Cardiac Imaging Special
The clinical usefulness of coronary CT angiography – results from the COME-CCT consortium
Experience with a new CT scanner dedicated solely to cardiac imaging
Iodine in cardiovascular CT: options for radiation & contrast dose reduction
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CT Angiography in acute minor stroke
Challenging the ALARA Principle
Technology Update

Imaging chest pain patients with prior CABG
Interact and Enhance Communication in Radiology

1 - 3 November 2020, Dubai

Featured Speakers

Prof. Edward Y. Lee
Associate Professor, Harvard Medical school, Boston, MA
Pediatric Radiologist – Children’s Hospital Boston, MA, USA

Prof. Pia Maly Sundgren
Head of the Department of Radiology, Clinical Sciences, Lund University, Co-Director for Lund University Bioimaging Center, Senior consultant in neuroradiology, Skåne University Hospital, Lund, Sweden

Prof. Stacy E. Smith MD
Distinguished Barbara N. Weissman Chair, Division of Musculoskeletal Imaging and Intervention, Department of Radiology, Medical Director, Brigham Orthopaedics and Arthritis Center, Asst, Director, STRATUS Center for Simulation Medical Education Brigham and Women’s Hospital, Harvard Medical School

Prof. Jay P. Heiken MD, FACR
Professor, Department of Radiology, Mayo Clinic College of Medicine, Senior Associate Consultant - Division of Abdominal Imaging, Department of Radiology, Mayo Clinic, Rochester, Minnesota, USA

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Under the patronage of His Highness Sheikh Hamdan bin Rashid Al Maktoum
Deputy Ruler of Dubai, Minister of Finance and President of the Dubai Health Authority
Recovering from the COVID-19 - induced falls in general radiology volumes

In the short time since the COVID-19 pandemic broke, hospitals have had to become flexible, nimble and quick-reacting to be able to provide appropriate resources for the rapidly growing numbers of COVID-19 patients. All hospitals have been forced to adapt to the rapidly evolving situation, with most radiology practices being obliged to reschedule non-urgent and routine imaging. The result has been significant declines in imaging volumes, especially in the outpatient setting. One group of New York researchers analysed the precise impact of the pandemic on radiology in their hospital when faced with the tsunami of patients with COVID-19, (Naidich JJ et al Coronaviruses Disease 2019 (COVID-19) Pandemic Shifts Inpatient Imaging Utilization. J Am Coll Radiol. 2020: S1546-1440(20); 30651-7. doi: 10.1016/j.jacr.2020.06.011 and Naidich JJ et al Impact of the Coronavirus Disease 2019 (COVID-19) Pandemic on Imaging Case Volumes. J Am Coll Radiol. 2020 Jul; 17(7): 865-872. doi: 10.1016/j.jacr.2020.05.004). They found that there was an overall 28% decline in the total imaging volume during seven weeks of the COVID-19 pandemic including all patient service locations and imaging modality types. The biggest decline was in outpatient (88%) followed by the emergency department (46%) and inpatient (4%) settings. Imaging volume decline also varied by modality type, with the greatest fall seen in mammography (94%), followed by nuclear medicine (85%), MRI (74%), ultrasound (64%), interventional radiology (56%), CT (46%), and x-ray (22%). Of course individual hospitals will have different statistics, but it is likely that the overall trends will be broadly similar. In any case, studies like these provide real-world data to inform radiology practices toward evidence- based decisions. For the moment at least, the almost panicked shift of medical resources away from elective and non urgent procedures toward critical care seems to have halted in most areas in Europe, allowing radiologists to draw their breath and to start to actively plan for the new post-COVID-19 normal and regain at least some of the previously normal imaging volumes.

However, in this context, one thing seems certain already, namely things will never just revert to exactly the familiar pre-COVID situation. As Kees Wesendorp of Philips points out in the “Learning the Lessons” interview article on page 12 of the current issue of DI Europe, “the big lesson coming loud and clear out of the COVID-19 experience is how it is inexorably accelerating the digital transformation in healthcare”. This trend to increasing digitalisation covers increased use of tele-consulting between physicians and patients throughout the hospital and institution. More particularly, in radiology, increased digitalisation will be seen in a greater use of telediagnosis and artificial intelligence (AI)-assisted reading of radiology images as well as AI-based clinical decision support. In yet another article in the burgeoning COVID-19 literature, a group from Stanford in the USA analysed the factors that could be used to predict future radiology volumes after the COVID-induced fall (Madhuripan N et al Variables Influencing Radiology Volume Recovery During the Next Phase of the Coronavirus Disease 2019 (COVID-19) Pandemic. J Am Coll Radiol. 2020; Jul;17(7): 853-864. doi: 10.1016/j.jacr.2020.05.02). They speculated that there are six major variables that will probably predict future radiology volumes: (1) the local severity of COVID (2) the rate at which social distancing restrictions are relaxed; (3) patient perception of risk of leaving home and entering imaging facilities; (4) the efficiency of the management of pent-up demand for imaging delayed during the acute phase of the pandemic, including institutional capacity; (5) impact of the overall economic downturn and (6) the profile of the radiology practice reflecting the amount of elective imaging performed, including the type of patients seen by the practice such as emergency, inpatient, outpatient mix and subspecialty types. The task of predicting the recovery of radiology volumes is manifestly complicated by the fact some of these factors, e.g. the state of the general economy, are totally outside radiology’s control. No-one ever said it was going to be easy.
WHICH IMAGING MODALITY FOR CHEST PAIN PATIENTS WITH PRIOR CABG?

Resource and cost considerations

The results of a recent trial suggest that CCTA could be an austere choice for investigating recurrence of chest pain in CABG patients but may stretch health care utilization with increases in downstream testing.

REPORTS

RESULTS FROM THE COME-CCT STUDY LEAD TO THE DETERMINATION OF THE PPV AND NPV OF CTA FOR DIFFERENT RANGES OF CLINICAL PRE-TEST PROBABILITY.

THE HEART AND VASCULAR CENTER, SEMMELWEIS UNIVERSITY, IN BUDAPEST DESCRIBE THEIR EXPERIENCE WITH THE CARDIOGRAPHE, A CT SYSTEM SOLELY DEDICATED TO CARDIAC IMAGING.

CONTRAST MEDIA WITH A HIGHER CONCENTRATION OF IODINE OFFERS GREATER FLEXIBILITY FOR ALL CT APPLICATIONS AND, IN PARTICULAR, FOR CARDIOVASCULAR APPLICATIONS.

CARDIAC IMAGING

Prognostic impact of baseline and follow-up cardiac MR scans in acute myocarditis: evidence from the multicentre Italian ITAMY trial. CMR should be repeated at six months after symptom onset.

Magnetocardiography. The results of a recent study show that a novel, rapid magnetocardiography system has potential for the assessment of coronary artery stenosis in non-high risk chest pain patients.

BREAST IMAGING

Leveraging AI to optimize breast cancer screening in the era of COVID-19.

Artificial Intelligence evolution paves the way for the future.

COMPUTED TOMOGRAPHY

CT Angiography for the screening of patients with acute minor stroke: a cost-effectiveness analysis.

RADIATION DOSE

ALARA: Evidence against the use of the radiation protection principle as used in the healthcare sector.

COMING IN THE NEXT ISSUE:

Breast Imaging
Launched on Jun 25, the RICORD data collection (RSNA International COVID-19 Open Radiology Database) has already attracted support from many radiology organizations around the world who have responded to RSNA's call to build a COVID-19 imaging data resource. The RICORD data base will provide imaging data with annotations and supporting clinical information for use in education and research.

RSNA has also developed data sharing agreements and tools to organize, de-identify and transfer data. The RICORD data collection pathway will enable radiology organizations to contribute data to RICORD safely and conveniently.

Substantial datasets have already been contributed to RICORD and are being used for education and research projects, including one that will develop a detailed annotation schema for COVID-19 imaging. The repository will build on collections of imaging data that RSNA has already assembled to support imaging research — such as the substantial set of chest X-rays annotated for the presence of other community-acquired pneumonias assembled during the 2018 Pneumonia Detection Challenge. RICORD is envisioned as the largest open database of anonymized COVID-19 medical images in the world. More than 200 institutions around the world have expressed their interest in participating. The database will include supporting clinical information and expert annotations. It will be freely available to the global research and education communities.

“The strong positive reaction speaks to the determination of the global radiology community to contribute its resources and expertise to addressing the pandemic,” said RSNA COVID-19 AI Task Force chair Dr. Matthew P. Lungren, assistant professor of radiology at Stanford University and associate director of the Stanford Center for Artificial Intelligence in Medicine and Imaging. “This effort is the result of countless hours by volunteer task force members and a broad community of radiologist annotators led by our close partners at the Society of Thoracic Radiology.”

“This unprecedented spirit of collaboration has accelerated clinical testing, therapeutic drug discovery, epidemiologic tracking and vaccine development,” Dr. Lungren said. “All of these advancements were completed in weeks to months, rather than at the typical pace of months to years, and were catalyzed by this act of open-source scientific collaboration. This is perhaps one of the most dramatic examples of an open source research effort saving countless lives.”

More information at RSNA www.rsna.org/covid-19/
The COVID-19 outbreak, has severely affected European countries and put strain on healthcare systems’ capacities to provide optimal care to patients. Medical imaging plays a part in this endeavour by offering expertise to accurately diagnose and treat COVID-19 patients. The European Society of Radiology (ESR) has issued a position statement regarding the role of medical imaging in the current pandemic

1. MEDICAL IMAGING IN SUPPORT OF AN ACCURATE DIAGNOSIS OF COVID-19
While confirmation of the diagnosis relies on the DNA sampling technique known as 'polymerase chain reaction' (PCR), medical imaging, and Computed Tomography (CT) in particular, helps identify pulmonary symptoms and stratify patients selected from first-line clinical triage in an attempt to lower the pressure on DNA testing facilities. Experience shows that CT should not be considered a screening option for patients with mild or no symptoms. However, patients with severe respiratory symptoms may benefit from CT, a decision left to the discretion of the treating physician and dependent on the availability of local resources. Any final confirmation of diagnosis requires a PCR test, even when CT is highly suggestive of COVID-19 and the first PCR test was negative.

2. PROTECTING THE WORKFORCE AND OPERATIONAL CHANGE IN THE RADIOLOGY DEPARTMENT
In fighting COVID-19, healthcare professionals are exposed to increased risks of contamination. The ESR urges national authorities and hospitals to respect, and implement, the recommendations of the European Centre for Disease Prevention and Control (ECDC) and of the WHO. As with other hospital units, medical imaging departments should be geared towards a temporary emergency situation that calls for tightened safety measures and adjusted working procedures.

3. CONTINUED DELIVERY OF CARE
For the medical imaging community, there is no doubt that, at present, governments should prioritize the fight against COVID-19 by implementing measures to contain the spread of the virus and to offer accurate care to infected patients. However, the ESR believes that a balanced approach is appropriate to reconcile urgent needs in relation to the COVID-19 crisis with the maintenance of access to high-quality and essential healthcare services for all patients.

4. AVAILABILITY OF IMAGING TECHNOLOGIES
Coordination should be increased in order to identify areas and hospitals in need of medical technologies throughout Europe. The ESR relies on governments to gather information on shortages, through national and EU mechanisms that involve industry, hospitals and healthcare providers, so that any emergency can be timely addressed.

5. CONTRIBUTION OF MEDICAL SOCIETIES TO HEALTHCARE SYSTEMS
As guardians of clinical practice and patient safety, medical societies will be indispensable for healthcare systems to recover and remain effective care providers after the COVID-19 pandemic. National authorities, the EU institutions and medical societies should jointly agree on a coordinated plan that acknowledges the contribution of medical societies to the delivery of healthcare,

6. A EUROPEAN APPROACH TO THE CRISIS
The crisis requires a common European approach that transcends national interests. The magnitude of the COVID-19 crisis illustrates how prevention and sharing best practices should top the list of priorities in EU health policies.

The ESR welcomes European Union initiatives to address pressing health needs in response to the crisis, and the rapid mobilisation of funds to mitigate the devastating impact on healthcare systems. Furthermore, we call on the EU institutions and Member States to act in a spirit of solidarity and collaboration, across borders and sectors, to face this unprecedented health and economic challenge.

TAKE-HOME MESSAGES
- While DNA testing is required for confirmation, medical imaging contributes to an accurate diagnosis of COVID-19 in the triage phase as well as for patients with severe respiratory symptoms or co-morbidities
- Healthcare professionals must have sufficient supplies of PPE and their working procedures should be adapted to the COVID-19 crisis
- Governments should adopt measures to ensure access to high-quality essential care for corona- and non-corona patients
- Imaging and other medical technologies should be prioritized, but the free circulation of medical goods should also be upheld
- The contribution of medical societies to education, clinical practice and research should be acknowledged and used to sustain the delivery of high-quality healthcare services
- The EU should immediately address pressing health needs and mobilise resources to increase the resilience of healthcare systems to future crises

The full text of the ESR position statement can be found at www.myesr.org/
COVID-RADS: a proposal for a COVID-19 imaging reporting and data system (COVID-RADS)

A recently published paper[1] proposes a comprehensive lexicon for the description of the imaging findings in COVID-19 disease and suggests a grading system and structured reporting format for CT findings, (COVID-RADS), analogous to other “RADS” systems in use in the imaging of other organs, e.g. BI-RADS in breast imaging, PI-RADS in prostate imaging, LI-RADS in liver imaging, etc.

ROLE OF CHEST CT AND ITS RELATIONSHIP WITH RT-PCR TESTING

As Salehi et al. point out [1], CT imaging plays a key role in the diagnosis, management and follow-up of COVID-19 patients. RT-PCR is the confirmatory test for the diagnosis of COVID-19 and has high specificity. Numerous studies have endorsed the important role of CT in the management of these patients.

“... a systematic review of the CT manifestations of COVID-19 ... showed a substantial inconsistency in the description of imaging findings across a number of previously published studies ...”

However, several scientific societies have recommended against the routine use of CT for the screening of COVID-19. This said, some countries have established the use of imaging as their frontline diagnostic test. In the vast majority of laboratory-confirmed patients, CT examinations yield a typical pattern; the sensitivity of the modality has been reported to be 97%. The diagnostic value of the CT imaging modality has been proven in clinically suspicious cases with inconclusive laboratory test results, as well as asymptomatic individuals with known exposure. In many healthcare settings, such as in developing countries, CT imaging may be the only available diagnostic test because of a shortage of diagnostic laboratory kits, while validated COVID-19 laboratory test kits are sometimes limited in quantity even in industrialized nations.

