CTCA and the SCOT-HEART trial. A management strategy based on an imaging test for patients with suspected coronary heart disease can improve clinical outcomes.

Are coronary CT angiography and CT-Based FFR set to become a game-changer in coronary artery disease? An interview with Prof. PW Serruys.

Coronary CTA enhanced with CT-based FFR analysis provides higher diagnostic value than invasive coronary angiography.

Efficacy study of CT-FFR software using 3D printed patient-specific coronary phantoms.

CAD-RADS: a new era in coronary CTA reporting.

Cardiovascular Imaging. 3D imaging of the human carotid artery with volumetric multispectral optoacoustic tomography (vMSOT).

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**Machine Learning: the need to equip radiologists with sufficient knowledge of the future**

This year, there was no problem in determining what was the hot topic at the recent ECR meeting. The big subject on everybody’s lips this year is the continued, exponential growth of artificial Intelligence (AI). As the current president of the European Society of Radiology, Professor Lorenzo Derchi, pointed out, one of the promises of AI is the possibility to make sense of the huge amounts of data that are generated by a typical modern hospital, which generates approximately 50 petabytes, or 50 million gigabytes per annum, not just because of radiological images but also from clinical notes, lab images and results and genomics.

The amount of such data is so huge that in practice no human can extract all the information — it is estimated that only 3% of the data generated in the hospital is actually used. Of course, data by themselves are useless. To be useful the data must be analyzed interpreted and acted upon. AI systems could help in this and thus open up the possibilities of improved efficiency and, diagnostic accuracy and ultimately improved patient outcomes. Prof Derchi also made allusion to the fear felt by many radiologists that AI is an existential threat to the very profession of radiology. However whatever the threat the reality is that AI is coming and in fact is already here. And although radiology and image analysis are fields that are particularly amenable to the application of AI, it should be noted that many other healthcare disciplines (e.g., robot-assisted surgery or even hospital administrative workflows) are also set to undergo changes caused by the arrival of AI. If only because of the financial imperatives behind the implementation of AI in healthcare there is no doubt that it is here to stay, and grow. An analysis carried out by the consulting company Accenture estimated that the health AI market (not just radiology) would undergo 40% (!) compounded annual growth rate over the next years although exactly when is still not sure. The question that radiologists should pose is how best to prepare for this brave new world. Such preparation is complicated by the fact that many people are still not sure of the differences between the terms AI and machine learning (ML) that are sometimes bandied about and used (in error) interchangeably. (ML is the subset of AI whose aim is to enable systems to learn by themselves using provided data and to make accurate predictions). The use of ML in radiology is perhaps the most active area and it is important for radiologists to understand its implications, since there is a clear role for radiologists to play. As a group from Mass Gen Hospital in the USA have pointed out, although radiologists are currently expected to understand the imaging process from the production of ionizing radiation in a CT scanner to the visualization of a pixel on their monitor, there is currently no such standard for ML. (Wood et al. The need for an ML curriculum for radiologists JACR 2018 doi.org/10.1016/j.jacr.2018.10.008). The group argue that if radiologists are expected to utilize ML models safely and effectively for imaging interpretation, education for all levels of background and experience will be required, and a formalized ML curriculum targeted toward early career radiologists and trainees is urgently needed.

The group concludes that the emergence of ML technology in radiology cannot be denied. Rather than succumbing to fear and skepticism, future radiologists must be equipped with a working knowledge of ML to leverage the tools as they are deployed. To truly advance the standard of patient care, radiologists will not only be required to appropriately consume ML model output but also participate in its development and implementation to ensure that the most critical challenges in the profession are addressed.

Via such participation, a continuing, important role for the radiologist is assured, albeit somewhat changed from today’s role.
**COMPUTED TOMOGRAPHY CORONARY ANGIOGRAPHY AND THE SCOT-HEART TRIAL.**

Results of the SCOT-HEART (Scottish Computed Tomography of the HEArt) randomised controlled trial, whose 5-year follow-up data have recently been published, have established the role of CT Coronary Angiography for patients with symptoms of suspected coronary artery disease.

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**FEATURE ARTICLE**

**MRI. Utilizing DICOM metadata to improve radiology workflows**

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**IMAGING NEWS**

5 | Whole-body MRI stages colorectal and lung cancers more quickly, cheaply

6 | Interventional radiology treatment of ‘tennis elbow’

7 | Deep-learning model improves prediction of lung cancer survival

7 | Experimental PET scan detects abnormal tau protein in brains of former footballers

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**FEATURE ARTICLES**


Efficacy study of CT-FFr software using 3D printed patient-specific coronary phantoms.

CAD-RADS: a new era in coronary CTA reporting.

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**CARDIAC IMAGING NEWS**

Personalized ultrasound scan showing atherosclerosis helps patients reduce cardiovascular risk.

MRI coronary wall thickness is independent marker of heart disease in women.

PET/MRI predicts cardiovascular risk from arterial inflammation.

Combined SPECT and cardiac MR imaging can help guide ventricular tachycardia ablation.

Coronary Artery Calcium in South Asians.

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**IN THE NEXT ISSUE:**

Breast Imaging
Whole-body MRI stages colorectal and lung cancers more quickly, cheaply

Colorectal cancer and non small cell lung cancer (NSCLC) are leading causes of cancer-related deaths. In both diseases, accurate staging is vital for optimal outcomes, particularly for the identification of metastases. Current staging pathways, such as those recommended by the UK’s National Institute for Health and Care Excellence (NICE) rely on several individual high technology imaging modalities such as CT, PET-CT, and MRI, which differ in their diagnostic accuracies across individual organs. For colorectal cancer, the guidance on staging pathways includes CT of the chest abdomen and pelvis, supplemented by pelvic MRI for local staging of rectal cancer. It is also not unusual for patients to undergo PET CT and/or liver MRI if disease spread is suspected. Staging pathways in lung cancer are even more complex, with CT, PET-CT, MRI, US and endobronchial/ percutaneous biopsy all recommended at various points during staging. Since modern MRI scanners can image the entire body within 1 h, a multi-centric UK-based group of researchers hypothesized that whole-body MRI (WB-MRI) — which typically scans from the head to mid-thigh — is a potentially more accurate and safer alternative to standard multimodality staging pathways. The group set up two large prospective, multicentre trials, one for colorectal cancer and one for NSCLC. They involved nearly 500 patients across 16 hospitals in the UK. The results of these trials have now been published (Taylor SA et al. Diagnostic accuracy of whole-body MRI versus standard imaging pathways for metastatic disease in newly diagnosed non-small-cell lung cancer: the prospective Streamline L trial Lancet Respir Med. May 9, 2019. Doi: /10.1016/S2213-2600(19)30090-6; Taylor SA et al Diagnostic accuracy of whole-body MRI versus standard imaging pathways for metastatic disease in newly diagnosed colorectal cancer: the prospective Streamline C trial. Lancet Gastroenterol Hepatol. May 9, 2019 doi. 10.1016/S2468-1253(19)30056-1).

The findings show that WB-MRI scans reduced the average time needed to determine the size of tumors and how much they had spread, by five days for colorectal cancer patients and six days for lung cancer patients. The treatments decided upon were similar, since results from MRI were as accurate as those of standard investigations, but the costs per patient were reduced by nearly a quarter in the case of colorectal cancer and were almost halved for lung cancer. More research is needed to determine how this affects outcomes for patients. The authors are aware that despite their accuracy and efficiency, that MRI scanners are not as widely available as other imaging technologies and are in high demand. "Our results, obtained in a real-world NHS setting, suggest that WB-MRI could be more suitable for routine clinical practice than the multiple imaging techniques recommended under current guidelines," says lead author Professor Stuart Taylor from UCL, UK. "While demand on NHS MRI scanners is currently high, adopting WB-MRI more widely could actually save rather than increase costs, as well as reducing the time before a patient's treatment can begin."

For the first time, the two new trials compare the diagnostic accuracy and efficiency of WB-MRI with the standard NHS pathways, which use a range of imaging techniques for assessing colorectal and lung cancers. The standard imaging tests were undertaken as usual and the usual multi-disciplinary panel made a first treatment decision based on their results. Once this decision had been recorded, they considered images and reports from WB-MRI. The panel were then able to say whether their first treatment decision would have been different based on WB-MRI result. Patients were also followed up after 12 months to evaluate the accuracy of WB-MRI compared with standard tests. Sensitivity and specificity of diagnosis for WB MRI did not differ from those obtained by the standard tests for both cancers. The use of WB MRI reduced the time it took to complete diagnostic tests, from an average of 13 days to an average of 8 days in the colorectal cancer trial and from 19 days to 13 days in the lung cancer trial. Costs were reduced from an average of £285 to £216 in the colorectal cancer trial and from an average of £620 to £317 in the lung cancer trial.

In the colorectal cancer trial, agreement with the final multi-disciplinary panel treatment decision based on standard investigations and WB-MRI was high (95% and 96%, respectively), as were results for the lung cancer trial (99% for standard investigations, and 98% for WB MRI). The authors note that waiting times might not be representative of other UK hospitals or of hospitals in other countries. A further limitation of the lung cancer trial is that sensitivity in detecting the spread of cancers - including the development of secondary tumors and the spread to lymph nodes - was low using both current standard imaging techniques and whole body MRI. Writing in a linked Comment, Professor Andreas Schreyer from Brandenburg Medical School, Germany, said of the colorectal cancer trial: "MRI has faced considerable backlash within the medical community due to relatively high costs and the high demand. This is why it is particularly important to think "outside the box" and look out for new medical pathways and paradigms and not to be driven by prejudices. Such new pathways, e.g. the use of WB-MRI which are often thought of as more expensive and complex at first sight, can eventually change clinical pathways while being more time- and cost-efficient."
Interventional radiology treatment of ‘tennis elbow’

Tennis elbow, the painful chronic condition that can affect up to 3 percent of the active adult population, can be effectively treated through transcatheter arterial embolization (TAE), the image-guided, non-surgical treatment that decreases abnormal blood flow to the injured area to reduce inflammation and pain, according to research presented at the recent Society of Interventional Radiology’s 2019 Annual Scientific Meeting (www.sirtoday.org/tae-could-offer-relief-from-tennis-elbow/). The condition, also known as lateral epicondyliitis, stems from repetitive stress injuries that occur in activities such as sports, typing and knitting, and the injury can impact basic tasks that affect job performance and the quality of life.

The TAE treatment can be completed in approximately one hour and requires only a needle insertion under local anesthesia to access the radial artery in the wrist. A catheter is moved through the wrist to the elbow where the inflamed blood vessels are embolized, preventing excessive blood flow to the affected part of the elbow. The treatment is safe and effective and doesn’t require physical therapy, researchers said. No adverse events were observed and no patients experienced negative effects to the surrounding bones, www.sirtoday.org/tae-could-offer-relief-from-tennis-elbow/)

7T MRI tracks Multiple Sclerosis

The development of scars, or lesions, in the brain’s cortical gray matter is a powerful predictor of neurological disability for people with multiple sclerosis (MS), according to a recently published study (Treaba CA et al. Longitudinal Characterization of Cortical Lesion Development and Evolution in Multiple Sclerosis with 7.0-T MRI. Radiology. 2019 Apr 9. doi: 10.1148/radiol.2019181719). The findings suggest a role for ultra-high-field-strength MRI in evaluating the progression of MS.

MS is a disease in which the body’s immune system attacks the protective covering surrounding the nerves of the central nervous system. Recent research has shown that cortical lesions, or lesions in the gray matter of the outer layer of the brain, develop early in the course of the disease. These lesions are not easy to see with conventional-strength MRI. In the new study, researchers tracked MS patients using a 7-Tesla MRI scanner to determine if the lesions are correlated with neurological disability and disease progression. “In this study, we wanted to track the evolution of these lesions and better understand where in the cortex these lesions develop more frequently.” The researchers followed 20 relapsing-remitting and 13 secondary-progressive MS patients over time, along with 10 age-matched healthy controls. (Relapsing-remitting is the type of MS in which the symptoms sometimes improve and sometimes worsen, while secondary-progressive is characterized by more significant disability).

Twenty-five of the MS patients, or 80 percent, developed new cortical lesions, and the 7T MRI detected them more frequently compared to previous studies at lower-field 3T MRI strength. On average, the number of lesions that developed in the cortical region was more than twice the number that developed in the white matter of the brain. The total volume of cortical lesions was a predictor of neurological disability at both baseline and follow-up assessment.

“The 7T brain scans showed that the cortical sulci are the regions where most of these lesions develop,” Dr. Mainiero said. “We also found that these lesions can predict disability progression more than white matter lesions, which are the typical lesions of MS we’ve been studying for years.”

While the reasons for the accumulation of lesions in the sulci are not definitively known, researchers note that the flow of cerebrospinal fluid is likely to be restricted there, which might make the sulci more vulnerable to inflammatory responses.

The results suggest that assessment of cortical lesions should represent a main component in the evaluation of progression of disease burden in MS.

“This can have a very powerful impact on how we monitor patients with MS,” said Dr C Mainiero, lead author of the study. “We can also use this tool to see how potential treatments can affect the development and evolution of cortical lesions.”

doi: 10.1148/radiol.2019181719

Axial 7.0-T T2*-weighted images show examples of leukocortical lesions (white arrows) and intracortical lesions (black arrows) along with juxta cortical and periventricular white matter lesions in a 40 year old woman with secondary progressive MS (SPMS), CREDIT Radiological Society of North America

"Tennis elbow can be difficult to treat, leaving many patients unable to perform the simplest tasks, such as picking up their children, cooking dinner, or even working on a computer. With this frustration, many patients turn to invasive major surgery after years of failed physical therapy and medication use,” said Dr Y Okuno, lead author of the study. “We were interested to see if TAE, already in use in other areas of the body, would be effective for this common, debilitating condition and help people immediately regain a range of motion that many of us take for granted in our everyday tasks.”

Dr. Okuno’s team conducted a prospective study in 52 patients with tennis elbow who had not found relief from other forms of treatment. The patients received TAE and were followed for up to four years after the treatment. The researchers found statistically significant reductions in several well-established pain-rating scores. Additionally, images taken in 32 patients two years after undergoing TAE showed an improvement in tendinosis and tear scores.

The total volume of cortical lesions was developed in the cortical region was approximately one hour and requires only a needle insertion under local anesthesia to access the radial artery in the wrist. A catheter is moved through the wrist to the elbow where the inflamed blood vessels are embolized, preventing excessive blood flow to the affected part of the elbow. The treatment is safe and effective and doesn’t require physical therapy, researchers said. No adverse events were observed and no patients experienced negative effects to the surrounding bones, www.sirtoday.org/tae-could-offer-relief-from-tennis-elbow/)

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Axial 7.0-T T2*-weighted images show examples of leukocortical lesions (white arrows) and intracortical lesions (black arrows) along with juxta cortical and periventricular white matter lesions in a 40 year old woman with secondary progressive MS (SPMS), CREDIT Radiological Society of North America
Deep-learning model improves prediction lung cancer survival

Lung cancer is one of the most common cancers and a leading cause of cancer death worldwide. Non Small Cell Lung cancer (NSCLC) accounts for about 85 percent of all lung cancers. The standard assessment for diagnosis and response to therapy for NSCLC patients relies heavily on the measurement of maximum tumor diameter, which is susceptible to variations in interpretation between observers and over time. A multi-national group of researchers hypothesized that dataset of 581 images and an independent validation dataset of 178 images from 89 patients with NSCLC who had been treated with chemoradiation and surgery. The model’s performance improved with the addition of each follow-up scan. The area under the curve for predicting two-year survival based on pretreatment scans alone was 0.58, which improved significantly to 0.74 after adding all available follow-up scans. Patients classed by the model as having low risk for mortality had six-fold improved overall survival compared with those classed as having high risk.

Compared with the current clinical model that utilizes parameters of stage, gender, age, tumor grade, performance, smoking status, and clinical tumor size, the deep-learning model was more efficient in predicting distant metastases, progression, and local regional recurrence. “Radiology scans are captured routinely from lung cancer patients during follow-up examinations and are already in digitized data forms, making them ideal for artificial intelligence applications,” said lead author Dr H Aerts “Deep-learning models that quantitatively track changes in lesions over time may help clinicians tailor treatment plans for individual patients and help stratify patients into different risk groups for clinical trials.” He added “Our research demonstrates that deep-learning models integrating routine imaging scans obtained at multiple time points can improve predictions of survival and cancer-specific outcomes for lung cancer. By comparison, a standard clinical model relying on stage, gender, age, tumor grade, performance, smoking status, and tumor size could not reliably predict two-year survival or treatment response. To the best of our knowledge, this study is the first of its kind to investigate radiomics as a noninvasive biomarker for response to cancer immunotherapy.”

