, but a complete package that quickly gets to the point: What is wrong with an animal, how best to treat it and how can success be measured? The added value for me is more of a personal nature. I would like to develop myself with the technical challenge. I use 2D matrix technology for every clinical issue and can make better and safer diagnoses on this basis. It makes a difference whether I interpret a systolic function parameter with a lot of experience, or just several. The technical possibilities of the device allow me more security in diagnostic validity. I can, for example, make volume calculations using several methods (Teichholz, Simpson, speckle tracking, 3-DE) and, depending on the current study situation, draw my conclusions from the results. I have made significant progress with the device, especially in terms of monitoring. For example, the detection of systolic and diastolic dysfunctions has become simple and valid. Especially for difficult patients, like cats, the resolution of our Ultrasound system is unsurpassed. Despite all this device technology, clinical examination is still important in our field because our patients cannot speak. The credo is still to find a cost-effective way to maximum diagnostic safety.

What diagnostic benefits would you expect for a 3D matrix?
The search for intra- and extracavitary tumors is certainly an issue. More precise volumetric calculations, 3D-based regional wall motion analysis in different cardiomyopathies or for exampkle, after transient ischemic attack as a differential diagnosis to epileptiform attacks or clinically significant arrhythmia - even on the right ventricle.

What recommendations do you have for colleagues interested in education and training?
In the university sector, recognised training courses already offer a cardiology curriculum and advanced training is also very possible in Austria and abroad. When I dealt with echocardiographic diagnostics 25 years ago, there was not enough of what I had to offer, and we had to rely on results from human medicine for specific questions. At that time as well as today however the following was important: You have to learn the business yourself, because the inter-medical and pathophysiological basics of heart disease / or drug therapy must be the basis of a medical decision. Every clinical case is different, and after a certain routine, your own experience comes to the fore.

What are your expectations in terms of further developments in ultrasound diagnostics?
We have special requirements in veterinary medicine, because the patients are anatomically very differently built. Above all, it needs valid sound technology, which allows an assessment in a short time. Furthermore, I regularly review my own diagnoses, so it's important for me to have matching workstation applications that allow for reviews and proper archiving. Digital interfaces are already standard today. All together, of course, a reasonable price-performance ratio.

What is important to you when working with device manufacturers?
In addition to the support of a competent company, you also need a very good expert network to discuss specific details. For me, cooperation with human medicine was and is very important here. I have received a lot of input from radiologists, vascular physicians or cardiologists, which I can also transfer to my field of work. A short training on methodology is also important to me. This is the only way I can immediately and consistently provide the best for patients. My motto is "per aspera ad astra" (through hardships to the stars)!

Where do you see the trend in imaging diagnostics going?
It's difficult to say. Seven years ago, veterinarians had not seriously thought about 3D / 4D images. I still expect radical developments in transducer technology, smaller transducers tuned to the acoustic window we naturally have. For me it is important to have a network of tech-savvy contacts. In addition to the results of current cardiological research on small animals, I am able to get the maximum out of certain issues. But that is not so much a question of innovation as communication. //

Optimized CT Scan Sinus Protocol Makes X-ray Sinus Obsolete

Dr. I. Hernández Girón, Sr. A. van der Most, Dr. M.C. Kruit, Dr. B.M. Verbist

An optimized Computed Tomography sinus protocol (Ultra-low Dose sinus scan, dose equivalent to X-ray sinus), increases the clinical confidence and offers a more clear diagnosis and a detailed depiction of paranasal disease extent, compared to conventional radiography.

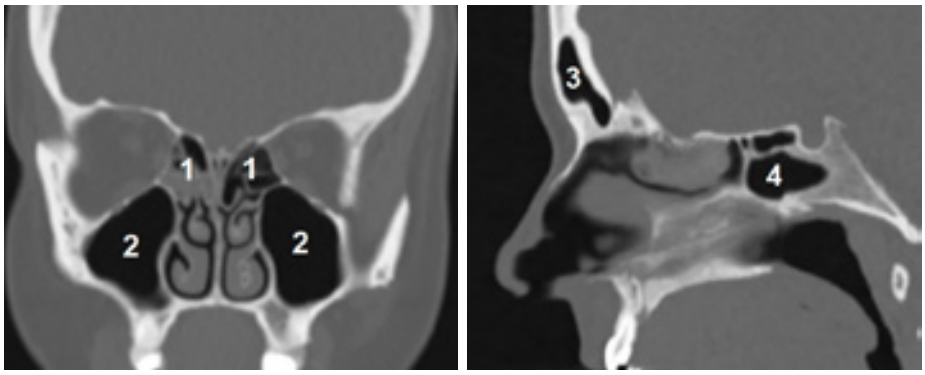
There is a growing interest in replacing conventional radiography with Ultra-Low-Dose Computed Tomography (ULDCT) for certain indications[1,2]. In comparison with conventional radiography, CT increases clinical confidence, thanks to the 3D-representation of tissues and structures, and provides superior image quality due to its high spatial- and contrast resolutions.

However, the introduction of iterative reconstruction, as well as advances in optics and detector technology in the past few years have enabled CT-doses to be lowered to a level comparable to conventional X-rays for certain indications[3].

Previously, in our Radiology Department (Leiden University Medical Center, Leiden, in The Netherlands), a study was performed to assess the clinical value of ULDCT thorax compared with conventional chest X-ray, led by Dr. L. J. M. Kroft and Dr. J. Geleijns.[4] The results of the study showed that ULDCT has added value for diagnosing chest pathology at doses equivalent to conventional chest X-ray, and that neither the dose, nor the in-room time were limiting factors in introducing ULDCT for thorax in the clinic.

Recently, a team within the Leiden University Medical Center started exploring the possibility of replacing X-ray sinus with a CT examination, but without increasing patient dose. The motivation behind this followed the scenario that despite the fact that Computed Tomography is the imaging modality of choice in sinonasal disease, conventional X-ray sinus examinations are still requested and performed in patients with rhinosinusitis in daily practice. Replacement by CT will only be accepted when the patient dose is at most equivalent to the conventional X-ray alternative, and the diagnostic image quality of the images is also sufficient.

The team comprised of: a Senior Radiographer, who created and optimized the new scan protocol based on a phantom study, together with two Clinical Physicists, who estimated the related effective doses and validated the measurements



1 ethmoid sinuses
2 maxillary sinuses
3 frontal sinuses
4 sphenoid

Figure 1. Anatomical regions. Sinuses identified over coronal- and sagittal CT images of a patient.