THE NEED FOR A UNIFORM LEXICON AND STANDARDIZED REPORTING SCHEME

Structured reporting systems simplify the interpretation and reporting of imaging examinations, serve as a framework for consistent generation of recommendations, and improve the quality of patient care. The authors carried out a systematic review of the CT manifestations of COVID-19 which showed a substantial inconsistency in the description of imaging findings across a number of published studies. Among the findings of this survey was the common use of several ambiguous and non-specific terms, such as fibrous stripes (or striped fibrosis), fibrotic streaks, lung fiber cord focus, vacuolar sign, bronchus distortion, patchy shadows, hazy opacities, patchy opacities, airspace disease, and interstitial disease. While cardiothoracic radiologists may be familiar with some of these terms, the present variability in lexicon may be confusing for other radiology sub-specialties and referring healthcare providers.

To ensure coherent and consistent communication between the healthcare providers, the development of a standardized reporting format and lexicon is essential. This will also be vital for ongoing clinical research, as well as an efficient organization of imaging data input for infectious disease registries.

METHODS

To produce the proposed COVID-RADS, the authors updated their systematic review on imaging findings in COVID-19 to include 37 published studies pertaining to diagnostic features of COVID-19 in chest CT. Using the reported imaging findings of 3647 patients, they summarized the typical chest CT findings, atypical features, and temporal changes of COVID-19 in chest CT. Subsequently, they extracted a list of descriptive terms and mapped it to the terminology that is commonly used in imaging literature.

They then composed a comprehensive lexicon that can be used for documentation and reporting of typical and atypical CT imaging findings in COVID-19 patients. Using the same data, the authors propose a grading system with five COVID-RADS categories. Each COVID-RADS grade corresponds to a low, moderate, or high level of suspicion for pulmonary involvement of COVID-19.

The proposed COVID-RADS and common lexicon should improve the communication of findings to other healthcare providers, thus facilitating the diagnosis and management of COVID-19 patients.

REFERENCE

Free clinical tutorial to help radiologists accurately diagnose COVID-19 cases faster from CT scans

New “CovED” clinical environment designed by clinicians for clinicians.

The Australian-based company DetectedX has developed a free virtual clinical educational tool that helps clinicians to become better at recognizing the early CT signs of COVID-19.

The system is available to every clinician, world-wide, free-of-charge and can be accessed via a simple registration process on the company’s URL (www.detectedx.com/)

As has now been proven, early diagnosis of COVID-19 is essential for optimal patient treatment and isolation. Lung CT scans have been shown to be a critical first tool for diagnosis of COVID-19. The number of patients suffering from this life-threatening illness is fast outpacing the numbers of skilled staff required to accurately diagnose the lung CT scans. In spite of all of the preventative measures being put in place, early detection of high-risk cases remains critical to keep the mortality rate to a minimum.

The new tool will help existing staff to accurately diagnose cases faster and it also provides rapid training of additional staff to quickly acquire CT interpretation skills which are required as the number of patients escalates rapidly especially in the developing world.

Known as DetectED-X - CovED, the powerful educational solution contains modules that takes between 1-2 hours to complete.

The system gains certification and CME points from the Accreditation Council for Continuing Medical Education in the US and elsewhere in the world and has been validated for assessing clinical performance.

IN PRACTICE
After registration and log-in, the participant then proceeds through a three-part process which typically takes 1-2 hours.

The three modules in the process are:

1) The participant is shown a series of approximately thirty CT lung images, with cases containing both COVID-19 features and others without COVID-19 features. The participant is invited to read and interpret the images.

2) A score is then generated which shows how good the participant is in the interpretation and correct diagnosis of the cases just evaluated.

3) The third module is then a review process in which the system shows on a case-by-case basis the comments made by the participant and compares these with the consensus opinions of the panel of experts. This review process allows the participant to understand the rationale behind the establishment by the experts of their consensus opinion.

PANEL OF EXPERTS
CovED was created through an international collaboration of experts in the field including Professor Stuart Grieve from the University of Sydney, respiratory radiologist Dr Sam McCormack from Alfred Imaging Group, Dr Nigel Sommerfeld CEO of Lungscreen Australia, Dr Paul Smith, a consultant radiologist at Epworth, Dr Marcus McMahon, radiologist with Epworth HealthCare, and Professor Greg Fox, respiratory clinician at Royal Prince Alfred Hospital, along with Italian partners, namely clinicians at the National Institute for Infectious Diseases in Rome Drs. Fabrizio and Cristofaro.

CovED follows on from the DetectEDx’s highly successful BREAST platform, which was created by the current team in 2010 at the University of Sydney and implemented across four continents. In 2019 the Australian government commissioned the team to deliver a similar solution for diagnosing dust disease using HRCT, so the company was in a unique position to rapidly deliver the new CovED platform.

INTRODUCTORY WEBINAR
GE Healthcare have sponsored an introductory webinar to the CovED system. In this webinar, Prof. P Brennan & Prof. S Grieve present CovED (from the University of Sydney start-up DetectED-X) and show how the world’s first virtual clinical environment can provide an intelligent education on COVID-19 appearances to radiologists across all developing and developed countries. The webinar can be viewed on GE’s GECARES website, accessible here.

GE Healthcare
SYDNEY, AUSTRALIA
https://www.detectedx.com/
**Reducing COVID-19 infection risk for radiology personnel**

To meet the challenges of COVID-19 the Department of Diagnostic and Interventional Radiology at Freiburg University Hospital (UKF) has since the end of March, been working with Siemens Healthineers on a joint project in the field of tele-imaging. Medical-technical radiology assistants (MTRAs) can now sit in a separate safe scanning room in the medical center or their home office and scan patients for MRI or CT examinations system in the radiology department, so they can reduce the frequency of contact with patients potentially infected with COVID-19.

Remote scanning is possible thanks to the syngo Virtual Cockpit software from Siemens Healthineers. The application is used to access the radiology systems via a secure network connection, adjust the MRI and CT settings, and perform the actual scans.

Medical professionals can use the syngo Virtual Cockpit software to access radiology systems via a secure network connection, adjust the settings of the MRI and CT systems, and perform the actual scans, thus minimizing the exposure of local personnel to bio-hazard risks such as COVID-19.

While scanning, they communicate with employees who are with the patient on-site using conference speakers and video.

“Two things are important for us here at Freiburg University Hospital right now: protecting our professional workforce from infection with COVID-19, and continuing to improve the quality of medicine in the hospital at the same time,” says Professor Frederik Wenz, Chief Medical Director at Freiburg University Hospital. “We therefore just began a very interesting project in our radiology clinic to deal with both challenges simultaneously. This is a perfect example of how we can use the current crisis to advance the digital transformation in healthcare and improve our quality of care.”

“Once the first stage of crisis preparation was in place, we quickly understood the potential that remote scanning offers,” explained Professor Fabian Bamberg, Medical Director, of the Department of Diagnostic and Interventional Radiology. “That was how we came to work with Siemens Healthineers to refine our original concept. We believe this will help us deal with a problem many radiology institutions face: How can we ensure and expand the increasing levels of quality and specialization needed in medical care, despite a shortage of qualified professionals in the field?”

In addition the remote scanning technology should make it possible to provide live assistance to new employees and also share special professional insights with them more easily. “At the University Hospital we’re able to offer our patients highly specialized examinations, which of course means that we need special knowledge to perform them,” Bamberg observes. “Now employees with less extensive experience can quickly and easily call on more experienced colleagues and receive support.”

Cornelia Walther, Senior MTRA at Freiburg University Hospital, highlights another application: “Right now, remote scanning lets us reduce the number of contacts with potential COVID-19 patients. But I can clearly imagine using this technology, for example, to assign staff to late or night shifts with more flexibility.” Remote scanning services could allow the work of MTRAs to be structured at a more decentralized level. That’s something that UKF and Siemens Healthineers want to investigate and further develop.

Remote scanning services enable radiology clinics and departments to call on remote support from additional MTRAs from Siemens Healthineers, for example. These employees, all with radiology training, will be located at the Siemens Healthineers Remote Service Center (RSC) in Erlangen. They’ll access the imaging systems via the Smart Remote Services (SRS) network and from there they can prepare and perform the scans using syngo Virtual Cockpit, depending on the legal regulations applicable in the country.

“Being able to set up workstations for remote scanning in such an incredibly short time was due to our close and excellent collaboration with Freiburg University Hospital,” comments Dr. Wolfgang Heimsch, President Customer Services at Siemens Healthineers. “In addition, we’ve now entered into an innovation partnership agreement under which we’ll develop a new kind of remote support for MRI scans: A remote scanning service that UKF can access from Siemens Healthineers when needed.”

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

**Using 3D Imaging software to spot COVID-19 symptoms**

The COVID-19 pandemic has been a grim education course for clinicians. Doctors and nurses have found themselves grappling with pneumonia, adverse immunological reactions and organ failure as well as a string of surprising symptoms, such as an impaired sense of smell, mental confusion and ‘COVID toe’. In all this, one important tool that’s vital for diagnosis is high quality medical imaging.

At the Morales Meseguer University Hospital in Murcia, Spain, clinicians are using digital radiography software called 3D tomosynthesis to instantly add a new dimension to chest X-rays: depth. The GE Healthcare-engineered application,
which can be installed on conventional digital X-ray machines, allows images of pneumonia-affected lungs to be browsed in 3D.

Dr. Jose Maria García Santos, head of radiology at Morales Meseguer, says the extra diagnostic ability and triaging speed allows clinicians to prioritize the hospital’s emergency care resources for the most critical patients, and send many more home to recuperate. “This 3D X-ray system has had a huge impact in terms of managing patients during this epidemic situation,” he explains.

Garcia Santos says 3D tomosynthesis sits between a traditional X-ray and a CT scan. In a conventional X-ray, radiation passes through the patient’s body, and generates a single, 2D grayscale image on the detector. In a CT, a cross-sectional view is generated.

The 3D tomosynthesis software works with a digital X-ray machine and acquires up to 60 successive images of the frontal region of the thorax and “collapses those images onto a single plane,” Garcia Santos explains. At a remote workstation, a clinician can then scroll through the slices from the front to the back of the chest.

This has been helpful during the pandemic. Clinicians want to measure the number and size of the characteristic COVID-19 lesions that lie just below the pleura. Such a cross-sectional study facilitates examination of any suspicious-looking feature and can uncover pneumonia-affected areas that might not show up clearly on a conventional 2D X-ray.

One such characteristic feature of COVID-19, is ground glass opacities that are hazy and difficult to see on chest X-ray. 3D tomosynthesis helps clinicians quickly identify such lesions. “This means it could be possible to isolate a patient earlier and so potentially avoid more infections,” said Santos.

The 3D X-ray procedure itself lasts just a few minutes, which is much quicker than CT. Patients undergoing a 3D X-ray also receive a much lower dose of radiation than in a CT scan. It is also much easier to sanitize an X-ray room and equipment than the larger gantry and table of a CT scanner.

3D tomosynthesis has allowed clinicians to find more suspicious lesions than conventional 2D techniques in COVID-19 patients at Morales Meseguer, said Garcia Santos. “That means pneumonia that would not have been clear in the X-ray.”

By equipping just one of the hospital’s six X-ray systems with 3D tomosynthesis software, the hospital has substantially eased the workload on the facility’s two CT scanners as well, smoothing the patient flow is crucial for the 450-bed hospital, which serves around 270,000 people. “Our way of managing patients is to try to avoid the emergency unit so as to avoid infection as much as possible,” Garcia Santos explains.

GE HEALTHCARE
CHICAGO, IL, USA
www.gehealthcare.com

Off-site radiology suites in converted shipping containers enhance patient/staff safety

Challenging times call for innovative solutions. So, when the healthcare personnel in the diagnosis and treatment of COVID-19 patients are at increased risk of contracting the disease themselves, maintaining a safe distance between staff and patients wherever possible becomes a necessity. Limiting the chance of cross-infection is especially important during triage, when infected and uninfected patients share the same diagnostic pathway.

With both CT and diagnostic X-Ray imaging currently playing an important role in assessing the pulmonary damage caused by COVID-19 — in some parts of the world also being used to triage suspected COVID-19 cases — the Philips team in the Philippines has come up with a novel solution to both meeting demand and keeping patients and staff as safe as possible. They are converting industrial shipping containers into CT and X-Ray imaging cabins which can then be located wherever they are needed – within hospitals, in hospital grounds, or out in the community.

The cabins are equipped with CT solutions such as Philips’
Access CT and Incisive CT, or diagnostic X-Ray solutions such as Philips’ DuraDiagnost and DuraDiagnost F30, configured to allow radiologists to perform diagnostic imaging procedures with minimal or no patient contact. Each cabin has an integral lead shield to reduce stray radiation, UV lamps to sterilize the workspace between use, and a laboratory-grade computer cubicle for the immediate analysis of results. The systems can also be linked into hospital IT networks so that radiologists can remotely view scans.

With laboratory-based COVID-19 tests typically taking up to 48 hours to complete, healthcare authorities in the Philippines are about to start using Philips’ new CT and X-Ray cabins to triage patients so they can be immediately isolated if their scan suggests they have COVID-19. In addition to supporting the response to the COVID-19 pandemic, the concept could also offer benefits in other situations – for example, in emergency rescue and disaster relief zones. For Philips’ CT and X-Ray cabins, putting everything inside the box is definitely an example of ‘outside-the-box’ thinking.

Philips has a comprehensive portfolio of services and solutions which can help to support the delivery of high-quality care to COVID-19 patients. It includes secure, connected and intelligent approaches to diagnosis, treatment and predictive monitoring in the hospital, plus screening, remote patient monitoring and care at home. For more information on how Philips is addressing COVID-19 globally, please visit the Philips COVID-19 hub.

Philips Healthcare
Amsterdam, The Netherlands
www.philips.com

COVID-19 specific configurations

Over the past few weeks, together with hospitals all over the globe, Agfa have been working to provide support in the fight against the COVID-19 outbreak, from supporting the set-up of remote reporting capabilities to configuring special radiology worklists, dedicated to COVID-19 cases. In the spirit of sharing the customer cases the company has published details of the COVID-19 configurations that can be used. These cover

- COVID-19 specific priority worklists;
- Faster reporting with COVID-19 drop-down menus and text macros;
- Remote and home reporting
- COVID-19 hanging protocols;
- Supporting triage of high-risk patients;
- Real-time collaboration across quarantine-lines;
- Balance the load – Image sharing across hospital networks and regions;
- Adding COVID-19 specific terminology to the speech recognition lexicon;
- Business Intelligence: using data to better measure, understand, predict;
- eLearning: 24/7 access to key knowledge.