Doi 10.1093/annonc/mdz108

Experimental PET scan detects abnormal tau protein in brains of former footballers


The researchers also found that the more years of tackle football played (across all levels of play), the higher the tau protein levels detected by the PET scan.

However, there was no relationship between the tau PET levels and cognitive test performance or severity of mood and behavior symptoms. CTE is a neurodegenerative disease that has been associated with a history of repetitive head impacts, including those associated with concussion symptoms in American football players. At the moment, CTE can only be diagnosed after death by a neuropathological examination, Like Alzheimer’s disease (AD), CTE has been suggested to be associated with a progressive loss of brain cells. In contrast to AD, the diagnosis of CTE is based in part on the pattern of tau deposition and a relative lack of amyloid plaques.

Results showed that the tau PET levels were significantly higher in the former NFL group (26 players) than in the controls (31 same age men) and the tau was seen in the areas of the brain which have been shown to be affected in post-mortem cases of neuropathologically diagnosed CTE.

Interestingly, the former player and control groups did not differ in their amyloid PET measurements. “Our findings suggest that mild cognitive, emotional, and behavioral symptoms observed in athletes with a history of repetitive impacts are not attributable to AD, and they provide a foundation for additional research studies to advance the scientific understanding, diagnosis, treatment, and prevention of CTE in living persons”, said co-author Dr. E Reiman,

Al software improves X-ray identification of pacemakers

A recent publication by a team from Imperial College, London, UK describes the development, validation, and public availability of a new neural network-based system which attempts to identify from a chest radiograph the manufacturer and even the model group of a pacemaker or defibrillator. (Howard, JP et al. Cardiac rhythm device identification using neural networks. JACC Electro Physiology, 2019; doi: 10.1016/j.jacep.2019.02.003)

The software has been able to identify the make and model of different cardiac rhythm devices, such as pacemakers and defibrillators, within seconds. Dr. J Howard, lead author of the study said: “Pacemakers and defibrillators have improved the lives of millions of patients from around the world. However, in some rare cases these devices can fail and patients can deteriorate as a result. In these situations, clinicians must quickly identify the type of device a patient has so they can provide treatment such as changing the device’s settings or replacing the leads. Unfortunately, current methods are slow and out-dated and there is a real need to find new and improved ways of identifying devices during emergency settings. Our new software could be a solution as it can identify devices accurately and instantly. This could help clinicians make the best decisions for treating patients.”

More than one million people around the world undergo implantation of a cardiac rhythm device each year. These devices are placed under the patients’ skin to either help the heart’s electrical system function properly or measure heart rhythm. In emergencies, clinicians need to determine the model of a device to investigate why it has failed. Unless they have access to the records where implantation took place, staff must use a flowchart algorithm to identify pacemakers by a process of elimination. The flowchart shows a series of shapes and circuit board components of different pacemakers designed to help identify the make and model of a patient’s pacemaker. Not only is this time-consuming, but these flow charts are now outdated and therefore inaccurate. This can result in delays to delivering care to patients, who are often in a critical state. In the new study, researchers trained a neural network software program to identify more than 1,600 different cardiac devices from patients.

To use the neural network, the clinician simply uploads the X-ray image containing the device into a computer and the software reads the image, to give the result of the make and model of the device within seconds.

The team tested the program on radiographic images of more than 1,500 patients acquired at Hammersmith Hospital, London between 1998 and 2018. They then compared the results with five cardiologists who used the current standard flowchart algorithm to identify the devices.

The team found that the software outperformed the current flow-chart based methods. The software was 99 per cent accurate in identifying the manufacturer of a device, compared with only 72 percent accuracy for the flow chart. doi: 10.1016/j.jacep.2019.02.003

Interventional radiologists key to increasing access to thrombectomies

Training interventional radiologists to perform endovascular thrombectomies results in positive outcomes for patients experiencing stroke, according to a study presented at the recent Society of Interventional Radiology Annual Scientific Meeting (www.sirmeeting.org) Expanding access to this treatment provides patients timely access to this gold-standard treatment.

“With a limited availability of providers, thrombectomy is only available to 2 to 3 percent of eligible patients in the United States,” said Dr. K Hong, of Johns Hopkins University. “Patients don’t plan where and when they have a stroke. Our model of training board-certified interventional radiologists can expand access to quality, evidence-based care, and reduce the lifelong disability associated with stroke.”

Thrombectomy, the treatment that clears a clogged artery in the brain, increases the survival rates among those suffering an acute ischemic stroke, reduces the likelihood of resulting disabilities, and speeds function recovery. However, to gain these benefits, thrombectomies must be initiated and performed quickly. Many hospitals do not have providers available to perform these treatments and must transfer patients to a facility where they can get this care, losing valuable time.

The Johns Hopkins University team developed an interventional radiology stroke team consisting of four interventional radiologists who were then specially trained by a neurointerventional radiologist for six months.

“We wanted to change the dynamic in stroke care by bringing in a specialist to perform the care and build the infrastructure necessary” said Dr. F Hui, “In a situation where every minute counts, we wanted to design our program to provide the training and organization necessary to bring 24/7 highly trained stroke interventionalists online as quickly as possible.”

Once the interventional radiologists were conducting the thrombectomies independently, the technical success of thrombectomy carried out by the newly trained physicians was found to be equivalent to that of established neurointerventional radiologists and neurosurgeons. sirmeeting.org.
MRI at birth can predict cognitive development at two years of age

Cognitive ability is an important predictor of mental health outcomes that is influenced by neurodevelopment. Evidence suggests that the foundational wiring of the human brain is in place by birth, and that the white matter (WM) connectome supports developing brain function. It is unknown, however, how the WM connectome at birth supports emergent cognition.


In this study, a deep learning model was trained using cross-validation to classify full-term infants (n = 75) as scoring above or below the median at two years age using WM connectomes generated from diffusion weighted MR images at birth. “This prediction could help identify children at risk for poor cognitive development shortly after birth with high accuracy,” said senior author Dr. J H. Gilmore. “For these children, an early intervention in the first year or so of life - when cognitive development is happening - could help improve outcomes. For example, in premature infants who are at risk, one could use imaging to see who could have problems.”

Gilmore said researchers at UNC and elsewhere are working to find imaging biomarkers of risk for poor cognitive outcomes and for risk of neuro-psychiatric conditions such as autism and schizophrenia. In this study, the researchers replicated the initial finding in a second sample of children who were born prematurely.

“Our study finds that the white matter network at birth is highly predictive and may be a useful imaging biomarker. The fact that we could replicate the findings in a second set of children provides strong evidence that this may be a real and generalizable finding,” he said.

doi. 10.1016/j.neuroimage.2019.02.060

CTA & Doppler both have low accuracy for predicting delayed ischemia after aneurysmal subarachnoid hemorrhage

Both CT angiography and transcranial Doppler have limited accuracy in detecting cerebral vasospasm and predicting delayed cerebral ischemia (DCI) in patients with subarachnoid hemorrhage (SAH) due to ruptured aneurysm, according to a study published in the inaugural edition of Critical Care Explorations (van der Harst JJ et al. Transcranial Doppler Versus CT-Angiography for Detection of Cerebral Vasospasm in Relation to Delayed Cerebral Ischemia After Aneurysmal Subarachnoid Hemorrhage Critical Care Explorations 2019; 1:1)

The results suggest that CVS after aneurysmal SAH is a common finding, and that neither test is an accurate predictor of DCI or unfavorable outcome. “Our study does not support a prominent role of screening with TCD or CTA,” Dr. van der Harst and coauthors conclude. “Detection of CVS that does not become clinically manifest likely leads to overtreatment and prolonged hospital stay.”

Critical Care Explorations 2019;1:1
Extremity CT: the basics and the promise

One of the regular features of the annual ECR meeting that is always highly appreciated by congress attendees is the program of industry-sponsored symposia. This year Carestream sponsored a symposium on “Advancements in Volumetric Extremity Imaging”. This article summarizes one of the presentations in this well-attended session, on the subject of “Extremity CT: the basics and the promise”, which was given by Dr Ian Yorkston. Senior Research Scientist, Clinical Applications Research, Carestream.

PRINCIPLES AND CHARACTERISTICS OF CONE BEAM CT

Dr Yorkston began his presentation by describing the basic principles of cone-beam CT (CBCT) and the main differences of the technology compared to classical CT. Traditional Multi Detector CT (MDCT) typically uses a relatively narrow detector and an X-ray field of about 3-10 cm, which necessarily means that it is not possible to image an extended volume of the patient at one time. The solution to this in MDCT is to use spiral CT, in which the X-ray tube and the detector are rotated at high speed – typically 3-5 revs per second – and the patient is translated through this to build up an extended imaged volume.

In contrast, cone beam technology involves a large area flat panel detector such that imaging one volume of the patient involves only a single rotation. In contrast to MDCT, the patient doesn’t move. This means that, compared to an MDCT system, cone beam is much simpler from an engineering point of view — in cone beam there is no need for slip rings or sophisticated balancing of the many kilograms of detector and X-ray tube hardware that are rotating at high speed [Figure 1].

As a result of this relative engineering simplicity, cone-beam systems are much lighter in weight, have a smaller footprint, are less expensive and are thus more cost-efficient than MDCT systems in routine clinical practice. One other consequence of the ability to acquire a complete image at one time in one revolution, is that CBCT has a uniform, or isotropic, spatial resolution in all three directions. In the Carestream CBCT system (POC Onsight 3D Extremity) the voxel dimension is 260 µm. The practical effect of this can be seen in Figure 2 where a higher spatial resolution of CBCT can be seen compared to classical CT.

APPLICATIONS OF CBCT

The principles of CBCT imaging have already been put to practical use in several well-established clinical applications where commercially available systems are employed in daily routine. For example, CBCT has long been used in dental or ear, nose and

Figure 1. Left Panel. Traditional CT uses a relatively narrow detector and X-ray field so it is not possible to image an extended volume at one time. In spiral CT, the X-ray tube and the detector are rotated at high speed in a spiral through the center of which the patient is moved. Right Panel. Cone beam uses a large area flat panel detector such that imaging one volume of the patient involves only a single rotation. CBCT systems are much simpler than classical CT from an engineering point of view.

Figure 2. Images of tibio-femoral joint. Left panel. Conventional 3D CT Siemens Somatom Sensation. Right Panel. 3D Cone beam CT Carestream’s Onsight 3D Extremity system showing higher spatial resolution. The inclusion of model-based iterative reconstruction and advanced scatter correction algorithms have resulted in a significant improvement in the Hounsfield Units accuracy in the CBCT system.
thorax applications. Likewise, CBCT has been routinely used in fields such as radiation oncology treatment, where often CBCT is standard-of-care. Other established applications of CBCT include intra-operative imaging and guidance, mammography, as well as in the veterinary field. However, for the purposes of his presentation, Dr Yorkston focussed only on CBCT in orthopedic/extremity applications.

**POINTER OF CARE ON SIGHT 3D EXTREMITY CT**

The CBCT system that Carestream (the POC On-Sight 3D extremity CBCT) has developed is specifically designed for the 3D imaging of extremities, i.e hand, wrist, elbow, ankle, and foot. Introduced into the market last year, the new system provides either 2D or 3D imaging capabilities with excellent image quality at high spatial resolution — isotropic voxel spacing of 0.26 mm and a large field of view of more than 20 cm. The system incorporates state-of-the art iterative reconstruction noise-reducing algorithms as well as advanced algorithms for metal artefact correction. As for radiation dose, the cone beam principle means that the new system has lower doses of ionizing radiation than typical MDCT systems.

Designed primarily for point-of-care or office practices, the new system can be installed in a space as limited as 2.5 X 3 metres. There are no special power requirements — the system plugs directly into standard 120V/230V mains outlets. The design enables an efficient workflow that is particularly suited to office applications for example by providing easy patient positioning through a lateral entry door [Figure 3]. Patients can be imaged either in sitting or standing position so images of upper and lower extremities can be acquired with minimum discomfort for the patient. Of particular clinical significance is the fact that images can be easily acquired under weight-bearing conditions.

**Larger anatomy coverage.** A design feature of the On-Sight 3D Extremity is that the system incorporates three X-ray tubes arranged along the z-axis, thus resulting in a larger (approximately 50% larger) reconstruction volume than that of a single-tube design [Figure 4]. The three-tube design also significantly reduces the so-called ‘cone-beam’ artefact that can appear at the periphery of the reconstruction volume in single source systems. Yet another advantage of the three-tube design is that this opens the way to future advanced acquisition protocols such as dual energy imaging (see below).

**Clinical Applications**

The practical clinical consequences of the high image quality of the new system have been reported in several case studies of extremity imaging.

**Wrist.** Several reports have described the superiority of CBCT over projection X-ray for the detection of scaphoid fractures. [1, 2, 3]. Although relatively common, scaphoid fractures are typically difficult to diagnose with confidence; accurate diagnosis is however more than usually important since inappropriate initial treatment can affect prognosis and outcomes. The encouraging results of CBCT vs 2D X-ray in the detection of scaphoid fractures suggest that, in the future CBCT may become standard of care in this field. In another example of the use of CBCT imaging of the wrist, fractures of the triquetral bone was clearly identified by CBCT whereas the fractures were not visible with 2D X-ray. [Dr T Jacques, Lille, France, personal communication].

**Knee.** Likewise, in fractures of the knee, reports have described impact fractures of the posterior aspect of the lateral tibial plateau that are clearly visible in CBCT but are not detectable by 2D X-ray [Dr T Jacques, Lille, France, personal communication].

**Ankle.** The significance and importance of the new system being able to acquire images under weight-bearing conditions has been reported by a team from the University of Buffalo, NY, USA who investigated ankle syndesmosis injuries [4]. With standard 2D X-ray imaging, it is difficult to differentiate the stable or unstable status of these injuries, although such clinical differentiation is critical in terms of deciding treatment options, namely surgery/no surgery. The team from Buffalo found that the use of weight bearing CBCT (WB CBCT) enabled the clear differentiation of the stable/unstable status of supination - external rotation (SER) injuries [4].

**Likely Future Developments**

Two highly promising and inter-related areas can be identified for the future development of CBCT, namely quantitative imaging coupled with improved workflow tools.

An example of the potential of these approaches can be found in foot/ankle trauma injuries where traditionally multiple measurements are made manually from weight-bearing classical X-Ray images. This
is a time-consuming process and frequently gives irreproducible results. Compared to 2D, a 3-D image of course provides much more information, enabling for example the possibility of measuring subtle movement and the relative rotation of bones. The practical problem is that the very increase in the amount of information generated by 3 D image acquisition means that even more time is needed for measurement/analysis. There are more than thirty established measurements of clinical relevance that can be taken from 3D foot and ankle images. In the reality of routine clinical practice, no-one has the time for such measurements, interesting though they may be clinically. This is where we at Carestream see the future potential for automated measurement capabilities of 3D CBCT images. In already published work in this field, a team from Johns Hopkins University used automated, algorithms to streamline the measurement-taking process in 3D images of the tibiofemoral joint and so reduce the user-dependence of the metrics that are associated with manual identification of the anatomical landmarks [5]. The Hopkins team found that the automated method for the measurement of anatomical metrics of the tibiofemoral joint correlated with the data generated manually by expert radiologists, but, of course, without the need for time-consuming and error-prone manual selection of landmarks [5]. Such kind of algorithms will be necessary to make the most of the increased amount of clinically relevant information that is generated by CBCT systems [Figure 5]. However the development of these automatic measurement tools will in itself be insufficient. What is needed in addition is to understand the clinical significance of the data. To address this question, a “Weight-bearing Study Group” was established a couple of years ago. Involving a collaboration of clinical and industrial participants, this international study group (www.WBCTStudyGroup.com) has as its mission the promotion of dialogue and co-operation on weight-bearing CT research initiatives. The group is working actively to create standardized protocols for weight-bearing CT measurements and analyses.

Developments in this field are not restricted to the foot/ankle. The team from Johns Hopkins has been developing a novel methodology of the characterization of knee joint space morphology using high-resolution 3D images from CBCT of subjects with and without osteoarthritis (OA) [6]. Other approaches to quantitative bone measurements are being explored for the early detection of osteoarthritis, with the objective of developing improved metrics to identify and stage OA and the ultimate goal of improving the prediction of the osteoarthritic patient’s optimal response to therapy. In addition to the study of overall bone morphology and joint space analyses, interest is also being focussed on trabecular pattern analysis and bone density measurements to identify potential OA patients pre-symptomatically and also monitor their response to therapy. The same approaches are being adopted to assess the appropriateness of hardware placement and fracture risk in osteoporotic patients as well as the assessment of fracture healing, which is important in decisions regarding the suitability of the patient to return to work.