Posterior-Anterior (PA) | Angled Posterior-Anterior | Lateral

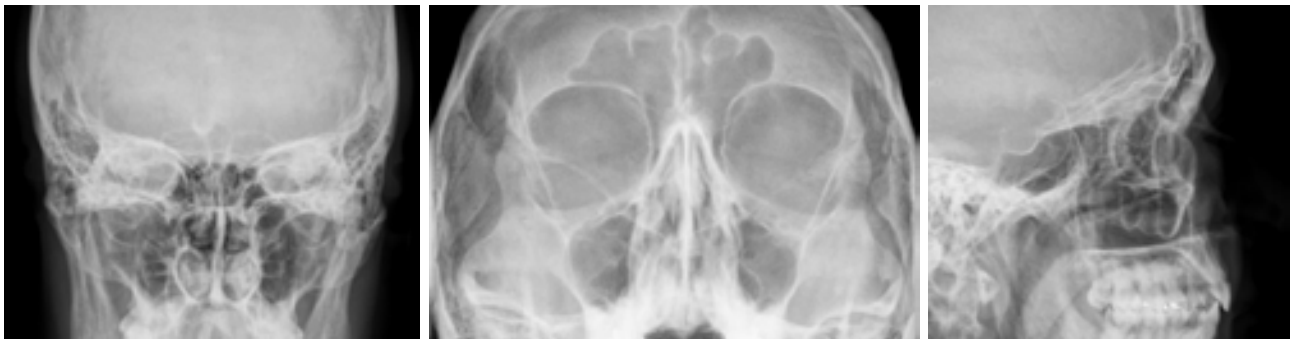


Figure 2. Examples of the Images obtained with the default standard sinus protocol using conventional X-rays of a patient.

performed by the Senior Radiographer; two Head- and Neck and a Radiographer, who judged the quality of the CT images; and finally Radiographer, who collected image data during the clinical trial.

On conventional X-rays, opacification and air-fluid levels within the four paired sinuses (maxillary-, ethmoidal-, sphenoidal- and frontal sinuses) can be seen in inflammatory disease, but the precise extent of disease or complications cannot be assessed. CT provides not only a detailed view of the paranasal sinuses (Figure 1), but also allows for evaluation of the cause and spread of disease within the nose and sinuses or into the surrounding soft tissues. Moreover, CT gives excellent anatomic bony detail that can guide the surgeon in cases of future endoscopic treatment.

Study purpose

The purpose of this study was to develop a CT sinus protocol dose-matched to conventional sinus X-ray with sufficient image quality to evaluate bone and soft tissues.

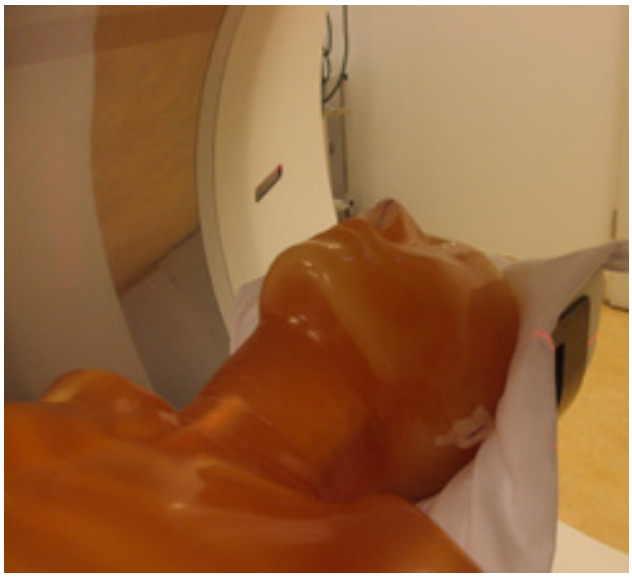
Dose and image quality benchmark: ULDCT vs. conventional XR for sinus protocol.

To calculate the dose related to the existing conventional X-ray sinus protocol, Monte Carlo simulations were performed using PCXMC 2.0 software, which combines a rough model of the X-ray system, including the filtration and the X-ray spectrum related to the selected kV and exposure to calculate the effective dose related to the three exposures related to this indication, based on a digital anthropomorphic phantom based on simple geometrical shapes.[5] The conventional imaging system for this study was a Triathlon DR vertical bucky unit (Delft DI, Odelft-Benelux, Delft, The Netherlands). The three acquisitions during the default protocol were simulated in the software (posterior-anterior, angled posterior-anterior and lateral). The effective doses calculated with PCXMC software are shown in Table 1.

Default standard sinus protocol conventional X-rays associated effective doses	
1. Posterior-anterior (PA)	0.017 mSv
2. Angled Posterior-anterior (Tschebull or Caldwell)	0.022 mSv
3. Lateral	0.010 mSv
Total effective dose	**0.05 mSv**

Table 1. Calculation of the effective dose related to conventional X-ray sinus imaging default protocol, performed with PCXMC 2.0 Monte Carlo simulation software.

The Senior Radiographer and the Clinical Physicists performed a phantom study to achieve a dose-matched CT scan protocol with clinically acceptable image quality. The scanner used was the Aquilion ONE GENESIS, running on software version 8.3. For quality control and protocol testing the CT Torso Phantom CTU-41 was used (Kyoto Kagaku Co., LTD.). This one-piece anthropomorphic phantom contains an anatomical representation of the skeleton and all relevant



(Figure 3) CT Torso Phantom CTU-41 Positioned in the CT-Scan.

	CTDIvol (mGy)	3Eff. Dose overview, evolution of CT-Sinus Protocol
CT sinus Low Dose (default protocol)	5.1	0.10 mSv
ULDCT sinus (Version 1)	3.1	0.06 mSv (First clinical trials)
ULDCT sinus (Version 2)	2.8	0.05 mSv (Final implemented optimized protocol)

Table 2. Effective dose related to the default sinus protocol and the ULDCT optimized protocols.

organs, which have HU values that correlate with/similar to the human body in CT images. For the purpose of the CT sinus quality, this phantom has state-of-the-art synthetic bones, brain with cerebral ventricles and eye balls.

A stepwise approach was taken to reduce the dose. A first version of the CT protocol (low dose sinus protocol) was defined, images of the phantom acquired and doses calculated. The latter were obtained scaling the dose-length product in the scanner by a k-factor, as recommended in ICRP-103, for an adult patient and acquisitions at 120 kV, that for head protocols is k-factor=0.0019 $mSv \cdot mGy^{-1} \cdot cm^{-1}$.[6]

Two experienced Neuro-Radiologists evaluated the image quality of the studies, in terms of artifacts and the visualization of the relevant structures and soft tissues in and around the paranasal sinuses. The first defined low dose sinus protocol (shown in Table 2) led to a $CTDI_{vol}$ of 5.1 mGy (DLP=51.4 mGy·cm) and an effective dose of 0.1 mSv (twice as much as the target conventional X-ray dose, shown in Table 1).

In successive iterations (Table 2), the dose of the protocol was further reduced (varying the mA and the rotation time, keeping kV constant (120kV), because of high bone absorption) until it was comparable to conventional X-ray sinus dose, without degrading the diagnostic information, according to the Radiologists.

The final Ultra-Low-Dose sinus protocol parameters and related effective dose is shown in (Table 3).