More information available from
AGFA HEALTHCARE
MORTSEL BELGIUM
https://global.agfahealthcare.com/

Ensuring continued cancer diagnosis and treatment in times of COVID-19

During the COVID-19 pandemic, patients with cancer represent a high-risk group, with recent studies estimating that delays in cancer diagnosis and treatment will increase the indirect death toll, of COVID-19 by several thousands in the coming years.

Cancer care providers need to be able to provide less-demanding treatments, with fewer side effects and the potential for improved outcomes at lower costs. Radiation therapy is one of the few treatment modalities able to meet these demands.

COCIR — the European Coordination Committee of the Radiological, Electromedical and Healthcare IT industry — has issued a call for action to national governments and the European Commission in which COCIR urges them to acknowledge the importance of radiotherapy, particularly during these times of COVID-19. As the European Commission is currently developing “Europe’s Beating Cancer Plan”, it is important that this plan and those of Member States address this inequality of patient access to radiotherapy. This applies both to the availability of access to radiotherapy overall and to the modern equipment needed to deliver the newest treatments. With the focus on ensuring that cancer patients and their needs are not left behind, it is now time to radically rethink priorities and increase investment in modernizing radiotherapy capabilities.

The first short-term action must be to ensure that radiotherapy departments return to full capacity working and receive the required support to be able to do so. However, many of the challenges will require long-term sustainable solutions; to achieve these before it’s too late, it is essential to start immediately

COCIR
BRUSSELS, BELGIUM
www.cocir.org
Learning the lessons

Healthcare systems throughout the world have been shaken to the core by the dramatic impact of the COVID-19 pandemic. Although signs are now appearing that the pandemic can be controlled if and when appropriate measures are strictly applied, it is unlikely that hospital procedures will ever return to the “old normal” of the pre-COVID-19 age.

On the contrary, the pandemic has been the stimulus for irreversible sea-changes in the way hospitals are run, as can be seen particularly in a dramatic increase in the adoption of digital healthcare.

To find out more we spoke to Kees Wesdorp of Philips Healthcare who have been actively involved in the combat against COVID-19 and have investigated the likely long-term impacts of the pandemic.

Q Before we get on to the broader lessons to be drawn from the pandemic, how in practice has Philips faced up to the immediate healthcare crisis?

As a major healthcare provider we of course have had a role to play in support of our customers and healthcare professionals throughout the world. As the pandemic unfolded, it was apparent that the challenges facing different countries — and different areas in the same country — could be quite distinct. The situation in Bergamo was much more severe than in the rest of Italy, New York City was a hot-spot in the United States and Wuhan City in China had its own unique approach to handling the crisis. The common key to an efficient response to all these disparate situations is to carefully listen to the end-users in the front-line, to understand what is actually happening on the ground and so to be able to react appropriately to sometimes unique local critical care needs.

Many of our products play vital roles in the routine operation of healthcare establishments but ventilators and Point-of-Care Ultrasound systems are particularly relevant in meeting the COVID-19 challenge. In addition, chest CT, as well as mobile x-ray, has become one of the most effective tools for detecting early signs of COVID-19. Philips received many extra orders for CT scanners and mobile x-ray units from China and throughout the world; as a result we had to adjust production schedules to meet the demand.

However local critical needs are not just limited to medical equipment. Other needs that can be just as critical are for example the need to maximise patient safety in waiting rooms or the expanded use of IT systems to ensure that patients’ data can be delivered when needed to the relevant hospital. This is particularly true when the pre-crisis roles of hospitals may have been changed to allow focus on COVID-19 patients. Yet another local critical need that is now becoming more and more pressing is the ability to handle the back-log of elective non-COVID-19 care that has been put on hold at the peak of the crisis. At Philips we are of course always ready and willing to partner up with our customers, to face and solve these challenges together.

Q and what about the practical challenges in meeting these needs?

There were indeed real challenges. After all, in most cases the hospitals whose needs we were trying to satisfy were right slap in the middle of tight lock-down areas. In addition to the issues of how deliveries can be made to such confined areas, appropriate infection/de-contamination procedures had to be implemented. On top of all this we have to ensure that the appropriate, highly qualified technical personnel are needed to ensure optimal operation of sometimes sophisticated equipment are supplied with appropriate full personal protective suits.

Meeting these challenges was very strenuous, but one, perhaps unexpected, effect of meeting local COVID-19 needs on Philips personnel was that, without exception, everyone became highly motivated and really proud to be working for a company that was so clearly active in supporting the...
Of course digitalization has been around for some time, but transformation in healthcare. 19 experience is how it is inexorably accelerating the digital

The big lesson coming loud and clear out of the COVID-19 crisis is how they foresee operations in the future. Understand how they are coping at the moment but also, and more importantly, how they see the way healthcare establishments will have to operate in the future?

As with many human activities, it takes a disruption to break a habit. COVID is turning out to be the disruptor agent which will usher in much more widespread tele-radiology.

So the COVID-19 pandemic has already shown the need for urgent, rapid intervention at the front-line of urgent healthcare scenarios. But what about the more fundamental long-term implications that COVID will have for the way healthcare establishments will have to operate in the future?

And talking about remote access, what about remote reading of radiology images or teleradiology?

And talking about radiology, what’s the outlook for artificial intelligence in the reading of radiology images?

One huge change brought about by COVID-19 is that many radiologists, cardiologists, and oncologists were suddenly forced to work from home – creating an unprecedented need for home PACS workstations and secure clinical informatics solutions to allow them to read images remotely.

Proximity to peers and patients is one element in favor of retaining the radiologist in their hospital-based reading rooms. Proximity to peers and patients is one element in favor of retaining the radiologist in the hospital but the existence of powerful digital communication systems meant that there were already very few technological reasons to stop efficient tele-radiology and radiologists operating successfully from home. Despite this, in many cases radiologists preferred to stay in hospital reading rooms purely out of habit. As with many human activities, it takes a disruption to break a habit. COVID is turning out to be the disruptor agent which will usher in much more widespread tele-radiology.

Ever since the pandemic broke, we have made it a top priority to listen very carefully to all our end-users not only to understand how they are coping at the moment but also, and more importantly, how they foresee operations in the future. The big lesson coming loud and clear out of the COVID-19 experience is how it is inexorably accelerating the digital transformation in healthcare.

The requirements exposed by COVID-19 to keep patients safe and to personalize their care undoubtedly mean that digitalization will become more pervasive and vital than ever. There are several areas where such increased digital engagement is really appreciated by patients. One of these is digital platforms which, for appropriate indications, allow remote patient consultations to be carried out, i.e. without the need for the patient to be physically present. The advantages of the reduced risk of infection in such scenarios are clear, and with the use of ever-more powerful digital tools, the process is much more efficient — unrecognizable from the uninspiring old telephone calls that were once used for remote consultations. Nowadays with state-of-the-art technology, bandwidth is generally no longer an issue. The process can also be carried out in several dimensions, so images can be consulted. In addition, several persons can participate if required.

And talking about remote access, what about remote reading of radiology images or teleradiology?

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Interestingly, another recent survey among radiologists indicated that more than half of them saw enough benefit in their current remote COVID-19 workflows to actively consider continuing them post-COVID-19. With 65% of responding radiologists reporting decreased stress levels, there is a clear message that remote radiology reading could finally be a lasting change.

Again, it is true that tele-radiology systems were available pre-COVID, but in many hospitals radiologists preferred to stay in their hospital-based reading rooms. Proximity to peers and patients is one element in favor of retaining the radiologist in the hospital but the existence of powerful digital communication systems meant that there were already very few technological reasons to stop efficient tele-radiology and radiologists operating successfully from home. Despite this, in many cases radiologists preferred to stay in hospital reading rooms purely out of habit. As with many human activities, it takes a disruption to break a habit. COVID is turning out to be the disruptor agent which will usher in much more widespread tele-radiology.

And talking about radiology, what’s the outlook for artificial intelligence in the reading of radiology images?

In a word — indispensable. A few years ago, AI was considered by some people to be a hype but not any more. Rather than being...
considered as a threat to the continued existence of radiology as a profession, the sheer increase in radiology work-load means that more and more radiologists are coming to rely on AI as a helpful tool. AI is clearly here to say. One example is with COVID-19 where, in an effort to aid rapid diagnosis and patient monitoring, researchers around the globe are increasingly coming to rely on AI. In China, Philips partnered with Shukun Technology to jointly deploy an AI algorithm that, using a chest CT dataset can quickly identify and characterize any affected regions in the lungs, translating the scan into a report within 30 to 120 seconds. Used by more than 20 hospitals in China in over 20,000 patient cases, the AI algorithm can also help analyze patient scans over time, enabling physicians to monitor disease progression and to facilitate decisions on patient discharge after successful treatment. However it’s wrong to consider that AI’s role will be limited to reading images, flagging fields of interest or identifying incidental findings. The technology has the potential to go much further than just support in the interpretation of images. AI could provide opportunities in work-flow patient management optimization and clinical decision support.

**Q** With the need to resorb the back-log of postponed elective interventions caused by COVID-19, it is going to be more important than ever that hospitals become more efficient and cost-effective. What’s the outlook here?

Yes resorbing the back-log of postponed medical interventions in addition to dealing with the on-going routine work-load will be a major challenge. As a result of COVID-19, the need for greater efficiency and responsiveness has become even more urgent than it was pre-COVID-19. Some hospitals have reported an estimated 50-70% drop in imaging volume during the peak of the pandemic. Apart from the hit to the revenue income for the hospital, there is a drop in imaging volume during the peak of the pandemic. This means that radiology departments in particular will be tested to the limit as to how best to resume elective exams and procedures for patients with cancer, heart disease and other conditions, while continuing to provide on-going support for critical care of COVID-19 patients.

A linear approach to such back-logs that implies just progressively inserting postponed cases into the current work-load will only result in stretching out the waiting list. What is needed is to work smarter not just harder. One way this can be achieved is by standardizing pre-sets and protocols. For example, in an effort to support radiology staff with fast acquisition of CT scans, we developed CT chest protocols for suspected COVID-19 patients. With staff sometimes reduced to one technician to reduce risk of exposure to COVID-19, having a clear and easy-to-follow protocol to hand helps to promote consistent image quality for first-time-right diagnosis or reliable disease tracking over time. Similarly, our Lumify portable ultrasound system comes with tissue-specific presets that support the examination of specific organs such as the lungs or the heart – allowing clinicians to quickly obtain relevant images at the point of care.

In the same spirit, we are working with clinical partners around the world to adapt and expedite protocols in MR. For example, by incorporating an acceleration technique that shortens MR exams by up to 50%, radiology departments can scan more patients and alleviate some of the burden on staff who must deal with new, COVID-related standards of care and disinfection.

**Q** What about data sharing aspects in this “new digital normal”?

The potential for huge efficiency gains and improvements in patient care will only be realized if the patient data can always be accessible when needed, no matter where the patient is actually being examined or treated. For example, in the COVID-19 pandemic limited ICU capacity caused by the rapid outbreak of the virus prompted hospitals in many countries to transfer patients to hospitals outside of their own networks. This created an immediate need for seamless, secure sharing of medical information, while safeguarding patient privacy. In March, Philips collaborated with the Dutch government and two leading hospitals to create an online portal that connected 95% of all Dutch hospitals to enable digital exchange of COVID-19 patient data. We also continue to support healthcare IT leaders in other countries to build the necessary digital bridges, making it easier for overburdened networks to transfer patients to less impacted networks. It’s vital that we learn from this crisis in order to advance an agenda of greater interoperability and increased sharing of patient data. In all this, it goes without saying that patient privacy must be protected i.e. by respecting the spirit and the letter of the European GDPR and other appropriate regulations.

**MORE INFO**

To access clinical and technical information to help care for patients affected by COVID-19 visit www.philips.com
A collaborative meta-analysis of the clinical usefulness of coronary CT angiography – results from the COME-CCT Consortium

By Viktoria Wieske, MD & Marc Dewey, MD

Accumulated scientific evidence has shown the accuracy of coronary computed tomography angiography (CTA) for the diagnosis of coronary artery disease (CAD) in patients with stable chest pain and suspected CAD. Over the last two decades, there have been several clinical studies including a meta-analysis by Schuetz et al. [1] evaluating the potential of coronary CTA. However, so far, no collaborative meta-analysis has yet been carried out based on the exchange and analysis of individual patient data (IPD). We set up such a collaborative study, combining worldwide data and studies using IPD, with the aim of providing further data on the clinical usefulness of coronary CTA in the diagnosis of CAD in patients with stable chest pain.

In particular, we wanted to address key clinical questions, namely in which patient subgroup is coronary CTA indicated and how should the technology be best used to facilitate the implementation of coronary CTA guidelines.

METHODS
The Collaborative Meta-Analysis of Cardiac CT (COME-CCT) Consortium [2] is an international collaboration of researchers, all of whom have a cardiovascular imaging background including participation in prospective studies comparing coronary CTA with invasive coronary angiography (ICA) for the diagnosis of CAD in patients with stable chest pain. In the COME-CCT trial we collected individual patient data from 76 eligible studies involving 7813 patients from 22 countries in our worldwide database. The results of the COME-CCT IPD-meta analysis have recently been published [3]. A total of 5332 patients with stable chest pain and suspected CAD and who did not have coronary stents or bypasses were used in the main analysis. Pretest probability was evaluated using the updated Diamond and Forrester model as described in [4]; the model is based on the use of age, gender, and type of chest pain. This was followed by a calculation of the diagnostic accuracy of the CTA technique which was then supplemented by a calculation of the post-test probabilities. These data led to the determination of the positive and negative predictive values of CTA for different ranges of clinical pre-test probability.

Finally, we combined all three calculations with the corresponding pre-test probability range according to a no treat (<15%) or treat (>50%) threshold based on the post-test probabilities as introduced by the previous European guidelines [5].

RESULTS
A total of 5332 patients from 65 studies were included in the main analysis. Of the participants, 65% were male, the median age was 61 years and the prevalence of CAD was 48.3%. Compared with the gold standard technique of invasive coronary angiography (ICA), CTA showed good diagnostic accuracy with an area under the receiver-operating-characteristic curve of 0.897 (95% confidence interval, 0.889 to 0.906). Overall, it was found that CTA had an improved diagnostic performance in male patients and in patients of younger age. The diagnostic performance of CTA was also found

The Authors
Viktoria Wieske, MD & Marc Dewey, M.D.
Department of Radiology,
Charité - Universitätsmedizin Berlin, Charitéplatz 1, 10117 Berlin, Germany

Corresponding author:
M Dewey, (ORCID 0000-0002-4402-2733)
Email: dewey@charite.de
to be increased when the CT scanner being used for the imaging had more than 64 detector slices. By combining pre- and post-test probabilities with the negative and positive predictive values of CTA we showed that for patients with a pre-test probability range of 7-67%, we could establish a “no-treat” threshold (i.e. post-test probability of below 15%, so other reasons for the chest pain should be considered) and a “treat” threshold (post-test probability of above 50%, so subsequent ischemia testing is recommended).