Weight bearing CB CT datasets are also being investigated in the pre-operative planning for total joint replacements surgery (e.g. knee or ankle).
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Personalized ultrasound scan showing atherosclerosis helps patients reduce cardiovascular risk

A new randomized trial of over 3000 people has found that sharing pictorial representations of personalized scans showing the extent of atherosclerosis (vascular age and plaque in the arteries) to patients and their doctors results in a decreased risk of cardiovascular disease one year later, compared to people receiving usual information about their risk. (Näslund U et al. Visualization of asymptomatic atherosclerotic disease for optimum cardiovascular prevention (VIPVIZA): a pragmatic, open-label, randomised controlled trial. Lancet 2019; 393: 133 doi.org/10.1016/S0140-6736(18)32818-6)

Smoking cessation, physical activity, statins, and antihypertensive medication to prevent cardiovascular disease are among the most evidence-based and cost-effective interventions in health care. However, low adherence to medication and lifestyle changes mean that these types of prevention efforts often fail.

"Cardiovascular disease is the leading cause of death in many countries, and despite a wealth of evidence about effective prevention methods from medication to lifestyle changes, adherence is low," says Professor Ulf Näslund, Umea University Sweden. “Information alone rarely leads to behavior change and the recall of advice regarding exercise and diet is poorer than advice about medicines. Risk scores are widely used, but they might be too abstract, and therefore fail to stimulate appropriate behaviors. This trial shows the power of using personalized images of atherosclerosis as a tool to potentially prompt behavior change and reduce the risk of cardiovascular disease.” Of the participants in the Swedish Västerbotten County cardiovascular prevention programme, 3532 individuals were included in the study and underwent vascular ultrasound investigation of the carotid arteries. Half were randomly selected to receive the pictorial representation of carotid ultrasound, and half did not receive the pictorial information.

Participants aged 40 to 60 years with one or more cardiovascular risk factors were eligible to participate. All participants underwent blood sampling, a survey of clinical risk factors and ultrasound assessment for carotid intima media wall thickness and plaque formation.

Each person in the intervention group received a pictorial representation of plaque formation in their arteries, and a gauge ranging from green to red to illustrate their biological age compared with their chronological age. They then received a follow up call from a nurse after 2-4 weeks to answer any questions. The same pictorial presentation of the ultrasound result was also sent to their primary care doctor. Thus, the study had dual targets.

Both groups received information about their cardiovascular risk factors and a motivational health dialogue to promote healthier life style and, if needed according to clinical guidelines, pharmacological treatment.

At one year follow up, the cardiovascular risk score for all participants (3175 completed the follow up) was calculated showing differences between the two groups (Framingham Risk Score decreased in the intervention group but increased in the control group [-0.58 vs +0.35]; SCORE increased by twice as much in control group compared to the intervention group [0.27 vs 0.13]). Improvements were also seen for total and LDL cholesterol in both groups, but the reduction was greater in the intervention group than in the control group. A graded effect was also noted, with the strongest effect seen for those with the worst results.

“The differences at a population level were modest, but important, and the effect was largest among those at highest risk of cardiovascular disease, which is encouraging. Imaging technologies such as CT and MRI might allow for a more precise assessment of risk, but these technologies have a higher cost and are not available on an equitable basis for the entire population. Our approach integrated an ultrasound scan, and a follow up call with a nurse, into an already established screening programme, which means that our findings are highly relevant to clinical practice,” says Prof Näslund.

Importantly, the effect of the intervention did not differ by education level, suggesting that this type of risk communications might contribute to a reduction of the social gap in health. The findings come from a middle-aged population with low to moderate cardiovascular disease risk. Formal cost-effectiveness analyses will be done after 3-year follow-up. 

Lancet 2019; 393: 133 doi.org/10.1016/S0140-6736(18)32818-6

MRI coronary wall thickness is independent marker of heart disease in women

The thickness of the coronary artery wall as measured by MRI is an independent marker for heart disease in women, according to a recently published study (Ghanem AM et al. Sexual dimorphism of coronary artery disease in a low- and intermediate-risk asymptomatic population; association with coronary vessel wall thickness at MRI in women, Radiology: Cardiothoracic Imaging. 2019; 1(1):e180007 doi/10.1148/ rct.2019180007)

Previous research has found limitations in cardiovascular risk assessment for women. For instance, there is evidence...
that the commonly used Framingham Risk Score, which provides estimates of cardiovascular disease risk based on age, sex and other factors, underestimates the chance of heart attacks and other cardiovascular events in asymptomatic women. Imaging tools such as coronary computed tomography angiography (CCTA) tend to be used in patients with symptoms or more advanced cardiovascular disease, but are not recommended for wider use in risk assessment among the general population with no cardiac symptoms.

Recently, cardiac MRI has emerged as a promising tool for early detection of coronary artery disease. MRI can detect thickening in the walls of the arteries, that occurs earlier in the course of heart disease than stenosis.

"Despite the significant advances in CCTA technology, it can be inappropriate to send all asymptomatic people to CCTA because of the exposure to radiation and the contrast media used for imaging," said study lead author Dr. K. Z. Abd-Elmoniem. "MRI might be a safer alternative that can be used more broadly to assist in the diagnosis of coronary artery disease without exposing patients to a procedure that carries some, albeit small risk. The advantage of MRI in this situation is that it can tell us that there is a thickening before stenosis, which is difficult to do with CCTA.

Over a period of years, Dr. Abd-Elmoniem and colleagues developed and refined an MRI technique that adjusts for the motions of breathing and the beating heart to directly visualize coronary wall thickness. They used the technique to assess coronary artery disease in 62 women and 62 men with low to intermediate risks based on their Framingham scores. The patients also underwent CCTA to investigate the association between vessel wall thickness and CCTA-based coronary artery disease scores.

The results showed stark differences between the two groups. "When we separated the patients into men and women, coronary artery disease in men was, as expected, associated with aging and a high Framingham score," said Dr. Abd-Elmoniem. "However, in women, both age and the Framingham score were not factors. Vessel wall thickness, as measured by MRI, was the strongest variable associated with coronary artery disease." doi: 10.1148/ryct.2019180007

PET/MRI examines were carried out on the carotid (above), the aorta and the femoral arteries. Image courtesy of JACC

PET/MRI predicts cardiovascular risk from arterial inflammation

Using advanced PET/MRI technology researchers at the Centro Nacional de Investigaciones Cardiovasculares (CNIC), Madrid, Spain detected arterial inflammation in regions that have yet to develop atherosclerotic plaques (Fernández-Friera L et al Vascular Inflammation in Subclinical Atherosclerosis Detected by Hybrid PET/MRI. J Am Coll Cardiol. 2019; 73(12): 1371. doi: 10.1016/j.jacc.2018.12.075.)

In the study, the research team used PET/MRI to analyze the inflammatory process in the arteries of a group of people who had already developed atherosclerotic plaques. The results show, for the first time, that inflammation is present at early stages of atherosclerosis, above all in regions that have not developed plaques. The study also shows that this arterial inflammation can be an early indication of the later appearance of plaques. The researchers are currently analyzing the role of arterial inflammation in this process. Although atherosclerosis is known to be a chronic inflammatory disease, the prevalence and distribution of inflammation at early disease stages was unknown.

Dr. Valentín Fuster, CNIC Director and lead investigator on the project, emphasized the power of modern diagnostic imaging technology, which "has revealed that inflammation is present in only 10% of established plaques." Study coauthor Dr. J Sanz explained that "the atherosclerotic plaques showing signs of inflammation are large, have a high cholesterol content, and tend to be located in the femoral arteries at the arterial bifurcations." Nevertheless, "most inflammation identified in the arteries of this study subpopulation are located in vessel regions free of atherosclerotic plaques."
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Combined SPECT and cardiac MR imaging can help guide ventricular tachycardia ablation

Adding functional imaging to structural imaging of patients with ventricular tachycardia (VT) has the potential to improve current VT ablation strategies, according to newly published research (Imanli H et al. Ventricular Tachycardia (VT) Substrate Characteristics: Insights from Multimodality Structural and Functional Imaging of the VT Substrate Using Cardiac MRI SPECT, 123I-Metaiodobenzylguanidine SPECT Innervation, and Bipolar Voltage. J Nucl Med. 2019; 60: 79. doi: 10.2967/jnumed.118.211698). Iodine-123 metaiodobenzylguanidine (123I-MIBG) SPECT imaging, when combined with cardiac magnetic resonance imaging (MRI), helped to identify specific subsets of heart tissue more prone to arrhythmia, which may allow physicians to achieve improved VT suppression and shorter procedure times.

Ventricular arrhythmias, are the main cause of sudden cardiac death in the United States and are responsible for up to 300,000 deaths each year. Ablation of ventricular tachycardia is a proven treatment for arrhythmias in patients with a history of heart attacks. Identifying the area of the increased scar tissue that is responsible for the current arrhythmia and possible future arrhythmias has been challenging, with up to 50% of patients suffering a recurrence during the 6 months following the ablation. “The amount of scar tissue can often account for more than half of the left ventricle myocardium,” noted Dr. Timm Dickfeld, of the University of Maryland School of Medicine. “Ablating such a large amount of the myocardium is often not desirable and very time-intensive.”

In the study, researchers followed 15 patients with ischemic cardiomyopathy who were scheduled for radiofrequency ablation for drug-refractory VT. Each patient underwent imaging with 123I-MIBG SPECT and cardiac MRI, as well as high-resolution bipolar voltage mapping. These three mapping tools assessed various adaptations found in VT: abnormal innervation, tissue scarring and low-voltage area, respectively. The adaptations were then compared to determine which were present in the affected heart tissue.

Areas with abnormal innervation, cardiac tissue scar and low bipolar voltage were seen in all patients. While approximately 25 percent of patients had abnormalities found by all three mapping tools, researchers found that significant areas of the affected heart tissue showed adaptations only noted by one or two of the tools. The largest of these areas had abnormal innervation only (18.2 percent), cardiac scar tissue and abnormal innervation (14.9 percent), and MRI scar only (14.6 percent). “Results from this study show that nuclear medicine can be used to develop novel, cutting-edge strategies for risk stratification and arrhythmia treatment,” said Dickfeld. doi: 10.2967/jnumed.118.211698

Coronary Artery Calcium in South Asians

South Asians are known to have a high chance of developing cardiovascular disease and represent more than 60 percent of cardiovascular disease patients worldwide. They also develop risk factors such as high blood pressure, cholesterol and diabetes at a younger age than other racial and ethnic groups. Specks of calcium in the heart’s artery walls could be an important prognostic marker of early cardiovascular disease in South Asians and may help guide treatment in this population, according to a recent study. (Kanaya AM Incidence and Progression of Coronary Artery Calcium in South Asians Compared With 4 Race/Ethnic Groups. J Am Heart Assoc. 2019; 8 :e011053. doi: 10.1161/JAHA.118.011053). In a study of nearly 700 patients with ethnic backgrounds from India, Pakistan, Bangladesh, Sri Lanka, Nepal and Bhutan, UCSF researchers found that South Asian men had the same high rates of change in calcification of their artery walls over a five-year period as white men, the group with the highest rates of cardiovascular disease.

“While South Asians have high cardiovascular disease rates, there are few prospective studies in the world that have focused on determining the risk factors,” said lead author Dr. Alka Kanaya, professor of medicine at UCSF. “The presence and change of coronary artery calcium may be useful for risk prediction in this ethnic population and may better guide the judicious use of statin and other preventive therapies.”

Early signs of coronary artery calcification (CAC) can be detected through a computed tomography (CT) scan. In other ethnic groups, high CAC scores have been proven to be an early sign of those at high risk of developing cardiovascular disease. “Both CAC burden and progression have been shown to be independent predictors of coronary heart disease in whites, blacks, Latinos and Chinese Americans,” Kanaya said. doi: 10.1161/JAHA.118.011053
Coronary heart disease (CHD) is a leading cause of mortality and morbidity, and a frequent cause of primary and secondary care attendance with chest pain. It is therefore paramount that patients who are at high risk are identified early, and appropriate treatment organised. However, clinical assessment alone can be challenging, as patients often present with atypical symptoms and pre-test probability scoring systems both under- and over-estimate risk. Furthermore, whilst non-invasive testing with exercise electrocardiography or functional testing can risk-stratify patients, their application has not demonstrated an improvement in clinical outcomes, such as rates of myocardial infarction. On the other hand, Computed Tomography Coronary Angiography (CTCA) provides a rapid, non-invasive method to evaluate the coronary arteries with a high diagnostic accuracy (sensitivity 96%, specificity 72%, to detect a >70% stenosis [1]) and involves only a relatively low radiation dose.

The results of the SCOT-HEART (Scottish Computed Tomography of the HEART) randomised controlled trial, whose 5-year follow-up data have recently been published, have established the role of CTCA for patients with symptoms of suspected coronary artery disease [2, 3, 4], leading to important changes in guidelines. The SCOT-HEART trial was an open-label, parallel-group, multicentre randomised control trial, recruiting patients who were referred to cardiology outpatient chest pain clinics by their primary care physician or other healthcare providers. Over a four-year period, 4146 eligible patients with suspected angina due to coronary heart disease were randomised to undergo standard care, or standard care plus computed tomography (CT). An important strength of the trial is the fact that SCOT-HEART had broad inclusion criteria, including patients between 18 and 75 years and recruited a half of all eligible patients. The trial therefore investigated a clinical approach that is readily generalisable in the real world.

The aim of the SCOT-HEART trial was to assess the role of CT in the diagnosis, management and outcome of patients with suspected angina compared to standard treatment. For patients in the CT group, the results of the coronary artery calcium score and CTCA were provided to clinicians. For patients in the standard care group, the 10-year cardiovascular risk score was provided. The primary outcome was the diagnosis of angina secondary to coronary heart disease. Long term assessment included outcomes such as death, myocardial infarction, and coronary revascularisation.

At six-weeks, CTCA led to a change in the diagnosis of angina due to coronary heart disease in 23% of patients compared with just 1% of patients in the standard care arm (p<0.0001) [3]. According to the clinicians reporting the CTCA scans, this led to an increase in the certainty (relative risk 3.76, 95% confidence interval (CI) 3.61 to 3.89, p<0.0001) but reduced the frequency (relative risk 0.78, 95% CI 0.70 to 0.86, p<0.0001) of the diagnosis of angina due to coronary heart disease [3]. This clarification of diagnosis had several important implications for subsequent patient management.

- Firstly, CTCA led to a change in medication use in 23% compared to 5% in the standard care arm (p<0.0001) [3]. This included an increase in the use of preventative medication (aspirin, statin, angiotensin converting enzyme inhibitor). CTCA can therefore be used to target appropriate use of medical therapy. It is likely that the early, confident diagnosis of coronary heart disease in the CTCA arm allowed for more frequent and effective preventative treatments.

- Secondly, CTCA led to a change in subsequent investigations. An early criticism of the use of CTCA in the assessment of angina was that it would lead to more frequent, potentially unnecessary, investigations. However, SCOT-HEART has proven the contrary to be true. In the CTCA group, there was a significant change in the number of subsequent planned investigations (15% vs 1%, p<0.0001) [3]. In the first 12 months, there was a slight increase in the number of invasive coronary angiograms performed in the CTCA group. However, there was also a reduction in the number of...
patients with normal coronary arteries identified at invasive coronary angiography. Beyond the first year, patients in the CTCA group had lower rates of invasive coronary angiography, and at 5 years there was no difference in the frequency of invasive coronary angiography between the two groups (23.6% vs 24.2%, hazard ratio 1.00, 95% CI 0.88 to 1.13) [4]. Similarly, whilst there was a higher rate of coronary revascularisation in the CTCA arm in the first 12 months, at five years there was no difference between the two groups (13.5% vs 12.9%, hazard ratio 1.07, 95% CI 0.91 to 1.27) [4]. This shows that patients in the CTCA group had more appropriate, timely use of invasive coronary angiography and revascularisation compared to those in the standard care group.

