**CARDIOVASCULAR IMAGING SPECIAL**

Vector concentration: a new ultrasound parameter for stenosis assessment using Vector Flow Imaging

Perfusion Cardiac Magnetic Resonance as a first line technique for the assessment of suspected ischemic heart disease

Left Ventricular Mass as assessed by MRI and long-term risk of cardiovascular events

**PROSTATE IMAGING**

High diagnostic performance of short MRI protocols for the detection of prostate cancer in biopsy-naïve men: the next step in making MRI more accessible

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Analysing the growth in AI-based algorithms in radiology

With even a cursory glance at the contents pages of the latest radiology, the programmes of radiology congresses or the slogans of the latest products being proudly introduced by radiology manufacturers at technical exhibitions, it's impossible to be unaware of the current excitement/hype surrounding the introduction of artificial intelligence-derived (AI) products in radiology. This development is not just a temporary phenomenon or a passing fashion, as is made clear by a recent global trend analysis of AI-based research productivity in radiology and subspecialties (West E, Mutasa S, Zhu Z, Ha R. Global Trend in Artificial Intelligence-Based Publications in Radiology From 2000 to 2018. AJR Am J Roentgenol. 2019 Aug 15:1-3. doi: 10.2214/AJR.19.21346). Recognizing the burgeoning nature of AI-based radiology, West and colleagues wanted to accurately quantify the trend based on the number of published AI radiology research papers. Their interrogation of PubMed and the MEDLINE databases over the period 2000 to 2018 confirmed that there is not just a growing trend in the field, but that this trend is exponential. Worldwide there were a total of approximately 1500 radiology AI research papers published in 2018, compared to a paltry 100 in 2000. As might be expected, the highest AI publication output over the period examined came from the United States (approximately 35 – 50% of the total) with China being the second most productive country, followed by Germany and the U.K. Interestingly, the analysis was able to identify the most productive individual centers in the field. In Europe, these included the University of London in the U.K., the French Institut National de la Santé et de la Recherche Médicale (France), the German Helmholtz Association and the Radboud University in Nijmegen in the Netherlands. Other nuggets of information from the survey revealed that the neuroradiology subspecialty was the most active research area in AI-radiology, which is perhaps not of radiology, but of human radiologists. As Pinto dos Santos Ghosla — not a radiologist — who proclaimed that “radiologists are toast,” and that in 10 years they flat out “shouldn’t be a job”.

Although it will only be after many years that the accuracy of such predictions can actually be checked, the danger right now is that these prophecies of doom are likely to influence the career choices of medical graduates about to make their choice regarding their specialization. Much anecdotal evidence has suggested that undergraduate medical students are shunning radiology as a future career, but hard data on this subject are hard to come by. To address this, a recent study (Pinto Dos Santos D et al. Medical students’ attitude towards artificial intelligence: a multicentre survey. Eur Radiol. 2019 ;29:1640. doi: 10.1007/s00330-018-5601-1) reported on the attitudes towards AI of undergraduate medical students in three major German universities. The findings showed that, despite the anecdotal suggestions to the contrary, medical students who chose radiology as a future specialty seem not to be over-worried that AI will replace human radiologists. As Pinto dos Santos and colleague say, the alarmist message is becoming a bit more nuanced: “AI will not replace the radiologist, but radiologists who use AI will replace those who do not.”
THE POTENTIAL OF VFI FOR GRADING STENOSIS.

Vector Flow Imaging (VFI) is a new, angle-independent ultrasound method for blood flow assessment. The VFI parameter known as vector concentration has recently been proposed for the evaluation of flow complexity. This article describes the basic principles behind the technique and summarizes recent studies which show the potential of vector concentration for the grading of stenoses.

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

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Novel multispectral photoacoustic imaging technique accurately assesses cardiovascular risks.

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Evaluating blood flow is key to early diagnosis and treatment for people with critical limb ischemia. AHA scientific statement.

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Non-contrast cardiovascular magnetic resonance imaging can be carried out in short 15 minute exam.

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AI shown to be able to harvest information hidden in chest X-ray

The most frequently performed imaging exam in medicine, the chest X-ray, holds ‘hidden’ prognostic information that can be harvested with artificial intelligence (AI), according to a recently published study by scientists at Massachusetts General Hospital (MGH). (Lu MT et al Deep Learning to Assess Long-Term Mortality From Chest Radiographs. JAMA Netw Open. 2019; 2: e197416. doi: 10.1001/jamanetworkopen.2019.7416).

Gradient-weighted class activation maps (Grad-CAM) of anatomy contributing to the CXR Risk score. Left panel shows the Grad-CAM and the right panel shows the chest radiograph of a man in his 60s from the Prostate Lung and Ovarian (PLCO) trial who died of respiratory illness in 2 years. Grad-CAM highlights an enlarged heart with prominent pulmonary vasculature indicating pulmonary edema (very-high risk CXR risk score). Image courtesy of JAMA Netw Open from Lu MT et al JAMA Netw Open. 2019; 2: e197416. doi: 10.1001/jamanetworkopen.2019.7416).

Most chest radiographs are reported as normal, in that they rule out a specific diagnosis such as pneumonia. However, even normal radiographs manifest additional minor abnormalities, such as aortic calcification or an enlarged heart that may provide a new window into prognosis and longevity with the potential to inform decisions about lifestyle, screening, and prevention. Whereas physicians may interpret thousands of chest radiographs during a career, they rarely know the outcomes in these patients a decade later. Therefore, it is difficult to develop an intuition to articulate which features have long-term prognostic value.

Artificial intelligence (AI) has already been responsible for major advances in medicine; for example, several groups have applied AI to automate diagnosis of chest X-rays for detection of pneumonia and tuberculosis. “If AI technology can already make such diagnoses”, asked radiologist Dr M Lu “could it also identify people at high risk for future heart attack, lung cancer, or death?”

Lu, who is director of research for the MGH Division of Cardiovascular Imaging, and his colleagues developed a convolutional neural network known as CXR-risk, for analyzing visual information. CXR-risk was trained by having the network analyze more than 85,000 chest X-rays from 42,000 subjects who took part in an earlier clinical trial. Each image was paired with a key piece of data: Did the person die over the following 12-year period? The goal was for CXR-risk to learn the features or combinations of features on a chest X-ray image that best predict health and mortality.

Next, Lu and colleagues tested CXR-risk using chest X-rays for 16,000 patients from two earlier clinical trials. They found that 53% of people whom the neural network identified as “very high risk” died within 12 years, compared to fewer than 4% of those that CXR-risk labeled as “very low risk.” The study found that CXR-risk provided information that predicts long-term mortality, independent of radiologists’ readings of the x-rays and other factors, such as age and smoking status.

Lu believes this new tool will be even more accurate when combined with other risk factors, such as genetics and smoking status. Early identification of at-risk patients could result in more patients taking part in preventive and treatment programs. “This is a new way to extract prognostic information from everyday diagnostic tests,” says Lu. “It’s information that’s already there that we’re not using, that could improve people’s health.”


Ultrasound guidance improves first-attempt success in IV access in children

The need to place an intravenous line is a common but challenging requirement for pediatric health care providers. Previous research has shown first-attempt success rates for pediatric intravenous line access of approximately 75%, although some children with difficult intravenous access may require multiple attempts. Difficulty in obtaining intravenous line access may result in diagnostic and treatment delays, in addition to increased pain and anxiety for the patient and family. If intravenous line access cannot be obtained, more invasive procedures, including central or intraosseous line placement, may be required.


The researchers from Children’s Hospital of Philadelphia (CHOP) report that this technique reduces the number of needle sticks in their young patients. “The need to place an intravenous line is a common but challenging requirement for pediatric healthcare providers,” said Dr. Alexandra M. Vinograd, an emergency medicine physician at CHOP and the lead investigator...
of this study. “Our research shows that both the children and their parents are happier with ultrasound-guided line insertion.”

The researchers prospectively enrolled 167 patients identified as having difficult IV access and who were randomized to receive either traditional IV line or care from a multidisciplinary team trained to place ultrasound-guided IV lines on the first attempt. The children were divided into two groups, age zero to three years old, and over age three. First-attempt success was higher in the ultrasound-guided IV line placement group (85.4 percent) compared to the traditional intravenous line group (45.8 percent). When asked to score their satisfaction with the IV line placement, parents favored the ultrasonically guided placement over the traditional method. “In our study, ultrasound-guided intravenous lines remained in place longer than traditional insertion, without an increase in complications,” said Dr. Joseph J. Zorc, senior author of the study. “These results may be used to update guidelines for intravenous line access in children in an effort to limit the number of needle sticks they experience.”

Both nurses and physicians had high rates of first-attempt success. The high rate of nurse success led to a training program in CHOP’s Emergency Department that broadly trains nurses in ultrasound-guided IV line placement. “Ultrasound-guided access is now standard procedure for patients with presumed difficult intravenous access,” added Vinograd.

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Worrisome increase in some medical scans during pregnancy in the USA

Use of medical imaging during pregnancy increased significantly in the United States according to a new study with nearly a four-fold rise over the last two decades in the number of women undergoing computed tomography (CT) scans. (Kwan ML et al. Trends in Medical Imaging During Pregnancy in the United States and Ontario, Canada, 1996 to 2016. JAMA Netw Open. 2019;2: e197249. doi: 10.1001/jamanetworkopen.2019.7249).

This is the first large, multi-center study to assess the amount of advanced imaging occurring during pregnancy. Over the 21-year study period, rates of CT increased nearly four-fold in the United States, and doubled in Ontario, Canada.

“Most pregnant women get routine ultrasound to monitor fetal growth, which of course delivers no ionizing radiation,” said co-lead author Dr. Diana L. Miglioretti. “But occasionally, doctors may want to use advanced imaging to detect or rule out a serious medical condition of the expectant mother, most often pulmonary embolism, brain trauma or aneurysm, or appendicitis.”

That imaging could include CT, which involves a large dose of ionizing radiation -- many times more than a chest X-ray. Ionizing radiation carries potential health risks to the developing fetus, including congenital abnormalities, developmental delays, or cancer.

“Imaging can be helpful, but it can be overused,” said senior author Dr. Rebecca Smith-Bindman. “The question should always be asked, but especially if the patient is pregnant, whether it is really medically necessary to have any imaging test that involves ionizing radiation.”

The researchers said alternative methods that do not use radiation should be considered whenever possible to avoid unnecessary exposure of women and fetuses to imaging radiation.

“There’s a tradeoff,” Smith-Bindman said. “CT scans provide the clearest images, they can be done quickly, and are less expensive and more widely available. However, CT scans have the most ionizing radiation and they are commonly done in places of the body where the fetus is exposed to the radiation.”

The authors said that professional organizations have not consistently recommended minimizing medical imaging during pregnancy. Their research opens a new avenue of inquiry into the potential risks involved.

“This study has given us a chance to look more closely at the use of advanced imaging in pregnancy,” said Dr. Marilyn L. Kwan, co-lead author. “It’s important to quantify exposure to ionizing radiation because it can cause cancer and birth defects, and should be kept to a minimum, especially during pregnancy.”

For their study, which tracked the combined use of advanced medical imaging during pregnancy, the researchers analyzed more than 3.5 million pregnancies at six U.S. health systems and the provincial health system of Ontario, Canada, between January 1, 1996, and December 31, 2016. They reviewed the use of advanced imaging, including CT, MRI, conventional radiography, angiography and nuclear medicine.

During the 21-year study, 5.3 percent of pregnant women at U.S. sites and 3.6 percent in Ontario underwent imaging with ionizing radiation, the authors said. Rates of CT scanning during pregnancy in the U.S. started leveling off in 2007 and have been trending downward since 2010, the study found. Meanwhile, overall rates continued to climb in Ontario, but in 2016, they were nonetheless 33 percent lower than in the U.S. They also found that Ontario utilized MRI more often than CT which does.