**CONCLUSION AND OUTLOOK**

Against the background of many studies carried out over the last two decades comparing the diagnostic accuracy of CTA with that of ICA as the gold standard and also incorporating our recently published IPD meta-analysis, we have been able to provide additional information showing that the use of CTA should be focussed on stable chest pain patients with 7-67% pre-test probability range.

However, there is still no clear and especially no consistent implementation of the guidelines, neither within European countries nor worldwide. The recently published European guidelines [6] focus more on an evaluation of clinical likelihood as a continuum. Stratification using pre-test probabilities is completely absent in the relatively new UK NICE guidelines which recommend CTA being considered as a first line test for all patients with typical or atypical angina. Although this approach is interesting scientifically it also has significant implications from a purely practical point of view, including how such CTA diagnostic testing could be made sufficiently widely available in routine clinical practice. The NICE approach would, for example, greatly increase the need for certification of more radiology readers such as by their participation in cardiac CT “hands-on” courses.

In contrast, the use of individual calculation of pre-test probabilities could make precise diagnostic patient care much more feasible. However more evidence on long-term clinical outcomes is needed.

This was one of the objectives of the European multi-center DISCHARGE trial (www.dischargetrial.eu), which has only recently been completed [7]. Being carried out in 26 clinical sites DISCHARGE is a pragmatic randomised controlled trial, in which patients with suspected CAD are randomised to either ICA or CTA [7]. The primary study endpoint of the DISCHARGE trial was the number of major adverse cardiovascular events (MACE), defined as cardiovascular outcomes.
Clinical trial by setting one of the assessment in the DISCHARGE individual pre-test probability death, non-fatal myocardial infarction and non-fatal stroke. We included individual pre-test probability assessment in the DISCHARGE clinical trial by setting one of the inclusion criteria of the trial to require an intermediate pretest probability of the likelihood of CAD lying between 10-60%, which corresponds with the COME-CCT results described above.

Thus, analysis of the DISCHARGE data should enable us to answer the question whether CTA can and should be used in patients with stable chest pain who were referred to ICA but who had an intermediate pretest probability of the presence of CAD. This answer will be obtained not just through analyses of the incidence of MACE in the CTA and ICA groups but also through comparison of several secondary factors such as gender, procedural complications, cost-effectiveness and radiation dose exposure.

REFERENCES

Figure 3. Receiver operating characteristic curves of CTA for obstructive coronary artery disease, by subgroup and after excluding non-diagnostic examinations (NDX). Diagnostic performance results are shown for all patients versus results obtained after exclusion of non-diagnostic test results. The inclusion of all patients (top left panel) resulted in lower performance, which is a more accurate prediction of the real world performance to be expected. Thus, all subgroup comparisons in the other three panels are provided for all patients (including non-diagnostic examinations); diagnostic performance was higher in men and lower in patients older than 75, and angina pectoris types were not significantly associated with performance. Curves were generated by a generalised linear mixed model and predictions based on these models. Computations were performed with the statistical package R and packages lme4 and pROC. Areas under the curve were constructed by use of the observed data and model based predictions, which also included the random effects reflecting variability between studies and unobserved influential variables Image reproduced from ref [3], courtesy of BMJ.

Author disclosures
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Institutional master research agreements exist with Siemens, General Electric, Philips, and Canon. The terms of these arrangements are managed by the legal department of Charité – Universitätsmedizin Berlin. Professor Dewey holds a joint patent with Florian Michalek on dynamic perfusion analysis using fractal analysis (PCT/EP2016/071551).
A renowned Hungarian cardiovascular center describes their experience with a new CT scanner dedicated solely to cardiac imaging

One of the most eminent cardiovascular centers in Eastern Europe, The Heart and Vascular Center, Semmelweis University, in Budapest Hungary is an interventional cardiology center with substantial diagnostic capabilities. Throughout its 100-year history, the center has enjoyed a reputation not only for highest quality clinical care, but also for keeping abreast of the latest technological advances in the cardiac imaging and interventional fields. Recently the center acquired a CardioGraphe CT scanner from GE Healthcare — the CardioGraphe is the first CT system on the market that is solely dedicated to cardiac imaging.

We wanted to find out more about the work of the Center in general and their experience of the CardioGraphe in particular so we spoke to Dr. Adam Jermendy, cardiac radiologist in the center.

Q Before we get on to the CardioGraphe, please give us a bit of background to your unit and the patients you see.

Our institution essentially serves the capital Budapest and the surrounding counties, so covers a population of roughly three million people. From time to time we also see patients — usually more complicated cases — from further afield in the country. Since other centers in the region only started cardiac imaging program very recently, we have seen a large number of cases in the last couple of years. Most of the patients are referred to us for imaging from our own institute and from different outpatient clinics in Budapest, but smaller cardiac centers from the region also refer patients to us regularly.

Annually we scan around 3000 cardiac patients. On top of this we also provide general radiology services as well. We also take part in several multicenter imaging trials and our research group is involved in the evaluation of some of the very latest techniques such as on-site FFR, CT-perfusion or iterative reconstruction methods.

In our cath lab approximately 5000 invasive angiographies and 2700 coronary interventions are performed each year. Since non-invasive coronary assessment is a relatively new technique in Hungary, there are still a relatively high number of patients referred for invasive procedures who could have undergone CCTA. But with the growing number of cardiac-capable scanners around the country we expect this balance between invasive and non-invasive approaches to change in the near future. In our institute the demand for cardiac imaging is already very high.

Q To deal with these patients, what imaging modalities and equipment do you have?

In addition to the CardioGraphe, we have a Philips Brilliance iCT 256-slice scanner which we use for both general and cardiovascular imaging purposes. It’s a fast scanner that gives excellent quality images with good temporal and spatial resolution and is also very reliable. It was one of the first scanners in Hungary that was capable of coronary imaging. Our MRI system is a recently acquired Siemens Magnetom Aera 1.5T which is mainly used for cardiac examinations although we perform general studies with it as well. We have a total of 24 radiologists and cardiologists working in the imaging department together with 15 operators. The medical staff

Dr. Adam Jermendy is a cardiac radiologist at the Heart and Vascular Center, Semmelweis University, in Budapest Hungary.
email: adam.jermendy@gmail.com
consists of mostly young and ambitious doctors who benefit from the environment created by the director of the clinic Prof. Bela Merkely, whose philosophy was to make possible not only the practice of healthcare at the highest level but also to encourage participation in advanced research and teaching programs.

Q Since when have you had the GE CardioGraphe system?

We were one of the first two test sites for CardioGraphe in the world as part of a collaboration with Arineta, the company who originally developed the system and also with GE who now distribute it. Our CardioGraphe scanner was installed in December 2017. We participated in the R&D and evaluation of the scanner, giving continuous feedback to the engineers to help in the fine tuning of the system. The new scanner has a very small physical foot-print, which was a very important aspect for us, since our imaging department is already packed to bursting with equipment and is located in a relatively small building next to the main hospital facility, so we have little room for any expansion. In fact, the Cardiograph was installed in the place of one of our reading rooms. The installation itself went smoothly and once familiarization with the interface is achieved, there was no lengthy learning curve.

We tailor our acquisition settings individually for almost every patient, so easily customizable protocols are very important for us — the CardioGraphe completely meets our requirements in this regard.

Understandingly enough in the first couple of months there were some technical teething troubles, such as relative instability of the system. These issues were rapidly dealt with by the very competent and responsive engineering support team — after a few software updates the stability was significantly improved. A recent update has introduced bolus tracking which makes the workflow much easier.

Q When there is a reduction in physical size and cost of the system compared to “usual” high performance CT systems, it could be imagined that there will be some compromise on performance. Is this the case with the CardioGraphe?

For the vast majority of the patients we deal with we don’t see any such performance compromises, although the tube power is indeed a little lower compared to our other scanner, so obese patients and those with heavy calcification/stents can sometimes present challenges. The image quality was suboptimal in the beginning but the Arineta engineers successfully made a great effort to implement new filters and iterative reconstruction algorithms which improved the image quality. We are currently working on a new denoising algorithm that hopefully will be included in the next software update.

The CardioGraphe’s rotation time of 0.24 sec beats that of our Philips scanner which is 0.27 sec. This apparently small difference is actually huge in terms of motion artefacts — we see much less motion in our scans. And the 14 cm coverage allows us to scan the whole heart in one beat, thus eliminating step artefacts. Obviously

The Cardiographe - an accessible CT scanner designed specifically for high performance cardiac imaging

Developed to enable affordable and easy access to high performance cardiac imaging, the CardioGraphe has a very small foot-print of only 15 m².

Principal Technical features include:
- Unique Stereo CT technology. Two overlapping x-ray beams rotate around the patient in parallel trajectories, achieving excellent image quality and wide z-axis coverage with no need for two detectors.
- Focused field-of-view (FOV). CardioGraphe’s focused FOV of 250mm generates high-resolution images of the area of interest, while highly reducing radiation dose to peripheral anatomies compared to whole-body CT systems.
- Fast gantry rotation. The 0.24 second rotation speed with partial scan mode achieves excellent cardiac imaging, with a temporal resolution of 120 msec.
- Unique imaging chain hardware and Stereo CT reconstruction algorithm. Unique imaging chain and reconstruction technologies generate outstanding image quality.
- ASiR-CV. Integrated, advanced iterative reconstruction technology reduces noise and improves low-contrast detectability even at very low signal levels. This technology is designed to deliver reduced noise levels, improved low contrast detectability and may enable a reduction in dose for all clinical applications.
- Ultra-short gantry geometry. The ultra-short geometry makes efficient use of the x-ray sources.
- One-beat, high-definition, motion-free coronary images at any heart rate, with intelligent motion correction
- Comprehensive cardiac assessment for every patient – coronaries, structure & function
- Peripheral vascular imaging, from carotids to aorta, main pulmonary, renal and femoral arteries
- Whole organ acquisition for 4D imaging to visualize vascular flow, organ motion or kinetic properties
- SnapShot Freeze: algorithm to freeze coronary motion in high heart rate coronary CT exams to reduce motion blurring in vessels by up to a factor of six and improve effective temporal resolution accordingly.
these are also features that are very useful when we scan patients with high heart rates or arrhythmia. In these cases there is also the possibility of extending the padding for systole and diastole, while maintaining a reasonable radiation dose. Despite this possibility, we still use our standard beta-blocker administration regime for the general patient population, in order to achieve as low heart rates as possible, so as to reduce the radiation dose to as low a level as possible. Generally, our average effective radiation dose with the CardioGraphe is 30-40% lower than that of our other scanner.

Q How many patients have you now imaged using the CardioGraphe?

So far we have performed around 1400 coronary CTA scans and a couple hundred other vascular cases such as TAVI, carotid, aorta scans. At the beginning we were cautious and only scanned selected cases, but when we were gained more confidence with the improved image quality and technical stability, we gradually increased the patient numbers. Nowadays, with the system up and running at its full capacity we can perform around 50-60 coronary cases per week. I think outpatient centers with this number of cases, say 50 patients a week would definitely benefit from a dedicated scanner like the CardioGraphe.

Q Presumably one reason for the good temporal resolution is high gantry rotation speed, which in turn is facilitated from an engineering point of view by a narrow bore. Is the down-side of the narrow bore a difficulty in handling obese patients or those connected to cumbersome medical appliances?

In practice, we've never had any patient who couldn’t fit in the bore, and we have scanned many patients who had a BMI greater than 40. While technically it is always possible that a patient might be too large to fit in the bore, such obesity would mean that the image quality would inevitably be suboptimal, so the patient wouldn’t benefit from CCTA scanning in the first place. Thus I feel that in practice the bore size is not a real issue. On the other hand, for example a patient on mechanical ventilation with multiple perfusor pumps could present some handling problems. However it should be remembered that the new scanner is mainly intended to serve outpatient centers rather than emergency departments.

Q What are the principal indications you use the CardioGraphe for? How do you decide which cases should be imaged on the CardioGraphe and which on high-end general use CT systems?

The principal indications cover a broad spectrum of applications. We carry out examinations not only of cases of suspected coronary artery disease, but also stent and bypass graft follow-ups, heart transplant patients for allograft vasculopathy assessment, congenital heart disease patients and structural intervention planning. In addition, a large percentage of our scans are carried out for Electrophysiology (EP) planning, — the clinicians love the fact that we can rule out significant CAD and left atrial appendage thrombus in one setting, thus sometimes saving the patient from further testing.

Nowadays, we try to handle every cardiac case on the CardioGraphe. However, in cases where we need a large field of view, for example an additional lung scan, we choose the Philips scanner. CardioGraphe has a 25 cm FOV, which, while fine for the heart is not enough to encompass the full chest for most patients.

Q The guidelines in some countries recommend cardiac CT as the first-line test for the evaluation of stable CAD in chest pain pathways. What’s the situation in Hungary?

For patients with suspected coronary artery disease, we try to comply with ESC guidelines, so more and more CCTAs are performed for the work-up of cases of stable CAD. This trend is especially true for major cardiac centers in large cities like our institute. However, Hungary as a whole is far from ideal in this respect, since our country lacks the sufficient number of scanners necessary to be able to routinely consider the CCTA modality as a real-life gatekeeper determining access to the cath lab. The overall trend towards this goal is positive, but we still need time for our infrastructure to reach the ideal level.
of some western European countries. Nevertheless, recent studies and guidelines that confirmed the central role of CCTA should encourage health care executives to invest in the modality. Hopefully in the future we will be able to further improve patient management and outcomes with the extended use of cardiac imaging in Hungary.

**Q** What about CT-derived FFR, which notoriously requires a high level of image quality for calculation of the parameter?

Up till now we have only used CT-derived Fractional Flow Reserve (CT-FFR) in the context of clinical trials in which we have an ongoing collaboration with HeartFlow, and they regularly analyze our images. HeartFlow is the US-based company that is the only one to have had its advanced CT-FFR software approved by the FDA. In practice CCTA images are sent to HeartFlow who use their advanced algorithms to calculate and return the calculated CT-FFR values. These have been shown to correlate well with what has been up till now the standard method for calculating FFR, namely the wire-based pressure measurement system, which is of course invasive. The reliability of the CT-FFR calculated from CCTA depends on the quality of the images submitted — images that are not of good quality will be rejected without any calculations being attempted. According to HeartFlow, the quality of the images produced by the CardioGraphe are among the best in the field for FFR determination. CT-FFR and CT-perfusion will definitely be the main focus as regards developments in CT over the next couple of years.