The initial 1.7-year follow-up of the SCOT-HEART trial showed a 38% reduction in the rate of the combined endpoint of fatal and non-fatal myocardial infarction in patients in the CTCA group, which just failed to reach statistical significance (p=0.0527) [3]. A landmark analysis was performed which censored the initial 50 days of the trial period, which was the median time it took to perform imaging, communicate results to clinicians and patients and organise a change in management strategy. This showed a 50% reduction in the rate of myocardial infarction and death in the patients in the CTCA group (hazard ratio 0.50, 95% CI 0.28 to 0.88, p=0.020) [5]. The 5-year results of the SCOT-HEART trial have recently been published. This confirms the significantly lower rate of coronary heart disease death or non-fatal myocardial infarction in the CTCA group compared to the standard care group (2.3% vs. 3.9%, hazard ratio 0.59, 95% CI 0.41 to 0.84, p=0.004) [4]. Thus, for the first time, a management strategy based on an imaging test for patients with suspected coronary heart disease has been shown to significantly improve outcomes. Indeed, the number needed to test (NNT) for CTCA to prevent one fatal or nonfatal myocardial infarction over 5 years is only 63 patients [4].

At the same time as the initial SCOT-HEART trial results were published, the results of the PROMISE trial were also published [6]. PROMISE was a large randomised controlled trial which compared CTCA with functional testing. Over a three-year period, 10,003 patients were recruited and randomised to anatomical testing with CTCA or functional testing (68% nuclear stress testing, 22% stress echocardiography and 10% exercise electrocardiogram). PROMISE demonstrated no differences in mortality between the CTCA and functional testing groups after 2 years of follow-up. Unfortunately, longer term follow-up is not available. A meta-analysis of the 2-year combined results of PROMISE, SCOT-HEART and other smaller studies, with a total of 14,817 patients, demonstrated that there was a 31% relative risk reduction of myocardial infarction for patients undergoing CTCA compared to standard care, but no change in mortality [7].

Subsequent registry studies have confirmed the ability of CTCA to appropriately target medical management and revascularisation identified in SCOT-HEART. A large Danish registry study of 86,705 patients showed that there was a change in medication use in patients undergoing CTCA compared to functional testing (26% vs 9% statin use, p < 0.001 and 13% vs 9% aspirin use, p < 0.001) [8]. The PROMISE study and other registry studies have also shown that CTCA can more appropriately select patients for invasive coronary angiography and reduce the proportion of patients with normal coronary arteries at invasive coronary angiography.

Figure 1. CT (A, B) and invasive coronary angiography (C) images from a 56 year old female who attended the cardiology out patient department with a history of atypical chest pain. She was an ex-smoker with a family history of coronary artery disease. An exercise tolerance test was inconclusive. CTCA curved planar reformation (B) shows a mild calcified plaque and a severe non-calcified plaque (arrow) in the proximal LAD. Invasive coronary angiography (C) showed a severe stenosis in the proximal LAD (arrow) and this was treated with a coronary artery stent.

“...significantly lower rate of coronary heart disease death or non-fatal myocardial infarction in the CTCA group compared to the standard care group...”
Angiography. Thus, the results of the SCOT-HEART trial have been supported by other subsequent research.

CTCA now has a central role in the UK NICE (National Institute of Health and Care Excellence) guidelines for patients with stable chest pain [1]. The NICE guidelines no longer advocate assessment of the pre-test probability of obstructive coronary artery disease and CTCA is the first line test for patients with possible angina [Figures 1 and 2]. The current European Society of Cardiology and American College of Cardiology reserve CTCA for certain subgroups. However, these guidelines were published in 2013 and 2012, and are therefore likely to be revised.

An ongoing challenge for patients and clinicians is the fact that myocardial infarction frequently occurs in coronary arteries without prior obstructive coronary artery disease. In the SCOT-HEART trial, patients with obstructive disease had the highest rate of myocardial infarction, but for those with non-obstructive disease, the event rate was also higher than those with normal coronary arteries. In the PROMISE trial over 50% of myocardial infarctions occurred in patients with normal functional stress tests or non-obstructive coronary artery disease on CTCA. On CTCA adverse coronary artery plaque characteristics can be identified which correlate with invasive assessment of plaque vulnerability. In both the SCOT-HEART and the PROMISE trial, the presence of adverse coronary artery plaque characteristics has been associated with worse outcomes [9, 10]. However, at 5 years in the SCOT-HEART trial this was not independent of the overall coronary artery plaque burden assessed with the coronary artery calcium score. This is in keeping with our current understanding of atherosclerosis as a dynamic process, where vulnerable atherosclerotic plaques may stabilise without clinically apparent myocardial infarction. In addition, the future cornerstone to improve coronary artery disease outcomes may be the early identification of atherosclerotic plaque burden, prior to the onset of symptoms. With this in mind, the SCOT-HEART 2 randomised controlled trial will assess the use of CTCA in asymptomatic populations.

CONCLUSION

In conclusion, the SCOT-HEART trial has established the role of CTCA in patients with suspected coronary heart disease. CTCA lead to more appropriate targeted use of medical therapies, subsequent investigations and revascularisation. Importantly, SCOT-HEART has shown, for the first time, that a management strategy based on an imaging test for patients with suspected coronary heart disease can improve clinical outcomes.

REFERENCES

Are coronary CT angiography and CT-Based FFR set to become a game-changer in the diagnosis and treatment decisions in coronary artery disease?

Ever since publication last year, the results of the SYNTAX III Revolution trial [1] have been making waves and stimulating intense debate between radiologists, interventional cardiologists and cardiac surgeons involved in the treatment of patients with coronary artery disease. The trial results showed that there was almost perfect agreement between heart teams who used either conventional invasive coronary angiography (ICA) or Coronary CT angiography (CCTA) to decide which revascularization approach should be used for the treatment of patients with severe, multi-vessel coronary artery disease.

We wanted to find out more about the trial and the implications of the results, so we spoke to Prof. Patrick Serruys, Principal Investigator of the trial.

So what is the significance of the findings of the SYNTAX III Revolution trial, do the results mean that invasive coronary angiography will be replaced by coronary CT angiography?

Well that is a big question, but to cut to the chase, yes many of us in the field do believe that conventional ciné angiography that is used as a diagnostic tool will progressively be replaced by multi-slice CT scans. More work and further trials will be needed, but the results of our SYNTAX III trial do suggest a promising, real change in future practice, with a central place for CCTA in guiding decisions for the treatment of patients with coronary artery disease. There are many reasons and data to support this belief, but one key underlying factor is that the technology — both hardware and software — behind CT scans has made dramatic and continuing advances over the years. In the SYNTAX III Revolution trial, the multislice CT scanner used to carry out the CCTA examinations was the Revolution scanner from GE Healthcare [Figure 1]. With a 160 mm coverage in the z-axis and 0.28 second rotation speed, the system allows the acquisition of the whole heart within a single beat; any motion artefacts can be handled by post-processing; all in all a performance that was unimaginable several years ago.

In addition CCTA exams carried out on the Revolution multislice scanner involve relatively low levels of ionizing radiation of approximately 5mSv versus a typical 10mSV for conventional angiography. The technological progress of multislice CT scanners and their suitability for cardiac imaging is beginning to be recognized by the advisory authorities. Recently, the UK’s National Institute for Health and Care Excellence (NICE) issued guidelines (CG95) for the management of stable chest pain which recommended coronary CTA as a preference over functional testing for the first-line test for evaluation of chest pain in patients without known coronary artery disease (CAD). Importantly, the NICE guidelines suggest first-line coronary CTA testing at all levels of pre-test risk probability of CAD. This is a radical departure from existing U.S. and European societal guidelines, which currently recommend limiting the use of coronary CTA to patients with low to intermediate pre-test risk.

In practice, NICE proposed that in the UK the number of tests carried out in the future by other cardiac imaging modalities, such as stress echocardiography, myocardial perfusion imaging, stress MRI, CT calcium scoring and invasive coronary angiography should be reduced by 100%; 50%; 50%; 50%; 100% and 60% respectively. However, NICE proposed a 400% increase in the number of CT angiography tests to be carried out. The contrast with NICE’s proposed usage of invasive coronary angiography (60% decrease) is striking. In addition, a financial analysis of the impact of these proposed NICE guidelines showed a cost saving of nearly 20 million pounds.

The manufacturers of CT scanners are also aware of the increasing potential of CT technology in cardiac imaging. To meet this potential GE Healthcare have for example recently introduced a new CT system, the CardioGraphe specifically designed for cardiology. The CardioGraphe is a small multi-slice CT scanner which only takes up 15 sq metres floor...
The small size of the system means that the rotation speed can be high, so giving a temporal resolution of 120 msec. The spatial resolution is about 285 micron, so not so far from the resolution of coronary angiography which is typically 200 – 220 micron. Image quality is high and the system gives whole heart, one beat cardiac image acquisition.

Yes but let’s first recap a bit on the various SYNTAX Scores. Approximately 10 years ago I created the original SYNTAX scoring system with my team in the Thorax Center in Rotterdam when we were conducting a large trial comparing the two different cardiac revascularization approaches, namely surgery (Coronary Artery Bypass Grafting, CABG) versus Percutaneous Coronary Intervention (PCI) in patients with multi-vessel three vessel and main stem disease. The SYNTAX score we developed is an angiographic grading tool to determine the complexity of coronary artery disease. One advantage of the scoring system was that it forced the surgeons and the interventionalist cardiologists to closely examine the angiography images before taking any decision about the revascularization approach to be adopted. Although in the beginning, the surgeons and interventional cardiologists did not fully understand the significance of the actual numerical value the detailed attention they paid to the angiography images was very useful. In addition, soon after its introduction, we realized that the score correlated with the patient outcomes and so had an important prognostic value. However we also noted that the prognostic value of the score could be affected by the patients’ clinical characteristics and co-morbidities, e.g. Chronic Obstructive Pulmonary Disease (COPD), Peripheral Vascular Disease, creatinine clearance, etc., etc.

So we took the anatomic SYNTAX score and combined these with the clinical co-morbidities to create the SYNTAX II score, which was very reliable in predicting all-cause mortality at four years. This robust score allows for meaningful discussions between surgeons and patients in terms understandable to the patient. The score in fact became a decision maker so that although the patient is unaware of the underlying algorithms that generate the score, it enables the patient to better appreciate, in conjunction with the interventionalist or cardiologist, the relative chance of mortality associated with the choice of therapeutic route. For example it is now possible to say to a patient “if you opt for CABG surgery you have a 15 % chance that you will be dead in four years whereas if you opt for PCI the risk is 42%, or vice versa”.

Powerful as the SYNTAX II score is, it soon became clear that this was not the whole story. Even precise anatomical measurements of the coronary vasculature such as measures of stenoses did not correlate with the actual physiological characteristics of the hemodynamic flow as measured by Fractional Flow Reserve (FFR). Traditionally FFR is measured in the cath lab by the invasive procedure based on the use of a pressure sensitive wire. In recent years the development of advanced CT systems has enabled the production of high quality images of the coronary tree to which sophisticated flow dynamic algorithms and software (for example from the Heart Flow company) can be applied to generate an FFR value derived from the CTA data-set (FFR_CTA). The correlation between the FFR and FFR_CTA has been carefully studied and has been shown to be quite good, with FFR_CTA having the clear advantage of not being as invasive as the conventional wire-based system [Figure 3, 4]. The UK’s NICE guidelines mentioned above predicted an additional cost saving if the HeartFlow FFR_CTA was used rather than invasive investigation and treatment.

So to recap, after the SYNTAX score based on anatomy, we can add the physiological consequences of the anatomy via FFR and build in the effect of any co-morbidities to yield the SYNTAX III score.

The aim of the trial was to determine, the level of agreement between heart teams on treatment decision-making using either CCTA or conventional angiography. The patients all had severe coronary artery disease (so at the tip of the CAD pyramid, Figure 5) and the treatment options were either CABG or PCI. The design of the trial is shown in Figure 6. Separate heart teams, composed of an interventionalist cardiologist, a cardiac surgeon, and a radiologist (the inclusion of a radiologist in the heart team is an innovation) were randomized to assess the coronary artery disease with either coronary CTA or conventional angiography. Each
heart team, blinded for the other imaging modality, quantified the anatomical complexity using the SYNTAX score and integrated clinical information using the SYNTAX Score II to provide a treatment recommendations based on mortality prediction at 4 years. 

Thus, for the first time in a clinical trial the clinicians, namely the two heart teams were randomized to the patients as opposed to the patients being randomized to one methodology or another. The primary endpoint was the level of agreement between heart teams on the revascularization strategy, with a secondary end-point being the impact of FFRCT alone on treatment decision and planning.

Q So what were the results of the trial?  
The results were outstanding. We found that there was an almost perfect statistical agreement on the decisions regarding the optimal revascularization strategy that the heart teams came to, no matter whether they used conventional angiography or CCTA-derived information. As regards the secondary end-point, namely the impact of CCTA and FFRCT alone (i.e. without using any conventional angiography data) on the surgeon’s willingness to carry out CABG or not, it was found that 84% of the surgeons who were presented with only the CCTA and FFRCT data indicated that they would be happy to base their CABG surgery decision on these data alone.

Q And what are the implications of these findings?  
Well as regards the agreement on treatment options between CCTA or conventional angiography, this clearly suggests the feasibility of treatment decision-making based solely on non-invasive imaging modality and dramatically extends the use of CCTA to patients with severe CAD. Some observers have described this as a “paradigm shift to a situation where CAD is diagnosed and thoroughly characterized non-invasively, with revascularization planning made in a collaborative fashion integrating the heart team”. The implications could be far-reaching, particularly as regards the future roles of the members of the heart team. Up till now the role of “gatekeeper” of access to the cardiac surgeon lay with the interventionalist.

Now, given the potential of CCTA and FFRCT, the role of gatekeeper to cardiac surgery will increasingly be fulfilled by the radiologist. In such a scenario, a third party, such as an internal medicine clinician can request a multi-slice CT exam for the patient. As a function of the results, the radiologist would then propose the case to the surgeon or the interventionalist. Of course, the people in the diagnostic cath labs are uneasy with these scenarios, particularly since diagnostic conventional angiography is a significant revenue source for the cath lab.

Q What are the next steps?  
There are many next steps and one has already begun, namely a trial to confirm that surgeons are really confident to base their surgical decisions on CCTA and FFRCT alone. Of course, the study of the cohort of the SYNTAX III Revolution trial suggested that they would be, but this was a retrospective analysis, and we have to recognize that surgeons are not (yet) really familiar with analyzing multi-slice CCTA or FFRCT data. So making a decision purely on CCTA and FFRCT data alone and without any access to conventional cine angiography could be tough for a surgeon and at least require a learning curve. The CABG Revolution trial that we are currently undertaking is designed to answer these questions.

In the longer term, who knows, we could imagine applying CCTA and FFRCT to all categories of patients with CAD, not just the severe cases at the tip of the CAD pyramid who participated in the SYNTAX III Revolution trial.

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Coronary CTA enhanced with CTA-based FFR analysis provides higher diagnostic value than invasive coronary angiography

By Dr. M Kruk, Dr. Ł Wardziak, Dr. M Demkow & Dr. C Kepka

INTRODUCTION
Invasive coronary angiography (ICA) remains the gold standard for the diagnosis of coronary artery disease (CAD), and is recommended in patients with a higher probability of significant CAD, and who are potential candidates for further invasive therapies. Coronary computed tomography angiography (coronary CTA) has recently been gaining momentum as a noninvasive and effective tool for ruling out obstructive CAD and is recommended in patients with a lower probability of CAD.

Both coronary CTA and ICA are anatomic imaging methods that have high sensitivity. On the other hand, both modalities suffer from low specificity in the detection of functionally significant coronary stenoses. Recently, it has been shown that there is no difference between coronary CTA and ICA in their ability to predict which coronary stenoses could cause myocardial ischemia [1]. This diagnostic equivalence of the two modalities, coupled with the clear practical advantages of the noninvasive method (lower patient risk and costs), is already sufficient for coronary CTA to be considered as a challenger for the traditional role of ICA in CAD diagnostics.

However, in addition, recent advances involving the use of virtual fractional flow reserve (CT-FFR), i.e. FFR estimated via software using hemodynamic flow algorithms operating on coronary CTA data sets, have shown that when coronary CTA is enhanced with CT-FFR, the specificity is improved [2,3,4,5,6 &7]. This combination may actually translate into the diagnostic superiority of coronary CTA over ICA. Such a development has the potential of bringing about a profound transformation in the field of chest pain diagnostics.

In the light of this, we carried out a trial to test the hypothesis that the diagnostic accuracy of coronary CTA enhanced with CT-FFR would be higher than that of the current reference method, ICA.