Altogether, nearly one in 100 pregnancies in the United States and approximately 0.6 in 100 in Canada involved CT in 2016, researchers found. Imaging rates during the course of the study were highest in women under 20 and over 40 years old, as well as those who delivered preterm or were black, Native American or Hispanic.

doi:10.1001/jamanetworkopen.2019.7249
Surgical planning for head and neck cancer benefits from FDG-PET/CT


The nonrandomized phase two trial, ACRIN 6685, followed 287 patients with newly diagnosed stage T2 to T4 disease, all being considered for surgery when at least one side of the neck had no evidence of lymph node involvement based on a physical exam, preoperative MRI and/or a CT evaluation (clinically node-negative or cN0). The study found that FDG-PET/CT imaging achieved a true negative in 94 percent of patients (by standardized uptake value (SUV) analysis), or 87 percent of patients (by visual assessment).

“The information provided by FDG-PET/CT of the cN0 neck changed the surgical plan 22 percent of the time,” said the study’s principal investigator and lead author Dr. Val J. Lowe, a nuclear medicine specialist at Mayo Clinic in Rochester, MN. “These findings suggest that FDG-PET/CT may assist the clinician in deciding on the best therapy for the clinically N0 neck in head and neck squamous cell carcinoma, possibly preventing patient morbidity and/or saving significant costs.”

The reliability of FDG-PET/CT in detecting lymph node metastases in head and neck cancer is well proven and is reported to be cost-effective in staging patients with cN0 necks. Most of the data are single-institutional and retrospective. Surgeons often perform elective neck dissections in patients with cN0 necks at high risk for recurrence because clinical exam and structural imaging do not reliably identify all metastatic disease. This approach has been found to improve survival but may be associated with substantial complications for patients.

“A negative scan in the cN0 neck has been demonstrated by our study to have a very high negative predictive value,” said co-principal investigator and co-author Dr. Brendan C. Stack, “Additionally, the positive PET leads the surgeon to consider resection of nodal levels that might harbor occult metastatic disease.”

Participants older than 18 years of age with newly diagnosed, first-time head and neck squamous cell carcinoma were recruited from 22 qualified sites in the United States and one in Beijing, China. FDG-PET/CT was compared with pathology findings at neck dissection. Participants all received a pre-surgical FDG-PET/CT scan to which the surgeon was initially blinded and a contrast-enhanced MRI or CT scan of the neck (all within four weeks of surgery).

The surgical plans were devised by the local surgeons on the basis of physical examination and CT and/or MRI results, but not PET/CT and thereafter formulated with the available PET/CT result. Both plans were collected prospectively with questionnaires. All data were anonymized to protect the identities of the participants.

FDG-PET/CT scans and pathology findings were available for 270 cN0 neck sides from 212 participants. Pathology was randomly over-read by a central pathologist and all scans were reviewed by a team of central readers. For visual assessment, the negative predictive value (NPV) specific to the cN0 sides was 0.868 (95 percent CI, 0.803 to 0.925). For dichotomized maximum SUV, the NPVs specific to the nodal basins were 0.940 and 0.937 at prespecified cutoffs of 2.5 and 3.5, respectively. The optimal cutoff maximum SUV was determined to be 1.8, with an NPV of 0.942.

The FDG-PET/CT-informed surgical treatment plan was changed in 51 of 237 participants (22 percent) compared with the PET/CT-blinded surgical plan. In 34 participants (12 percent), this led to planned dissection of additional nodal levels. In 12 participants (5 percent), this led to fewer planned dissected nodal levels. Negative PET/CT scans in N0 necks were true negative in 87 percent and false negative in 13 percent.

“This trial is an excellent example of a means to implement personalized medicine in the setting of head and neck cancer management,” said Dr. Stack.

doi: 10.1200/JCO.18.0118
FDG PET is a better indicator of cognitive performance in Alzheimer’s Disease than amyloid protein PET

While the presence of beta-amyloid plaques in the brain may be a hallmark of Alzheimer’s disease, giving patients an amyloid PET scan is not an effective method for measuring their cognitive function, according to a new study from a group of US researchers (Khosravi M et al. 18F-FDG Is a Superior Indicator of Cognitive Performance Compared to 18F-Florbetapir in Alzheimer’s Disease and Mild Cognitive Impairment Evaluation: A Global Quantitative Analysis. J Alzheimers Dis. 2019;70(4):1197-1207. doi: 10.3233/JAD-190220).

Two of the most significant biomarkers found in Alzheimer’s are decreased glucose uptake and the accumulation of amyloid plaques in the brain. FDG-PET is one of the most commonly used imaging techniques to diagnose Alzheimer’s. However, in recent years, several other radiotracers, such as florbetapir, have been developed to detect the deposition of amyloid plaques.

The researchers concluded that fluorodeoxyglucose (FDG) PET, which measures the brain’s glucose consumption as a marker of neural activity, is a stronger approach for assessing the progression and severity of Alzheimer’s and mild cognitive impairment (MCI) than florbetapir-PET scans, which reveal amyloid protein deposits in the brain. This suggests that FDG-PET is a better means for determining the effectiveness of Alzheimer’s therapies, as well as tracking patients’ disease advancement, in both clinical and research settings.

“Both florbetapir-PET and FDG-PET are approved diagnostic methods for Alzheimer’s disease, and both appear to be effective in indicating some sort of cognitive impairment. However, we have now shown that FDG-PET is significantly more precise in clinical studies, and it is also available for routine use at modest cost,” said the study’s co-principal investigator Dr. A Alavi, “Our results support the notion that amyloid imaging does not reflect levels of brain function, and therefore it may be of limited value for assessing patients with cognitive decline.”

Recently, the effectiveness of amyloid imaging as a strategy for monitoring dementia symptoms has been called into question. While the presence of amyloid plaques in the brain is considered as being characteristic of Alzheimer’s, some studies have shown that large amounts of amyloid plaques were present in healthy, non-demented individuals. Conversely, recent clinical trials have shown that the intended removal of amyloid from the brains of patients with Alzheimer’s disease led to no change in, or even worsened, cognitive performance.

In the study, the researchers evaluated 63 individuals, including 19 with clinically diagnosed Alzheimer’s disease, 23 with MCI, and 21 healthy individuals. The study participants underwent both FDG- and florbetapir-PET imaging. They were then assessed with a Mini Mental Status Examination (MMSE), a widely used diagnostic test for detecting and assessing the severity of cognitive impairment. The researchers used a novel “global quantification approach” to generate data from five different regions of the brain, which were correlated with the results from the MMSE scores.

The study revealed that both FDG- and florbetapir-PET scans are able to effectively discriminate the individuals with dementia from the healthy control group. However, when compared with the MMSE scores, the correlation between low cognitive performance and high levels of amyloid was significantly weaker than the correlation between FDG and low cognitive performance for all groups included in the study. This suggests that FDG-PET is a more sensitive indicator of cognitive decline.

“Amyloid imaging has a value in diagnosing or ruling out Alzheimer’s disease, but it’s a bit like all or nothing. Our study shows that it can reveal disease, but you wouldn’t be able to differentiate between someone who had very mild or very severe symptoms,” said co-principal investigator Dr. Andrew Newberg. While FDG-PET may not be a perfect diagnostic tool, the study confirms that currently it is the best available method for monitoring symptoms of dementia, according to Alavi.

“Right now, FDG is king when it comes to looking at brain function, not only in Alzheimer’s disease, but also in diseases like vascular dementia and cancer,” Alavi said.

doi: 10.3233/JAD-190220

Diagnostic ultrasononographic comparison of major types of arthritis

A recent review presents an analysis of the diagnostic value of the well-established, non-invasive and relatively inexpensive imaging modality of diagnostic ultrasonography to compare different types of arthritic conditions. (H Sikka Roy et al. Comparison Between Major Types of Arthritis Based on Diagnostic Ultrasonography. Open Medical Imaging
The seven major arthritic conditions included in the study are osteoarthritis, rheumatoid arthritis, gouty arthritis, pseudogout (calcium pyrophosphate deposition disease), psoriatic arthritis, infectious arthritis and spondyloarthritis.

In the review, researchers at the SouthWest Medical University in China carried out a computerized literature search in PubMed and identified a list of 206 publications related to arthritis. Out of this list, a total of 52 studies met the search criteria for involving diagnostic ultrasonography. The researchers found that ultrasound was effective in delineating characteristic features in each of the above mentioned seven major types of arthritis. When carried out by a trained sonographer and combined with a good patient’s history and physical examination, ultrasound proved to be a convenient, feasible, economic and accurate imaging modality in the evaluation and monitoring of disease process and progression in each type of arthritis. Some of the features overlapped while some were specific to one type of arthritis.

Although MRI has been considered as the main modality for the evaluation of musculoskeletal (MS) pathology, high resolution ultrasound with colour doppler imaging is suggested as the imaging method of choice for the assessment of superficial MS lesions.

Mamourian at Penn State Health used a phantom to show that magnetic eyelashes worn during MRI can cause substantial artifacts “Our purpose was to evaluate the magnitude of the susceptibility artifacts created by magnetic eyelashes on multiple standard imaging sequences and compare these artifacts with those created by aneurysm clips, which are a common source of image distortion,” wrote Slonimsky and Mamourian. Using two sets of magnetic eyelashes from the same manufacturer that were randomly selected and purchased online, a phantom was created by drilling multiple 2-mm holes in a plastic container and then running monofilament line through these holes to create a grid. The two sets of eyelashes were attached to single nylon strings, placed diagonally within the phantom. The phantom was then submerged in a container filled with distilled water, covered with a layer of plastic film to prevent free movement of the lashes, should they detach.

MRI was performed using a 3-T scanner with T2-weighted images, FLAIR images, T1-weighted images, susceptibility-weighted images, DW images, T1-weighted magnetization-prepared rapid-acquisition gradient-echo images, and T2-weighted sampling perfection with application-optimized contrasts using different flip-angle evolutions.

Ultimately, the magnetic eyelashes evidenced an artifact much larger than that created by the aneurysm clips (two made of cobalt alloy, one made of titanium) using the same sequences—measuring 7 × 6 cm maximal on susceptibility-weighted images, obscuring the entire phantom. Although the eyelashes stayed attached to the strings during the scan, upon removal of the phantom from the bore, one set of eyelashes detached from its string. Restrained by the plastic covering, it became attracted to the other eyelashes still attached to the phantom.

“Although friction and adhesion may differ from patient to patient, depending on the width and character of the native eyelashes of an individual,” Slonimsky and Mamourian wrote, “we strongly recommend inserting a line about magnetic eyelashes in the MRI safety questionnaire and adding stops in the screening system to prevent the entry of anyone with these lashes, including staff, into the MRI scanner room.”

Magnetic eyelashes: a new source of MRI artifacts

A new cosmetic product, magnetic eyelashes, should be of interest and concern to radiology professionals working in the MRI environment, according to a group of US researchers (Slonimsky E & Mamourian A. Magnetic Eyelashes: A New Source of MRI Artifacts. AJR Am J Roentgenol. 2019 Jul 24.1-3. doi: 10.2214/AJR.19.21550). False eyelashes are a growing segment of the cosmetics industry. In addition to the usual offerings, a new version uses magnets rather than glue to adhere the false eyelashes to the native lashes. Although the staff of the research group had little to no awareness of the existence of magnetic eyelashes, the Wall Street Journal has reported that instruction on their use and application was the top trending beauty-related search on Google in 2018. Einat Slonimsky and Alexander Mamourian used a phantom to show that magnetic eyelashes worn during MRI can cause substantial artifacts “Our purpose was to evaluate the magnitude of the susceptibility artifacts created by magnetic eyelashes on multiple standard imaging sequences and compare these artifacts with those created by aneurysm clips, which are a common source of image distortion,” wrote Slonimsky and Mamourian. Using two sets of magnetic eyelashes from the same manufacturer that were randomly selected and purchased online, a phantom was created by drilling multiple 2-mm holes in a plastic container and then running monofilament line through these holes to create a grid. The two sets of eyelashes were attached to single nylon strings, placed diagonally within the phantom. The phantom was then submerged in a container filled with distilled water, covered with a layer of plastic film to prevent free movement of the lashes, should they detach.