**Q** So, all-in all, what’s your opinion of the CardioGraphe?

My opinion of CardioGraphe is absolutely positive. In particular, the constantly improving image quality, the large coverage and fast rotation time make it a robust clinical tool in cardiac imaging. Being a dedicated scanner there are only a limited types of scans you can perform with it so the lack of a general purpose ability could be considered a drawback. But it should be remembered that the system is not intended for any use other than cardiovascular imaging — if it is a general workhorse that is required there are plenty of other scanners on the market to choose from.

For a dedicated cardiovascular program this scanner is an excellent choice. In the future we hope to further improve image quality and an additional objective is to develop the possibility of performing CT-perfusion examinations with the CardioGraphe. CT-FFR and CT-perfusion will definitely be the main focus as regards developments in CT over the next couple of years.

**Q** Finally an unrelated but topical question. What has been the effect of the COVID-19 pandemic on your institute?

Because of “lock-down” constraints imposed by the current COVID-19 situation, many patients in most countries in Europe haven’t been able to keep their appointments for follow-up radiology examinations. Fortunately in Hungary our lockdown came very early compared to some other European countries and the Hungarian people in general were very disciplined and took all the proposed preventative measures very seriously. This resulted in what could be described as only a mild pandemic with a generally modest number of cases that required hospitalization. Our health care system was challenged, but not overwhelmed. The big COVID-19 rush we had been expecting never came, and the biggest problem we now face is the number of patients whose care was put on hold — in our case many cancelled cardiac CT appointments. The Hungarian government and health authorities banned all non life-threatening care for a month and a half, and most of our cardiac program was included. Now that this ban has been lifted, we are faced with a significantly increased number of requests for scans. We have to take care that our imaging department doesn’t get overwhelmed — but this is still a much better scenario than what it could have been if COVID-19 had hit us harder.
The role of iodine in cardiovascular CT: Options for radiation & contrast dose reduction

Computed Tomography (CT) is today the diagnostic imaging modality of choice among radiologists to evaluate the cardiovascular system. Its ease-of-use, accessibility, cost-effectiveness and high diagnostic accuracy make CT invaluable for numerous cardiovascular applications. The rapid technological development of CT and its suitability for disease conditions that affect significant proportions of adult and pediatric subjects has led a dramatic increase in the worldwide utilization of cardiovascular CT over recent years [1]. The latest international guidelines will certainly increase the use of CT in the management of coronary artery disease [2].

Unfortunately, as with all CT examinations, cardiovascular CT requires the use of ionizing radiation and the increased utilization of CT in routine practice is inextricably associated with increased patient exposure to ionizing radiation [3-6] and, ultimately, to a greater long-term risk of radiation-induced cancer [7-9]. Moreover, cardiovascular CT inevitably requires the use of iodinated contrast media which may potentially increase the risk of contrast-induced nephropathy / contrast-induced acute kidney injury (CIN / CI-AKI) in certain predisposed patients [10].

As illustrated in Figure 1 the potential risks to health from routine CT examinations vary with the age of the patient. In younger patients the radiation dose is far more of a concern than possible risks associated with administered CM. Younger patients have a much longer life-expectancy and thus the risks of radiation-induced cancer are far greater than in elderly patients whose extended life expectancy is considerably shorter. If CT examinations are required for pediatric patients the focus should therefore be on acquiring optimal images with the lowest radiation dose possible to prevent unnecessary radiation exposure, as recently recommended by the Filiale de Cardiologie Pédiatrique et Congénitale (French Society of Pediatric and Congenital Cardiology; FCPC) and the Société Française d’Imagerie Cardiaque et Vasculaire diagnostique et interventionnelle (French Society of Diagnostic and Interventional Cardiovascular Imaging); SFICV) [11]. Importantly, in the absence of known renal failure there does not appear to be an increased risk of developing renal toxicity among neonates given standard doses of iodinated CM despite their comparatively under-developed renal function [12]. Conversely, elderly patients are much more likely to have reduced renal function and thus the risk of CIN / CI-AKI is potentially a greater concern than the excess lifetime risk of radiation-related cancer. Although recent studies suggest that CIN / CI-AKI may be less of an issue than previously thought [13, 14], the focus of the CT examination in elderly patients may nevertheless be on acquiring optimal images with the lowest CM dose and the lowest possible volume of administered CM particularly in patients at increased risk (i.e. patients with eGFR <30 ml/min/1.73 m²) while at the same time looking to minimize radiation exposure as much as possible [15]. Tailoring the CT examination to the individual needs of the patient is therefore increasingly important to minimize potential risks to patient health.

IMPACT OF IODINE CONCENTRATION ON CONTRAST AND RADIATION DOSE REDUCTION

Numerous technological innovations such as customized tube current (mA) and tube voltage (kV) modulation and iterative reconstruction (IT) are widely incorporated into CT protocols to help lower the radiation dose delivered to patients. Less widely appreciated is the potential role of iodine in further lowering radiation dose when administered in combination with established dose reduction protocols [16]. As regards contrast dose reduction, since the attenuation of iodine increases at lower kVp (down to the k-edge of iodine at 33 keV) fewer iodinated molecules are needed to achieve...
adequate attenuation at low kVp (e.g. 80 kVp) meaning that the dose of CM can be reduced when CM dose reduction is considered important. There are essentially two approaches to reducing the dose of CM (i.e. number of iodinated molecules) to maintain adequate contrast attenuation at lower kVp, one approach involving use of a CM with a low/medium concentration of iodine (e.g. 300-350 mgI/mL) and the other involving use of a smaller volume of a CM with a high concentration of iodine (e.g. 400 mgI/mL). A drawback of using a CM with a lower concentration of iodine is that the requisite number of iodine molecules are formulated in a larger volume. At a given injection rate this results in a longer contrast bolus which leads to a greater cardiac pre-load and the possibility of artifacts involving the right cardiac chambers and SVC. Moreover, a larger injection volume and longer contrast bolus means that a part of the CM volume does not contribute to the enhancement and is thus, essentially, wasted, particularly when faster CT scanners are used with rapid scan acquisition times. Although a faster injection rate can help to shorten the contrast bolus, faster injection rates may not be feasible in very young patients with small veins or older, more frail patients with poor venous access and more fragile veins.

The alternative approach is to use a higher concentration of iodine in which the equivalent number of iodine molecules are formulated in a smaller volume. The principal advantage of a higher iodine concentration at equivalent injection rate is that the iodine delivery rate (g Iodine/s) is greater resulting in a shorter, sharper contrast bolus with more CM in the acquisition window (i.e. less waste). Applied kVp meaning that radiation dose reduction is feasible also when higher kVp protocols are unavoidable such as in CT of obese patients.

Although low kVp protocols are increasingly utilized in routine practice for those patients where low kVp is feasible, a potential drawback of CT examinations at low kVp is that the image noise is inherently increased due to the lower number and, to a lesser extent, energy of photons delivered. Although the iodine attenuation is also increased at low kVp, the signal-to-noise ratio (SNR) is invariably reduced relative to that at higher kVp assuming no compensatory increases in tube current (mA) and no confounding issues related to patient size. A reduced SNR might potentially impact assessment of small vessels and structures resulting in reduced diagnostic performance. To offset the greater image noise and reduced resolution at low kVp a compensatory increase in effective mAs is typically required to maintain adequate SNR. Unfortunately, mAs is directly proportional to the number of the delivered photons and thus to the radiation dose delivered, thereby potentially resulting in increased radiation exposure. The value of high concentration CM in this setting is in providing greater signal enhancement during image acquisition (due to the shorter, sharper CM bolus with more iodine molecules in the acquisition window). The greater signal enhancement achievable with high concentration CM at equivalent (or reduced) iodine dose at low kVp offsets the inherently increased image noise to maintain the SNR constant. This means that a lower mAs can be maintained and that the effective radiation dose is reduced [16].

Confirmation of the benefits of higher iodine concentration CM in reducing radiation exposure in routine practice has been demonstrated by Sun et al. [17] who compared equivalent (22.8 g) doses of low and high concentrations of CM at 100 kV in patients undergoing coronary CTA.

In group A patients received 76 mL of a 300 mg I/mL formulation (iopromide-300; Bayer) while in group B patients received 57 mL of a 400 mg I/mL formulation (Iomeron-400; Bracco). The injection rate (5.0 mL/s) was the same for both groups resulting in an iodine delivery rate of 1.5 g Iodine/s for group A and 2.0 g Iodine/s for group B. The greater signal enhancement achieved in group B enabled a reduction of the effective mAs from 236 ± 52.8 in group A to 157.3 ± 39.2 in group B resulting in an overall reduction of effective radiation dose from 4.5 ± 1.2 mSv in group A to 2.6 ± 0.8 mSv in group B (a mean effective radiation dose reduction of 42%; p<0.0001). Although the image noise was higher for patients in group B due to the reduced mAs, this was offset by the gain in signal enhancement which resulted in maintained SNR and image quality [17].

## IMPACT OF HIGH IODINE CONCENTRATION ON CONTRAST DOSE REDUCTION

The second practical benefit of a CM with higher iodine concentration is that the time for injection and overall contrast dose can be reduced. As demonstrated in Figure 2, 80 mL of a CM containing 300 mgI/mL (i.e. 24g) injected at 4 mL/s would require an injection time of 20s (A). In this case iodine would be delivered at an IDR of 1.2 gI/s. Conversely, if a CM containing 400 mgI/mL were injected at the same rate (4 mL/s), only 60 mL would be required to administer the same dose (24g) and the overall injection time...
would be reduced to 15s (B). In this case iodine would be delivered at a higher IDR of 1.6 gI/s giving a shorter, sharper bolus which might be more practical for more modern scanners with rapid scan times. The greater enhancement obtained due to the shorter, sharper bolus derived from the higher IDR can then be utilized either to compensate for increased noise when radiation dose reduction is the primary focus of the examination, or to permit a reduction of the CM dose when CM dose reduction is considered necessary. In this latter setting, the higher IDR achievable with the higher concentration of iodine more easily permits a lowering of the total volume and thus dose of CM administered and a further shortening of the total injection time (C) without impacting the IDR and targeted peak enhancement.

**SUMMARY**

In summary, a CM with a higher concentration of iodine (i.e. 400 mgI/mL) offers greater flexibility for all CT applications and, in particular, for cardiovascular applications. The greater IDR achievable with high concentration CM means that contrast injection parameters (i.e. flow rate, volume) can be more easily adjusted to suit the specific needs of individual patients. Thus, lower flow rates and volumes can be utilized more readily in pediatric patients with small veins and in older, frailer patients with possibly poor venous access without impacting contrast enhancement relative to that achieved with larger volumes of lower concentration CM administered at higher flow rates. Importantly, the higher contrast attenuation achievable at equivalent injection rate can be utilized to further reduce radiation dose and/or to reduce the contrast dose. The benefits of a higher iodine concentration and shorter contrast bolus are particularly relevant for newer, faster scanners.

**REFERENCES**

Prognostic impact of baseline and follow-up CMR scans in acute myocarditis: evidence from a prospective multicentre Italian study (ITAMY trial)

By Dr. GD Aquaro & Dr. C Grigoratos

Cardiac magnetic resonance (CMR) is nowadays considered as the gold standard, non-invasive imaging technique for the diagnosis of acute myocarditis (AM) [1]. The main strength of CMR is its ability not only to detect non-ischemic myocardial damage associated with AM but also to assess its localization, extent, [2] and occasional pericardial involvement [3]. Moreover, CMR may offer a method for differential diagnosis with respect to other ischemic or non-ischemic causes of cardiac damage such as myocardial infarction with normal coronary arteries (MINOCA) [4]. For these reasons and in order to obtain a definite diagnosis, CMR is usually performed within the first 7-10 days after presentation of symptoms.

In the clinical setting, after a CMR diagnosis of AM has been established, a follow-up scan is considered appropriate in order to monitor the evolution of the myocardium and to document any resolution of signs of acute damage such as myocardial edema/hyperemia as well as to evaluate myocardial systolic function. Usually the follow-up scan is carried out approximately six months after symptom onset but up until recently there was only limited scientific evidence available regarding the real clinical significance of such repeat CMR exams.

Last year a number of AM studies provided additional evidence of the diagnostic and — more importantly — the prognostic importance of CMR. The presence of late gadolinium enhancement (LGE) was found to indicate poorer prognosis in a large series of patients with AM and preserved left ventricular ejection fraction (LVEF), especially when the LGE was located in the midwall layer of the interventricular septum [5]. LGE is universally accepted as a marker of definitive damage representing reparative fibrosis of irreversible myocardial damage [6]. However this dogma has for some time been questioned in the acute setting and specifically in the context of AM. By repeating CMR six months after the first diagnosis, Mahrholdt et al. [7] reported a complete disappearance of LGE in 26% of patients. This may suggest that LGE is not necessarily only a marker of myocardial fibrosis but rather could also be associated with acute inflammation, which after a few months may disappear completely in a number of patients.

In a recent publication from our group, we sought to examine the evolution of CMR signs of myocardial damage in detail and to investigate their clinical and prognostic significance in the acute setting of patients with AM and who had a follow-up CMR scan [8]. This study was the continuation of the ITAMY (ITAlian study in MYocarditis) multicenter investigation on the prognostic value of CMR in AM [5].

STUDY DESIGN

A total of 200 consecutive patients were enrolled from 2008 to 2014. The patients were all clinically suspected of having AM, i.e. were either symptomatic patients with pericarditic or pseudoischemic chest pain fulfilling one or more diagnostic criteria (new electrocardiogram modification, elevated troponin, wall motion abnormalities with preserved LVEF on echocardiography) or were asymptomatic patients with two or more of the diagnostic criteria. All patients had preserved LVEF.

A definite diagnosis of AM was made when two or more of the original CMR Lake Louise criteria (myocardial edema, hyperemia, and LGE) were present [9]. Endomyocardial biopsy was performed in cases where the CMR was inconclusive; the absence of obstructive coronary artery disease was verified by coronary artery angiography in all patients greater
than 30 years of age. A follow-up CMR examination was performed six months (median 177 days) after the first exam.

The population we studied involved 187 patients (82 men, mean age 33 ± 13 years). Scans were interpreted by three CMR experts blinded to the clinical data. LV global and regional function on bSSFP images, myocardial edema on T2-weighted images, and LGE on post-contrast T1-weighted GRE images were assessed both in the baseline and follow-up CMR scans. Myocardial hyperemia was evaluated as previously reported [10] using post-contrast cine-SSFP images. Clinical follow-up of all enrolled patients was carried out for a median time of 7 years. During the follow-up, the occurrence of several major events was recorded. These were: cardiac death; resuscitated cardiac arrest; ventricular assist device implantation; transplantation; and appropriate implantable cardioverter defibrillator (ICD) shock.