STUDY DESIGN & METHODOLOGY
In a single-center prospective study we included 90 subjects with intermediate pre-test probability of CAD. The patients underwent coronary CTA and had at least one intermediate coronary stenosis (50-90%) as assessed visually on CTA; the patients were scheduled for ICA and invasive FFR.

Coronary CTA was performed using a dual source CT scanner (2x128; Somatom Definition FLASH, Siemens Medical Solutions, Forchheim, Germany) according to standard procedures. The luminal diameter stenosis was assessed using a dedicated workstation (SyngoVia, Siemens). CTA-based FFR was assessed using dedicated software (cFFR v2.1, Siemens) which is based on machine learning algorithms. Mid-diastolic reconstructed CTA datasets were analyzed on-site on the dedicated workstation to generate virtual FFR values in each location of the coronary tree based on CTA.

ICA and FFR were performed according to standard procedures, FFR was measured with the ComboWire XT guidewire (Volcano Therapeutics, Rancho Cordova, California). The pressure sensor was located beneath the most distal stenosis and the FFR was recorded during the intravenous adenosine infusion of 140 mg/kg/min, for 3 min. A stenosis with FFR value ≤0.80 was considered to be hemodynamically significant. Coronary stenosis assessment based on ICA images was quantified using dedicated software (QCA 7.3, Medis Medical Imaging Systems BV, Leiden, Netherland) by an independent observer blinded to previous visual coronary CTA and FFR data.

The primary end-point of our trial was the comparison of the area under the ROC curves between the percentage stenoses derived either...
ReSuLtS
96 intermediate stenoses in 90 subjects (mean age 63.4 years (±8.2), 61 males) were analyzed. In 41 patients, 41 stenoses (44%) were found to be functionally significant. The median FFR value was 0.83 [IQR 0.74 to 0.90] and the median CTA-FFR value was 0.81 [IQR 0.75 to 0.89] (p=0.200). The median diameter stenoses, as assessed visually on CTA and ICA were: 70±12 and 67±11 respectively, and for quantitative assessment: 52±12 and 47±12, respectively. On CTA and ICA, respectively 95 and 93 (p=0.625) arteries had at least 50% stenosis by visual assessment, 61 and 58 (p=0.749) arteries had at least 70% stenosis by visual assessment, respectively. The detailed per-lesion diagnostic accuracy, sensitivity, specificity, PPV and NPV for visual and quantitative ICA, CTA and CTA based FFR values are shown in Table 1.

There was no statistically significant difference in the areas under the curve for quantitative coronary angiography (QCA), ICA, quantitative CTA (qCTA) and coronary computed tomography angiography (CTA) in the identification of significant stenosis, [Figure 2]. The AUC for CTA-based FFR for the identification of significant stenosis was 0.835 (0.745 to 0.903) and was significantly higher than any of the other AUCs [vs qCTA (p=0.010), vs QCA (p=0.004), vs CTA (p=0.007) vs ICA (p=0.004)]. Detailed data are shown in Figure 2.

SIGNIFICANCE OF THE RESULTS AND FUTURE DIRECTIONS
The results of our trial show that the triage of chest pain patients based on the use of noninvasive coronary CTA supported by CT-FFR analyses leads to more accurate diagnoses than those based on traditional, routine invasive coronary angiography. These results suggest that coronary CTA has the potential to replace ICA, which could ultimately represent a verifiable revolution in coronary artery disease diagnostics.

Coronary CTA is recognized as a useful diagnostic tool in ruling out significant CAD in patients with intermediate probability of CAD.

Table 1. Diagnostic parameters of qCTA, QCA, CTA based FFR for identification of significant stenosis (invasive FFR<=0.80).

<table>
<thead>
<tr>
<th>Stenosis diameter</th>
<th>Sensitivity [%]</th>
<th>Specificity [%]</th>
<th>PPV [%]</th>
<th>NPV [%]</th>
<th>Accuracy [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>qCTA ≤70%</td>
<td>12</td>
<td>95</td>
<td>63</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>qCTA ≤70%</td>
<td>12</td>
<td>98</td>
<td>83</td>
<td>66</td>
<td>61</td>
</tr>
<tr>
<td>qCTA ≤50%</td>
<td>78</td>
<td>51</td>
<td>54</td>
<td>76</td>
<td>63</td>
</tr>
<tr>
<td>qCTA ≤50%</td>
<td>66</td>
<td>53</td>
<td>51</td>
<td>67</td>
<td>58</td>
</tr>
<tr>
<td>CTA-FFR ≤0.8</td>
<td>76</td>
<td>72</td>
<td>67</td>
<td>86</td>
<td>74</td>
</tr>
</tbody>
</table>

Figure 1. Examples of the imaging methods used in the trial. (a) Left circumflex (LCx) coronary artery with 80% stenosis as assessed visually on coronary CTA and ICA. The red arrow indicates the tip of the pressure wire which is located distally to the stenosis (FFR=0.92). (b) QCA measurement of the stenosis, (c) CT reconstruction of LCx (d) color-coded CTA-FFR rendering of the LCx artery. The red arrow indicates the position where the CTA-FFR measurement was taken (CTA-FFR=0.90). The FFR and CTA-FFR results were in agreement.

"... the use of noninvasive coronary CTA supported by CT-FFR analyses leads to more accurate diagnoses than those based on traditional, routine invasive coronary angiography...."
and, unlike any other noninvasive coronary diagnostic modality, has been shown to improve patient outcomes [7]. Several landmark studies, followed by other, smaller investigations, have focused on the evaluation of the added diagnostic value of coronary CTA-based FFR analysis compared to coronary CTA alone in predicting functionally significant coronary stenoses. The results of studies of CTA-FFR showed that the approach resulted in an improvement in specificity and positive predictive value of approximately 50% compared to coronary CTA alone, while still maintaining high sensitivity and negative predictive value [5].

Financial impact analysis of clinical studies involving CT-FFR have also shown a reduction in the overall costs of CAD diagnostics when CT-FFR is used. Several clinically validated CT-FFR methods have been developed, based on different operational models, e.g. on-site vs off-site analysis, various algorithms (based on either in silico simulation or machine learning), and differing in the time needed to retrieve the results (from minutes to hours). So far, however only one method has been FDA-approved and is thus available for routine clinical purposes.

Our study reinforces the concept of the equivalence of coronary CTA with ICA in patients for whom ICA is currently indicated. This concept has been tested in two randomised trials: CAT-CAD and CONSERVE [8, 9]. The results of these trials showed that the use of CTA dramatically decreased the number of nonactionable ICAs (i.e. ICA not followed by further invasive therapies). Given the superiority of the combination of coronary CTA with added CT-FFR analysis over ICA in providing accurate diagnosis, our results may lead ultimately to the complete eradication of exploratory coronary invasive diagnostics, except for patients requiring immediate coronary intervention, such as in acute coronary syndromes.

CONCLUSIONS

Our results indicate the superior diagnostic accuracy of conventional coronary CTA diagnostics coupled with additional CT-FFR analysis over ICA in patients with intermediate coronary stenosis.

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Efficacy study of CT-FFR software using 3D printed patient-specific coronary phantoms

By Dr LM Shepard, Dr. KN Sommer, Dr. E. Angel & Prof CN Ionita

In the last decade 3D printing has made significant technological advances which have catalyzed acceptance and the development for a variety of health-related applications, including development of comprehensive patient-specific coronary phantoms that mimic some of the tissue mechanical properties while being capable of sustaining physiological flow and pressure conditions. In this article, we present a summary of a more extensive study where patient-specific phantoms were used for CT cardiac imaging, flow measurements and validation of a research level CT-FFR software currently being developed by Canon Medical Systems.

In recent years, 3D printing has become an invaluable tool in many medical applications. These include surgical planning, structural disease simulations, and device testing [1]. This technology provides the capability to replicate complex patient anatomy and diseases. These phantoms can be used in both benchtop flow systems and can be imaged according to patient protocols, making this tool particularly useful for validation of image-based diagnostic software. Thus for technical efficacy studies, 3D printing can save significant time in the validation process by reducing the wait time needed for medium or large patient cohorts. In addition, highly controllable physiological measurements can be obtained using 3D printed patient-specific phantoms in benchtop flow systems.

This work expands upon recent applications of 3D printed patient-specific coronary phantoms within a physiological benchtop flow system for accurate CT imaging of coronary blood flow [2, 3]. In our paper titled “Initial evaluation of three-dimensionally printed patient-specific coronary phantoms for CT-FFR software validation” [4], we investigated the technical efficacy of using 3D printed patient-specific coronary phantoms to assess a CT-FFR research software (Canon Medical Systems, Otawara Japan). Using CT imaging, the 3D printed phantoms were successfully imaged using the patient coronary CT angiography (CCTA) protocol and were implemented in the CT-FFR software to assess the accuracy of replicating the patient results. The accuracy of the phantoms was verified using measurements from the CCTA images and benchtop assessment of Fractional Flow Reserve (FFR) for comparison with the reference invasive FFR measurement. This research thus verifies the use of 3D printed patient-specific phantoms as an invaluable tool for highly controllable benchtop experimentation and imaging for validation of image-based diagnostic software.

MATERIALS AND METHODS
Patients included in this study gave written and informed consent following IRB approval. All patients underwent clinically indicated 320-detector row CCTA followed by coronary catheterization that included invasive FFR measurement. The CCTA patient data was automatically segmented using a Vitrea workstation (Vital Images, Minnetonka, MN) to include the aorta, left anterior descending (LAD), left circumflex (LCX), and right coronary artery (RCA); contours were reviewed and edited as needed. The coronary vasculature was manipulated into a previously reported three branch approach [5] to create a phantom capable of
undergoing physiologically accurate simulated flow and pressure conditions. The phantom creation steps are outlined in Figure 1.

Each phantom was established in a flow loop that simulates pulsatile flow rates mimicking those seen in the coronary arteries using a CompuFlow 1000 programmable physiological flow pump (Shelley Medical Imaging Technologies, London, Ontario, Canada). Each phantom had pressure sensors appended to the aorta and three coronary arteries using access ports that were created in the mesh manipulation to ensure each phantom was undergoing physiologically accurate pressure conditions. Once physiological flow conditions were achieved, the patient-specific phantoms underwent 320-detector row CCTA (Aquilion ONE, Canon Medical Systems), triggered during the 70–99% R-R cycle by the CompuFlow 1000 flow pump. Figure 2 demonstrates one of the phantoms in the CT gantry and CCTA images. Both the patient and phantom CCTA images were then utilized in a CT-FFR algorithm that is currently an on-site research tool (Canon Medical Systems). CT data between the 70–99% R-R cycle is imported into the software to calculate CT-FFR. Details regarding this software have previously been published [6]. An example of patient data in the CT-FFR software is shown in Figure 3.

RESULTS
Pressure measurements were collected during flow experimentation to determine the benchtop FFR, defined as the ratio of distal to proximal pressure. The benchtop FFR results were compared to invasive FFR as well as the CT-FFR measured for both patient and phantom images. All FFR values were measured at approximately the same location as the invasive FFR, about two lesion lengths below the distal end of the stenosis. Results showed agreement for treatment outcome in all cases except for one case measured in the phantom CT-FFR. Pearson correlation values for invasive FFR to patient CT-FFR and to phantom CT-FFR were both 0.92. In addition, the patient CT-FFR and phantom CT-FFR had a Pearson correlation value of 0.95. In addition, CT-FFR was recorded at 10 mm increments from the ostium of each coronary artery, with a range from 10 mm to 100 mm in patient and phantom CT data. The Pearson correlation for all patient's CT-FFR and phantom CT-FFR values was 0.81 and the absolute mean percent difference was 4.34%. Figure 4 displays the comparison of all CT-FFR results for the three main coronary arteries as well as a line of unity.
CONCLUSION
We have expanded upon previous research using 3D printed patient-specific phantoms to develop a system that utilizes these phantoms with physiological flow and pressure conditions for successful imaging to simulate coronary CT angiography. We have presented the accuracy of 3D printed patient-specific phantoms produced using the current state of the art. As the temporal and spatial resolution of CT scanners and the print resolution of 3D printers continue to advance, we anticipate this accuracy will continue to improve.

3D printing offers a unique benchtop solution as patient-specific phantoms can be created that replicate the mechanical and elastic properties of vasculature. We have demonstrated the capability of our patient-specific phantoms to undergo clinical CT protocols and be utilized within a CT-FFR software. While the phantom accuracy and mechanical behavior of the phantoms can continue to improve, this is an important first step towards using 3D printed patient-specific phantoms for software validation. As medical 3D printing continues to improve, we believe these patient-specific phantoms within benchtop flow systems can become a standard tool for validation of not only a CT-FFR software, but any image-based diagnostic software.

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Figure 3. CT-FFR research software utilized for this research, patient data. Viewing imported images from 70-99% R-R and selecting the phase with the least amount of motion as the target phase (left image). Generation of centerline and contours (middle image). CT-FFR measurement with user control for distal measurement location indicated (right image).

Figure 4. Comparison of all CT-FFR results for both the phantom and the patient.

Book Review
Cardiac Mapping, 5th Edition
Ed by M Shenasa, G Hindricks, D J Callans, J M Miller, M E Josephson.

The effective diagnosis and treatment of heart disease may vitally depend upon accurate and detailed cardiac mapping and imaging. However, in an era of rapid technological advancement, medical professionals can encounter difficulties maintaining an up-to-date knowledge of current methods. This fifth edition of the much-admired Cardiac Mapping is, therefore, essential, offering a level of cutting-edge insight that is unmatched in its scope and depth.
CAD-RADS: a new era in coronary CTA reporting

By Dr. S. Ramanathan

Coronary artery disease (CAD) is one of the leading causes of death and of disability-adjusted life years (DALY) lost. Approximately 15.5 million persons ≥20 years of age in the USA have CAD according to the 2016 Heart Disease and Stroke Statistics update of the American Heart Association (AHA) [1]. It is well established that CAD has a long asymptomatic latent period and mortality and morbidity can be decreased by early detection and targeted preventive therapy. Various imaging modalities for evaluating patients at increased risk for CAD include Coronary CT angiography (Coronary CTA), cardiac MRI, cardiac perfusion scintigraphy, echocardiography, and positron emission tomography (PET). Among these non-invasive imaging modalities, Coronary CTA has gained more acceptance and popularity due to its high diagnostic accuracy in the noninvasive estimation of coronary arterial stenosis similar to invasive coronary angiography (ICA). A new standardized reporting system CAD-RADS (Coronary Artery Disease Reporting and Data System) was introduced in 2016 to develop a uniform reporting pattern to enable more effective communication of the results to the referring physicians. This review aims to explain the essential features of individual CAD-RADS categories, their clinical implications, potential benefits and pitfalls.

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CURRENT STATUS OF CORONARY CTA

Coronary CTA has now emerged as an effective non-invasive diagnostic test to evaluate coronary arteries in patients with low to intermediate likelihood of obstructive CAD in outpatient as well as emergency settings. Due to rapid advancements in CT technology such as multislice CT (from 16 slice to 64 slice and now reaching 320 slices), dual energy CT and radiation dose reduction algorithms, moderate to high diagnostic accuracy has been achieved. The reported sensitivity and specificity for 64-slice CT ranges from 85 to 99% and 86 to 96% respectively. Furthermore, with the advent of 320 slice Coronary CTA, the diagnostic accuracy has improved to 95% with 100% negative predictive value for detection of >50% coronary stenosis [2,3].

The main clinical benefit of coronary CTA is derived from its high sensitivity and negative predictive value. This helps in confidently ruling out significant CAD thereby avoiding further diagnostic tests and invasive procedures. The positive predictive value of coronary CTA is lower, and especially intermediate lesions may be overestimated regarding their relevance [4].

Based on these various randomized controlled trials, the American Heart Association/Society of Cardiovascular Computed Tomography (AHA/SCCT) and the British National Institute for Health and Care Excellence (NICE) guidelines recommend Coronary CTA as an appropriate test to rule out obstructive CAD in low-to intermediate risk patients with stable or acute chest pain [5,4]

WHY CAD-RADS?

SCCT guidelines published in 2009 and the last update in 2014 stressed the reporting of qualitative and quantitative coronary arterial stenosis, as the main purpose of Coronary CTA is to rule out significant CAD. Due to recent technological advancements the spatial and temporal resolution of current scanners has since improved drastically. This in turn facilitated development of various new scanning and post-processing techniques like computed tomography-derived fractional flow reserve (CT-FFR) and perfusion imaging. Hence Coronary CTA is no longer just an anatomic imaging modality but is being increasingly used for characterizing the plaque morphology to predict current and future cardiac events.
and also for functional imaging [6,7]. As the complexity of Coronary CTA has increased enormously, standardization becomes a necessity to maximize the clinical impact. Various professional societies have issued guidelines and expert consensus documents on the performance, acquisition, necessary training, reporting, indications and radiation dose. The recent addition to this is the standardized reporting system CAD-RADS.