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Radiomics in Alzheimer’s Disease: seeking new imaging biomarkers to identify the early stages of the disease

By Dr. R. Ortiz-Ramón and Dr. D. Moratal

The valuable intrinsic information contained in many medical images has been under-exploited for too long. Now, new and rapidly developing technological advances for the acquisition of high-quality images and the processing of the underlying information in a rapid and intelligent way are allowing use of these “hidden” data, with the potential to revolutionize the field of radiology. The advances already achieved by this approach in oncology are sufficiently encouraging to justify its application to other difficult clinical challenges such as the diagnosis and staging of Alzheimer’s disease (AD).

This article summarizes the current status of radiomics analysis in AD and describes the potential of newly developed software for the identification of image texture biomarkers.

INTRODUCTION:
The term dementia describes a set of neurodegenerative symptoms that mainly affect memory, attention, intellectual capacity and personality, among other human mental functions. Dementia englobes a variety of diseases that occur because of physical changes in the brain based on degeneration or destruction of brain tissue and nerves. Dementia constitutes a major health problem worldwide. In 2011, it was estimated that 35.6 million people around the world suffered from dementia, whereas, in 2018, this figure had already increased to 50 million. At this rate, it is expected that this figure will almost double by 2030 and more than treble by 2050 [1]. Alzheimer’s Disease (AD) represents the most common type of dementia, accounting for an estimated 60 to 80 percent of cases [2]. Alzheimer’s disease involves a continuous brain degradation that is broadly characterized by a preclinical stage, followed by a phase of mild cognitive impairment (MCI), and a final phase of dementia in the strict sense. The differences between typical age-related cognitive changes and signs of AD can be subtle. The most common initial symptom is a gradually worsening of the ability to remember new information. This occurs because the first neurons to be damaged and destroyed are usually located in brain regions, like the hippocampus, which are involved in forming new memories, [2]. Currently, the diagnosis of AD remains nowadays fundamentally clinically based, which means that it cannot be diagnosed until the first symptoms appear, or even later, as the early symptoms are usually associated with consequences due to normal aging. Definitive diagnosis can only be made with histopathological confirmation of beta-amyloid plaques and tau tangles, usually at autopsy [3]. This situation is the main reason behind the exploration of new biomarkers for the early detection of AD. The hope is that patients could benefit from more efficient treatments if AD were diagnosed in its early stages, or even before the first symptoms appear. To this end, in recent years many studies have focused on the analysis of MCI, which is considered as a prodromal stage of the disease or a transitional phase between normal ageing and AD, although not all patients with MCI develop AD [4]. The pre-symptomatic phase is still the focus of active research but current analyses are focused on finding biomarkers for this stage since experimental evidence indicates that pathophysiological alterations take place in the brain more than a decade before clinical decline [5].

IMAGING BIOMARKERS IN ALZHEIMER’S DISEASE
Imaging has played an important role in the study of AD over the last few years, but the potential use of imaging biomarkers for the early detection of AD is still limited. However, recent years have seen advances in this area, with the development of new software and methods for the analysis of imaging data. One of these methods is radiomics, which involves the extraction of texture and morphological features from medical images. These features can be used to identify disease-specific patterns and to develop imaging biomarkers for early detection of AD. In this article, we will summarize the current status of radiomics analysis in AD and describe the potential of newly developed software for the identification of image texture biomarkers.
decades. From the diagnostic point of view, imaging has moved from a minor role to a central position. In particular, structural magnetic resonance imaging (MRI) has gained more attention than other imaging techniques because, as shown in Figure 1, the modality allows in vivo visualization of the progressive cerebral atrophy that characterizes the neurodegenerative process of dementia, thus contributing to improved diagnostic accuracy [6]. This progressive cerebral atrophy firstly affects the medial temporal lobe, with the entorhinal cortex being the earliest site of atrophy, closely followed by the hippocampus, amygdala, and parahippocampal gyrus. Consequently, new biomarkers for the early diagnosis of AD could be defined by processing and studying structural MRI of these brain structures [7].

In the past few years, a brand new field has arisen with the purpose of encompassing several individual but connected processes in order to study, validate and share new imaging biomarkers. This field is known as radiomics.

Broadly speaking, in practice radiomics involves: (a) image acquisition, (b) identification, segmentation and pre-processing of the regions (2D) or volumes (3D) of interest (i.e., those that contain tissue with possible valuable information), (c) extraction of descriptive features from these regions or volumes, and (d) mining of these data to develop classification models to predict outcomes either alone or in combination with additional information, such as demographic, clinical, histologic or genomic data [8].

The rationale behind such radiomics analyses is based on the hypothesis that medical images contain information at the tissue/organ level (macroscopic level) that reflects the underlying pathophysiology of the tissue (microscopic level) and that these relationships can be revealed through quantitative imaging features.

Radiomics analyses have been proven to be a valuable source of information to improve diagnostic precision, to determine prognosis or to predict treatment response. Most of the reviews covering the basics of the practice of radiomics focus on its application to cancer. However, radiomics can also be employed in the study of other diseases using the same basic principles that medical images may possess abundant, valuable, yet unexplored information. These represent different pathophysiologic aspects of the tissue under examination and so could be used to assess many kinds of diseases.

In particular radiomics can be applied to study AD and many studies have demonstrated the potential of imaging biomarkers to define the disease. Traditionally, the imaging features that have been used as biomarkers of AD are related to volume and/or shape changes of specific brain structures, thus only taking into account macroscopically apparent alterations that occur when neurodegeneration has already taken place [10]. However, in the past years, texture analysis has been considered as a promising source of imaging biomarkers for characterizing AD. Texture analysis covers a wide range of techniques that enable the quantification of pixel interrelationships, gray level patterns, and spectral properties of an image.

**TEXTURE ANALYSIS IN ALZHEIMER’S DISEASE**

Several studies of the application to AD of imaging biomarkers based on texture analysis have been carried out recently with the objectives of distinguishing AD from other types of dementia [11] or for predicting which patients with MCI are likely to progress to AD [12]. However, most of the efforts over the past decade have been directed towards differentiating AD patients from cognitive normal (CN) and MCI patients. Many studies have been published on this subject [13-16] indicating the increasing interest in classifying AD stages by texture biomarkers.

Most of these studies prove that AD patients could be differentiated with good accuracy, (by means of statistical analyses or machine learning techniques) from CN and MCI patients using texture features but that the predictive ability of texture features was reduced when classifying CN and MCI patients. This is not specific to the issue of texture biomarkers. In a recent exhaustive systematic review carried out by Pellegrini et al. [17], the authors evaluated the state-of-the-art of all types of imaging biomarkers for diagnosing cognitive impairment and dementia with machine learning techniques. The conclusions are clear: imaging biomarkers do not yet allow differentiation of the clinically relevant disease categories. The authors concluded that, although the results of the differentiation of healthy controls from AD are encouraging, the poor
patients present hippocampal asymmetry, some studies which have shown that AD in the performance of texture analysis higher classification results. Differences from the right hippocampus provided concluded that measures of the texture differentiate AD and CN patients, and they and subcortical regions in order to differentiate, challenging task that can result in imprecise hippocampal borders, especially in 3D images of patients with AD, where the atrophy of the hippocampus is visible [27]. For small regions like the hippocampus that may present different sizes between groups of patients, geometric regions of a predefined size are recommended. It is important to take into account that the ROI size should be sufficiently large to capture the texture information and that several texture features may in fact be dependent on the ROI size. Differences in the size of the ROI could probably explain different results between groups [28].

THE ALTEA SOFTWARE TOOL
To explore new texture biomarkers for characterizing AD, we decided to develop a modular tool in order to simplify, accelerate and standardize this task: the ALTEA (ALzheimer’s TExture Analyzer) software tool [29]. The design of the tool is very intuitive; it is divided in two blocks, namely the “Feature Extraction” and “Feature Evaluation” blocks. At the same time, each block is further subdivided in modules all of which are interconnected so the user can access the different modules in an easy and guided way [Figure 2]. The tool was designed to follow the four main steps of the radiomics practice described above. Therefore, the “Feature Extraction” block includes a first module for image processing and ROI definition and a second module for extracting the texture features. The “Feature Evaluation” block includes three modules for evaluating the texture features through data visualization, statistical tests and machine learning techniques. At present, ALTEA is available only for research purposes. As explained above, texture biomarkers have not yet been proven to identify precisely all the stages of AD, so the application of the tool in clinical routine is not possible for now. However, this is a field of active research and the ALTEA tool may help in the performance of standardized, reproducible analyses.

PRELIMINARY RESULTS
When the first version of the ALTEA tool was created, we decided to use it to perform a preliminary analysis of the statistical significance of 2D and 3D texture features extracted from the hippocampus of T1-weighted images for differentiating between three stages of the AD: pre-symptomatic (CN), prodromal (MCI), and advanced (AD) stages. Using a machine learning approach, we also investigated whether the combination of these parameters could be useful to generate classification models to distinguish between these three groups. We used the study of Zhang et al. [30] as a basis for this analysis.
The images used in our study were obtained from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database (https://adni.loni.usc.edu) [31]. This is a large database of complete neuroimaging data sets for the study of AD. The database is very popular among AD researchers since it enables standardized analyses to be carried out and allows meaningful discussion and comparison with other related results. From our preliminary study, we concluded that local texture features extracted from spherical ROIs on T1-weighted images of the left hippocampal region were appropriate for differentiating AD patients from both CN and MCI subjects (AUC > 0.8 in both cases when using a machine learning approach with support vector machines or multilayer perceptrons). However, the first stage of the illness (CN versus MCI) could not be identified with the features evaluated in this phase of the study, a finding that is in agreement with most of the studies that have applied machine learning to neuroimaging for the detection of AD, as mentioned above. We plan to carry out a more intensive study in the next few months. This study will incorporate several improvements, such as the inclusion of more features and the implementation of more predictive models designed to make the most of the ALTEA software.

CONCLUSIONS
Radiomics analyses are the future of radiology. The already established progress of radiomics in the field of oncology is encouraging and it is reasonable to assume that the same approach can also be usefully applied to other clinical challenges which involve the interpretation of medical imaging. The diagnosis of the stages of AD is one example of such challenges. So far, however, the results of the application of radiomics analyses to AD are still unsatisfactory, at least as far as the confirmation that imaging biomarkers are capable of identifying precisely each stage of the disease is concerned. There is still a lot of work to be done. More diverse datasets, combinations of different types of imaging data, improved interdisciplinary collaboration and closer clinical integration of radiomics techniques will facilitate advances in the field.

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BREAST IMAGING

In cooperation with the Breast Diagnostics Section of the Hungarian Society of Radiologists
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 Scar, 123I-Metaiodobenzylguanidine SPECT Innervation, and Bipolar Voltage. J Nucl Med. 2019; 60: 79. doi: 10.2967/jnumed.118.211698). The researchers found that the use of Iodine-123 metaiodobenzylguanidine (123I-MIBG) SPECT imaging, combined with cardiac 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.

Image courtesy of Hasan Imanli et al.

Different colors further stratify electro anatomic mapping (EAM) of the low voltage (< 1.5mV) area according to voltage. Each green point represents ventricular tachycardiac channel/exit site according to local bipolar voltage. Abbreviations CMR-Sc: CMR-Structural; LGE CMR scar; Abnormal innervation zone; LowVolt=low-voltage area <1.5mV Image courtesy of Hasan Imanli et al.

Ventricular arrhythmias are the main cause of sudden cardiac death in the Western world. 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). In all cases, the VT site of origin was localized to areas of the tissue with abnormal innervation and MRI scar, identifying an area of abnormal tissue that is likely to be an appropriate target for VT ablation.

“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. “The study highlights the importance of close collaboration among the nuclear medicine, radiology and electrophysiology departments, which we are lucky to have at the University of Maryland, to move the field forward. We hope that we can build on the insights provided by this research to develop new treatment algorithms that will result in potentially shorter and more efficient treatment of patients with ventricular arrhythmias.”