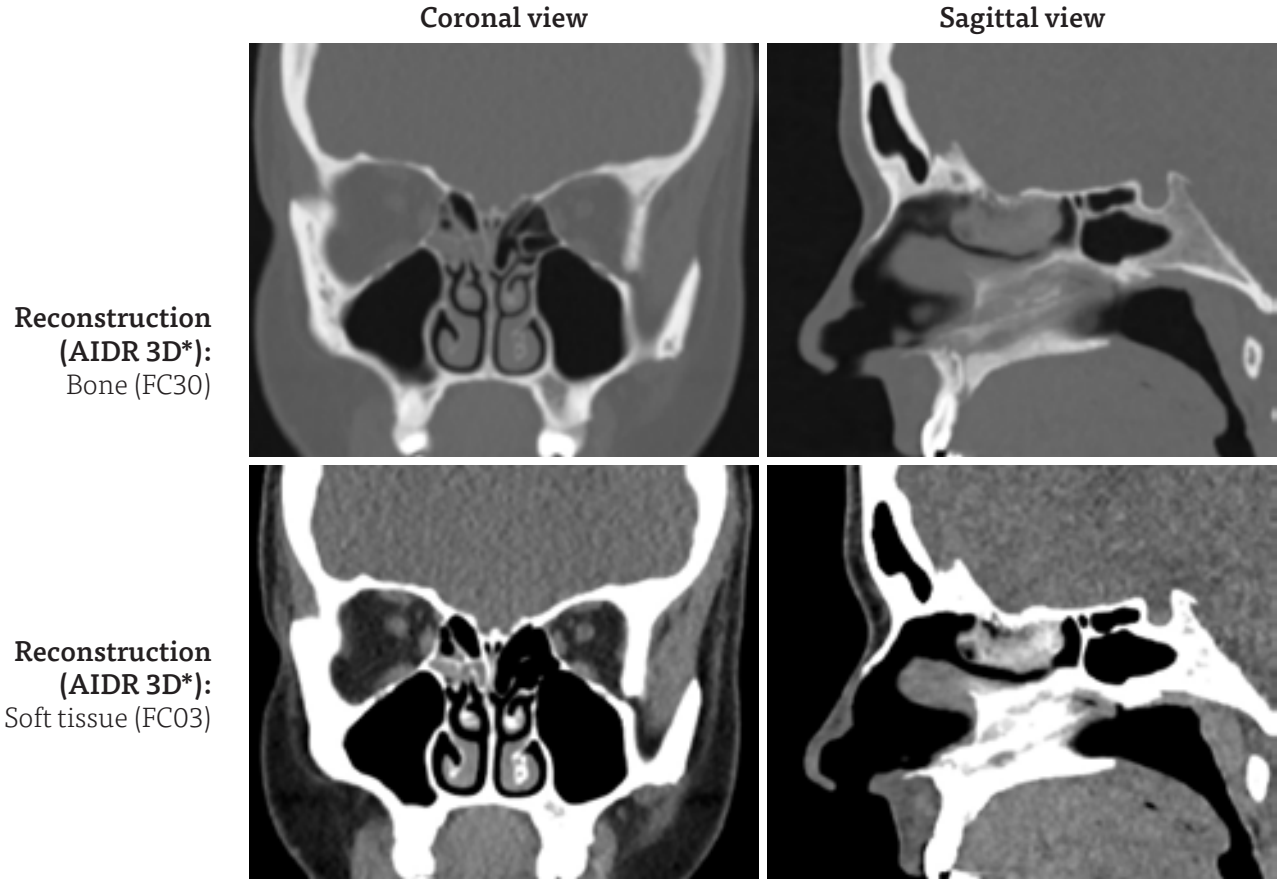


Figure 4. Central coronal- and sagittal views of a patient's ULDCT sinus protocol.

Serie	Aquisition	kVp	mA	FOV	Rot (s)	Reconstructed Filter	Process Recon	Scan Range (mm)	CTDI-vol 16-Cm phantom
Scano	-	80	10	-	-	FL 03	-	200	-
Sinus	Volume	120	30	Small	0.75	FC 03/FC30	AIDR 3D* Enhanced	100	2.8 mGy

Table 3. ULDCT sinus protocol; Canon Medical's Aquilion ONE GENESIS DLP: 28.5 mGy.cm (Scan Range 100 mm, 16 cm Head phantom).

It must be noted that the scouts were not included in the dose calculation. As the sinus protocol does not use automated tube current modulation, we also optimized the scout doses, reducing mA and kV, to the minimum values allowed by the system, compared to the default sinus protocol. The final acquisition and reconstruction parameters used in the ULDCT sinus protocol, can be seen in Table 3.

Conclusion:

By using step-by-step optimization, a ULDCT sinus scan protocol was realized:

- Radiation dose was reduced with 50% compared to the original low dose sinus protocol.
- Radiation dose was equal to the X-ray sinus.
- Image quality was equal to the original low dose sinus protocol.
- Further optimization for the pediatric patient is work in progress.

What benefits are there for the patient and the Hospital?

The largest benefit is the increased information obtained from images.

- ULDCT sinus provides a dose-matched alternative to X-ray sinus.
- Increased reader-confidence.
- Clear diagnosis and detailed description of extent of paranasal disease.

Is there still a role for conventional sinus X-ray?

We've shown that ULDCT sinus can be obtained at a dose similar to conventional sinus imaging. In addition, it provides detailed information on the bony structures and soft tissues. Therefore, sinus X-ray should no-longer be considered for the diagnosis of sinus disease.

Will CT replace all conventional X-ray examinations?

Since the nineties of the last century, the number of CT scans performed has increased linearly by approximately 7-10% per year. The concomitant increase in patient dose delivered is a matter of concern.

This project illustrates the possibility to reduce the patient dose considerably, while maintaining diagnostic quality due to the use of new techniques and adjustments in how scanning is performed.

Using volume scans (one rotation, no over ranging, no helical overlap), advanced iterative reconstruction algorithms and very sensitive detectors, the radiation dose can be reduced significantly.

With Ultra-Low-Dose scan techniques, there is a growing possibility to replace the conventional X-ray examinations. //

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Acknowledgement:
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* *AIDR 3D, Adaptive Iterative Dose Reduction, is designed to lower radiation dose and maximize image quality all with accelerated workflow.*

Sports MRI - How Next Generation Imaging Systems are Giving Greater Insights

Dr. Steve McNally

Dr. Steve McNally, Head of Football Medicine & Science at Manchester United Football Club, examines how the rich depth of innovative MRI imaging better supports health surveillance, performance management & injury grading, with the ultimate aim of improving sporting outcomes.

There has been a long standing need for diagnostic imaging information to help quickly identify, prevent and treat injury in valuable elite athletic assets, such as footballers in the Premier League. Demand to pre-empt future conditions and manage the long-term performance of players through proactive health surveillance is now on the increase. The long-term value of a sports person impacts the bottom line at many sporting organisations, and therefore a breadth of medical imaging modalities and technologies is required to unlock information from deep within the body.