The presence of common reporting terminologies and categories with streamlined management recommendations helps in simplifying the reporting structure and makes it more understandable for the referring physicians. This is based on the success of similar models in breast (BIRADS), liver (LIRADS), and prostate imaging (PIRADS). It creates consistency in the conclusions of the report which in turn guides the referring physicians to take clinical decisions. Apart from decreasing the variability among the reporting radiologists, CAD-RADS also facilitates education, research, peer review and quality assurance leading to improved patient care.

CAD-RADS categories
A new standardized reporting system proposed by the Society for Cardiovascular Computed Tomography (SCCT), the American College of Radiology (ACR), and the North American Society for Cardiovascular Imaging (NASCI), and was endorsed by the American College of Cardiology (ACC) and published in JACC in 2016 [8-10].

This recommendation is intended for two groups of patients:
(1) Patients presenting with stable chest pain.
(2) Patients presenting with acute chest pain, negative first troponin, negative or non-diagnostic electrocardiogram, and low to intermediate risk.

CAD-RADS aims to classify CTA based results on the severity of stenosis and to link this data to clinical patient management. The indication for coronary CTA, scan protocols and performance standards remains the same. Interpretation, training standards and quantification of coronary arterial stenosis is based on the 2014 SCCT reporting guidelines in both acute and non-acute settings [7].

There are six CAD-RADS categories, based on degree of luminal diameter stenosis. This is adapted from SCCT 2014 recommendations. They range from CAD-RADS 0 (absence of plaques and stenosis) to CAD-RADS 5 (presence of at least one total occlusion) in both acute and non-acute settings. It is based on the most severe coronary finding. Apart from these six categories, an additional category N is added which represents non-diagnostic study. Furthermore category 4 is subdivided in to 4A - single or two vessel 70-99% stenosis and 4B-Left main >50% or 3-vessel obstructive (>70%) disease. This classification is applicable only for vessels greater than 1.5 mm in diameter. Detailed discussion on the management strategies in individual categories is beyond the scope of this mini-review but is freely available in the source publication [8-10].

MODIFIERS
In addition to the main categories, there is an option to add modifiers at the end of each category (separated by /) to provide additional relevant information. Four modifiers are available: N (non-diagnostic), S (stent), G (graft) and V (vulnerability). If more than one modifier is applicable, they should be separated by the slash symbol “/” and written in the same order as above.

BENEFITS OF CAD-RADS [11]
1. Consistency - The most important utility of any standardized reporting system is improved consistency. This helps in providing a uniform report consistently with the usage of common language and accepted terminologie. One recent study shows excellent inter-observer agreement in assigning CAD-RADS categories, including the degree of stenosis and modifiers leading to a more consistent final report [12].

2. Communication - In the long run, using a consistent reporting template improves communication to the referring physicians as they get used what to expect in the report.

3. Clinical management - Including the clinical pathway in the imaging report is the most innovative aspect of CAD-RADS. It helps in choosing
the best investigation and further treatment options based on the categories thereby somewhat simplifying the clinical management protocol

4. Research - Uniform reporting helps in the future data collection in a more organized manner leading to more effective research and education

PITFALLS OF CAD-RADS [13,11]

1. Misinterpretation - This is an inherent pitfall of coronary CTA rather than CAD-RADS itself and can present in the form of under- or over-estimation of the degree of stenosis and in the risk assessment of high risk plaque features, both leading to assign wrong categories

2. Misclassification - Some components of CAD-RADS such as category N, 4A, 4B, grafts and stents can be a potential source of error in the initial period due to overlap and some similarities. These should improve with continuous usage and training

3. Missing components - Although CAD-RADS system is extensive, few components like location and extent of disease, coronary anomalies and extra cardiac findings are not included. With accumulation of more data and knowledge, these might get a place in the future versions

4. Misguidance - Although considered generally as a benefit, recommendations regarding further investigations and treatment options included in the CAD-RADS can be a potential pitfall as well. In clinical practice, there could be many other factors apart from the stenosis which can influence the management along the individual physician judgement. Sometimes these can be different from the CAD-RADS recommendation and can thus be a source of conflict

FUTURE OF CAD-RADS

CAD-RADS is just the first step in the attempt to standardize enormously the increasing numbers of coronary CTA examinations. Many of the pitfalls described above can be resolved in the future versions as we gain more experience by using this system on a daily basis. There could be additional categories and subcategories to include the missing components. By having more healthy discussions with clinicians, we can agree to minimal management recommendations which will give the cardiologists enough space to make individualized patient decisions. Of course more training and stimulating the residents, fellows and young radiologists to strictly use the system is essential for its success and further improvements

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Non-invasive 3D imaging of the human carotid artery with volumetric multispectral optoacoustic tomography (vMSOT)

By I. Ivankovic & Prof. D. Razansky

The majority of ischemic strokes are caused by atherosclerotic carotid arteries, specifically in the carotid bifurcation area [1]. Much effort in stroke prevention is directed towards early diagnostic or screening methods that could categorize patients as either high or low risk. In such screening methods it is essential to characterize the stability of any atherosclerotic plaque rapidly and in a non-invasive manner.

OPTOACOUSTIC IMAGING

OA imaging has attracted much attention in recent years because of its potential applicability to a range of biological and medical imaging applications. OA is based on the use of non-ionising laser light, which is absorbed by biomolecules at specific wavelengths, creating a transient thermoelastic expansion which results in acoustic waves being emitted that can be detected by an ultrasound transducer. OA imaging can therefore provide images of high optical contrast with spatial resolution equivalent to that of typical ultrasound devices. OA imaging is particularly powerful in the near-infrared (NIR) window, since such light can penetrate deeper into human tissue. In the NIR wavelength range, oxygenated and deoxygenated hemoglobin have different absorption spectra, thus allowing the discrimination of veins and arteries in the human body. In addition, lipids, water and melanin also have strong absorption in the NIR wavelength window, so offering a multispectral optical contrast image of living tissue [2]. For these reasons, OA imaging, and in particular imaging of the human vasculature has become an extremely active area of research and development.

vMSOT EVALUATION STUDY

We carried out an evaluation study whose goal was to investigate the feasibility of using volumetric MSOT in clinical imaging of the human carotid artery [7]. In this study we used a custom-designed probe, composed of a spherical surface array capable of isotropic 3D resolution of 200µm [Fig. 1 (A)], [8]. The probe has a central opening to allow the laser output to pass through the fibre bundle connecting the probe to the laser. A surface array containing 256 piezoelectric elements detects the acoustic signal. The OA signals that are generated are simultaneously acquired by a custom-built parallel data acquisition system.

To evaluate the system, we recruited 16 healthy volunteers for non-invasive imaging of the carotid bifurcation.

The potential of the emerging imaging modality of Multispectral optoacoustic tomography (MSOT) has been described in recent clinical studies where MSOT has shown its capability to image tissues in diseases such as breast cancer [3] and inflammatory bowel disease [4]. OA imaging has also been shown capable of imaging atherosclerotic disease by utilising the absorption spectrum of lipids, which is a key constituent of vulnerable plaques. Ex vivo studies have shown that by imaging at 1200nm a clear identification of plaque in human aorta is possible [5]. In vivo intravascular studies using an endoscopic device have demonstrated vulnerable plaque detection in rabbits [6]. (Of course endoscopy is an invasive procedure and is not suitable for screening).

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The volunteers were imaged in the NIR wavelength range between 730-900nm and 1064nm, in compliance with the safety standards of the American Laser Institute [9]. Within one single laser pulse, an entire volumetric image (20mm x 20mm x 20mm) of the carotid bifurcation could be acquired [Figure 1B]. Initially the handheld probe was moved freely around the carotid bifurcation area and, once the desired region was located, the probe was held stationary for optimal image acquisition.

RESULTS

The scanned data sets consisted of multiple 3D images, which were stitched together by means of a spatial compounding algorithm, allowing for visualisation of the scan (area of 45mm²) of the carotid artery in one single image. The common carotid (CC), internal carotid (IC), external carotid (EC) and other small surrounding vessels can all be seen at the same time [Figure 2A].

The depth of the carotid arteries was measured in all volunteers, and lay between 4-16mm depth from the skin surface. The signal to noise ratio (SNR) was subsequently calculated, and plotted against the depth of the carotid for all volunteers. It could be seen that there was a clear decrease in SNR in deeper carotid arteries, mainly attributable to light attenuation [Figure 2B].

Five volunteers were then imaged at wavelengths between 730-900nm for multispectral evaluation. It was found that the carotid artery was best visualised between 800-900nm, corresponding to the increased absorption of oxygenated hemoglobin and decreased absorption of deoxygenated hemoglobin [Figure 3]. The differentiation between arteries and veins is striking when the appropriate wavelength is used for OA imaging. Multispectral evaluation is critical in demonstrating the capabilities of MSOT, and is particularly so in detecting lipid rich vulnerable plaques, where lipids have a peak absorption at 1200nm.

Anatomical features resolved from MSOT were validated against ultrasound (US) images in two volunteers, where the carotid arteries were scanned by an experienced vascular surgeon using a clinical B-mode ultrasound scanner. Whereas the entire carotid bifurcation area could be readily visualized with volumetric MSOT thanks to its three-dimensional imaging capabilities, it was not easily discernible in single cross-sectional US images. In fact, US visualization of the whole carotid bifurcation in a single cross-section usually requires a lengthy acquisition time to find the optimal orientation of the US probe. In contrast, a similar view can be directly obtained from the three-dimensional optoacoustic image.

CONCLUSION

Overall, our study demonstrates the potential of volumetric multispectral optoacoustic tomography for the characterisation of the carotid artery in a volumetric, non-invasive, real-time and handheld manner. Multispectral optoacoustics has the ability to identify clinically relevant biomarkers such as lipids, which are a key feature in vulnerable plaques. Our studies show that volumetric MSOT has a high potential for the non-invasive and functional assessment of cardiovascular disease.

REFERENCES

Carestream to sell its healthcare IT business to Philips

Carestream Health has signed an agreement to sell its healthcare information systems (HCIS) business to Philips. Carestream’s HCIS business unit provides imaging IT solutions to multi-site hospitals, radiology services providers, imaging centers and specialty medical clinics around the world. The business has developed strong customer relationships in attractive, high-growth healthcare segments and is positioned for continued growth and success. As a result of this acquisition, Philips’ expanded healthcare IT business will feature Carestream’s enterprise imaging platform — including best-in-class VNA, diagnostic and enterprise viewers, multimedia reporting, workflow orchestration and clinical, operational and business analytics tools — as part of its broad portfolio. “We have had global success in providing radiology and enterprise imaging IT systems to help medical professionals provide quality care and enhance their operations,” said Ludovic d’Aprea, Carestream’s General Manager for Healthcare Information Solutions. “By becoming part of Philips, the HCIS business will have a greater opportunity to thrive and grow. Both organizations share a commitment to meaningful innovation, which is deeply embedded in each company’s culture. Customers will have access to a broader portfolio of healthcare IT solutions to simplify medical image management, enable effective collaboration and enhance patient care.”

Like Carestream, Philips has built a strong, global business based on customer focus, world-class technical excellence and continuous innovation. “Philips partners with global healthcare providers to connect people, information and technology with the commitment to deliver on the quadruple aim of improved patient experiences, better health outcomes, improved staff experiences and lower costs of care,” said Robert Cascella, Chief Business Leader Precision Diagnosis at Royal Philips. “This acquisition will enhance our ability to provide flexible solutions to hospitals and health systems. The combination of our successful innovations in imaging system platforms, workflow optimization and artificial intelligence-enabled informatics, combined with Carestream’s cloud-based enterprise imaging informatics platform and complementary geographic footprint will provide a solid foundation to deliver on the promise of precision diagnosis.”

Carestream will retain its medical imaging, dental and industrial films, non-destructive testing, and precision coating businesses which are not impacted by the sale. “These established businesses have solid financial foundations, innovative technology platforms and have earned the trust of loyal customers around the world,” said David Westgate, Carestream CEO. “Our focus will be on delivering innovation that is life changing — for patients, customers, channel partners, communities and other stakeholders — and we will grow the company for long-term success.”

Carestream

PHILIPS Healthcare

UK patients get nationwide online access to their imaging scans

A network that connects every National Health Services (NHS) acute hospital in England is giving thousands of patients unprecedented and easy online access to their images such as x-rays, ultrasound, CT and MRI scans. The Image Exchange Portal, or IEP, is already relied on in the UK in the sharing of some 35–40 million images each week between NHS professionals. Now an extension to the network, IEP with Anyone is spreading benefits directly to patients, allowing people throughout the country to quickly view their imaging through a secure log-in. The move is helping to end a costly and outdated reliance on CDs for the UK NHS. Annie Pinfold, a senior PACS consultant at Oxford University Hospitals, said: “This makes a real difference to our patients who need their imaging for all sorts of reasons, including the support of claims, second opinions, specialist treatment or simply because they want to see their images. We have seen a surge in imaging requests from patients since the high profile General Data Protection Regulation (GDPR) came into place. Having access to IEP with Anyone is helping to manage this growing demand, with two thirds of patients who ask for their images now specifically requesting IEP with Anyone rather than CDs. We have been saving time and money – with each CD request from patients consuming up to 20 minutes of staff time, and nearly £9 in production and postage costs, compared to five minutes and only pence through IEP with Anyone”.

Sectra is the company which manages the Image Exchange Portal for the NHS. Jane Rendall, managing director for Sectra in the UK and Ireland, said: “Physical media is going out of fashion. The NHS needs to provide information in a way that is accessible, fast, easy and secure. This extension to one of the most widely used networks in the NHS allows that and is already helping thousands of patients each month”. Patients are given access to IEP with Anyone by their hospital through a secure log-in. Their imaging remains in the portal for up to 60 days during which time they can use forwarding features to easily share with trusted third parties, who can view dynamic image sets from a secure link.

Sectra

LINKÖPING, SWEDEN

sectra.com/medical
iCAD partners with Karolinska to develop AI-based breast cancer risk prediction system

iCAD have entered into an exclusive relationship with two leading researchers at The Karolinska Institutet in Stockholm, Sweden, to develop an artificial intelligence (AI)-based solution that will identify a women’s individual risk of developing breast cancer. This partnership builds on an existing research agreement in which the researchers at the Karolinska developed a breast cancer risk prediction model using information identified in mammography images provided by iCAD’s AI cancer detection and density assessment solutions. Promising early results based on mammography images from over 70,000 Swedish women enrolled in The Karolinska Mammography Project for Risk Prediction of Breast Cancer (Karma) study indicated that the model enabled early identification of women who were at a high-risk for breast cancer and it was determined that additional examinations were warranted. The Karma results have been improved upon through the use of iCAD’s latest ProFound AI algorithm. Among other things, the model now takes asymmetry of mammographic features and masking of tumors into consideration. iCAD and the Karolinska researchers now intend to collaborate to develop an innovative solution for commercial use to assess an individual's risk of developing breast cancer.

Breast cancer is the most prevalent cancer among women worldwide, impacting over 2 million women each year. Breast cancer screening and early detection are key to improving outcomes and survival rates. However, today, most mammography screening programs are not individualized, so a significant need exists to be able to identify individual risk of the disease in order to most effectively screen for breast cancer.

“Models that accurately predict an individual woman’s risk of developing breast cancer are paramount to transitioning from age-based screening to risk-based screening,” said Per Hall, Professor, Senior Physician, Karolinska Institutet. “Most current risk models are population-based and focus on lifetime or long-term risk. Our research using the iCAD AI technology has shown that by simply using the information available in the mammogram images, we can more accurately stratify women based on short-term risk. Understanding short-term risk will open the door to new paradigms in both the prevention and treatment of breast cancer.”

iCAD announced the commercial availability of its ProFound AI for breast cancer detection in digital breast tomosynthesis in 2018. This delivers critical benefits, including improvement in cancer detection rates, a decrease in unnecessary patient recalls, and shorter reading times for radiologists.

“We envision the field of mammography moving from age-based screening protocols to “risk adaptive screening.” Concurrently, we foresee the emergence of individualized breast screening protocols based on risk characteristics,” said Mike Klein, Executive Chairman and CEO of iCAD. “This new frontier of predictive risk assessment for cancer is indicative of the continued expansion of our newly released ProFound AI offering for breast cancer detection. Correlating iCAD’s high cancer detection rates, low false positive levels and a 50% reduction in reading time with the burgeoning volume of patient risk data, may provide a quantum leap in clinical efficacy and patient care.”