RESULTS

The main findings of our study were that at six months, myocardial edema had resolved in the majority of patients (84%), and complete healing with absence of edema and LGE, was seen in 11% of patients [Figure 1]. Moreover, LGE had disappeared completely in 10% of the patients, and the extent of LGE, as measured by the number of myocardial segments involved, decreased in almost half of the patients, remained unchanged in 30%, and increased in 14% of the patients. Surprisingly, patients with LGE but without edema had a poorer prognosis than those with LGE and persistent edema. Likewise those patients with an increased extent of LGE at follow-up CMR had a poorer prognosis than those with an unchanged/decreased extent of LGE.

“... in AM cases with evidence of edema, LGE should not be considered as a sign of irreversible myocardial damage....”

Finally, midwall septal LGE and LGE without edema were independent predictors of cardiac events.

DISCUSSION

In interpreting these findings, we may speculate that LGE in AM is not necessarily due only to irreversible damage. A possible alternative explanation may be that LGE is caused by various conditions such as replacement fibrosis, edema, and protein overload (amyloidosis) that enlarge the interstitial space and consequently increase the volume in which gadolinium is distributed in the myocardium, thus causing a much slower wash-out rate [11]. The interstitial space could be increased not only by fibrosis but also by edema and inflammatory cell infiltration. Gadolinium contrast agents cannot enter into healthy and intact cells. However when macrophages phagocytize necrotic myocytes, then interstitial fluids containing gadolinium might in this way be incorporated into phagosomes.

Furthermore, inflammatory cells may obstruct lymphatic vessels, so slowing the wash-out of gadolinium from the interstitial space and participating in the creation of interstitial edema. For these and other reasons, it appears that, in AM cases with evidence of edema, LGE should not be considered as a sign of irreversible myocardial damage. This is emphasized by the finding that in some patients LGE actually disappears after six months.

The observation that in 14% of AM patients LGE increased, thus indicating a poorer survival rate, can be due to myocardial damage that had continued as the result of an autoimmune response or multiple relapse of myocarditis and can be associated with disease progression and worse outcome. Edema detected by CMR is only the “tip of the iceberg” in the inflammation process, and we postulate that in the chronic phase of AM, the autoimmune response might continue to induce myocardial injury albeit with slower progression and less aggressiveness than it does in the acute phase. In the chronic phase of AM, traditional CMR may not be sufficiently sensitive to...
In conclusion, we may say that patients with AM and preserved LVEF, LGE should not be interpreted as necessarily indicating definitive fibrosis when edema is also observed, since the LGE disappears during follow-up in a considerable number of patients. CMR should be performed in all patients where there is a clinical suspicion of AM and, when positive, CMR should be repeated at six months after symptom onset in order to assess the evolution of the signs of myocarditis. The presence of isolated LGE without edema six months after symptom onset is associated with a poorer prognosis, particularly when it involves the midwall layer of the interventricular septum. LGE without edema is to be considered as evidence of irreversible damage due to reparative fibrosis, whereas the persistence of edema, found in approximately one-third of patients, is a marker of ongoing inflammation and could be associated with a residual chance of complete recovery.

**CONCLUSION**

In conclusion we may say that patients with AM and preserved LVEF, LGE should not be interpreted as necessarily indicating definitive fibrosis when edema is also observed, since the LGE disappears during follow-up in a considerable number of patients. CMR should be performed in all patients where there is a clinical suspicion of AM and, when positive, CMR should be repeated at six months after symptom onset in order to assess the evolution of the signs of myocarditis. The presence of isolated LGE without edema six months after symptom onset is associated with a poorer prognosis, particularly when it involves the midwall layer of the interventricular septum. LGE without edema is to be considered as evidence of irreversible damage due to reparative fibrosis, whereas the persistence of edema, found in approximately one-third of patients, is a marker of ongoing inflammation and could be associated with a residual chance of complete recovery.

**FUTURE PROSPECTS**

In the future, studies should address and confirm our findings by the use of novel CMR sequences, mainly parametric imaging, in order to characterize the evolution and prognostic value of native T1 and T2 extracellular volume mapping in patients with acute myocarditis.

**REFERENCES**

SPECT perfusion or CT angiography for chest pain patients with prior CABG? Resource and cost considerations

By A Chow & Dr. G.R. Small

INTRODUCTION
On a global scale coronary artery disease (CAD) remains the number one cause of death accounting for 8-9 million casualties every year [1]. Much has been done in recent years to reduce these startling figures: from the introduction of rapid assessment centres, coronary intervention in acute coronary syndromes and improvements in ischemic heart failure therapy, rehabilitation and prevention [2]. It is not surprising therefore that the health care demands of CAD are sizable from the point of view of both financial costs and resource utilization. The annual cost of evaluating chest pain in the US has been estimated at $10 billion [3] with over 4 million non-invasive tests performed yearly to investigate chest pain [4]. Identification of the optimal testing strategy has been the source of several high-profile research studies [5-7]. These studies compared functional investigation versus coronary computed tomography angiography (CCTA). However, they have an important deficiency in as much as they have largely chosen to exclude patients with previous coronary artery revascularization.

Coronary artery bypass surgery is one of the most common major surgeries performed in the US with 340,000 cases operated annually [8]. In Europe the figure is similar to this with between 258000 - 282000 surgeries per year [9]. International guidelines [2, 10-12] have determined that functional imaging is appropriate as a first line test in symptomatic patients with established CAD. Functional imaging does however have limitations in the CABG population and may not readily distinguish between native and graft disease [13, 14] [Figure 1].

Alternatively there is an argument for considering non-invasive anatomical assessment with CCTA in CABG patients. CCTA has well validated and reproducible diagnostic and prognostic utility in CABG patients [15-18] [Figure 2]. Investigators have demonstrated the utility of CCTA to readily identify graft disease and have developed prognostic tools such as the “unprotected coronary territory” algorithm to help risk stratify post CABG.

Thus, comparative data for CCTA versus SPECT in the post CABG population would help fill the gap in knowledge for this important health care need. Such data would also be useful to inform CAD guidelines and clinical practice. We sought to redress the absence of data in symptomatic CABG patients by examining downstream testing and costs in a local data base of 23,553 patients following either SPECT or CCTA [19].

STUDY DESIGN AND METHODS
Subjects with prior CABG were identified retrospectively from 23,553 patients that had undergone SPECT (17,000) or CCTA (6553) from January 2006 – July 2013. Subsequent downstream testing (invasive coronary angiography (ICA), SPECT, CCTA, position emission tomography (PET) and/or stress echocardiography) was captured using electronic record interrogation. Revascularization (percutaneous coronary intervention (PCI) or redo-CABG) was also recorded. In order to align the groups for comparison and decrease the possible impact of selection bias, a propensity adjustment was performed.

RESULTS
2754 CABG patients had non-invasive
testing for established CAD during the study period. A total of 591 CCTA patients and 2163 SPECT patients. The baseline characteristics differed between each cohort [Table 1]. SPECT patients were older, had lower BMI, and were less likely to smoke. The CCTA cohort presented with greater symptoms of chest pain and dyspnea, and dyslipidaemia. A propensity adjustment was performed to compensate for the differences of BMI, age, smoking status, presence of dyslipidaemia, diabetes and symptoms between cohorts.

DOWNSTREAM TESTING
15.4% (425) of total patients underwent downstream investigations, with the number of CCTA patients (23.2%) being significantly higher than SPECT (13.3%). 7.8% of total patients required multiple downstream tests; but there was no significant difference in the number requiring multiple tests between CCTA and SPECT cohorts. There was no interaction between the propensity adjustment and modality (CCTA versus SPECT) [Figure 3].

Invasive Coronary angiography
ICA was almost twice as common after CCTA (18.9%) than SPECT (9.9%). The increase seen in ICA post CCTA was the dominant cause of the dramatic increase in downstream testing with CCTA.

Redo-revascularization
Repeat revascularization rates were low in comparison to the number of patients initially tested: revascularization occurred in only 174 of 2754 patients (6.3%). Revascularization occurred more frequently after CCTA (12.0%) versus SPECT (4.7%). Redo-CABG was low in both groups, while PCI was more frequent after CCTA (11.5%), compared to SPECT (4.6%).

Monetary impact of increased resource utilization
The total costs for downstream testing was half a million US dollars ($578,745) or half a million Euros (€520,696) when calculated using the US Medicare system. These costs did not include additional hidden expenses from physician office visits, nursing care, and routine blood tests that might be expected with ICA and revascularization [Figure 4].
If downstream testing was costed per modality, CCTA resulted in greater financial expenditure versus SPECT. Since CCTA provoked twice as many investigations it is not surprising that the costs for these tests were two fold higher than downstream costs post SPECT. ($366.8±/25.6 versus $167.4±/10.1 p<0.001). Hidden in this analysis is however the expense of the index test itself.
When the cost of the index test (SPECT versus CCTA) was included in the analysis the results were reversed. With inclusion of the initial imaging test, the cohort SPECT was seen to be the more expensive than the CCTA group. Mean cost per patient was $765 for CCTA versus $1397 for SPECT. In this analysis SPECT was seen to be twice as expensive as SPECT in CABG patients [Figure 2].

Figure 1. Myocardial perfusion study in a CABG patient
A 65 years old male had undergone CABG 7 years previously (Left internal mammary artery (LITA) pedicled graft to distal LAD, Saphenous vein grafts (SVG) to LCx and RCA). He presented with recurrence of angina. A dipyridamole stress-rest 99m Tc-Tetrofosmin SPECT was performed. There are basal to mid inferior-lateral and inferior reductions in tracer uptake on the stress images (solid white arrow). In addition, there is a basal anterior-septal reduction in tracer uptake on the stress images (broken white arrow). On rest images both areas show mild improvement in tracer uptake. This is consistent with non-transmural scar and mild ischemia in the LAD and LCx/RCA territories. The LAD ischemia would be in keeping with progression of native vessel disease since the distal LAD territory is non-ischemic implying the LITA to distal LAD is patient. Determining whether the LCx/ RCA ischemia is due to native or graft disease is less certain.

A coronary angiogram demonstrated severe proximal and mid LAD disease with a patent LITA to distal LAD. The mid RCA was occluded but there was a patent SVG to the distal RCA. The native LCx had severe proximal and mid stenosis and occluded SVG to OM2. The patient underwent successful PCI to proximal and mid LCx with relief of symptoms. Medical management was pursued for the basal-LAD ischemia.

Figure 2. Coronary and graft CT angiogram. A 70 years old male with prior CABG in 2010. The patient re-presented with angina. CT angiography demonstrated severe native three vessel disease. Patent LITA to LAD (not shown). Occluded SVG to RCA (A), 50-60% stenosis in SVG to OM2 (B and C). The patient underwent double vessel stenting to native RCA and to SVG-OM2 with relief of symptoms.
CARDIOVASCULAR IMAGING

DISCUSSION

The study presents novel, exploratory data comparing functional imaging versus anatomical assessment in symptomatic CABB patients. The findings raise controversial discussion points concerning the impact of an index test in terms of resource utilization and financial costs. Our data begin to address an expanding health care need and expense hitherto largely ignored by current CAD trials.

If close to 1.67 million people a year receive bypass surgery in Western societies alone, the implications for health care expenditure and resource allocation from our data are substantial. The implications are further magnified by the observation that the population with prior CABB is not static, it continues to expand. In view of the length of time the procedure has been in widespread use, it is likely that the prevalence of prior CABB is 10-20 million in the Western world by conservative estimates. A reduction in health care costs by 50% for this population would therefore have significant impact. Two main factors contributed to the results we observed: the cost of the index test and the expense induced by an increase in invasive coronary angiography.

Index test costs of CCTA versus SPECT perfusion

The cost of the index test was considerably more for SPECT than for CCTA. Prior investigators have noted this in populations suspected of coronary disease. Costs for index testing with SPECT are largely attributable to the running costs of the service: technical staff; radiotracer generation, administration and precautions, and physician reading. Camera costs are low and often quickly recouped following regular testing. Camera costs were not accounted for in our study.

Conversely, costs for day-to-day running of CCTA have traditionally been much less expensive. Some expenses are similar such as those for technical staff whereas others are understandably lower: iodinated contrast is much less expensive that radiotracer. Health care payee remuneration for CCTA interpretation is a fraction of that paid for SPECT or invasive coronary angiography. This reflects the somewhat discrepant nature of health care funding for radiology procedures versus nuclear or invasive techniques. It is unlikely that reimbursement for CCTA will change and the cost savings observed for CCTA will continue to exist.

Hidden costs that were not considered in our study include the financial outlay involved in camera acquisition. SPECT camera costs will vary somewhat between vendors and purchaser agreements but typically will be $400,000-$600,000 versus $2-2.5 million for a modern CT scanner. The cost differential is equivalent to the expense of 1400 SPECT studies. In a busy SPECT laboratory that performs 10 studies a day on a single camera, the cheaper initial outlay from a SPECT camera would be consumed by running costs within 6 months. Some of the discrepancies in camera costs can also be offset by the use of CT for non-coronary applications. Over time therefore it is perceived that the differential cost in camera expenses would not be detrimental to the overall cost saving demonstrated in our study for CCTA versus SPECT.

Invasive coronary angiography increases post CCTA in CABB patients

Our study did identify a potential disadvantage of CCTA to promote more invasive coronary angiography and percutaneous revascularization. Other studies have shown similar findings when the follow-up period after the index test is modest. Our follow up period was 6 months. This was chosen to increase the likelihood that any downstream test was premised on the findings of the index SPECT or CCTA. If a longer time period had been selected it might have been harder to suggest that downstream testing was influenced by the index test.

The PROMISE trial recruited patients with suspected CAD and investigated whether functional or CCTA index testing influenced clinical outcomes. In this population of patients that was followed for a median of 2 years there was an increase in ICA and PCI however there was no difference in prognosis. In the SCOT HEART study that recruited patients with chest pain, the vast majority without prior revascularization, initial results at 1.7 years suggested an increased rate of ICA. Subsequently on longer follow up at 4.8 years there were no differences in ICA or revascularization rates between CCTA and usual care groups. Prognosis was improved in SCOT HEART however in the CCTA arm. This was attributed to the commencement of preventative medication in more CCTA patients than those receiving usual care.