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Novel multispectral photoacoustic imaging technique accurately assesses cardiovascular risks


Most ischemic strokes, or strokes related to a build-up of plaque in the arteries, are associated with carotid artery disease originating from the area where the arteries bifurcate. Imaging techniques such as ultrasound, CT and MRI are useful for revealing the extent of narrowing in the carotid arteries, but less helpful in determining the function and molecular composition of the plaque itself. This is a crucial limitation because plaque composition is associated with vulnerability to rupture, setting in motion the chain of events that leads to life-threatening strokes.

“Rapid characterization of tissue function and molecular composition is limited with these modalities, which commonly results in poor diagnostic accuracy and ineffective treatments,” said
senior author Dr. Daniel Razansky director of the Functional and Molecular Imaging Lab at the University of Zurich and the Swiss Federal Institute of Technology in Zurich.

Dr. Razansky and colleagues studied a new technique for carotid artery assessment known as volumetric multispectral optoacoustic tomography (vMSOT). As with ultrasound, vMSOT is performed with a handheld device that is moved against the neck. However, vMSOT employs spectroscopy to investigate tissue at the molecular level, so providing information about the artery that is not attainable with other methods. The method can also detect lipids, the pigment melanin and other disease-related biomarkers early enough to provide better treatment options.

“The developed handheld vMSOT imaging approach holds promise for rapid volumetric assessment of the carotid artery and plaque vulnerability in an entirely noninvasive manner,” Dr. Razansky said. “It also has the additional potential for label-free identification and assessment of clinically-relevant biomarkers of carotid artery disease, which helps with early and accurate diagnosis, timely treatment planning and monitoring.”

In the future, vMSOT could be combined with ultrasound for a more comprehensive characterization of the carotid artery.

“Given its fast imaging performance, excellent molecular contrast, portability and affordability, I truly believe that vMSOT will soon be routinely used in the clinic,” Dr. Razansky said. “One day, it may even become as popular as ultrasound.”


Evaluating blood flow is key to early diagnosis and treatment for people with critical limb ischemia

American Heart Association issues scientific statement


The statement provides perspective on the strengths and limitations of current imaging techniques, including the ankle-brachial index, toe brachial index, toe systolic pressure, transcutaneous oximetry (TcPO2) and skin perfusion pressure (SPP). It also examines tools such as the laser Doppler, speckle imaging devices and others, as well as identifying opportunities for technology improvement and reducing disparities in detection and treatment. The

Noninvasive hyperspectral imaging of the plantar aspect of the foot illustrating progressive improvement in oxyhemoglobin (red spectrum) in 2 separate angiosomes after lower extremity revascularization.

Image copyright © 2018, BIBA Medical Ltd.
Non-contrast cardiovascular magnetic resonance imaging can be carried out in short 15 minute exam

Coronary artery disease (CAD) - caused by plaque-based stenosis in the artery walls that constricts the flow of blood to the heart and is the most common form of heart disease and a leading cause of death for both men and women in the Western world. Non-invasive imaging such as cardiovascular magnetic resonance imaging is often used to diagnose coronary heart disease. However, current techniques are cumbersome, costly and expose patients to adverse health risks.

Researchers at Beth Israel Deaconess Medical Center (BIDMC) have developed a novel imaging approach that has the potential to identify patients with coronary disease without administration of drugs or contrast dye and within a short 15 minute exam protocol (Nakamori S et al. Changes in Myocardial Native T1 and T2 After Exercise Stress: A Noncontrast CMR Pilot Study. JACC Cardiovasc Imaging. 2019 Jul 17. pii: S1936-878X(19)30552-2. doi: 10.1016/j.jcmg.2019.05.019.). The technique involves measuring changes in blood flow in the myocardium after physical exercise by measuring the magnetic properties of the tissue, thereby eliminating the need for any contrast media or pharmacological stress agents.

“Current stress cardiac imaging requires administration of gadolinium contrast agent,” said corresponding author Dr. Reza Nezafat, scientific director of the Cardiovascular Magnetic Resonance Center at BIDMC. “However, recent data have shown that gadolinium administration can result in deposits in the brain and other organs. We aimed to develop a non-invasive imaging technique that eliminates the need for any contrast administration to measure changes in the blood flow in the myocardium.”

To do that, researchers in the Cardiovascular Magnetic Resonance (MR) Center at BIDMC developed a technique that measures changes in the magnetic property of tissue without gadolinium contrast agent as they performed exercise stress tests.

First, healthy subjects underwent a series of baseline imaging scans. Next, lying on their backs at the opening of an MRI machine, the healthy adults pedaled an exercise bicycle to increase their heart rate. Within 30 seconds of pedaling, participants underwent an MRI scan that measured changes in tissue properties of myocardium to quantify changes in the blood flow in the myocardium.

Next, the researchers tested participants with known or suspected coronary artery disease with a similar imaging protocol. Taken together, images from the two groups revealed that magnetic properties of myocardium change differently in areas impacted by coronary atherosclerosis than in normal areas and that these differences can be quantified using this technique.

“In this proof-of-concept study, we demonstrated that a quantitative cardiac MR approach that measures tissue properties of heart muscles, combined with an exercise protocol using an MRI-compatible ergometer in an MRI suite might have the potential to assess flow-limiting coronary artery stenosis in patients with suspected CAD without the need for gadolinium contrast injection or pharmacological stress agents,” Nezafat said. “Larger studies are warranted to confirm the clinical performance of our quantitative cardiac MR approach with exercise stress as an alternative to the currently common method of non-invasive assessment of coronary artery disease.”

doi: 10.1016/j.jcmg.2019.05.019.
Vector concentration: a new ultrasound parameter for stenosis assessment using Vector Flow Imaging

By Dr. K L Hansen

Vector Flow Imaging (VFI) is a new, angle-independent ultrasound method for blood flow assessment. The VFI parameter known as vector concentration has recently been proposed for the evaluation of flow complexity. This article describes the basic principles behind the technique and summarizes recent studies which show the potential of vector concentration for the grading of stenoses.

Stenoses of vessels and cardiac valves are common pathologies. For example, the prevalence of asymptomatic stenosis of the carotid artery is as high as 5.7% in males aged 80 years and above, while the prevalence of stenosis of the aortic valve is 4.6% in persons aged 75 years and above [1, 2].

Stenosis disturbs the local blood flow because of narrowing of the lumen; the disturbance is characterized by an increase in the velocity of the blood flow within the stenosis and in the jet leaving it, as well as flow separation and recirculation, vortex formation and turbulence downstream of the stenosis [3].

One of the imaging modalities for the assessment of stenosis is ultrasound (US). With B-mode US, the anatomy of the stenosis can be assessed by evaluation of the lumen reduction and the length of the stenosis, while the alteration in blood flow through the stenosis can be assessed using Doppler US in three different modes; color, power and spectral Doppler US.

Whereas color and power Doppler US are qualitative flow methods, in which blood flow is visualized but not measured, spectral Doppler US can be used for blood flow quantification, using parameters such as velocity, volume flow or pressure gradient. However, conventional Doppler US has a major limitation, namely the angle dependency of the technique, which affects all three Doppler modes, since in Doppler US only the velocity component of the blood flow that is directed along the axis of the emitted US beam can be measured. Therefore, in conventional Doppler US, assumptions of flow direction are necessary for flow quantification — flow is not visualized at 90 degrees to the beam direction, and flow complexity can only be evaluated in terms of flow directed towards and away from the transducer [4].

Vector Flow Imaging and Transverse Oscillation (TO)

Over the last decades, several approaches have been proposed to solve the limitations of angle dependency in conventional Doppler US and to achieve angle-independent blood flow estimation [5]. Such methods are known as vector flow imaging (VFI) techniques, in that the flow motion is characterized by vectors indicating direction and speed of the blood flow.

Several methods using various combinations of pulse emission, signal processing and quantification schemes have been described for VFI measurement [5]. One of these solutions, which was originally proposed by Jensen et al., is based on the technique known as Transverse Oscillation (TO), which can provide real-time, angle-independent VFI [6].

In brief, the TO method simultaneously tracks scatterer motion along two orthogonal axes from the echoes of pulse emissions identical to those in conventional Doppler US. The motion in the axial direction is determined in the same way as in conventional Doppler US, i.e. with the echoes of the moving scatterer being received by the central elements of the transducer array, while the motion in the transverse direction is determined by receiving echoes using elements on the periphery of the array. The 2D vector velocity of the blood flow can then be found by combining the two obtained velocity components for each scatterer [6, 7].

Several papers have evaluated the TO VFI method in simulations, in flow rig and in vivo [7-9]. Recent studies have indicated that the TO method is more accurate and precise than conventional spectral Doppler US for velocity estimation in the carotid artery with MRI as reference and more precise than the US dilution technique for volume flow estimation in arteriovenous fistulas [10, 11].

Complex flow assessment

Another advantage of VFI is its ability to visualize complex flow [Figure 1]. Flow complexity is difficult to measure and interpret using conventional Doppler US because of the angle dependency of the method. Visualization and quantification of complex
flow patterns can be achieved with MRI. However, compared to US and VFI, MRI has a lower temporal and spatial resolution, is more time-consuming and expensive, and is neither a real-time nor a mobile, portable imaging modality [5]. Hence from the purely practicability point of view, VFI has the potential of being a highly useful and valuable alternative for flow evaluation to both conventional Doppler US and MRI.

Vector concentration
Flow complexity and vorticity in complex vessel geometries such as the heart, the ascending aorta and the carotid bifurcations have been investigated using VFI and have been described in several recent papers [12-17]. For the quantification of flow complexity, the VFI parameter known as vector concentration was introduced by Pedersen et al. [18]. Instead of measuring the length of the vector arrows within a region of interest (ROI) as is done in the conventional estimation of velocity, the evaluation of flow complexity concerns the angle diversity, or angle spread, of the scatterer motion within a ROI. Using vector concentration, flow complexity can be presented as a single parameter on a scale ranging from 0 for completely chaotic flow to 1 for perfectly laminar flow.

The vector concentration parameter was initially used to distinguish complex flow in the carotid bulb from laminar flow in the common carotid artery [18]. More recently, the parameter has been used for stenosis assessment of the aortic valve [Figure 2]. With vector concentration, VFI was able to assess the degree of stenosis by evaluation of the flow complexity of systolic flow in the ascending aorta. There was a strong linear correlation (p<0.0001, R=0.89) between vector concentration and the corresponding peak systolic velocity (PSV) estimates obtained using continuous wave transesophageal US (TEE) [13,19].

Since VFI using the TO method is based on a pulsed US system, the phenomenon known as aliasing can take place. (Aliasing happens when imaging an event that is occurring too fast for the rate at which it is being sampled/observed. As a result the system will show a flow motion that appears to be backward). Aliasing only occurs when the Nyquist limit is broken, i.e. when the velocity of the blood flow exceeds the sampling limit as defined by the pulse repetition frequency (PRF) [6,7]. It was however observed that, even for systolic velocities above the aliasing limit of the TO system, the vector concentration still correlated tightly with the PSV obtained using continuous wave TEE, in which the estimates are unaliased [13,19]. This indicates that vector concentration is probably less affected by aliasing than velocity estimation in pulsed US systems, since aliasing of complex flow only resulted in an insignificantly small addition to the angle spread already present. In contrast, aliasing in conventional velocity estimation produces erroneous estimates going in the wrong direction of the true flow.

In laminar flow situations, vector concentration is in theory probably more likely to be affected by aliasing since ordered flow will be perceived as complex. However, as laminar flow can be measured below the Nyquist limit, in practice the clinical relevance of vector concentration estimation remains intact. To avoid aliasing, it is recommended that velocity estimation of cardiac flow in patients with aortic valve stenosis be carried out with continuous wave US [20]. However, continuous wave US acquires the velocities along a line, with the spectrum being a representation of all velocities in this direction. With VFI based on a pulsed US system, data sampling is achieved at defined depths. Hence, measurement using VFI provides spatial information not present in continuous wave US.