ICAD
NASHUA, NH, USA
www.icadmed.com

Esaote and DiA Imaging Analysis partner on advanced AI-based cardiac ultrasound analysis

DiA Imaging Analysis, a leading provider of artificial intelligence (AI)-powered ultrasound analysis tools has announced that it has partnered with Ebit (part of the Esaote Group), to offer DiA’s LVivo Cardio Toolbox as an integrated part of Ebit’s SUITESTENSA CVIS (Cardiovascular Information System) PACS. The LVivo Cardiac Toolbox is designed to analyze cardiac ultrasound images based on more objective and reproducible information, as opposed to manual measurement or visual analysis methods which are currently used. DiA’s LVivo Toolbox is based on advanced pattern recognition and machine learning algorithms which automatically imitate the way the human eye detects borders and motion. DiA’s automated tools deliver fast and accurate clinical indications to support the decision-making process. LVivo is both vendor-neutral and easily implementable as part of the daily evaluation workflow. The integration of the LVivo toolbox will enable the support of DICOM clips from all ultrasound devices, thus making LVivo AI analysis accessible to all users using the PACS and ultimately improving patient care. “AI is becoming a real driver in the imaging arena. Through collaboration with strategic partners such as DiA, Ebit will offer healthcare providers with the best possible tools added to its system in order to improve patient outcomes”, said Franco Fontana, Ebit’s CEO. “The SUITESTENSA CVIS PACS system achieves a superior workflow from patient admission through exam execution in addition to reporting, administration and distribution by encompassing all cardiology specialties into one single platform. By joining forces with DiA, we are expanding the boundaries of our system by equipping our customers with an advanced AI-based cardiac analysis toolbox”. Ebit’s cardiovascular SUITESTENSA software, is a vendor-neutral comprehensive enterprise platform that allows physicians to archive, manage and share data reports and clinical images produced by any cardiological equipment.

Hila Goldman Aslan, DiA’s CEO said, “The LVivo cardiac toolbox is the missing link in making ultrasound accessible to users with different experience levels.”
With the LVivo toolbox as part of Ebit’s SUITTESTS ENA CVIS PACS, users will now be able to get automated and objective AI analysis that reduces variability and increases efficiency in an effort to provide better patient care”.

ESAO TE, GENOA, ITALY
www.esaote.com/healthcare_IT

Siemens partner with Portuguese Heart Center

The Hospital da Cruz Vermelha Portuguesa (Red Cross Hospital) in Lisbon has signed a ten-year partnership agreement with Siemens under which, Siemens Healthineers will manage the medical imaging equipment in the Heart Center for the next ten years. The Heart Center will focus on the full cardiovascular continuum – prevention, early detection, treatment and follow-up of cardiovascular diseases, aiming at being one of the most modern in Portugal. The value partnership with Siemens includes provision of solutions and services for clinical workflow design, medical equipment for cardiology, and maintenance and technology development plans. Siemens Healthineers will also provide a digital solution for a full patient-centric view, including patient monitoring using smart devices. The scope of the contract includes research & development, strategic consulting and ongoing change management with the aim of continuously improving the patient experience. This is in accordance with the focus of the privately run Red Cross Hospital on seamless patient monitoring and aftercare n the follow-up of cardiovascular diseases. Patient monitoring has been structured in such a way that different technologies can be used. The patients can use their smart phones, smart watches and other portable devices for the continuous transfer of health data. In addition, data from examinations or the laboratory, for example, can also be handled. In this way, the medical team can accompany the patient based on real-time data collection and thus respond as needed.

The main purpose of the partnership is to increase treatment success and improve the satisfaction of the patients and their overall experience. Over the next ten years Siemens will oversee, maintain and regularly replace the equipment in the areas of MRI, CT, angiography and ultrasound systems. Siemens will also supply the appropriate software for the devices and keep them updated

In addition to the digital solutions and services, the partnership also includes strategic consulting, change management consulting and staff education. The Heart Center and Siemens Healthineers have also agreed to intensify their cooperation in research and development

“Value partnerships from Siemens Healthineers focus on establishing flexible and lasting business relationships that ensure the reduction of operational complexity through a single point of contact for all medical device related issues and budget safeguards”, said João Seabra, Global Head of Enterprise Services at Siemens Healthineers. “Value partnerships enable healthcare providers to increase enterprise value to achieve their immediate and future goals and focus on patient care.”

SIEMENS HEALTHINEERS
ERLANGEN, GERMANY
www.siemens-healthineers.com/

Volpara expands relationship with GE Healthcare

Volpara Solutions have announced the launch of an expanded agreement enabling the worldwide distribution of its industry-leading VolparaDensity software by GE Healthcare. Now installed in more than 35 countries, the VolparaDensity clinical application analyzes mammograms using machine learning to provide radiologists with automated, objective, and volumetric breast density assessments and a breast density category that has been shown to correlate to BI-RADS 4th and 5th Editions. With more than 100 peer-reviewed papers and more than 250 publications, VolparaDensity is the most clinically validated breast density assessment software in the world. Having an objective and validated measure of breast density allows providers to deliver personalized breast care to their patients by easily identifying women with dense breasts. Such women have an increased risk of developing breast cancer and are also at a greater risk of having a cancer go undetected using conventional 2D and 3D mammography. Since both dense breast tissue and tumor lesions can appear white on a mammogram, women with dense breasts may benefit from additional screening such as that delivered by the GE Invenia Automated Breast Ultrasound (ABUS) which has been shown to find small, invasive cancers missed by mammography, particularly in dense breasts.

“We are excited to expand access to VolparaDensity as part of our product portfolio,” stated Luke Delaney, General Manager of Automated Breast Ultrasound at GE Healthcare. “Now, our customers outside the US will also have access to a proven technology that will help them identify women who may benefit from a supplemental screening modality, such as the Invenia ABUS system.” Dr. J P Russo, Section Chief of Women’s Imaging at St. Luke’s University Health Network in Bethlehem, PA, said: “There are still certain signs of breast cancer that are best seen on a mammogram, which is why the Invenia ABUS is used in addition to mammography. ABUS screening helps find cancers obscured by dense tissue. Accurate density measurements and quality imaging are very important in breast cancer detection. I encourage women to learn their breast density, understand the risk, and talk to their healthcare providers to get the personalized healthcare they need.”

VOLPARA SOLUTIONS
WELLINGTON, NEW ZEALAND
The work supported by the grant will involve the company stratifying patients with type 2 diabetes using quantitative MRI assessment of associated organs, including the liver, kidneys, pancreas, spleen and aorta. Building on Perspectum’s existing in-house capabilities, this project will provide disease stratification, improve patient compliance, reduce costs, and enable precision treatment.

This multi-organ project was preceded by Perspectum’s MRI-based research using the UK Biobank, which highlighted the significant burden of unrecognized liver disease, such as Non-alcoholic Fatty Liver Disease (NAFLD), which is three times more prevalent in type 2 diabetes.

Dr. Gaya Thanabaslingham, who specializes in Endocrinology and Metabolic Medicine at Oxford University Hospitals, believes that “this project has the potential to greatly enhance our understanding of organ dysfunction and type 2 diabetes severity. Hopefully, this will enable us to improve patient stratification, which will accelerate diagnosis of diabetes-related complications and support the development of personalized treatments.” Consultant in Endocrinology, Diabetes and General Medicine at the Royal Free London, Dr. Sarah Ali, added: “Type 2 diabetes is dramatically increasing worldwide and can cause damage to multiple organs in time if not treated effectively. This innovative research study will allow us to visualize these organs early on in type 2 diabetes, which will assist pathways to stratify treatment in the management of the disease.”

Diabetes is a global pandemic, of increasing prevalence. At present, care for diabetic patients is based on routine biochemical tests that independently monitor glycemic control, cardiovascular (CV) risk, chronic kidney disease (CKD) and liver health. In order to tailor effective treatment, diagnosis must account for the presence or absence of multi-organ complications. Professor Dan Cuthbertson, Consultant Diabetologist at University Hospital Aintree, commented on the Perspectum’s award: “The prevalence of obesity and type 2 diabetes is increasing at an alarming rate, and with it the rate of associated liver and cardiovascular complications. Screening for these liver and cardiovascular complications is still sub-optimal and this multi-organ assessment in the diagnosis and treatment of type 2 diabetes allows us to better understand the prevalence and progression of disease as well as the impact of different treatments. It hopefully will lead to improved treatment stratification.”

Philips to collaborate with Medtronic on image-guided treatment of atrial fibrillation

Philips announced recently that it will be collaborating with Medtronic to further advance the treatment of paroxysmal atrial fibrillation (PAF), the common heart rhythm disorder. Through the agreement, Medtronic will facilitate sales of products on behalf of Philips to provide an innovative, integrated image guidance solution for cryoablation procedures. Philips will bring to market the novel KODEX-EPD cardiac imaging and navigation system with cryoablation specific features to enable electrophysiologists to perform cryoablation procedures - with reduced need for X-ray imaging.

Atrial fibrillation (AF) affects more than 33 million people worldwide. Cryoballoon ablation is used in a minimally invasive procedure to isolate the pulmonary veins, which are a source of erratic electrical signals that cause AF. The technology uses cold energy rather than heat (radio frequency (RF) ablation) to create scar tissue and interrupt these irregular electrical pathways in the heart. “This integrated solution can guide physicians during the treatment of AF patients with ablation, as they can view detailed, CT-like 3D anatomy, so reducing the need for X-ray imaging,” said Marlou Jansen, Business Leader Philips EPD Solutions. “Partnering with Medtronic extends the reach of our KODEX-EPD cardiac imaging and navigation system. Today, this technology is simplifying navigation, and in the future it has potential for a wide range of applications, including addressing the key unmet need of real-time therapy assessment – one of the more significant limitations of the current standard of care.”

“Philips’ KODEX-EPD system uses dielectric imaging to create CT-like 3D, high-definition images of a patient’s cardiac structures in real time. A completely new approach to imaging the heart, dielectric imaging offers many benefits compared to current approaches, for both cryo- and RF-ablation procedures.”

**Medical Imaging**
Utilizing DICOM metadata to improve radiology workflow

By Mr. I A Talati & Dr. R W Filice

As the need grows to provide patient-centered care that is not only high in quality but also cost-effective, radiology departments must find methods to improve the efficiency of their processes as well as developing detailed level analyses to improve patient outcomes [1]. Radiology departments handle a large amount of imaging data that must be processed, organized and easily retrievable. A prime example is Magnetic Resonance Imaging (MRI), a complex and potentially time-consuming exam which is often hampered by process variability. MRIs are an excellent target to review and streamline radiology workflow. Radiology departments typically rely on Radiology Information System (RIS) data, which while useful, often provides limited and sometimes inaccurate information that limits the ability to fully assess radiology workflow processes and to produce optimal interventions for improvement.

This article summarizes a recent study that evaluated the use of Digital Imaging and Communications in Medicine (DICOM) metadata as an alternative to RIS data to optimize quality control in radiology workflow [2].

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As medical services are increasingly being tied to the quality of patient care, radiologists must be cognizant of the need to optimize care while controlling costs [3]. In the real world radiology department, multiple moving parts impact radiology workflow and efficiency. These factors include patient registration, scheduling, protocoling, reporting, but — importantly — the image acquisition itself. This complexity is even more evident in a multicenter radiology enterprise which has the added variabilities of protocol choices, the operation of the modality, and the experience of the radiology technologists. Informatics techniques for imaging can be helpful to organize and process the extensive data that radiology departments produce, as well as to optimize protocols and evaluate the performance of complex workflows [4]. Radiology departments often use Radiology Information Systems (RIS) to provide data related to examinations such as volumes, turn-around times, and start/end times which can provide useful high-level overviews of examination efficiency. However, RIS data are often manually entered into the system and therefore subject to human error or approximation, and do not include granular series, sequence, or other sub-examination level information. On the contrary, Digital Imaging and Communications in Medicine (DICOM) systems facilitate automatic data capture at a highly detailed and granular level. This is useful in analyzing radiology information from complex imaging modalities such as magnetic resonance imaging (MRI) that utilize multiple sequences and protocols within a single patient examination. Understanding these data may identify process variability or suboptimal utilization that affects patient satisfaction or interferes with clinical outcomes. The following study aimed to determine if analyzing DICOM data from MRI examinations would provide more useful feedback to radiology staff [2].

**DESIGN AND METHODOLOGY**

Within a large and multi-center radiology department, we reviewed information related to MRI examinations of the abdomen, prostate, magnetic resonance cholangiography (MRCP), and brain during a 30-day period. RIS data were compared to DICOM metadata that provided study, series, technologist, and timestamp information to evaluate the time duration of the examinations and the steps within each examination. Within the period, there were 519 examinations including 24 different study descriptions. We then narrowed these down to 443 examinations from the eight most common study descriptions. Seventy-six studies were excluded as they did not have enough series information, were incorrectly coded or were performed infrequently. The remaining
exams were matched by body part (brain, abdomen, and prostate) as well as by series level data that included analogous techniques and the same patient positioning. The DICOM data were compared to RIS information to evaluate data accuracy and factors related to examination length.

RESULTS
Manually tracked RIS timestamps completed by technologists were compared to automatically generated DICOM exam timestamps. Across all exam modalities, RIS tracking times were consistently and substantially lower than DICOM data. Additionally, evaluation of median exam times stratified by technologist revealed that shorter median examination times were associated with technologists who had conducted more exams.

DISCUSSION
Our results indicated that DICOM metadata are more accurate, reliable, and detailed than those offered by the RIS. By providing accurate timestamps and resulting duration of examinations, there is improved feedback to technologists and site directors that allows them to target inefficient areas within the radiology workflow for correction. DICOM data further revealed an association between length of study and increased technologist experience, suggesting a benefit of technologist specialization within a subset of exams [Figure 1].

The analysis allowed easily reproducible scatterplots to quickly identify the technologists or exams that were outliers in terms of time and efficiency [Figure 2]. This visual analysis simplifies subsequent root cause analysis (RCA) to determine the underlying cause.

LIMITATIONS
The study did reveal a limitation of utilizing DICOM level data. Examination names may not be standardized, especially in a large enterprise, and some manual coercion may be required to categorize examinations. We found that utilizing DICOM data to analyze MRI workflow was helpful, but did slow down processing and also required human input. An option for managing this issue could be using internally recognized or commercially available standardized study descriptors, such as the RSNA RadLex Playbook [5]. Finally, we found that even with manual coercion of examinations, we still had to exclude 15% of rare examinations due to the difficulty of matching them to more common exams and protocols. Even so, the majority of examinations can be evaluated for quality improvement.

STUDY IMPLICATIONS AND FUTURE DIRECTIONS
DICOM metadata provide valuable and much more granular information regarding MRI studies that help to streamline workflow and reduce exam times thereby increasing efficiency and patient satisfaction, and hopefully augmenting the quality of care by decreasing variability. Using these granular level data enables large, multicenter radiology departments to identify opportunities to improve their processes. Future directions will be to extend this analysis to other examination types, to attempt to further automate the analysis, and perhaps incorporate artificial intelligence techniques to identify exam and body types to facilitate this automation.

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Setting new standards in neuroradiology

An angiography system with special functions for neuroradiology, the recently introduced Artis icono biplane from Siemens Healthineers, features significantly enhanced 2D and 3D imaging procedures, which improves image quality and reduces the radiation dose required. As the C-arm can now perform new movement patterns, areas such as the cranial base and skull cap can now be represented with practically no artifacts in a 3D visualization. The extremely fast and flexible axial movements are the result of new, high-precision industrial drives from Siemens. Interventions are highly efficient thanks to the intelligent system control such as switching seamlessly between 2D and 3D imaging during an intervention, thus making intra-procedural progress checks much easier.

Michael Scheuering, Head of Interventional Radiology at Siemens Healthineers, said "Improving the visualization of bleeding that occur anywhere in the cranial area can make it possible to skip prior conventional imaging for certain patients with a suspected stroke – which means that these patients can be taken directly to the angio lab for diagnosis and treatment, shortening the lead time before the vascular occlusion is removed."

A number of studies now show that treatment in the form of thrombectomy can be extended to a broader range of patients than previously assumed. This lets neurointerventionalists treat ischemic stroke patients who were previously not eligible for this highly effective treatment. Artis icono was developed to help physicians in stroke centers deal with the challenge of treating more patients faster and with greater accuracy.