We are lucky in sports medicine that the pace of innovation in next generation imaging systems is evolving swiftly. Whilst ultrasound has to date been the quick de-facto choice, the depth of information delivered by the larger modalities such as MRI is expanding through next generation developments, giving much more data to base decisions on. The procedural times of MRI, for example, were once considered a negative factor but are now discernibly quicker as innovative software applications automate operational and clinical processes. In addition, image outputs are greatly improved to give rich clarity of detail to assist with sports science management.

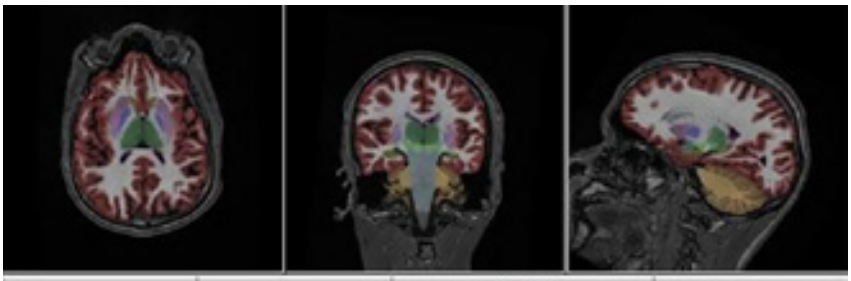
MRI in sports health surveillance

Cardiac screening for proactive health surveillance is firmly on the radar for all sporting organisations. This is not only to identify undetected anomalies that could put life and health at risk, but also to monitor for the onset of coronary artery disease as players age. Indeed, from youth teams to the veteran professional footballer, anyone undertaking vigorous training and competitive matches is regulated to receive cardiology profiling every 2 years[1].

The imaging tool that has traditionally been used is ultrasound echocardiography, looking at the structure of the heart at rest and during stress exercise. Now, and increasingly, the structure and functionality of the heart is examined via the latest generation in MRI.

For example, new developments have accelerated the examination time for cardiac MRI, with fewer patient breath holds needed to deliver much more detailed, richer image outputs that give another level of screening and profiling of the more subtle presentations of cardiac anatomy.

MRI is also an excellent choice of tool for the diagnosing and monitoring of Chronic Traumatic Encephalopathy (CTE), the result of repetitive brain trauma from blows to the head and repeated episodes of concussion, which in football may have come from player contact or heading the ball. It is a hot topic in all contact sports such as boxing, rugby and martial arts and follows research at the University of California, Los Angeles (UCLA) using MRI as the option to explore CTE without any dose implications to patients[2].



Hippocampus	Volume (cm³)	% of ICV (5%-95% Normative Percentile*)	Normative Percentile*
Left	2.69	0.18 (0.20-0.28)	< 1
Right	4.68	0.31 (0.20-0.28)	>99
Left-Right Asymmetry Index**: -54			< 1

Fig 1: Next generation MRI is being used to gather data on brain tissue volumes

Canon
CANON MEDICAL SYSTEMS

From this season at Manchester United Football Club, we have started to gather data by using MRI (see fig 1) to measure volumes of brain tissue in specific areas, to monitor for a decrease in volumes over time. If the volumes become unusual or deviate from the norms that we would expect, it may help us identify early changes of CTE that need closer monitoring. This is a new, long-term data gathering study in our cohort of players that has been facilitated with the new next generation MRI[3] now in place at our medical centre.

Advanced MRI applications will also assist in the surveillance of joint and articular cartilage health, a key consideration in athletic populations, that could limit and impede sporting careers or restrict performance capacity. New generation MRI will also assist alongside ultrasound in primary and secondary muscle injury prevention.

Managing player performance using imaging innovations

Using MRI Spectroscopy over the last four years we have been able to undertake 'muscle talent scans' as part of managing player performance. This has enabled us to code the muscle fibre type of all our young professional players and estimate the measures of carnosine content in soleus and gastrocnemius muscles. This is a much more accepted and non-invasive approach to muscle fibre typing than undertaking muscle biopsies.

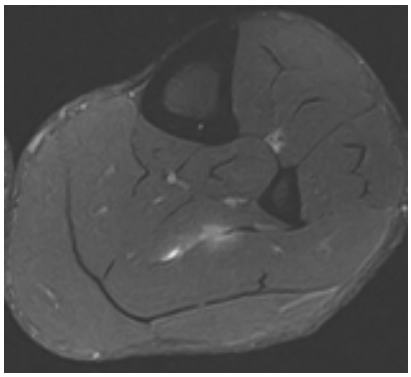


Fig 2: Very small fibre tears identified using high resolution MRI

Muscle fibre typing tells us who can twitch their calf muscles quickly or more slowly. We know that this can correlate to performance characteristics indicating those that are sharp and quick versus those that are more endurance based. This information helps us manage the players and the squad's performance over the long term. For example, a very fast twitcher would suggest that muscles will fatigue more readily and require extra rest or nutrition, so informing our care plan.

The power of MRI to pick up subtle injuries

Even the smallest injury in elite sports has implications. Having the right diagnostic tool at the peak of its development is vital to diagnosing subtle injuries that could impact player health. Using high resolution MRI therefore helps to identify very minute intra-articular joint injuries, muscle oedema changes or very small fibre tears (see fig 2).

Detailed diagnostic information is crucial to then accurately give the injury a grading using classification systems[4]. This grading severity then translates into an estimate of the mean number of player and training days that will be lost.

Although there is conflicting research about the value of using MRI to determine time out, undoubtedly having higher clinical confidence in injury analysis by using high clarity imaging outputs from new generation systems has the potential to be intrinsically linked to the rehabilitation and recovery time of the player. This, of course, also impacts long term asset performance and financial value.

The advancement of sports imaging techniques

The ongoing advancement in research and development of imaging systems, in part due to clinical research partnerships pushing systems further than ever before, is an exciting time for us sports clinicians. Gaining wider diagnostic information about the structure and function of the body will steer our decision making to improve and speed up accuracy and expand surveillance of elite sports people. Next generation MRI is undoubtedly an increasingly vital tool in elite sports medicine management. //

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New Ultrasound Products Boost Canon Medical's Contribution to Women's Healthcare

The 29th ISUOG World Congress of Ultrasound in Obstetrics and Gynecology was held in Berlin, Germany, October 2019. The four-day event attracted more than 3,100 attendees, and was the largest ISUOG Congress ever. Canon Medical made a major contribution to the event demonstrating its commitment to Women's Healthcare. Alongside introducing a trio of dedicated Women's Healthcare Ultrasound systems, Canon Medical also hosted a four-day program of educational activities that included insight sessions and live scans.