VFI vs DSA-derived lumen reduction
A recent study compared VFI to digital subtraction angiography (DSA) for the grading of stenosis in the superficial femoral artery [Figure 3], [15]. In this study, vector concentration and velocity ratio obtained with VFI were both compared with the lumen reduction calculated from DSA. (Velocity ratio is a well-established US measure for grading stenosis in peripheral arterial disease, and is determined by normalizing the velocity within the stenosis with respect to the velocity measured in an adjacent, normal vessel segment).

A moderate correlation was found between velocity ratio from VFI and the lumen reduction determined by DSA (R=0.50, p<0.07). Among 17 stenoses evaluated for the velocity ratio, two outliers were found which had shadowing calcified plaques which limited the US window. When these outliers were excluded, it was found that VFI was able to differentiate stenoses as being over or under 50% lumen reduction (p<0.01).

Figure 1. VFI of blood flow in the ascending aorta in long (a) and short (b) axis view in a patient with normal aortic valve and normal aortic flow. The direction and velocity magnitude of the blood flow are displayed as colored pixels defined by the 2D color bar and with arrows superimposed for flow interpretation. Image from Hansen et al. [14], reprinted with permission of Ultrasound in Medicine and Biology.

Figure 2. VFI of systolic blood flow in the ascending aorta in long axis view in a patient with normal aortic valve (A), and a patient with aortic valve stenosis before (B) and after (C) implantation of a biologic prosthesis. For each ROI, the vector concentration calculated to quantify flow complexity is shown. Image from Hansen et al. [13], reprinted with permission from Ultrasound in Medicine and Biology.
When the vector concentration was calculated instead of the velocity ratio from the same VFI data set, it was found that there was a strong linear correlation with the DSA-derived lumen reduction, with no outliers, (R=0.93, p<0.001). This VFI study thus indicated that flow complexity as characterized by vector concentration has a higher agreement than velocity ratio with the lumen reduction found by DSA for grading stenoses in the superficial femoral artery. Flow complexity has also been quantified with a VFI technique based on plane wave emission. A recent study of this method evaluated flow in the carotid bifurcation in healthy volunteers and in patients with carotid stenosis [17]. A modified version of vector concentration was applied to the vector maps. The results of the study showed that healthy and diseased vessels could be differentiated [17].

**Calcifications and eccentric flow**

Stenoses are often found in atherosclerotic vessels with calcifications. These can pose a problem in the US evaluation, since shadowing from calcified vessel segments can hide the blood signal, thus making accurate flow estimation in the stenosis difficult or even impossible [21]. As shown by Hansen et al., it can be cumbersome to estimate peak velocities in the stenotic vessel segment when there is such shadowing even when data are acquired using angle-independent VFI [15]. Moreover, eccentric flow is a common flow pattern even in normal vessels, as has been shown by MRI studies of flow in the carotid artery, which found that the highest velocities can often be off-plane [8]. In contrast to conventional US velocity assessment, where the highest peak systolic velocity measurement is required for stenosis grading, vector concentration is a measure obtained from a 2D vector map. The region of interest from which the vector concentration is calculated covers the entire lumen and includes all flow components around, and within, the stenosis. The measure is therefore less sensitive to any shadowing from calcifications and does not require the highest PSV for stenosis grading, i.e. is less sensitive to off-plane measurements.

**Future development**

The initial in vivo studies of VFI used post-processing for the quantification of vector concentration. Nowadays VFI is available real-time on modern commercial US scanners. Improved commercial implementation of VFI with real-time flow quantification will enable larger studies involving more patients and observers to be carried out so that the full potential of VFI and vector concentration can be confirmed.

**Conclusion**

Vector concentration is a new US parameter for flow assessment that is obtained by angle-independent VFI estimation. Initial studies have shown that vector concentration has the potential to be a highly promising alternative to velocity estimation for stenosis assessment. VFI provides spatial information not available in continuous wave Doppler US, uses more data for flow evaluation and offers new insonation windows to the flow compared to conventional Doppler US. In addition, preliminary studies indicate that compared to conventional Doppler US evaluation of stenosis, vector concentration is less PRF-sensitive, less sensitive to off-plane evaluation, and less hampered by calcifications.

**REFERENCES**


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Perfusion Cardiac Magnetic Resonance as a first line technique for the assessment of suspected ischemic heart disease

By Dr E Nagel, Dr. M Kolentinis, Dr. E Vidalakis & Dr. V Puntmann

Perfusion imaging with cardiovascular magnetic resonance (perfusion-CMR) is a diagnostic test for myocardial ischemia, which can be performed rapidly (within approximately 30 minutes) and without using ionizing radiation. It provides highly accurate, strong prognostic data and elucidates the cause of symptoms, such as chest pain, so reducing the need for unnecessary coronary angiographies. Perfusion-CMR is attractive for a wide range of patients as a first line work-up method for their symptoms. A recent international clinical effectiveness trial in 918 patients, who presented with chest pain and intermediate to high pretest probability for coronary artery disease (CAD) has demonstrated the non-inferiority of perfusion-CMR in comparison to an invasive strategy based on fractional flow reserve to guide patient management. Perfusion-CMR demonstrated a high positive predictive value for the presence of significant coronary artery disease and a high negative predictive value for the occurrence of events. A positive test result should be followed by coronary angiography, most likely with revascularization. A negative test result aids in the diagnosis of the underlying, non-coronary, origins of the pathology, such as micro-vascular disease or inflammation, which could explain the patients’ symptoms and guide therapy.

BACKGROUND EVIDENCE

Numerous studies involving a total of more than 4000 patients have evaluated the diagnostic accuracy and predictive value of perfusion-CMR, with coronary angiography being used as the reference standard, with or without additional fractional flow reserve (FFR). Meta-analyses show sensitivities of 89% (88-91%), specificities of 76% (73-78%) and accuracies of 86% versus coronary angiography [1], with slightly improved values being obtained with higher field strengths (3 Tesla versus 1.5 Tesla) or with stricter angiographic criteria (70% stenosis versus 50% stenosis) [2]. Similarly, the data are slightly improved when FFR is used as the reference standard (89%/87%/88%) [3]. The diagnostic accuracy was not affected by sex (similar for men and women) or the number of epicardial vessels involved. Perfusion CMR has demonstrated superior diagnostic accuracy compared to SPECT in two large studies, namely the multicenter MR-IMPACT II [4] and the single center CE-MARC [5], as well as in multiple smaller studies summarized in meta-analyses [2,3]. Similarly, Lipinski et al. summarized the finding of 19 studies of prognosis and demonstrated the strong prognostic power of perfusion-CMR [6]. In this meta-analysis, 11636 patients who had an average follow-up time of 32 months, showed very low event rates for cardiovascular death 0.3±0.3% and for myocardial infarction 0.4±0.3% when they had a negative CMR result (0.8±0.7% for the combined endpoint of cardiovascular death or myocardial infarction). On the contrary, with a positive perfusion CMR event rates were 2.8±1.6%, 2.6±2% and 4.9±3.1% respectively (p<0.0001 for all), resulting in hazard ratios of 7.7, 6.96 and 6.5. Similar to SPECT, ischemia of ≥10% of myocardium in perfusion-CMR denotes the cut-off percentage where revascularization may improve the outcome [7]. The presence of a previous myocardial infarction or diffuse fibrosis/edema adds additional prognostic value [8].
The recently published MR-INFORM trial [9] is an international, randomized controlled trial, which compared the clinical effectiveness of a perfusion-CMR guided strategy with an FFR-guided strategy to manage patients with chest pain and medium to high pre-test probability of CAD. The results indicate that perfusion-CMR can guide further management as effectively as invasive angiography supported by FFR [Figure 1]. In the study, 918 patients with stable chest pain, ≥2 risk factors or positive ECG stress test were randomized into a non-invasive arm guided by stress perfusion-CMR or an invasive arm guided by angiography with supplementary FFR. All patients received guideline-directed medical therapy. In the CMR-informed arm only 40.5% required an invasive angiography despite an intermediate to high pre-test likelihood of 74% according to a modified Diamond and Forrester score and fewer patients were revascularised than in the FFR-informed arm (35.7% in the MR guided group vs. 45.0% in the invasively guided group, p=0.005). There was no significant difference between perfusion-CMR or FFR-guided therapy regarding the occurrence of symptoms such as angina pectoris (50.8% vs. 56.2%, p=0.21) or major adverse cardiac events (death, myocardial infarction, target vessel revascularization) (3.56% vs. 3.72%, HR: 2.68 – 2.36 p=ns) [Figure 2]. These data show that perfusion-CMR is a safe and effective alternative to invasive, FFR-supported coronary angiography in the guidance and optimal management of patients with stable chest pain.


**CMR IN PATIENTS WITH CHEST PAIN BUT NO SIGNIFICANT CORONARY ARTERY DISEASE**

CMR is highly valuable tool in the assessment of the underlying etiology of a multitude of cardiovascular diseases due to its ability to assess function, regional or diffuse fibrosis, edema due to inflammatory processes and micro-vascular flow. For this reason, CMR is the main diagnostic modality used after a negative coronary angiography in patients who present with chest pain and a positive troponin test [13]. In patients with this syndrome– originally known as myocardial infarction with normal coronary arteries (MINOCA), CMR was reported as being able to elucidate in 87% of cases the underlying mechanism of the troponin rise [14], with the most frequent causes being myocarditis, takotsubo cardiomyopathy or acute myocardial infarction. Furthermore, other causes of chest pain in patients with low pre-test likelihood for CAD, such as pericarditis, myocarditis or micro-vascular disease can be identified by CMR; these would be missed if invasive or computed tomography coronary angiography were used to rule out coronary disease.

**GUIDELINE RECOMMENDATIONS**

Perfusion-CMR is cited in all international guidelines for the detection of coronary artery disease. In the ESC and EACTS guidelines for revascularization (2018) and stable coronary artery disease (2013), perfusion-CMR was given a Class Ia recommendation for symptomatic patients with intermediate pre-test probability for CAD. In addition, the 2013 ESC guidelines on the management of stable coronary artery disease recommend, for the above class of patients, an imaging stress test, including perfusion-CMR, instead of stress ECG, if the appropriate local expertise is available. Furthermore, perfusion–CMR is one of the imaging stress tests that should replace stress ECG in those patients.
who have ECG abnormalities that make the interpretation of ECG during stress difficult. According to the same guidelines, symptomatic patients with prior revascularization either by coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI) benefit from an imaging stress test such as perfusion-CMR [15,16]. ACC appropriateness criteria from 2014 consider perfusion-CMR as appropriate in patients with intermediate pre-test probability and non-diagnostic exercise ECG as well as in patients with high pre-test probability independently of the interpretability of the exercise ECG [17]. These guidelines are currently being updated.

SUMMARY
As demonstrated by the evidence presented in this article, perfusion-CMR is a powerful diagnostic tool for the work-up of patients with stable chest pain. New evidence may further expand the use of perfusion-CMR in clinical practice into a broader spectrum of patients, particularly those with low- to intermediate- pre-test probability, where a negative test carries a favorable prognosis and also frequently allows the identification of the underlying non-coronary cause of the symptoms. More importantly, in patients with intermediate to high pre-test likelihood for CAD, the current invasive strategy can be safely replaced by a 30-minute imaging test, thus obviating the need for radiation exposure or invasive access.

REFERENCES
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Left Ventricular Mass as assessed by MRI and long-term risk of cardiovascular events

Cardiovascular disease is the leading cause of death for men and women in developed countries and is potentially reversible with treatment. Therefore, methods are needed to identify at-risk patients who might benefit from intervention. Traditional cardiovascular risk factors include dyslipidemia, hypertension, smoking, diabetes mellitus, obesity, and physical inactivity. However, all current cardiovascular risk estimation systems have limitations. Ongoing research efforts have focused on improving risk estimation through identification and incorporation of new risk markers, including noninvasive imaging findings.