In our study we did not have longer follow up data available for ICA and revascularization. We did however take a closer look at the potential effects of those undergoing revascularization. It might be argued that those undergoing repeat revascularization would have undergone their procedures which ever test was performed first. In these cases it could be proposed that the clinical scenario rather than the imaging modality was the major determinant of their subsequent testing procedures. To negate this potential effect we examined whether the exclusion of
such factors influenced the study outcome. We found that there remained a significant increase in downstream tests following CCTA, however the degree of increase was reduced from 200% to 136%.

“...Our study is the first to demonstrate in symptomatic CABG patients that the index test induces sizable differences in cost and resource utilization...”

Future studies and influencing guidelines

Our data were from a single centre, retrospective, non-randomized population and there are no clinical outcome data available. Nevertheless, their significance is in their novelty and the magnitude of the observed findings in an understudied population. Future multicentre, randomized prospective studies in these patients will be required to promote changes within clinical practice and guideline recommendations.

CONCLUSIONS

CABG patients are under-represented in recent landmark trials to determine optimum non-invasive strategies for chest pain. This is an increasing population and investigative strategies could have a major influence on health resource utilization and spending. Our study is the first to demonstrate in symptomatic CABG patients that the index test induces sizable differences in cost and resource utilization. The data suggest that CCTA could be an austerer choice for investigating recurrence of chest pain in CABG patients but may stretch health care utilization with increases in downstream testing.

DISCLOSURES

The authors have no financial relationships to disclose in relation to this work.

REFERENCES

A 90-Second Magnetocardiogram using a novel analysis system to assess coronary artery stenosis in chest pain patients

By Dr. ME Pena, Dr. C Pearson, Dr. MP Goulet, Dr. VM Kazan, AL Derita, Dr. SM Szpunar & Dr. RB Dunne

This article describes the results of a recently published study [1] evaluating a novel, rapid magnetocardiography (MCG) system for the assessment of coronary artery stenosis in non-high risk chest pain patients under observation. The results suggest that a resting 90-second MCG scan has promise in evaluating such patients and that the new system warrants further, larger, studies as an alternative testing modality to identify patients safe for discharge.

Emergency physicians are tasked with rapidly identifying patients with acute coronary syndrome (ACS) to optimize care and outcomes, while also identifying patients who can be safely discharged. Only a minority of patients are high-risk for ACS and will rule in for ACS with either ischemic or infarction ECG changes, positive serial cardiac biomarkers, or other high-risk features. The majority will not have a diagnosis of ACS after initial ED evaluation [2,3]. Patients where there is a concern regarding possible ACS are commonly placed in an observation unit (OU) for further monitoring, cardiac diagnostic testing and/or cardiology consultation [3,4].

Magnetocardiography (MCG) is a method of noninvasive measurement and mapping of the magnetic field arising from the physiologic electrical activity of the heart. MCG has similar morphological features as ECG such as QRS complexes and P-and T-waves. Information is obtained passively, rapidly, at rest, and without radiation. MCG, however, does not require skin contact as it is much less affected by conductivity variations of different tissues in the body [5]. MCG detects magnetic field strengths created by cardiac ion currents within myocytes and can more accurately detect depolarization and repolarization abnormalities seen in cardiac ischemia compared with ECG [6,7]. Clinical studies have investigated MCG in the detection of coronary artery disease (CAD) in patients with chest pain [8-10] and found that MCG detects abnormalities in patients with normal ECGs and negative cardiac biomarkers [6, 7, 10, 11]. More recent MCG studies have demonstrated superiority to echocardiography in detection of acute ischemia [12, 13].

Most studies evaluating MCG in chest pain patients include non-ED patients with known CAD, ACS or high risk for ACS evaluated with coronary angiography (CA). [10-15] Of great importance to the emergency physician is which chest pain patients without clear ACS can be safely discharged after initial ED evaluation. No study has prospectively evaluated MCG in non-high-risk ED chest pain patients to assess for coronary artery stenosis (CAS). Neither has any study directly compared MCG to traditional cardiac diagnostic testing in this patient population. Cardioflux (CF) is a novel MCG imaging and analysis system developed by Genetesis, Inc. USA that uses a series of diagnostic algorithms to convert and interpret magnetic field data into dynamic images in a 90-second imaging time. The aims of this pilot study were to evaluate utilization of a 90-second resting MCG scan using this novel imaging and analysis system to assess for CAS in non-high risk Emergency Department Observation Unit EDOU patients and compare results to stress testing (ST) and/or CA.

The Authors
Margarita E. Pena, MD; Claire Pearson, MD; Marc P Goulet, MD; Viviane M. Kazan, MD; Alexandra L. DeRita; Susan M. Szpunar, PhD & Robert B. Dunne, MD.
Ascension St. John Hospital, Department of Emergency Medicine, Wayne State University School of Medicine, Detroit, Michigan USA.
Corresponding Author:
Dr. ME Pena. Email: margarita.pena@ascension.org

Figure 1. The Cardioflux device Developed by Genetesis, Inc.
METHODS

Study Design and Setting

Study design and patient flow are shown in Figure 2. This was a prospective, single center pilot study of ED patients placed in EDOU for evaluation of non-high-risk chest pain. The patients underwent a 90-second MCG scan between August 2017 and February 2018 in an urban teaching hospital. This study was approved by the hospital Institutional Review Board (IRB) and registered in ClinicalTrials.gov (NCT03255772).

Selection of Participants

This study used a convenience sample of patients. Consents were obtained for study participation and release of medical information.

Patients presenting to our ED with acute chest pain suspicious for ACS undergo a standard clinical evaluation including ECG and two troponin T cTnT blood draws three hours apart. Patients with a diagnosis of ACS after initial ED evaluation undergo standard of care therapy with emergent CA or medical management and admission to an inpatient cardiac telemetry unit and are not placed in the EDOU. Patients with non-ACS are discharged from the ED. According to our ED protocol, non-high risk patients with possible ACS, who were ≥ 18 years of age and who consented to have an MCG scan. Exclusion criteria included patients with metallic items in the chest area, claustrophobia, patients who were non-ambulatory, unable to fit into the MCG device or lie supine for 2 minutes, who had atrial fibrillation with rapid ventricular response; prisoners, and repeat participants.

Stress Testing diagnostic evaluation included persantine stress test (PST), stress echocardiography (SE) and dobutamine echocardiography (DE) and followed our standard EDOU protocol. The decision to undergo CA was left to the discretion of the consulting cardiologist. A positive CA was defined as ≥ 50% stenosis of at least one coronary artery branch of first or secondary order.

The MCG device [Figure 1] was located in a non-magnetically shielded room. The device comprises a bed on rails and a shielding chamber to prevent outside magnetic interference. The system is connected to a standard 120-volt electrical outlet. The regulatory status of the device was FDA 510K pending. Our

Figure 2. Design of the study showing patient flow. Abbreviations ST: stress tests; CA: coronary angiography; MCG: magnetocardiography.

Figure 3. Magnetocardiogram examples

Top Panel. A normal magnetocardiography (MCG) scan associated with no coronary artery obstructive disease with no significant current deviations within the myocardium as demonstrated by lack of angle shift (see blue arrow) between the positive red pole and negative blue pole between T wave onset (T-onset) and T wave peak (T-peak).

Middle Panel. An abnormal MCG scan demonstrating significant dipole angle deviation (see blue arrow) at T-peak compared to T-onset.

Bottom Panel. An abnormal MCG scan with significant disruption of myocardial current demonstrated by significant, near reversal of magnetic pole orientation (see blue arrow) at T-peak compared to T-onset.
IRB determined that because of the minimal risk, there was no requirement for an Investigational Device Exemption (IDE).

With the patient supine, a sensor plate containing 14 optically pumped magnetic field sensors records the magnetic field data in a 90-second scan. The data are stored in an encrypted database and sent to a HIPAA secure cloud. Patients underwent MCG scanning either prior to ST or CA, or immediately after ST.

The MCG device signal was evaluated by an automated function of the software, and secondarily by Genetesis personnel. MCG scan data were aggregated and processed into 3 components: averaged MCG waveforms, Equivalent Current Dipole (ECD), and magnetic field maps. These components were analyzed by Pthe CF software algorithms which look for significant deviations from a referenced database of normal MCG imaging. Because cardiac ischemia causes biologic injury currents and repolarization abnormalities reflected as abnormalities in the magnetic field pictures, it was theorized that shifts in dipole angulation or disorganization in the magnetic field map during repolarization would indicate coronary artery stenosis; the greater these changes the greater the degree of stenosis. According to this theory, patients without significant coronary artery stenosis would have organized magnetic dipole orientation without dispersion or splitting during the repolarization phase. Therefore, an automated report of negative MCG scan was defined as having no current dipole deviation pattern and a positive MCG scan was defined as having current dipole deviation with dispersion or splitting during the repolarization phase compared to a referenced database of normal MCG imaging.

Hospital data were collected using hospital electronic medical record (EMR) and included assessment of further diagnostic testing with ST or CA and MACE 30 days and 6 months post-discharge, and 30-day ED re-visits.

T Treating emergency physicians and cardiologists were blinded to MCG scan results and the study team blinded to the results of the MCG scans until after patient discharge and all index visit testing results were in the hospital EMR. All patient and hospital data and diagnostic testing results were entered into a secure Research Electronic Data Capture (REDCap) form blinded to Genetesis personnel.

**Data Analysis**

Study group characteristics were described using mean and standard deviation for continuous variables and frequency distributions for categorical variables. MCG scan results were compared first with only ST results. In a separate analysis, if a patient underwent both an ST and CA, then only the CA result was used for comparison with the MCG scan instead of the ST result since CA is a more accurate diagnostic test for CAD. Data analysis were performed with SPSS v. 24.0.

**RESULTS**

Figure 3 shows typical examples of normal and abnormal MCG scans. Of 125 consented patients, 101 underwent MCG scanning and were included in the data analysis and 24 were excluded. Eleven patients were not scanned due to: body habitus (5), claustrophobia (3), metal in thorax (1), vasovagal episode (1) or leaving the OU (1) prior to scanning. Eleven MCG scans were inadequate and had incomplete sensor capture due to body habitus and patient movement; two patients did not undergo testing after cardiology evaluation. A total of 97 patients underwent ST and 18 underwent CA; 14 underwent both ST followed by CA during the index visit and 4 only underwent CA.

Of the 101 study patients, the mean age was 56 years, 53.6% were male and 56.5% African American. Mean number of cardiac risk factors was two and 28.7% had >3 risk factors for CAD. Of the 97 ST performed, 55 were stress echocardiograms (SE), 16 dobutamine echocardiograms (DE), and 27 persantine stress tests (PST).

Table 2 shows the results of MCG scan compared to ST (Table 2a), and ST and CA (Table 2b). In table 2b the CA result was used instead of ST result in patients who underwent both. Of 8 patients with positive CA, 4 underwent percutaneous intervention, 1 coronary artery bypass grafting and 3 were treated medically without intervention.

Sensitivity, specificity, PPV and NPV of MCG scans compared to ST, and MCG scans compared to ST and CA (where CA result was used instead of ST result in patients who underwent both) are shown in Table 3.
No patients underwent ST or CA or had MACE on 30-day follow-up. On 6-month follow-up, one underwent ST (negative) and patients underwent CA (negative); both had corresponding negative MCG and ST. No patients had MACE 6-months post discharge. The 30-day ED re-visit rate was 12.9% (13/101); none were admitted, one observed and discharged, the rest were discharged from the ED.

DISCUSSION

In the ED, identifying which patients with chest pain or other anginal equivalent symptoms and an initial negative work-up can be safely discharged is challenging. Reported pooled ST results from multiple studies and meta-analyses show a specificity of 77–82% for detection of ≥50% stenosis as defined by quantitative CA [16]. When compared to data from other MCG studies evaluating specificity or NPV, results from this pilot study are also comparable. [10, 11, 17].

Incorporation of MCG into the ED workflow of evaluation of chest pain should be explored. Instead of requiring an extended, often overnight stay in the ED or OU due to limited availability of cardiac testing [18], MCG can be completed within minutes and be performed 24 hours per day. Risks to the patient associated with ST, including radiation, adverse reactions to pharmacologic and contrast agents, as well as risks associated with hospitalization would be avoided with a rapid means of evaluating cardiac function. Furthermore, cost savings to patients and the hospital could be substantial.

As with any new technology reliant upon computer algorithms, machine learning may improve accuracy [19]. In this pilot study, MCG scans were compared to ST or CA using a deep learning computer algorithm which was naïve to recognition of myocardial ischemia. It could be hypothesized that the software needs further machine learning to better recognize various forms of negatives and positives.

Moreover, the small number of positive ST or CA (n=9) which would be expected in this population of non-high-risk chest pain patients is a limitation to assessing accuracy as seen in the large confidence intervals of the sensitivity or PPV results.

This pilot study was not designed to examine performance characteristics of a new diagnostic modality, but rather to illustrate potential of new technology in a real-world clinical setting. Evaluation of MCG in patients with various risk profiles and prevalence as well as further development of the computer algorithm is the focus of ongoing studies. Recently, a study using this data was used to develop parameter-based interpretation (PBI) rules for the MCG scans and is publication pending. Additionally, device improvements are being implemented, such as increasing the diameter of the shielding chamber to enable accommodation of patients who would otherwise be excluded because of their body habitus.

CONCLUSIONS

The results of this pilot study suggest that a resting non-invasive, 90-second MCG scan using a novel imaging and analysis system that does not require a magnetically shielded room has promise in evaluating patients for coronary artery stenosis. This alternative testing modality warrants further comparative study with current testing to identify patients who are safe for discharge. Larger studies are needed to assess accuracy.

ACKNOWLEDGEMENTS:

This work was supported by funding from Genetesis, Inc.

REFERENCES


Table 3. Comparison of magnetocardiography scan vs. stress test results, and magnetocardiography scan vs. stress test and coronary angiography results. Abbreviations ST: stress tests; MCG: magnetocardiography; CA: coronary angiography.
Leveraging AI to optimize breast cancer screening in the era of COVID-19

By Axel Gräwingholt, MD

COVID-19 AND ITS IMPACT ON BREAST CANCER SCREENING

Many breast cancer screening programs were halted worldwide during the height of the COVID-19 pandemic. Now that a number of countries in Europe have lifted confinement restrictions, breast cancer screening has begun to resume, yet patients may still be hesitant to come into the clinic for breast cancer screening out of fear – not just of breast cancer, but also due to fear of the novel coronavirus.

In 2018, breast cancer accounted for 26.4 percent of all new cancer cases in European women [1], indicating that regardless of the COVID-19 pandemic, cancer remains a major health concern. Although initially the hold on routine screening was intended to protect patients’ health and safety, in general, the long-term effect of deferring breast cancer screening could have negative consequences in the years ahead – for patients and clinicians alike.