Syngo DynaCT Multiphase was developed to provide time-resolved DynaCT volumes to identify areas of the brain suffering a reduced blood flow or experiencing a delay in the flow of contrast agent. Volumes acquired at eight different time points during a 50-second period help to assess the status of the collateral vessels in order to determine the most appropriate treatment.

Artis icono biplane is a member of the Artis icono product family, which comprises novel angiography systems to permit both multidisciplinary and specialized use. Whereas Artis icono biplane can be used for neuroradiological, cardiovascular, and abdominal interventions, Artis icono floor, a floor-mounted single-plane system, is used in vascular and interventional oncology procedures.

Until now, healthcare institutions have invested in fixed-configuration systems tailored to particular clinical specialties. The new Artis icono systems adapt flexibly to the differing needs of interventional radiology, neuroradiology, cardiology, and vascular surgery. For example, the lateral plane of the Artis icono biplane can be switched from a radiological to a cardiological configuration and vice versa in just seconds, using the Lateral Plane Switch. The expanded flexibility of the floor stand and lateral plane makes Artis icono highly versatile to enable operators to get the most out of their system. This is a relevant operational advantage in light of today's increasing consolidation and cost pressures.

In addition to the multidisciplinary approach, connectivity and digitalization of interventional labs are becoming increasingly important. With the Third Party Broker system, Artis icono provides a uniform interface to enable system parameters to be readily shared with devices from other manufacturers.

MRI contrast media injectors

For radiology departments and practices, the special multi-use concept for the disposables used in ulrich medical’s new range of MRI contrast injectors means a much simpler workflow, since after the initial set-up, the systems are ready to go for the rest of the day. The preparation is extremely simple. All that is needed is to insert the Easy-Click-Cassette, close the cover, connect the patient line, connect the media container, and the system is ready for the first injection. The Easy-Click-Cassette remains in the injector for 24 hours and according to the multi-use concept is ready for as many injections desired. The contrast medium is injected from the original media containers, which means that multiple patients can be treated in succession without changing the container. When it comes to the scan acquisition, the user has to perform only a few simple steps – everything else is taken care of automatically by the injector. Between patients, all that needs to be changed is the patient-specific tubing, which takes just a few seconds. The multi-use concept has been shown to be
extremely successful and is helping users worldwide cope with ever-increasing patient numbers.

There are two device versions available. The Max 2M is a cost-effective solution for lower patient volumes and is particularly suitable for first time automated contrast injector users. For larger patient volumes the Max 3 is recommended. This version features three media connection points (one NaCl and two contrast media). These enable the user to work with different contrast media and select the appropriate medium for each patient. Alternatively, if the same medium is placed in both connection points, the injector automatically switches from the empty bottle to the second, full bottle. This ensures there are no interruptions during an examination and minimizes leftover contrast medium.

Ulrich Medical provides wide-ranging, practice-focused training programs on their systems as well as general training on topics such as “Hygiene and Safety” for radiology specialists.

**ULRICH MEDICAL**
**ULM, GERMANY**
www.ulrichmedical.de/en

**Augmented-reality concept for image-guided minimally invasive therapies**

Philips has introduced a unique mixed-reality concept for the operating room of the future that was jointly developed between Philips and Microsoft. Based on the state-of-the-art technologies of Philips’ industry-leading Azurion image-guided therapy platform and Microsoft’s HoloLens 2 holographic computing platform, the technology enables novel augmented-reality applications for image-guided minimally invasive therapies.

In contrast to open surgery, minimally invasive therapies only require a small incision. Dedicated instruments such as catheters are inserted through the incision and guided to the treatment area, which can include the heart, blood vessels, brain, liver and other major organs. During such procedures physicians rely on advanced medical imaging technologies such as ultra-low dose X-ray imaging and ultrasound, as well as other navigation technologies, to visualize the intervention and guide their actions. Philips is a leading provider of high tech interventional suites and hybrid operating rooms for such procedures.

The Philips and Microsoft augmented reality concept, built for HoloLens 2, brings live imaging and other sources of vital data currently displayed on large 2D screens into a 3D holographic augmented reality environment that can be ergonomically, easily and intuitively controlled by the physician. HoloLens is a self-contained holographic computer that enables hands-free, heads-up interaction with 3-dimensional digital objects. HoloLens 2 builds on the breakthrough technology of HoloLens and is even more immersive, more comfortable and delivers more value right out of the box. The concept is being used to gather further clinical insights to support the development of future commercially-available augmented reality solutions for use in image-guided procedures. Philips previously announced that it is developing an augmented reality solution for spine, cranial and trauma procedures.

“The transition from open surgery to image-guided procedures has driven a seismic shift in improving patient outcomes and reducing costs – not least by dramatically reducing the length of time a patient stays in a hospital after their procedure,” said Dr. Atul Gupta, Chief Medical Officer for Image Guided Therapy at Philips and a practicing interventional and diagnostic radiologist. “On our Azurion platform we seamlessly integrate a range of data sources in a way that’s intuitive to understand and control. By collaborating with Microsoft and HoloLens 2 we can now take it to the next level, immersing the physician in a tailored augmented reality environment. This concept allows the real world to be seen, superimposed with the live data and 3D medical imagery needed to guide our precision therapy, and importantly also lets the interventionalist control Azurion with voice recognition, eye tracking and advanced gestures. It’s all about keeping our focus on the patient.”

“Mixed reality is giving people new ways to interact with the digital and physical world, bringing the benefits of the digital revolution to entirely new experiences across the globe,” said Alex Kipman, Technical Fellow, AI and Mixed Reality at Microsoft. “I am thrilled to see companies in a broad range of industries achieve more using the products that we build with our partners and our ecosystem. Mixed reality holds great potential in healthcare, and our collaboration with Philips shows how that potential is already beginning to be realized.”

HoloLens 2 is complemented by existing and new Azure cloud services and with built-in AI.

Since its global launch in February 2017, over half a million patients have been treated in more than 80 countries using the Azurion platform, which is powered by Philips’ proprietary ConnectOS and combines technical innovations in both software.

**PHILIPS**
**EINHOVEN, THE NETHERLANDS**

**A practical approach to implementing AI**

Tera Recon is a leader in the fields of advanced visualization and artificial intelligence industries and incorporates world-class image processing tools into next-generation medical image viewing, interpretation, sharing and collaboration solutions.

The company has recognized the paradox of a huge and growing interest in artificial intelligence in radiology on the one hand and, on the other, the frequent absence of a clear understanding on the part of many radiologists as to how to practically Implement AI in their daily practice.

To address this issue, TeraRecon have produced an 8-page brochure on the practical approach to implementing AI, available for free at www.terarecon.com/resources.
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The company recognises that we are certainly at the precipice of broadly implementing AI and machine learning (ML) in radiology and other specialties. To do so, it is important to leverage the lessons learned from deploying other clinical applications while, at the same time, taking novel approaches. Failure to approach the opportunity from multiple perspectives will slow the adoption and raise the cost. The path to a successful implementation begins by realizing that the solution is often non-linear, an adjunct to clinical workflow, and that typical approaches and integrations will not suffice. It’s important to gather all the stakeholders and take a holistic approach. The starting point for these solutions to become mainstream is to recognize and prepare for some of the core differences in technology and workflow vs. PACS or VNA projects, and avoid thinking of AI as a singular application. This will require a new approach that puts outcomes and workflow gains first and technology second.

All this and more is explained in the PDF on the Practical Approach to Implementing AI.

**TERARECON**

**FOSTER CITY, CA, USA**

www.terarecon.com

**Ultrafast 30 ultrasound system**

The latest example of disruptive technology from Supersonic Imagine, the new Aixplorer MACH 30 system incorporates a new generation of UltraFast system which helps optimise all modes of imaging (Doppler UltraFast, Angio PL.U.S – Planewave UltraSensitive Imaging and TriVu) to provide better diagnostic performance while offering exceptional image quality on all conventional imaging modes thanks to preserved purity of the ultrasound signal. A new generation of ShearWave elastography (SWE PLUS), even more powerful than previous versions has also been introduced, making it possible to view and measure tissue stiffness in real time on a significantly improved colour map, notably in terms of acquisition speed, size of the elastography region of interest and examination depth.

It includes the SonicPad touchpad, an unprecedented enhancement in the world of ultrasound systems, designed to simplify user experience. The SonicPad improves the radiologist’s workflow by reducing by approximately 77% the user’s movements, thus reducing the time per exam of more than 30%.

“We are very excited to present Aixplorer MACH 30. An increasing number of our new ultrasound systems are being installed across Europe; we have begun to install them in radiology departments of university hospitals and private radiology clinics in Germany, Romania, Italy and of course France. Users underline the image quality and optimised diagnostic performance of the different modes, notably ShearWave PLUS, as well as the new ergonomics making the ultrasound system easier and quicker to use”, points out Michèle Lesieur, CEO of SuperSonic Imagine

**SUPERSONIC IMAGINE,**

**AIX EN PROVENCE, FRANCE**

www.supersonicimagine.com/

CE Mark for Wireless Breast Lesion Localization System

The market leader behind the 3D Mammography exam, Hologic has announced the granting of a CE Mark to their LOCAlizer wireless radio frequency identification (RFID) breast lesion localization system. The system is designed for precise and easy marking and targeting of lesions for breast-conserving surgery guidance.

The LOCAlizer tag is designed to replace the traditional wire-guided localization method, helping to provide increased comfort and convenience for patients and their healthcare teams. The tag can be implanted up to 30 days prior to a breast-conserving surgery, providing increased flexibility for patients and providers. This improved workflow is designed to help reduce scheduling and logistical hurdles for care teams and aims to deliver added convenience for an enhanced patient experience. Following placement, the miniature implantable tag can be detected by a portable, handheld reader that indicates the location and distance in millimeters to the lesion, enabling the surgeon to pinpoint the correct area of breast tissue for removal.

Hologic has expanded significantly in recent years through insight-driven innovation and strategic acquisitions to address the entire clinical continuum of breast health. Along with the LOCAlizer system, the company’s new products include the SmartCurve breast stabilization system, Clarity HD high-resolution 3D imaging technology, the Viera portable breast ultrasound system, and the Brevera breast biopsy system with CorLumina imaging technology, which features real-time imaging and sample verification.

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Interventional imaging microcatheters get CE approval

Guerbet, has announced that SeQure and DraKon, the company’s two novel microcatheters used in peripheral embolization procedures have received the CE mark for the delivery of intra-arterial therapy and embolic materials into all peripheral vessels.

The SeQure microcatheter is an innovative reflux control microcatheter that uses flow dynamics to create a fluid barrier designed to deliver more treatment to the target vessel and reduce the risk of non-target embolization, for reduced potential damage to surrounding tissue. The catheter consists of side slits whose size has been specifically designed to allow the outflow of contrast media, creating a fluid barrier around the microcatheter to reduce microspheres reflux and assist delivery to the target vessel.

The image above shows a standard microcatheter, positioned in the artery irrigating the tumor. The embolization microspheres travel not only downstream (desired effect) but also upstream (undesired effect) in an arterial branch irrigating healthy tissues that need to be preserved.

The above image shows the anti-reflux microcatheter: Its design and technology result in sending the embolization microspheres downstream into the area to be treated. The healthy tissue continues to be irrigated by blood free of microspheres.

The DraKon peripheral microcatheter is the same as SeQure but without the side slits. It has been designed to optimize pushability, flexibility and torqueability for improved trackability and highest performance standards.

“Guerbet is expanding its interventional portfolio with new solutions for interventionalists, to further enhance and secure their embolization cases. This new range of microcatheters will allow us to help the interventional radiology community deliver a higher quality of care during image-guided embolization procedures,” commented Thomas Bonnefont, VP Commercial Interventional Imaging.

GUERBET
VILLEPINTE, FRANCE
www.guerbet.com

Innovative 1.5T MRI improves workflow with clinical confidence

Representing a new standard in the premium wide-bore 1.5T market with new technology designed to boost productivity, enhance patient comfort and deliver diagnostic clinical confidence the Vantage Orian 1.5T from Canon offers a range of innovative hardware features. These include a detachable table option enabling preparation outside the scan room, thus enhancing workflow and allowing medical staff to respond to patient requirements quickly and easily. The system also incorporates the company’s Saturn Technology for high performance imaging capability, including a new slim gradient with a maximum amplitude of 45 mT/m and a slew rate of 200 T/m/sec. Other features include PURE-RF Rx technology that gives an increase in Signal-to-Noise Ratio of up to 38 percent. A re-designed digital gantry interface displays important patient-related and coil information, allowing clinicians to ensure proper and complete setup without leaving the patient’s side.

The Vantage Orian also offers a suite of software enhancements to help reduce scan time and increase productivity. These enhancements include the MultiBand SPEEDER, which enables clinicians to reduce DWI acquisition times, and the k-t SPEEDER (up to x8 accelerated), which allows high frame rate cardiac cine and perfusion imaging with free breathing. The system also features EasyTech technology enabling clinicians to improve workflow with automatic slice alignment for neuro, spine and cardiac exams, as well as WFS (Water Fat Separation) DIXON, which allows clinicians to take four contrasts in just one scan to show uniform fat-suppression in difficult-to-shim areas.

Existing patient-friendly MRI features from Canon are also included in the system: the 71cm wide bore and in-bore immersive virtual experience encourages patients to relax and thus enables clinicians to produce stable, high-quality images; Pianissimo technology significantly reduces the noise in and around the MR, as well as Pianissimo Zen quiet sequences which further reduce noise to just above ambient noise level, making exams even more comfortable and easier to complete.

“We are committed to offering premium diagnostic imaging tools to our customers, enabling them to deliver accurate, confident and effective patient care,” said Dirk Berneking, Senior Manager of the MR Business Unit at Canon Medical Systems Europe. “The Vantage Orian was designed to increase productivity while ensuring patient comfort and delivering uncompromised clinical confidence.”

CANON MEDICAL SYSTEMS EUROPE
ZOETERMEER, THE NETHERLANDS
https://eu.medical.canon
Hitachi introduces next generation CT and MRI systems

In a major launch of new products at the recent ECR meeting, Hitachi Healthcare introduced two new systems, one a CT system and the other MRI, each providing even higher levels of diagnostic imaging solutions.

The new CT scanner, the SCenaria View, features a totally new design that raises the bar for versatility and affordability in the 64/128-slice sector which is the “workhorse” segment of the overall CT market and the one in which the most CT scans are performed. The new system enhances patient comfort through its open design which, with its 80cm aperture provides improved flexibility in the scan plane and allows even the largest of patients to be accommodated and precise clinical targeting to be achieved. Even though the aperture has been widened, the gantry itself still remains compact, thanks to its innovative internal design.

Compared to Filtered Back Projection (FBP) and iterative approximative-based reconstruction, the Intelli IPV (Iterative Progressive reconstruction with Visual modelling) system enables a large reduction in noise at low levels of radiation so that image quality, texture and clarity are maintained.

As for MRI, the new ECHelon Smart Plus is a next level 1.5T conventional superconductive MRI system, featuring state-of-the-art technology, enhanced productivity and providing uncompromised diagnostic value. The new system has a powerful RF chain and features a 50cm FOV in all axes. Multiple coil connectors are available on the motorized patient table for highly sensitive receiver coils. As well as meeting all the needs of the imaging professionals, the new system also enhances patient comfort through very quiet examination procedures, thanks to the SoftSound Technology for silent gradients.

Applied to both CT and MRI modalities, the high-speed image reconstruction tool, SynergyDrive, impacts on a wide range of scan tasks, and with its sophisticated automatic features, massively shortens scan time. SynergyDrive is a comprehensive hardware- and software-based system and is designed to streamline operations for MRI and CT examinations. The system comprehensively addresses the bottlenecks in the MRI and CT scanning process from start to finish — from patient registration to post-processing and image sharing. A broad range of choices of clinical applications are available to meet all the needs of individual providers. SynergyDrive gives value not just to radiologists, technologists, department administrators but also, to patients.

Mr. Jean-Luc Budillon, President and COO of Hitachi Medical Systems Europe commented about the two new products being introduced to Europe: “SCENARIA View changes the outlook for CT examinations. It combines all of Hitachi’s experience and expertise in a remarkable new product providing an unmatched combination of speed, comfort and quality. In MRI, the ECHELON Smart Plus is consistently cited as an example of Hitachi’s social innovation, with its new workflow concepts designed for efficient and simple operations of coil setting, and patient positioning."

HITACHI MEDICAL SYSTEMS EUROPE
ZUG, SWITZERLAND
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