A recently published study analyzed the long-term impact of left ventricular (LV) hypertrophy as assessed by cardiac MRI for the prediction of cardiovascular events in a large, ethnically diverse patient cohort [1].

In the study led by Dr. Nadine Kawel-Boehm, a senior staff radiologist at Hospital Graubünden in Chur, Switzerland, and a team of researchers analyzed data collected in the Multi-Ethnic Study of Atherosclerosis (MESA) which is sponsored by the National Heart, Lung, and Blood Institute and involves a prospective multicenter study of a diverse, population-based sample of 6,814 men and women age 45-84 free of cardiovascular disease at study inclusion. This particular analysis is based on 4988 participants from MESA. According to Dr. Kawel-Boehm, there are few data and little research on predicting the long-term risk of cardiovascular events in ethnically diverse patients who have MRI-identified left ventricular (LV) hypertrophy, a condition in which the muscle mass of the heart's main pumping chamber is increased.

“Previous studies have used ECG or echocardiography, which have lower sensitivity in the diagnosis of LV hypertrophy, and typically follow patients for only several years,” she said. “The MESA study used MRI, which is the gold standard for quantifying LV mass, and had a long follow-up of 15 years.”

The researchers studied otherwise healthy individuals from the community in the MESA study. 4,988 MESA participants underwent a baseline cardiac MRI between 2000 and 2002 and participated in follow-up over a 15-year period. MRI showed that 247 participants in the study group had LV hypertrophy. The mean age of all participants at baseline was 62 years, and 52 percent were women. Thirty-nine percent were white, 13 percent were Asian, 26 percent were African American and 22 percent were Hispanic. At the 15-year follow-up, the research team found that 290 patients had a significant coronary heart disease (CHD) event, including 207 myocardial infarctions, and 95 CHD deaths. Cardiovascular disease-related deaths occurred in 57 patients, and 215 patients had heart failure.

A statistical analysis of the data demonstrated that LV hypertrophy was an independent predictor of significant CHD events, including myocardial infarction, coronary artery disease-related death and heart failure.

According to the analysis, 22 percent of the study participants with LV hypertrophy had a significant CHD event, compared to 6 percent of participants without LV hypertrophy. Patients with LV hypertrophy had 4.3 times the risk of coronary artery disease-related death compared to participants without LV hypertrophy. Deaths from coronary and non-coronary related cardiovascular causes were more strongly related to LV hypertrophy than to coronary artery calcium scoring done with a CT scan.

“In contrast to the widely used coronary artery calcium by CT, which measures a condition not known to regress under medical therapy, an elevated LV mass

![Figure 1. Flow diagram of events. Hard coronary heart disease events were a composite end point and included myocardial infarction and coronary artery disease–related death. The sum of myocardial infarction and coronary artery disease–related deaths does not equal the number of hard coronary heart disease events because some participants had myocardial infarction followed by coronary artery disease–related death. Other cardiovascular death excluded stroke and was adjudicated not to be atherosclerotic in origin (eg, pulmonary embolism, arrhythmia, and cardiomyopathy). MESA = Multi-Ethnic Study of Atherosclerosis.](image)
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LV hypertrophy may be a stronger predictor of coronary and non-coronary adverse events than CAC over long-term follow-up. Regression of LV hypertrophy has been shown to lead to a reduction in adverse cardiovascular events, making it a potential target for therapy. Identifying high-risk patients with LV hypertrophy could allow targeted therapy specifically to this group.

Dr. Hanneman emphasized that an important strength of the current study is the long duration of clinical follow-up (median, 13.5 years), which reveals a broader adverse impact of LV hypertrophy in relation to both coronary- and non-coronary-related events. Given the long follow-up duration and large patient cohort, a high number of adverse events were observed (290 hard CHD events). This allows for adjustment for multiple potential confounders in multivariable models, which is important as models become unstable and are prone to overfitting if too many covariates are used.

Dr. Hanneman added that other key strengths of this study include the large, ethnically diverse patient cohort, long-term follow-up, evaluation of LV hypertrophy by using cardiac MRI, and adjustment for established risk factors. Future studies will hopefully clarify the optimal definition of LV hypertrophy as a risk predictor and evaluate the potential for risk reclassification of LV hypertrophy in relation to CAC and traditional risk factors. Finally, given that most publications related to LV hypertrophy as a predictor for cardiovascular events derive from the MESA cohort, these findings should also be confirmed in independent populations by using current cardiac MRI techniques.

REFERENCES
GE & Fujitsu set up Australian partnership for diagnosis of brain aneurysms using AI

GE Healthcare, Fujitsu Australia, Macquarie University and Macquarie Medical Imaging have announced a new research collaboration to diagnose and monitor brain aneurysms faster and more efficiently using artificial intelligence (AI).

Brain aneurysms are caused by a weakness in the wall of a brain artery and are present in between two and eight percent of adults. Rupture of an aneurysm causes brain hemorrhage in eight percent of adults. Outcomes from the project include a planning tool for surgical intervention. This tool will use fluid dynamic modelling to predict the risk of aneurysm rupture.

Mike Foster, CEO of Fujitsu Australia and New Zealand, said: “We are pleased to be part of this important ‘co-creation’ initiative that leverages the strengths of each of our partners, as well as Fujitsu’s experience in AI to have a positive impact on peoples’ lives. AI in particular has the capability to make our daily lives more comfortable and contribute to solving difficult problems such as detecting serious medical issues early and allowing more timely treatment intervention. This is an excellent demonstration of Fujitsu’s commitment to creating human-centric innovation together with our customers and partners to build a trusted future where everyone can feel safe.”

Matt Tucker, CEO GE Healthcare Australia & New Zealand, commented, “As the consequences of brain aneurysm rupture are often fatal, effective and expedient detection is crucial. Unfortunately screening and monitoring takes time and specialist expertise not afforded by every radiology practice. The application of AI can give doctors better insights more quickly and produce fewer variable results.”

Professor John Magnussen, Diagnostic and Interventional Radiologist at Macquarie Medical Imaging, said, “This is an amazing opportunity to be able to address the problem of the rapid and accurate diagnosis of brain aneurysms. Even in ideal circumstances, detecting brain aneurysms is time and expertise intensive and missed aneurysms can have terrible outcomes. By creating an AI assistant to automatically flag potential aneurysms and allow for accurate follow-up, we can make a huge difference to patient care.”

www.gehealthcare.com

Siemens acquires specialist in robotic-assisted vascular interventions

Siemens Healthineers has entered into a merger agreement with Corindus Vascular Robotics, a global technology leader in robotic-assisted vascular interventions, whereby Siemens will acquire Corindus for $1.1 billion Based in Waltham, MA, USA, Corindus produces and sells robotic systems for minimally invasive procedures. These systems help clinicians to precisely control guide catheters, guide wires, balloon or stent implants via integrated imaging. The physician no longer has to stand close by the angiography table as usual but can control the procedure with a separate module and is thus less exposed to radiation. Corindus is currently one of the leading companies offering a robotic treatment platform for major vascular therapeutic markets, including coronary, peripheral vascular and neurovascular interventions.
Every year, more than four million percutaneous coronary interventions are carried out worldwide. Robotic-assisted minimally invasive procedures have the potential to reduce treatment times, increase precision during treatment, raise standardization levels in clinical procedures and ultimately improve clinical outcomes. The interplay of exact imaging and robotic-assisted interventions will thus enhance both the eyes and hands of the physician.

“With Corindus, Siemens Healthineers is well-positioned to be one of the leading players in the field of robotic vascular interventions and to perform minimally invasive procedures more accurately, more quickly and more effectively. With this acquisition, we are opening up a new field for our image-guided therapies business. Together with our strong portfolio in imaging, digitalization and artificial intelligence, we are creating significant synergies to advance therapy outcomes”, said Bernd Montag, CEO of Siemens Healthineers

The CorPath systems developed by Corindus will be used together with Siemens’ angiography systems which make minimally invasive treatment possible by using high-quality imaging before and during medical interventions. The company’s leading role in image-based minimally invasive procedures is now complemented by robotic-assisted precision medicine. This expansion strengthens the therapy position of Siemens Healthineers and underlines its role as one of the leading providers of solutions along the entire treatment path. This makes the acquisition of Corindus a strategically significant extension of Siemens Healthineers’ therapy business.

In addition, Corindus is driving forward the approval procedure for remote robotic treatment in vascular interventions. Due to the limited availability of specialists for minimally invasive procedures in many regions and the limited number of corresponding clinical facilities, remote treatment could significantly improve patients’ access to treatment in the future.

www.siemens-healthineers.com
www.corindus.com

First European MRI safety course and certification backed by Canon in UK

UK joins the USA and Australia with introduction of MRI safety accreditations to safeguard users and deliver higher standard of imaging patient care

Almost 200 radiologists, radiographers and medical physicists recently attended the first European MRI Safety Matters training seminar. The 2-day event, held in London and sponsored by Canon Medical Systems UK, was a platform to call for greater collaboration between industry and healthcare, and for a standardised approach to MRI safety culture of the UK MRI industry by embracing the certification.

Vanessa Ellis, MR Manager at Canon Medical Systems UK, said “The busier MRI modalities are becoming in frontline imaging care, the more accidents there are. Yet despite every incident being preventable, there is still no standardised MRI safety training or safety certification mandated for or even available for MRI staff. A big challenge is the disparity in the reporting of accidents which hampers learning. Whilst many healthcare organizations are great at ensuring safety practices and policies, there is nothing guiding a mandatory safety framework and so it remains a grey area in terms of managing radiology workforces. We were delighted with the positive feedback this year and look forward to championing more safety certifications and discussions at next year’s event.”

“Almost 200 radiologists, radiographers and medical physicists have recently attended the first European MRI Safety Matters® training seminar sponsored by Canon Medical Systems UK.

Almost 200 radiologists, radiographers and medical physicists recently attended the first European MRI Safety Matters training seminar sponsored by Canon Medical Systems UK.

Almost 200 radiologists, radiographers and medical physicists recently attended the first European MRI Safety Matters training seminar sponsored by Canon Medical Systems UK.
support the aims of the MRI Safety Matters team and the roll out of a standardized UK safety standard.”
https://eu.medical.canon/

Deep-learning, artificial intelligence technology for 2D Mammography receives CE Mark

iCAD have announced that its advanced artificial intelligence technology and workflow solution, ProFound AI for 2D Mammography, has received CE Mark approval. The technology is the latest addition to iCAD’s deep-learning ProFound AI platform, joining ProFound AI for Digital Breast Tomosynthesis (DBT), already CE marked and FDA-cleared. The technology was developed to support the detection of breast cancer through the identification of soft tissue densities and calcifications.

“Europe contains 9% of the world’s population but has more than 23% of the global cancer burden, with breast cancer being the most common cancer among European women,” stated Stacey Stevens, President of iCAD. “This CE Mark further validates our ProFound AI platform as a world-class artificial intelligence solution that offers benefits to both radiologists and screening-aged women in detecting breast cancer. iCAD is committed to improving patient care worldwide and we are pleased to offer this powerful technology to a growing number of hospitals, imaging centers and women across Europe.”

ProFound AI for 2D Mammography is a high-functioning, deep-learning algorithm that analyzes each mammography image and provides critical insight into each individual case, such as highlighting the most suspicious areas and assigning unique Certainty of Finding and Case Scores, which can assist radiologists in making clinical decisions and prioritizing caseloads. The ProFound AI platform is built upon the latest in deep-learning artificial intelligence and allows for continuously improved performance via ongoing software updates.