Introducing a robust portfolio of Women's Healthcare solutions

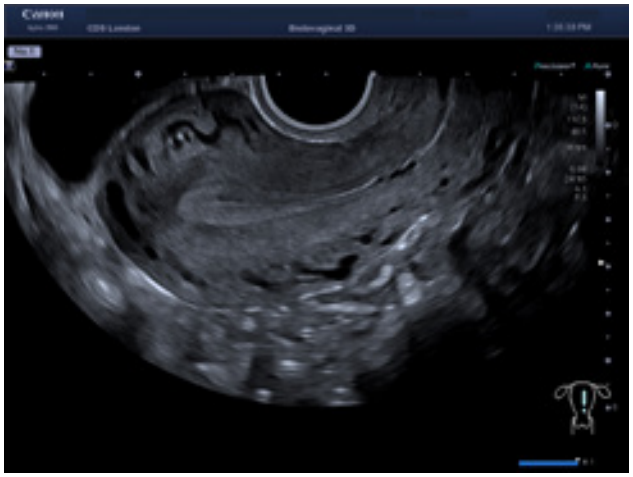
Canon Medical's portfolio of Women's Healthcare (WH) solutions is expanding rapidly. Its new Ultrasound range, which includes the Aplio i700 WH, Aplio a550 WH and Aplio a WH has been designed following full research of specialist's and patient's needs. As for all its product design and manufacture, Canon Medical is inherently guided by its corporate philosophy 'Made for Life'.

Visitors to the Congress were introduced to the flagship Aplio i700 WH with unique features that can include: Fetal Wall Motion Tracking - a raw-data-based speckle-tracking technology that helps clinicians assess fetal heart function in greater detail for earlier detection of fetal- and maternal risk during pregnancy; and a high frequency ultra-wideband active matrix transducer that delivers finer imaging details. In addition, the new Aplio a550 WH was unveiled. This system integrates technologies from Canon Medical's Aplio i-series, with a wide range of Women's Healthcare applications designed to enhance diagnosis for any busy high end routine imaging department. The complete new ultrasound system Aplio a WH – the perfect solution for daily routine, full customizable with only the possibilities and technologies that each individual prenatal or gynecological department needs - was also launched. The Xario g-series, which delivers an unique set of mobility and productivity features, including an impressive, eight-hour cable-free battery performance and two-second start up time, while continuing to offer Canon Medical's proven high-quality imaging capabilities, completed the suite of products presented at the Congress.

Canon Medical Systems Europe's Ultrasound Team at ISUOG 2019.

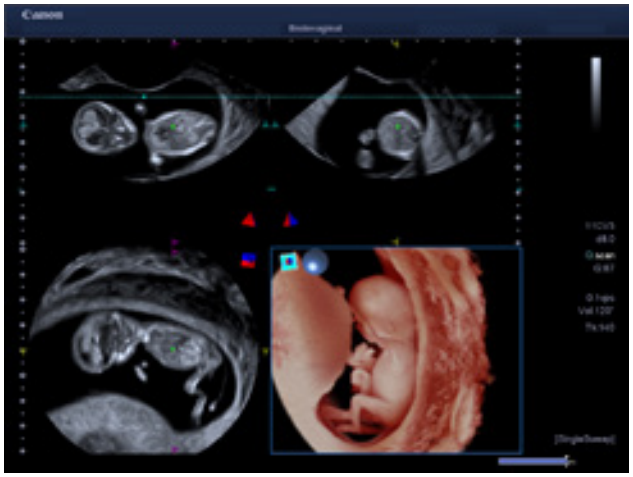
...with superior standard features

Canon Medical's dedicated Women's Healthcare systems with its pink pearl color accent include as standard: a 3D/4D software package with Luminance - a rendering mode that simulates shadows in 3D/4D for better depth impression; the unique Superb Micro-vascular Imaging (SMI) with excellent sensitivity and resolution, almost no motion artifacts and a high frame rate for accurate imaging at low flow velocities; horizontal endovaginal probe holder for specialist convenience; and a gel warmer for patient comfort.

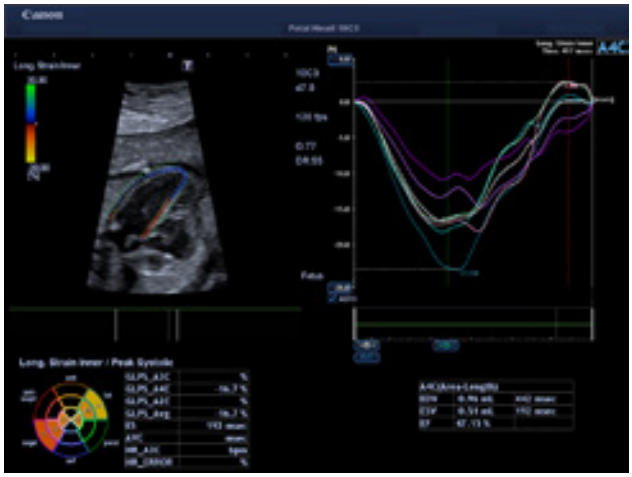


Endovaginal B-Mode ultrasound image of Uterus with endometrium.

Fetal profile with clear definition of nasal bone and corpus callosum.



3D Multiplanar image of 12 weeks fetus.



2D Speckle Tracking of the Fetal Heart.

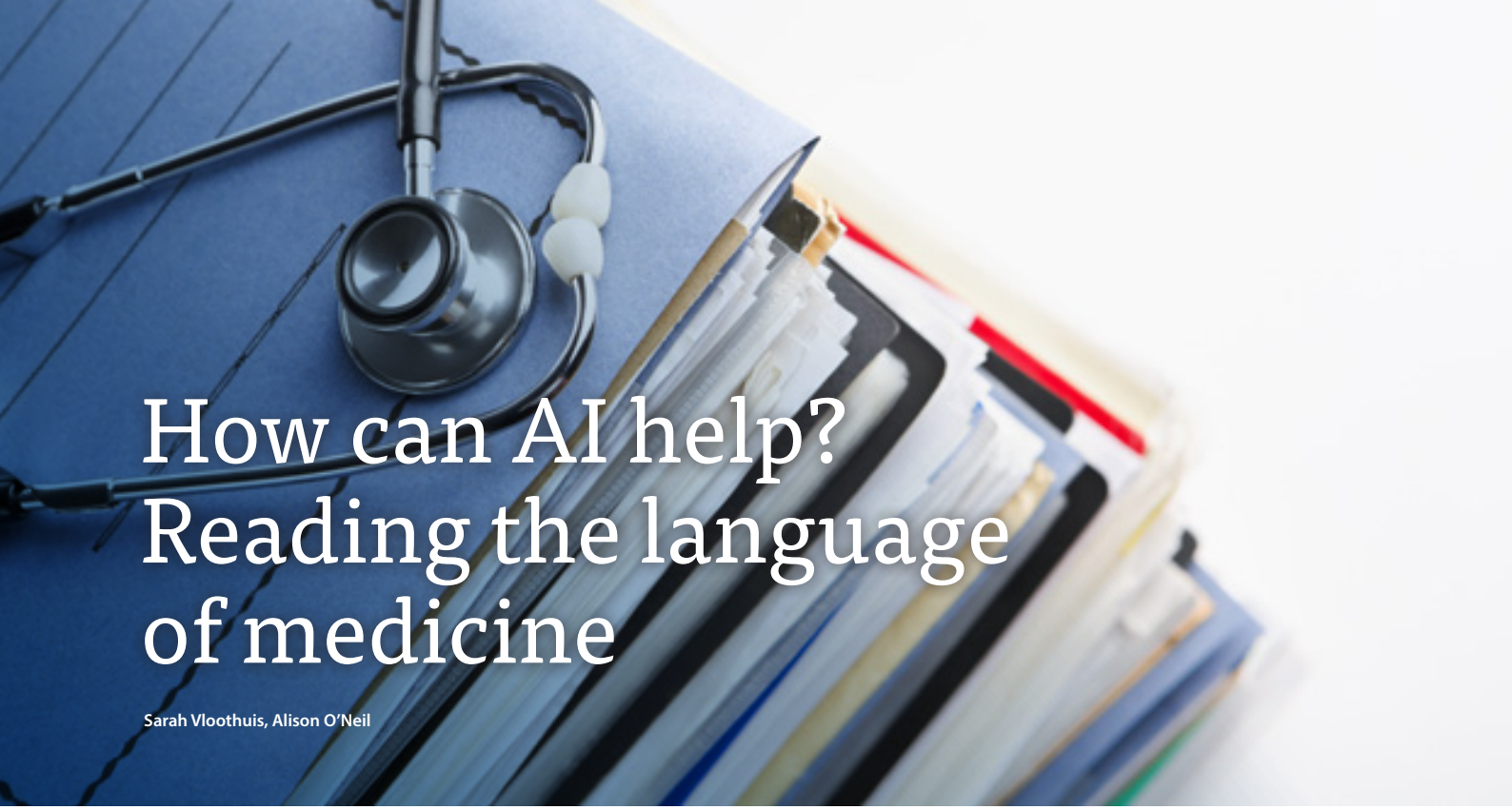
Specialist insight

With an intensive program of educational activities, including 14 insight sessions, as well as live scans, key opinion leaders in maternal fetal medicine and gynecology from all over the world presented the clinical value of Canon Medical's imaging technologies and new Women's Health portfolio, and shared their experiences with attending healthcare professionals. These sessions had a great educational value and were very well visited. Most of the sessions included educational live scans to demonstrate the full value of the technology in all trimesters, and are available on YouTube*.Besides the Canon Medical's insight sessions, visitors had the chance to watch live demonstrations supported by Canon Medical during the official congress program.

Full line-up

"We offer now a full line-up of comprehensive Ultrasound solutions for Women's Healthcare to fulfill specialists' expectations for clear and fast diagnosis from routine clinic to research university," said Petra Labs from Canon Medical Systems Europe/ Women's Health Ultrasound team. //

* *http://tinyurl.com/ye49oh54*



How can AI help? Reading the language of medicine

Sarah Vloothuis, Alison O'Neil

The era of digital patient records is upon us and new digital services to document a patient's medical journey are emerging – everything from GP referral letters and lab test results, to biopsy images and discharge summaries from hospital admissions. When a patient arrives at hospital in an emergency situation, clinical staff already have key – sometimes game-changing – information available to them. But when time to treatment is of the essence, how do clinicians quickly see the facts they need to save lives? At Canon Medical Research Europe in Edinburgh, this thorny challenge is being investigated by a team who are using a branch of Artificial Intelligence called 'Natural Language Processing' (NLP) to interpret medical text and pull out relevant information, creating a new diagnostic pathway for clinicians which is faster to access, easier to navigate, and ultimately more accurate than they have had before.

"When you're facing a body of text, reading and digesting information can take time."

Reducing 'door-to-needle' time in stroke treatment

Working within the Industrial Centre for AI Research in Digital Diagnostics (or iCAIRD), Canon Medical are researching new technology solutions for stroke diagnosis. By supporting better workflow and assisting clinical decision making, they hope to bring down 'door-to-needle time' – the time elapsed between admission and treatment in a type of stroke called 'ischaemic'. Ischaemic strokes make up around 85% of all confirmed diagnoses and happen when a blockage in blood flow leads to reduced oxygen supply to brain tissue. "The most important thing is to try to remove that clot, or occlusion, as soon as possible. Doing so restores blood to the deprived regions and maximises the amount of salvageable tissue," explains Clinical Researcher Shadia Mikhael. "The sooner you can remove the occlusion, the greater the chance of recovery." Current clinical guidelines state that after four and a half hours, treatment for an ischaemic stroke fails to have an impact – so time is of the essence.

Alongside all other elements that slow down proceedings, such as patient transfers and language barriers, painstakingly reading through piles of medical notes is a huge problem and an obvious barrier to fast and accurate treatment decisions. AI Scientist Maciej Pajak explains: "if you're a radiologist looking at a CT scan or a pathologist looking at pathology slides, quite often the abnormality in the image jumps out at you. However, when you're facing a body of text – or even worse, multiple documents that must be opened and reviewed one-by-one – reading through and digesting the information can take a long time." Additionally, Shadia adds, "Stroke patients, who are often elderly, frail and with a history of long-term chronic disease, can come in with massive piles of discharge letters."

The language of medicine

NLP is not a new technology. Those of us who use personal assistants, such as OK Google, Siri, Alexa or Cortana are using it every day – an algorithm identifies, extracts and converts our human language into a format that can be analysed. But, like humans, to get to this point, the algorithm needs to be 'taught' the language it is processing by exposing it to as many examples as possible. "You can take all of Wikipedia, for example and do some really smart training on that," Maciej explains. but in the context of medical applications, it's not an easy task,

as the language is specialist and confidential patient records are difficult to access. Medical data is also rife with idiosyncrasies, as an understandable need for speed causes typos and misspellings. Then there is the clinician's famous love of an acronym ¬– does 'ASD' mean 'Atrial Septal Defect' or 'Autism Spectrum Disorder'?

Canon Medical's AI scientists have already created a state-of-the-art algorithm for classifying medical reports and have partnered with Prof. Sotirios Tsaftaris of Edinburgh University (Canon Medical/Royal Academy of Engineering Research Chair in Healthcare AI) to develop an explainable model. "This is a breakthrough algorithm where we have shown that we can incorporate medical knowledge – in this case information from the International Classification of Diseases (ICD) – into the design of our model, to get higher accuracy," explains Team Lead, Alison O'Neil. "This ability to make use of existing medical knowledge in our AI algorithms will be key to learning to recognise rare diseases where we do not have a large set of historical examples to train the machine learning system."

Over the next year the team continue their research and focus on text algorithms that specifically support clinical decisions in the treatment of acute stroke. There are also challenges to address in adapting the solutions developed to other environments – non-English speaking countries, for example. However, the field of NLP has seen rapid progress and the future looks bright for AI development in text. Maciej gives Google Translate as a good example of how far machine translation has come in a short amount of time. "And it's just one of many NLP applications; we also have text generation, automatic summarisation, question answering, classification of sentences and documents. The methods are often based on similar underlying mathematical principles, such as deep neural networks. It's a quickly developing field and really transforming the way text is being used."