“ProFound AI for 2D Mammography has the potential to assist radiologists in their interpretation of 2D mammography images, as we have seen with ProFound AI for DBT,” according to Axel Gräwingholt, MD, Radiologie am Theater, in Paderborn, Germany. “As breast cancer rates continue to rise, it is imperative for radiologists to find cancers sooner, when they may be more easily treated, with fewer callbacks and false positives, which can be inconvenient and stressful for patients.”

www.icadmed.com

Philips and major French hospital announce 10-year enterprise informatics agreement

Philips and the Centre Hospitalier Régional Universitaire (CHRU) de Nancy, a leading academic hospital in the Grand Est region of France, have announced a 10-year agreement to implement Philips’ IntelliSpace Enterprise Imaging Solution, including Ilumeo with adaptive intelligence. CHRU de Nancy is a public health institution that receives 1.2 million consultation visits and inpatient stays each year. The agreement will enable the hospital to streamline complex medical image data management across its departments in order to enhance the delivery of care with better health outcomes and improved experiences for its patients and staff.

“As we transform to focus on delivering value in healthcare, this new enterprise informatics agreement with Philips will enable us to improve productivity, enhance collaboration between clinicians, and ultimately improve health outcomes for our patients,” said Jean-Christophe Calvo, Chief Information Officer and Head of the Biomedical Department, CHRU de Nancy. “The combination of our scale and expertise in research, and their comprehensive informatics solution, will enable us to better connect people and data, as well as providing a foundation for us to leverage artificial intelligence in healthcare.”

Philips and major French hospital announce 10-year enterprise informatics agreement

“The diagnostic value of medical imaging for the assessment of the anatomy and function of disease continues to increase, as the field evolves and new techniques emerge,” said Prof. Daniel Mandry, Head of the Imaging Department for Women and Children, CHRU de Nancy. “High quality medical imaging data management is key to providing a precise diagnosis. As the amount of data we capture for each patient dramatically increases, we expect Philips Ilumeo to help us improve our workflows and enhance the user experience by adapting to the clinical and user context. This will free up time for our radiologists to focus on diagnosis.”

www.philips.com

Philips IntelliSpace Enterprise Imaging Solution is a comprehensive offering designed to meet the evolving needs of healthcare providers. It includes: IntelliSpace Universal Data Manager, which enables true Enterprise Imaging by combining efficient care with comprehensive clinical data management; IntelliSpace Radiology, a clinical user interface designed to optimize the impact radiologists have on patient care; IntelliSpace Radiology Workspace, which offers intelligent workflow and collaboration tools to enhance radiologist efficiency; and Ilumeo with adaptive intelligence.

“In today’s rapidly changing healthcare environment, managing image data is increasingly challenging, with greater clinical demands and image data management complexity,” said Calum Cunningham, Business Leader for Enterprise Diagnostic Informatics at Philips. “Our partnership with CHRU de Nancy will support the hospital’s shift towards the delivery of value based care, securely connecting patients, the care team and data across the entire health system. Today’s announcement, alongside our recently-announced partnership with Lille University Hospital, demonstrates the pioneering role that health institutions in France are playing in the application of artificial intelligence in healthcare in Europe.”

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In collaboration with
High diagnostic performance of short MRI protocols for the detection of prostate cancer in biopsy-naïve men: the next step in making MRI more accessible

By Dr. M van der Leest, Dr. B Israel & Dr. J Barentsz

Multi-parametric prostate magnetic resonance imaging (mp-MRI) is currently recommended as a triage test for the detection of high-grade disease (ISUP Grade ≥2; Gleason score ≥3+4=7) and to avoid unnecessary biopsies in biopsy-naïve men with clinical suspicion of prostate cancer (PCa) [1-4]. However, the full imaging MRI protocol as recommended by the Prostate Imaging Reporting and Data System (PI-RADS) v2 guidelines is both time-consuming and costly which makes practical application of the approach challenging when MRI accessibility is limited [5].

To make MRI more accessible to men at risk of high-grade PCa, there is a need for quicker, simpler, and less costly MRI protocols. The recommended full MRI prostate protocol includes a three plane localizer sequence, high resolution three plane T2-weighted images (T2WI) to depict prostate anatomy and two functional MRI techniques, including diffusion weighted imaging (DWI) to display cell density as well as dynamic contrast-enhanced imaging (DCE-MRI) to show vascularity. Recently, abbreviated MRI prostate protocols with reduced examination times have been proposed with the objective of providing a cost-effective alternative to the standard multiparametric protocol while maintaining similar diagnostic performance.

EVIDENCE FOR SHORT MRI PROTOCOL
In their recent systematic review and meta-analysis, Woo and colleagues demonstrated that using DCE-MRI and T2WI in multiple planes did not in fact improve the overall accuracy of MRI [6]. As a result, short non-contrast bi-parametric (bp) MRI (i.e. T2WI and DWI) protocols have been suggested to reduce examination times and costs, while retaining sufficient diagnostic accuracy to ‘rule out’ high-grade PCa in biopsy-naïve men [7-11]. In addition, such proposed bpMRI protocols have the advantage that the need for intravenous access and any potential toxicity issues related to gadolinium-based contrast agents can be avoided.

We recently published the results of our multi-reader, multi-center, powered prospective head-to-head comparison study (n=626) in which we investigated the diagnostic performance of the currently used mp-MRI protocol versus non-contrast bp-MRI in three planes (bp-MRI) and bp-MRI in one-plane (‘fast’ bp-MRI; axial T2W and - DWI) for the detection of high-grade PCa in biopsy-naïve men [12]. The details of the bpMRI acquisition protocol and the examination times are shown in Table 1. Typical examples of images generated by the bp-MRI and the standard mpMRI protocols are shown in Figure 1.

Our study showed that the MRI-acquisition time can be reduced by almost 50% through use of the unenhanced bp-MRI protocol without impairing the detection of high-grade PCa, at the cost of a slightly increased (2%) number of biopsies and a slight increase (1%) in over-detection of low-grade PCa [Figure 2]. Both bp-MRI protocols had diagnostic performances similar to that of full diagnostic mp-MRI with respect to ruling out high-grade PCa. Using a ‘fast’ one plane bp-MRI protocol did not result in decreased detection of high-grade PCa, but as
pointed out above, came at the cost of 2% more biopsy procedures and 1% more over-detection of low grade PCa as compared to the full diagnostic protocol.

Although the negative predictive value (NPV) of ‘fast’ bp-MRI was lower than that of bp-MRI and mp-MRI, the difference in NPVs between the protocols was clinically negligible (0.15% [95%CI 0.05-0.31]), and in any case the NPV of ‘fast’ bp-MRI remains high (97%). This is in agreement with two recent studies which prospectively investigated bp-MRI protocols in biopsy-naïve men compared to PI-RADS v2 and reported NPVs of 93% and 96% [7,9,10].

CLINICAL IMPLEMENTATION

There are several important features of bp-MRI that facilitate clinical implementation of the technique in the general diagnostic workflow. The non-contrast bp-MRI examination times are much shorter, namely 20-50% faster than mp-MRI. Therefore, patient throughput can be doubled to four men per hour. Such increased accessibility also decreases direct costs. Additionally, there is no need for the intravenous administration of contrast agent, so the procedure is non-invasive. In this way, patients are not exposed to any risks associated with gadolinium-based contrast administration such as allergic reactions, nephrogenic systemic fibrosis or possible tissue deposition of gadolinium[13,14].

Omitting two T2WI planes makes it more difficult to assign lesions to their zonal region (peripheral or transition zone), which is crucial to determine the final PI-RADS score. This may explain why there is a 75% increase in the number of PI-RADS 3 ‘equivocal’ cases with the ‘fast’ one-plane bp-MRI approach compared to that of three-plane bp-MRI. The need to assess PI-RADS 3 cases is an indicator of increased diagnostic uncertainty and can thus result in more unnecessary biopsies. However, compared to the percentage of PI-RADS 3 cases found by Obmann et al. (27%) and by Boesen et al. (13%) the percentage of PI-RADS 3 cases we found in our study for both bp-MRI protocols is still low (7.8% and 11%) [7,9]. This may be a result of the high-quality image acquisition and expert-reading of both our bp-MRI studies. In lower-volume, non-expert centers the use of fewer planes and the absence of contrast could result in increased diagnostic uncertainty, an increased number of PI-RADS 3 assessments and thus in more unnecessary biopsies. This emphasizes the importance of high-quality standards in image acquisition and the need for standardized reading of prostate MRI images.

CONCLUSION

A bp-MRI protocol is not inferior to mp-MRI in that the detection rates of high-grade PCa in biopsy-naïve men are equal. A fast mono-planar bp-MRI can double prostate MRI capacity at lower expense. This is, however, at the cost of slightly more biopsies and a slight overdetection of low-grade PCa.
REFERENCES


Table 1. MRI acquisition protocol on 3T MRI-scanner. MRI= magnetic resonance imaging; mp= multi-parametric; bp= bi-parametric; T2WI: T2-weighted imaging; DWI= diffusion weighted imaging; DCE= dynamic contrast enhanced; TR= repetition time; TE= echo time; FOV= field of view; NEX= number of excitation; H= head; F= feet; R= right; L= left; BW= bandwidth. * Scan time per protocol includes T2WI localizers, green indicates sequences per protocol, red sequences are omitted.

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15. mp-MRI* | 15:57 |
16. bp-MRI* | 13:07 |
17. "fast" bp-MRI | 0:49 |

* Scan time per protocol includes T2WI localizers, green indicates sequences per protocol, red sequences are omitted.
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1a. What is your radiology sub-specialty? (check only one)
   - 50 Diagnostic Radiologist
   - 51 Other Physician (please specify)

1b. I am a Head of my department
   - 58 Yes
   - 59 No

Please continue with question #2 below

NON-PHYSICIAN PROFESSIONALS (respond below)

1c. What is your occupation? (check only one)
   - 60 Radiology Administrator
   - 61 Radiology Business Manager
   - 62 PACS Administrator
   - 63 Chief Information Officer/IT Manager
   - 64 Chairman/Managing Director/Executive Director
   - 65 Chief Financial Officer/Other exclusive titles

Please continue with question #2 below

ALL RESPONDENTS reply to the questions below

2. In what type of facility do you work? (check only one)
   - 20 Private Clinic
   - 21 Hospital (check number of beds):
     - a. More than 500 beds
     - b. 400-499 beds
     - c. 300-399 beds
     - d. 200-299 beds
     - e. 100-199 beds
     - f. 0-99 beds

3. With what technologies or disciplines do you work? (check all that apply)
   - 01 Diagnostic X-ray
   - 02 MRI
   - 03 Nuclear Imaging
   - 10 Mammography
   - 03 Interventional Radiology
   - 11 Bone Densitometry
   - 04 CT
   - 12 PACS/Teleradiology
   - 05 Ultrasound
   - 70 Cardiac Imaging

4. If you currently receive Diagnostic Imaging Europe, how many other people read your copy?
   - a. 0
   - b. 1
   - c. 2
   - d. 3
   - e. 4
   - f. 5 or more

5. Please describe your involvement in the decision to purchase medical imaging equipment/products for your department.
   - (Check all that apply)
     - 33 Approve purchase of product
     - 35 Recommend purchase of product
     - 34 Specify type of product to purchase
     - 36 None of the above

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First Name: ____________ Last Name: ____________

Title: ____________ Hospital/Office Name: ____________

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The growing impact of modern technology on radiology

The rapid rate of technological and software development is fundamentally transforming the entire healthcare sector and this transformation is more evident in the field of radiology than in any other medical specialty. Since the beginning of the profession, radiologists have been using medical imaging to establish diagnoses and monitor patient responses to the treatment of their condition. However, nowadays, the development and implementation of latest technologies such as artificial intelligence, robotic surgery and virtual reality are proving to be a game changer in this highly evolving field.

Today, new advances in medical imaging such as AI-assisted interpretation of images are helping clinicians to provide accurate and reliable diagnoses, which in many cases previously were difficult if not impossible. In addition, modern technologies such as Computer-Aided Detection are proving more and more useful in improving the efficiency of the process of image interpretation by the radiologist. The ever-increasing number of cases that today’s radiologist has to handle, together with the fact that more and more cases involve multidimensional images from modalities such as MRI and CT mean that radiology work-lists are becoming correspondingly over-loaded. AI tools are also being used to enhance spatial/temporal resolution and the overall quality of advanced imaging processes as well as enabling considerable reduction in the level of radiation to which the patient is exposed when being examined by modalities involving ionizing radiation such as CT. These advances are proving themselves to be vital in providing the specialised care required not just for serious health conditions but also for the more numerous, relatively minor cases. However for all its advantages, technological progress is not an end in itself; in the healthcare sector the patient must never be forgotten.