Trust and human decision-making

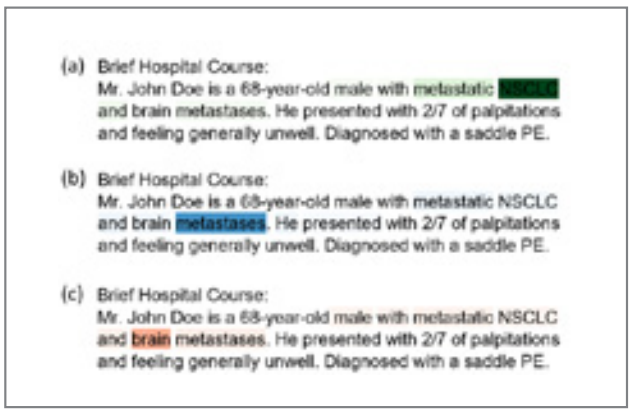
With AI always comes natural concerns around how it changes the landscape into which it is introduced. Dr. Ken Sutherland, President of Canon Medical Research Europe describes their role as "turbo charging clinicians", that is, "making their job as easy as possible and supporting the decision-making process". This is the core principle that underpins the work of the AI Research team. Even at this early stage of development, they are planning how humans interact with this technology. Clinicians will be able to drill down from the AI algorithm output and discover its source, giving both reassurance and context to the relationship. "Let's say you get a summary of multiple documents.

"Clinicians will be able to drill down from the AI algorithm output."

When you click on a sentence it could show a list of all the places where it took the information from," Maciej explains. "And you can agree or disagree with it," adds Shadia. "It's presenting the facts and they are making the decisions."

The team are keen to stress that this is only the beginning. Through effective collaboration and adaptation of state-of-the-art techniques they have already achieved a huge amount in just a year. But in the true style of medical professionals, they look to the purpose: "So far we have improved on an established benchmark by five percent. That's great, but ultimately we want to improve patient outcomes so we need to look at how clinicians would use the algorithms and come up with trustworthy algorithms that address their needs."

Canon Medical Research Europe would like to thank Prof. Keith Muir at Queen Elizabeth University Hospital in Glasgow and Prof. Sotirios Tsaftaris of Edinburgh University for their ongoing collaboration and support. //



Canon are working on explainable algorithms where the clinician can drill down and see the explanation of the AI algorithm predictions.

An onsite administration team in most hospitals adds International Classification of Diseases (ICD) codes to patient medical records.

From left to right: Valentin Prevost (Canon Medical Systems Corporation), Bei Zhang (Canon Medical Systems Europe), Prof. Tourdias (Bordeaux University Hospital), Prof. Dousset (Bordeaux University Hospital), Bruno Triaire and Nobuyasu Ichinose (Canon Medical Systems Corporation).

VISIONS spoke with Prof. Dousset and Prof. Tourdias, from the Bordeaux University, France.

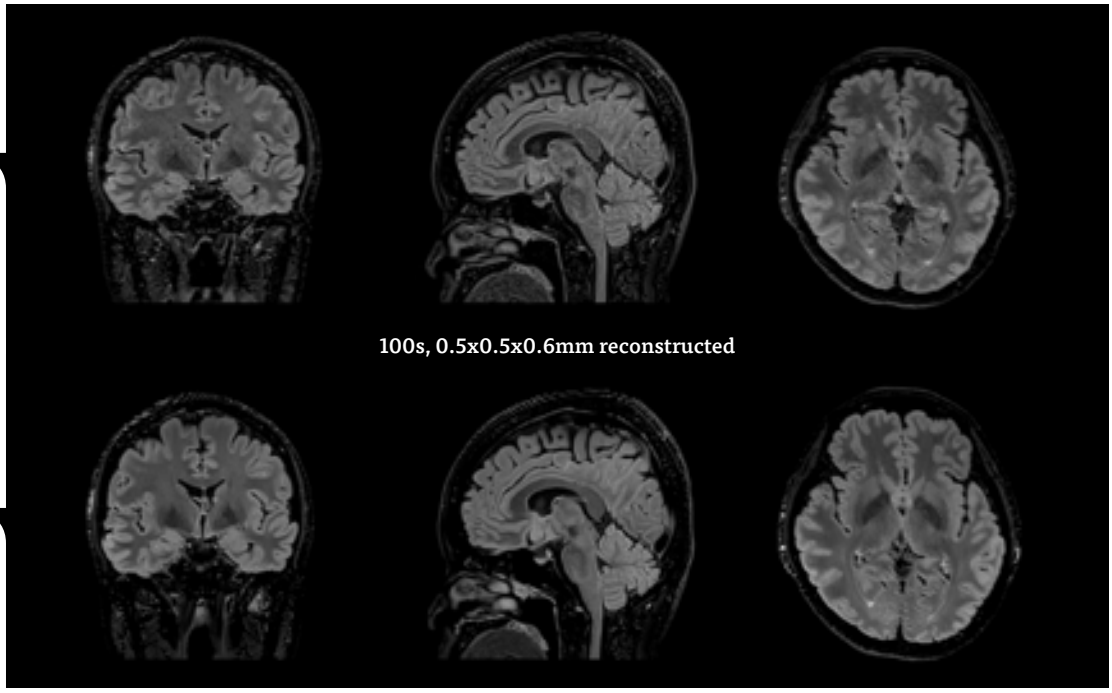
Deep Learning Reconstruction in Magnetic Resonance Imaging

Artificial intelligence continues to expand the possibilities brought by medical imaging and advance healthcare. In particular Deep Learning Reconstruction (DLR) used in combination with Magnetic Resonance Imaging has the potential to help diagnose diseases earlier, faster and better. In France, Bordeaux University is working with Canon Medical's DLR solution to fulfill these promises and take the best out of the technology in numerous applications in research and clinical practise.

DLR has the ability to improve image quality by eliminating noise. Removing noise from images with DLR increases signal to noise ratio, helping to obtain ultra high-resolution images. Based on the experience from Bordeaux University, this has provided the opportunity to see anatomy previously not possible on 3T systems.

Applications in research and clinical work

With the help of Canon Medical, the future has already started at the Bio Imaging Institute (French: IBIO[1]), an unique structure that serves as an interface between the clinical work performed at Bordeaux hospital and the research done at Bordeaux University.



3D FLAIR
Original image.

3D FLAIR
with DLR.

IBIO started integrating Canon Medical's DLR solution in November 2017. The workload progressively increased during the first six months, to find the optimal parameters and fine-tune the "denoising". The team has been using the system routinely for about a year now and is working on validating the tool scientifically.

Prof. Thomas Tourdias, Radiologist at Bordeaux University, uses DLR in almost all his research projects. "DLR helps to remove noise and obtain better image quality, which assists us to collect more information to answer research questions. Removing noise also helps us to reach a very high resolution that we previously couldn't achieve, which is very helpful for specific research areas," he said.

DLR can be implemented in a myriad of clinical scenarios, for example to help expedite workflow. "In our daily routine, we are challenged with a growing number of requests and the difficult task of examining all these patients. So probably the major clinical application for DLR is going to help us work faster. Many more patients could undergo examinations when we decrease the acquisition time," Prof. Tourdias explained.

DLR is easily integrated into the image reconstruction chain. Radiologists only have to plug in the option to improve the image quality. Switching to this new routine is effortless and brings real benefits, according to Prof. Vincent Dousset, Head of the diagnostic and therapeutic Neuro Radiology department at Bordeaux University Hospital.

"The first advantage is that we can achieve high resolution images with-

"Removing noise also helps us to reach a very high resolution that we previously couldn't achieve."

Prof. Thomas Tourdias, Radiologist at Bordeaux University and Hospital, Practitioner at Bordeaux University Hospital. Also member of INSERM Unit U1215 Pathophysiology of neural plasticity" at the Magendie Neurocentre.

"With DLR we can achieve both high resolution images without losing time or signal and reduce the image acquisition time."

Prof. Vincent Dousset, Head of the diagnostic and therapeutic Neuro Radiology department at Bordeaux University Hospital.

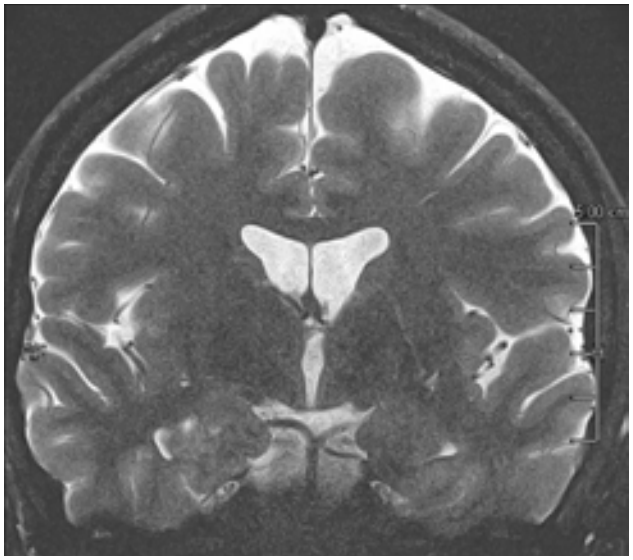
out losing time or signal. The second advantage is the reduction of image acquisition time, as we care less about the signal quality because the noise can be eleminated following the scan," Prof. Dousset said.

DLR is more than just a new tool, it's a major change in medical imaging history, Prof. Dousset believes. "Because the DLR will allow us to correct afterwards what couldn't be corrected at the outset, the first application is that we no longer have to improve the signal or the spatial resolution. This is revolutionary in medical imaging history. This is the main advantage I think: the image "denoising" technique."

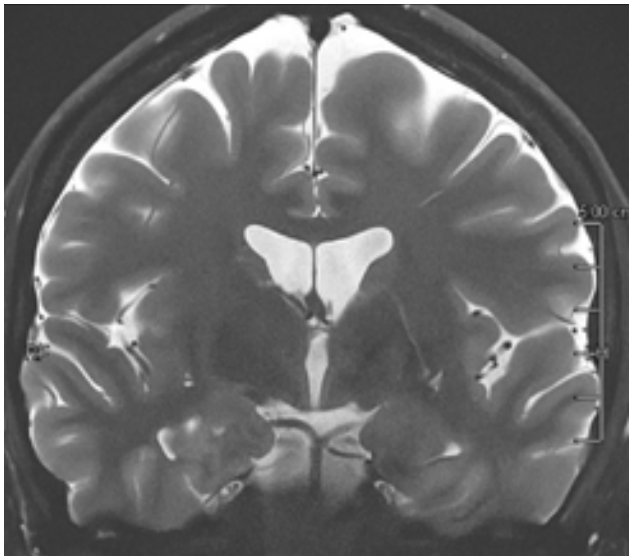
In particular DLR has an important clinical impact in anatomical regions that require a very high resolution, for example parts of the hippocampus and the claustrum.

"The DLR brings a spatial resolution that I have never seen before in neurologic imaging. I recently pointed out a brain area, for example the claustrum, that is almost invisible on standard MRI images even with very high resolution or high field devices. However, thanks to the DLR we could highlight this kind of brain anatomy. So, indeed, there is a considerable advantage to using this technique." Prof. Dousset said.

Prof. Tourdias worked at 7T to visualise extremely fine structures of the hippocampus while at Stanford. With DLR, he can now do this task with a 3T. "When we compared the images we realized that by pushing the 3T machine and processing with DLR that we were able to achieve a similar result to what we could achieve with 7T. I think this is the main surprise of the technology." he said.



Original Coronal T2w image.



Coronal T2w image with DLR.

Bordeaux University Hospital.

Mutual benefits

The synergy between the hospital and Canon Medical creates opportunities to find solutions for the patient, also in areas that had never been explored before. Working with Canon Medical enables physicians at IBIO to work with the most advanced technology on the company's latest MRI scanner for on-going clinical research, but benefits spread beyond the institute, Prof. Tourdias explained.

"There is an interest in transferring the technology back to the manufacturer, and we hope that the results of this research will quickly spread to the industry. And then it's interesting to put together research projects. So, there are multiple facets to our collaboration," he said.

The strong cooperation between Canon Medical and the medical team at IBIO has also placed the institute among the top, most competitive imaging centres in Europe.

"Canon Medical's collaboration with Bordeaux University helps us position ourselves internationally among the important European academic teams who work with major medical imaging manufacturers. This is a huge benefit," Prof. Dousset said.

Canon Medical's cooperation was essential in installing and becoming familiar with the system and more generally with AI. With Canon Medical's clinical scientists involved all through the process and visiting regularly, the medical team was able to find the optimal settings and make the most of DLR.

"There were a lot of questions about DLR's relevance and benefits, and the different technical parameters that it features. We proceeded to analyse a lot of images, so that we could make choices that had been transcribed by Canon Medical. The manufacturer's contribution was very significant to DLR's development at our site," Prof. Dousset said.

Innovating hand in hand with Canon Medical benefits not only the patient, but also the next generation of radiologists. "It's very important to integrate the industry in education, to prepare students for their future professions," he concluded. //

Reference

[1] *The Bio Imaging Institute (French: IBIO) project was initiated ten years ago to be the interface between Bordeaux Hospital and Bordeaux University. The building hosts research on both animals and humans, with a particular focus on MR imaging, but there are also on-going projects in X-Ray and optical imaging. The IBIO welcomes several academic teams from Bordeaux University and the French National Centre for Scientific Research (French: CNRS), who work on MRI biologic imaging development and neuroscience studies, as well as industrial teams, such as the Canon team for MR work.*

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

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

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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 O and the figure 0 (zero) should be easy to differentiate.

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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)

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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.

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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.

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