With this in mind, the 4th Annual Radiology Meeting (ARM), has adopted the theme ‘Patients First – Back to Basics’ for this year’s meeting of radiologists, radiographers and related specialists. The idea behind the slogan is to remind attendees at the meeting that the overall well-being of the patient must remain the top priority and that the powerful new technological advances being constantly introduced to radiology are only of value if they can be shown to contribute meaningfully to an improvement in patient care.

This year, the ARM conference will focus on chest X-Ray, musculoskeletal radiology, neuroradiology, chest imaging, cardiac imaging, with other sessions on whole body imaging and radiography aimed at general radiologists and radiographers. In addition a number of more specialized sessions and dedicated workshops will provide radiologists with detailed information and also enable exchange of practical experiences with various technical procedures. The exhibition provides leading equipment manufacturers with a perfect opportunity to showcase their cutting-edge technologies and the latest medical development and equipment.

The Annual Radiology Meeting will take place from the 15th to the 17th of October at Dubai International Convention and Exhibition Centre, Dubai, UAE

More information at https://radiologyuae.com/
Innovations in ultrasound and enterprise informatics to advance cardiac care

For the first time in Europe, Philips is presenting the latest release (Release 5.0) of its EPIQ CVx cardiology platform at the European Society of Cardiology’s annual meeting in Paris. The platform includes automated applications for 2D assessment of the heart, as well as robust 3D right ventricle volume and ejection fraction measurements, making accurate exams faster and easier to conduct.

The new advanced automation capabilities available on the EPIQ CVx cardiology ultrasound platform are aimed at increasing diagnostic confidence. By incorporating advanced automation, there is less variability between scans, leading to confident treatment decisions which benefit patients. The new release of EPIQ CVx is a major step forward, reducing the number of touches of the system by 21% in each exam, which is equivalent to more than 400 exams each year.

The AutoStrain LV application uses advanced Automatic View Recognition technology to identify the different views of the heart, providing exceptional visualization and analysis of left ventricular function – extremely important diagnostic information for patients at risk of developing cardiovascular disease. Also new are the AutoStrain LA and AutoStrain RV applications, which automate the measurement of left atrial and right ventricular longitudinal strain respectively. By creating reliable and reproducible strain measurements for the left ventricle, left atrium and right ventricle, the AutoStrain LV, LA and RV applications support clinicians treating patients with atrial fibrillation, arrhythmia and other complex heart conditions.

With the shift to value-based care, healthcare providers are increasingly focused on balancing the need to provide the highest quality care with managing their operational costs. Philips provides intelligent solutions that help clinicians to be more efficient and effective, enabling them to deliver a consistent standard of care, optimize care pathways, simplify workflows and drive better treatment outcomes.

Philips also announced that it is collaborating with digital health company LindaCare to combine the company’s innovative OnePulse cloud-based solution for the remote monitoring of patients with cardiac implantable electronic devices (CIEDs) with the Philips IntelliSpace Cardiovascular informatics platform.

“Monitoring and follow-up of cardiac arrhythmia patients with CIEDs can be often complex, with data trapped in different silos that need to be reviewed individually,” said Calum Cunningham, Business Leader for Enterprise Diagnostic Informatics at Philips. “LindaCare’s innovative OnePulse solution consolidates this data, and by incorporating OnePulse into our IntelliSpace Cardiovascular platform, caregivers can see this additional information as part of the broader cardiovascular history of each patient, allowing them to make the most appropriate treatment decisions for each patient.”

Philips IntelliSpace Cardiovascular system is a web-based image and workflow management platform which streamlines the workflow of cardiology departments and across hospitals by consolidating multi-modality images and data and enabling access to an open ecosystem of cardiovascular software applications. The seamless combination of IntelliSpace Cardiovascular with LindaCare’s OnePulse solution allows clinicians to more easily access data from their patients’ CIEDs remotely. This results in a more seamless overall workflow, including alert management and triaging, supporting more proactive care. Philips is also introducing a new module on IntelliSpace Cardiovascular which complements the remote monitoring workflow by automating, standardizing and streamlining reporting for patients with CIEDs during hospital visits. Both the OnePulse interface and the new module will be available on the platform later this year.

Advanced imaging software for flexible portfolio of mobile imaging systems

Carestream has announced that its ImageView software is now available on its CARESTREAM DRX-Revolution Mobile X-ray System as well as the CARESTREAM OnSight 3D Extremity Imaging System.
“We continue to expand our portfolio of imaging systems while simultaneously introducing new software features and enhanced functionality designed to improve the imaging process for radiology managers and technologists across the globe,” said Charlie Hicks, Carestream’s General Manager for Global X-ray Solutions. Carestream’s ImageView software offers advanced features and optimized workflow and uses a Microsoft Windows 10 operating system to deliver enhanced cybersecurity. It is designed to support advanced applications such as dual energy and digital tomosynthesis, and will be delivered on the DRX-CARESTREAM DRX-Revolution Nano Mobile X-ray System, which is a smaller, lower-cost mobile unit designed for pediatric imaging, morning rounds for chest exams or other dedicated imaging applications. CARESTREAM DRX-Transportable System/Lite offers a rapid, affordable upgrade to DR and features a lightweight wireless tablet that gives users complete control of the system and displays images after they are acquired. There is no need to work from a fixed console or use a bulky electronics box. A virtual access point in the detector makes this a flexible solution that enhances workflow. Carestream’s beam-sensing technology further simplifies this upgrade; and the New CARESTREAM DRX Plus 2530C Detector offers 98-micron image quality and a smaller size than the company’s previous small-format detector.

CARESTREAM, ROCHESTER, NY, USA
www.carestream.com

Vendor-neutral AI-Rad Companion Chest CT software registered for use in Europe

AI-Rad Companion Chest CT, an intelligent software assistant for radiology, has recently received the CE mark, which means Siemens Healthineers can start marketing this artificial intelligence (AI)-based software as a medical product in Europe effective immediately. AI-Rad Companion Chest CT helps radiologists interpret CT images of the thorax faster and more precisely, and to document the findings in less time with the help of automatic measurements.

AI-Rad Companion Chest CT is the first AI-based application on the new AI-Rad Companion platform, and is vendor-neutral, which means the software can evaluate image data from many CT systems from different manufacturers. Siemens Healthineers plans to expand this platform so that more and more intelligent algorithms will be available for additional organs and modalities. This will enable the company to consistently expand its portfolio of effective solutions for AI-based clinical decision support.

“We introduced the first AI-based assistant in our AI-Rad Companion product line, AI-Rad Companion Chest CT, at RSNA 2018 in November last year,” says Dr. Razvan Ionasec, director in charge of AI-Rad Companion at Siemens Healthineers. “We are pleased to be able to offer our customers in Europe this first AI-based assistant for use in clinical practice effective immediately. I can see huge potential in this new product line for growth in key areas of medicine and to provide support for physicians in their clinical decision-making processes.”

Results delivered by radiologists can vary by some 10-20 percent, depending on the investigator,” comments Dr. Bram Stieltjes, Head, Research Coordination Radiology and Nuclear Medicine, University Hospital Basel. “Algorithm-based diagnostics completely obviate this variability, generating constant results. That alone is a huge advantage of AI platforms like AI-Rad Companion.”

Using CT images of the thorax, the software can differentiate between the various structures of the chest, highlight them individually, and mark and measure potential abnormalities automatically. This applies equally to organs such as the heart and lungs, aorta, and vertebral bodies. The software automatically turns the findings into a quantitative report, which can be called up via the image viewing system used by the radiologist in the clinical routine. In certain circumstances, the intelligent assistant also alerts physicians to potential abnormalities that would otherwise have been missed because they were not the focus of the original examination, e.g. chance discoveries of pathological dilations of the aorta (aneurysms).

“Examination using a chest CT is a procedure often used in everyday clinical practice,” says André Hartung, head of CT at Siemens Healthineers.

Heart with coronary arteries recognized and segmented from thoracic CT images, highlighted in green by AI-Rad Companion Chest CT including measurements of calcifications of the coronary arteries. Image courtesy of Siemens Healthineers
“For radiologists, this means more examinations in a limited amount of time and usually for low reimbursement rates. AI-Rad Companion Chest CT is a tool that can actually simultaneously increase productivity and quality in diagnostic radiology. This is a big step on our way to becoming a leader in clinical decision making”.

AI-Rad Companion Chest CT is a cloud-based solution and uses certified, secure teamplay infrastructure that complies with the Health Information Portability and Accountability Act (HIPAA) in the U.S., and with the General Data Protection Regulation (GDPR) in the EU. The software conforms to Digital Imaging and Communications in Medicine (DICOM) standards. The images and all supporting information can be made automatically available in the picture archiving and communication system (PACS) in line with the radiologist’s individual requirements.

**SIEMENS HEALTHINEERS, ERLANGEN, GERMANY**

www.siemens-healthineers.com

How imaging could improve tumor boards

In a recent “Opinion” piece from GE Healthcare Prof Mathias Goyen, Chief Medical Officer, Europe at GE points out that, rather than empowering clinicians, data systems are frequently taking valuable time that can be spent with patients

Patient cases can be complex. And so is cancer. It often takes more than one type of doctor or specialist to decide on the course of care for a cancer patient.

A multidisciplinary care team, or tumor board brings together experts from various disciplines depending on the type of cancer, such as surgical and radiation oncologists, pathologists, radiologists, reconstructive surgeons and nurses. This allows them to meet as a team to discuss difficult cases and find the best way to treat each cancer patient. The team considers factors like patient history, radiology, surgical and pathological findings, medical issues, best practices and more.

Such tumor boards are still fairly new to the industry but important to their success is that patient information is readily available. However it can take hours, sometimes days, for a tumor board to compile the data needed to establish a course of care, most often because patient data are stored in multiple locations. Workflows around tumor board preparations are notoriously inefficient but siloed and fragmented systems is an industry-wide problem. Rather than empowering clinicians, data systems are taking valuable time that can be spent with patients.

Each tumor board is also set up differently, contributing to the data management problem. They use different tools and can have different workflows and tasks. This not only makes information sharing between them more difficult but inefficiencies in the process can also lead to missing information and longer time to treatment.

**Bringing the data together**

Recently, GE Healthcare and Roche announced the release of NAVIFY Tumor Board 2.0. This clinical decision support tool allows radiologists to upload their patient records to the same dashboard where patient files from other disciplines in the cancer care team are stored, enabling tumor boards to have a more comprehensive view of each patient in one place.

When Prof Goren was a hospital radiologist he had a tumor board meeting for 20 patients, for which he would have to physically assemble the data – images, tests etc. – often on paper or faxes, for each patient. It took a long time and only then could the team interpret the data based on their pooled medical knowledge. With NAVIFY Tumor Board 2.0, much of this can be done digitally.

Prof Goyen is personally convinced, that a single, holistic dashboard, including all relevant data and medical images, will enable oncology teams to prepare more efficiently and agree more quickly on the optimal diagnosis and treatment plan for the benefit of each patient.

**Enabling personalized care**

Some reports indicate that patients receiving targeted therapy following multidisciplinary molecular tumor boards recommendations had superior outcomes compared with patients not receiving such therapy, including longer overall survival, longer progression-free survival and a trend toward longer time-on-treatment.

Having all the necessary information in the same tool helps specialists use their limited time to align on the best possible treatment plan for each cancer patient and focus on more detailed discussions based on the review of all relevant files. The result is a more efficient process and complete view of the patient for more holistic disease management.

When the view of patients is more precise, the care of each patient can become more personalized.

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