For patients, delaying screening could mean the difference between life and death, which is why it is so important for screenings to continue now that the threat of COVID-19 has begun to subside. And for clinicians, new challenges are emerging, as compressing 12 months of routine screening appointments into ten months or less presents a number of workload issues. This is compounded by the radiologist shortage in Europe, which made it difficult for clinicians to maintain medical standards, even prior to the pandemic [2]. But the latest in AI technology can empower clinicians to combat these issues, while also offering a number of benefits to women, during the era of COVID-19 and beyond.

A NOVEL SOLUTION FOR EMERGING DEMANDS

As screening and diagnostic mammography programs resume, clinicians may encounter a set of new challenges, including: workflow difficulties, as radiologists address a backlog of patients who need screening; reading accuracy may suffer due to longer work days and higher volumes of patients; and in the rush to view more mammographic images, clinicians may find complex cases to be increasingly difficult to evaluate.

A new artificial intelligence (AI) solution can help clinicians address these emerging challenges. iCAD's ProFound AI is a high-performing workflow solution available for 2D and 3D mammography, or digital breast tomosynthesis (DBT). Trained with the latest in AI and pattern recognition technology, this solution rapidly and accurately analyzes mammography and tomosynthesis images to identify potentially malignant lesions and provides radiologists with crucial information, such as Certainty of Finding lesion and Case Scores, which assists in clinical decision-making and improving reading efficiency. ProFound AI for DBT is CE Marked and ProFound AI for DBT is CE Marked, FDA-cleared and Health Canada licensed.

This leading-edge technology not only improves radiologist confidence, even while reading complicated datasets, such as those with dense breasts, but also it offers increased sensitivity and specificity, which helps physicians find more cancers, while reducing recall rates for non-cancer cases. As clinicians struggle with the aftermath of COVID-19, this technology is uniquely positioned to help address newfound challenges they are beginning to encounter.

A GROWING BODY OF SUPPORTIVE CLINICAL EVIDENCE

Positive clinical data from a large reader study was recently published in *Radiology: Artificial Intelligence* [3]. The research involved 24 radiologists who read 260 tomosynthesis cases, both with and without iCAD's ProFound AI solution. According to study findings, ProFound AI for DBT improved cancer detection rates by 8 percent, reduced unnecessary patient recall rates by 7.2 percent, and slashed reading time for radiologists by 52.7 percent. Additionally, ProFound AI for DBT cut reading time by up to 57.4 percent for radiologists reading cases with dense breasts [4]. This research suggests that ProFound AI for DBT offers unparalleled time-savings benefits to clinicians reading complex tomosynthesis datasets, with a considerable improvement in reader sensitivity.

The efficacy of ProFound AI for 2D Mammography was also validated in another recent study presented at the European Congress of Radiology (ECR) virtual meeting this year [5]. Professor Sylvia H. Heywang-Köbrunner, a radiologist and researcher based in Munich, Germany, examined 18,002 consecutive screening mammograms acquired between January and November 2018, which were anonymized and processed using ProFound AI for 2D Mammography. The AI technology’s results were compared to that of two radiologists, who read the same cases. Researchers found ProFound AI for 2D Mammography achieved a sensitivity of 91.5 percent and a specificity of 80.2 percent for 32 ductal carcinoma in situ (DCIS) and 85 invasive cancers. This

The Author

Dr. Gräwingholt is the co-owner of a private radiology institute in Paderborn, Germany, and is the radiologist responsible for the regional screening unit. He is also clinical co-chair of the Guideline Development Group of the European Commission Initiative on Breast Cancer (ECIBC)

Email: axel.graewingholt@t-online.de
was compared to the first reader’s results, which were 84.6 percent for sensitivity and 91.6 percent for specificity, as well as the second reader’s results, which were 89.7 percent and 91.5 percent, respectively. ProFound AI’s ability to find cancers outperformed both readers in the study, as well as the standards that were found in a review by ECIBC in Europe [6]. The findings of this study suggest that AI can perform at similar levels as experienced radiologists and can be confidently used as a valuable tool in the screening process.

At my center in Germany, I am working on an ongoing retrospective study evaluating ProFound AI for 2D Mammography on interval cancers, or lesions that are detected between routing mammography screenings. This research involves a review of 37,367 women screened in 2011 and 2012.

In an organized population-based screening program, it is expected that the number of interval cancers found are comprised of about 50% true interval cancers that developed between screening rounds, and about 50% that are either missed cancers or minimal sign cancers that were not seen or misinterpreted in the previous screening.

According to the preliminary conclusion to this study, of the 50% that were missed or minimal sign cancers, ProFound AI identified 93.3 percent of these cancers. Thus, by using ProFound AI for 2D Mammography, we can have higher detection rates of cancer and fewer mislabeled interval cancers. In addition, we also ran ProFound AI on cancers detected during screenings and their prior images. In many cases, the algorithm found a lesion in the prior images, suggesting this cancer could have been detected earlier if the clinician had originally used ProFound AI.

As we recover from COVID-19, it is essential for breast cancer screening to resume, as a growing body of evidence suggests early cancer diagnosis leads to better outcomes [7,8,9]. It is currently a prime time for clinicians to leverage the latest technologies, such as ProFound AI, which can help us navigate emerging challenges following this pandemic.

REFERENCES
5. The value of 2D-AI-based CAD for second or third reading tested on 17,910 screening mammograms [RPS 702-4]. Accessed via https://event.crowdcompass.com/ecr2020/activity/78pY0IUG4N

CONCLUSION/HYPOTHESIS
If ProFound AI had been used for reading in the prior images from 2017, the lesion would have been identified by the radiologist. Although the gynecologist had not seen the lesion in the ultrasound, it is most likely that, knowing this lesion’s localisation from tomosynthesis with ProFound AI, either the radiologist or the gynecologist would have found it. Therefore, it can be concluded that this cancer may have been detected two years before; possibly in a more favorable stage than at the time of actual diagnosis.

Case Report

Reading Tomosynthesis with ProFound AI can help to anticipate tumor diagnosis.

A 59 year old woman was referred by her gynecologist to the department of diagnostic mammography. The gynecologist who performed the ultrasound detected a lesion at 6 o’clock in the right breast. Tomosynthesis revealed an ill defined mass at 6 o’clock consistent with the ultrasound findings. The size was 1.63 cm, distance to the nipple was 5.2 cm.

Tomosynthesis plane cc 2019
Lesion Score with ProFound AI 68%
Case Score with ProFound AI 93%

Prior
Tomosynthesis plane obl 2017
Lesion Score 35%
Case Score with ProFound AI 55%

Tomosynthesis plane obl 2019
Lesion Score with ProFound AI 81%
Case Score with ProFound AI 91%

Prior
Tomosynthesis plane obl 2017
Lesion Score with ProFound AI 41%
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The Cutting Edge of Modern Medicine

Cardiovascular and Interventional Radiological Society of Europe
Artificial Intelligence evolution paves the way for the future

By Dr. S Harvey

Artificial Intelligence (AI) is a topic that is growing more important in the health care industry each year. As a result, many professionals hypothesize about the future of this type of technology and its potential impact on patients and clinicians. The development and use of AI is not new for diagnostic imaging, particularly for breast cancer screening. For years, researchers and developers have explored how technology can help support clinicians, leading to today’s use and understanding of AI. Furthermore, examining some examples of how this technology has impacted breast cancer screening thus far may help us understand a logical pathway for where AI technology is headed in the future.

Years ago, recognizing that humans have limitations, and with the advent of digital mammography, Computer Aided Detection (CAD) was introduced in an effort to increase cancer detection by identifying potential cancers that a radiologist may have overlooked. With the previous CAD technology, the tool would search a mammogram for suspicious areas and mark them on the image for further review by a radiologist. Many articles reviewed the efficacy of the initial CAD products. Some showed positive accuracy increases and others showed declines in accuracy and increases in costs.

Since then, digital breast tomosynthesis (DBT) has increasingly become a standard of care tool for breast cancer screening around the globe, though adoption has been slower in Europe compared to the United States in recent years. The abundance of data and images, though helpful for seeing more breast tissue slices in detail, pose workflow challenges, especially in regions like Europe where double reading is recommended by the European Commission Initiative on Breast Cancer.

Throughout the years, AI technology has striven to combat the increasing workload issue. In fact, there are various iterations of technology that have used AI algorithms to review the high resolution tomosynthesis images to facilitate the generation of a high-resolution synthesized 2D image.

Such AI capabilities help workflow by navigating to the slice of interest, decreasing the burden of interpreting tomosynthesis slices one by one. The newest iteration of this type of technology, known as 3DQuorum Imaging Technology, powered by Genius AI – which currently exists in the United States and which will be available in Europe later this year – is an example of how current AI directly addresses this challenge.

3DQuorum technology uses Genius AI-powered analytics to uniquely reconstruct high-resolution 3D data to produce 6 mm “SmartSlices.” These analytics identify clinically relevant regions of interest and preserve important features during reconstruction of the SmartSlices. [1,2]

SmartSlices expedite interpretation time by reducing the number of images for radiologists to review, without compromising image quality, sensitivity or accuracy. With 3DQuorum technology, the number of 3D images to review is reduced by two-thirds, saving an average of one hour per eight hours of daily image interpretation time.[1,2,3].

It is evident that the common denominator for these breast imaging-centered AI innovations at this time is to detect cancer with the highest possible accuracy as well as with efficiency for the clinicians’ workflow. Higher accuracy can lead to improved patient outcomes, and this goal—alongside the goal to help clinicians save time—speak volumes about the future needs for patients and providers, thus informing the direction of new developments of AI tools.

As the algorithms continue to advance based on more data and even faster processing time, in the future, radiologists may be able to carry out a very cursory review of certain images or even cases altogether. This may be feasible when the technology signals that no suspicious findings are present so the clinicians may then be able to focus on areas of high suspicion, where their expertise is truly—and will always—be needed.

REFERENCES
1. Hologic Tech File: TFL-00059
2. Hologic Report: CSR-00116
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INTRODUCTION
Large vessel occlusion (LVO) accounts for one-third of ischemic strokes, but causes disproportionate morbidity and mortality in the stroke population. Endovascular thrombectomy (EVT) has become the standard of care for patients with LVO in the anterior circulation with a National Institutes of Health Stroke Scale (NIHSS) score of ≥6 who present within 6 hours of symptom onset and in selected LVO patients presenting 6 to 24 hours after onset [1].

Definitive diagnosis of LVO by clinical scales is difficult and not accurate. EVT results are highly time-sensitive and early diagnosis of LVO is critical. Current guidelines recommend vascular imaging with CT angiography (CTA) for potential candidates for mechanical thrombectomy [1,2]. However, limiting CTA to patients with baseline NIHSS score ≥ 6 may reduce the proportion of potentially treatable patients, and many stroke centers have implemented a CTA- for-All stroke imaging policy [3]. The effectiveness of CTA for patients with minor stroke (NIHSS < 6) is not well-established in literature. Minor stroke is common and may represent up to two-thirds of patients with acute ischemic stroke. LVO has been reported in about 18% of patients with NIHSS between 0 and 4, and the presence of LVO is associated with high risk of clinical worsening and adverse outcomes. Multiple recent studies have shown better outcomes for EVT compared to medical management in acute, minor stroke patients (NIHSS < 6) with LVO.

We sought to assess the cost-effectiveness of CTA for detection of LVO in acute, minor stroke patients from a societal perspective [4].

STUDY DESIGN AND METHODOLOGY
A decision-analytic model was constructed using TreeAge Pro Suite 2019 (Cambridge, MA) over the lifetime span of patients from a societal perspective. The base case scenario in this model was a patient of age 65 years presenting with minor stroke (NIHSS < 6).

The 3 management strategies considered were:
1) No vascular imaging, and best medical management (including IVT for eligible patients);  
2) CTA for all patients, and immediate thrombectomy (IMT) for LVO after intravenous thrombolysis (IVT) (if eligible); and  
3) CTA for all patients, and best medical management (BMM) including IVT, with rescue thrombectomy for LVO patients with neurologic deterioration.

The model was of a life-time horizon; differential mortality rates were assigned, and recurrent stroke risk was accounted for as well. All clinical parameters were derived from the best available evidence in the literature with preference for recently published large-cohort studies.

RESULTS
Base case calculation showed CTA followed by immediate thrombectomy for LVO patients to have the lowest cost and highest health benefits. CTA followed by best medical management and possible rescue thrombectomy for LVO patients had slightly higher cost and lower health benefits. “No vascular imaging” had the highest cost and lowest health benefits. Probabilistic sensitivity analysis showed CTA followed by immediate thrombectomy to be the superior strategy in 98.9% of 10,000 iterations (simulating 10,000 patients by varying the input parameter values based on their confidence intervals).

Sensitivity analysis varying the proportion of LVO amongst all acute, minor stroke patients showed that “no vascular imaging” was cost-effective only when proportion of LVO is <0.16%. When the proportion was higher, CTA followed by immediate thrombectomy in LVO patients became more cost-effective. Two-way sensitivity

The Authors
Ajay Malhotra, M.D., MMM & Xiao Wu, M.D.
Department of Radiology and Biomedical Imaging, Yale School of Medicine
Box 208042, Tompkins East 2
333 Cedar St New Haven, CT 06520-8042 USA
Corresponding Author
Dr A Malhotra,
Email : ajay.malhotra@yale.edu
analysis varying the cost of CTA and proportion of LVO patients showed that the threshold of LVO proportion at which vascular imaging became superior increased as the cost of CTA increased. When the cost of CTA was $5,000, the LVO threshold proportion was 1.32%. No vascular imaging was found to be cost-effective if the probability after good outcome after IVT in LVO patients exceeded 82.0%, which is highly unlikely given the existing literature. When the proportion of LVO was lower than 0.16%, vascular imaging was not a cost-effective strategy irrespective of outcomes after IVT. CTA with immediate thrombectomy remained the most cost-effective strategy when the proportion of rescue thrombectomy and the probability of a good outcome after rescue thrombectomy were varied from 0 to 25% and from 55-80% respectively. The conclusion remained unchanged when varying the patient age from 55 to 85 years, although the net monetary benefit of CTA became smaller with advancing age.

**SIGNIFICANCE OF RESULTS AND FUTURE DIRECTIONS**

Previous studies have shown that no NIHSS score threshold can be applied to select subgroup of patients for vascular imaging without failing to capture large number of cases with clinically important occlusive lesions [5]. The validity of NIHSS scores in predicting arterial occlusion is also time-dependent, decreasing with increasing time from symptom onset to clinical evaluation.[6] Our study results showed vascular assessment for LVO by CT angiography (CTA) to be cost-effective in acute, minor stroke patients. The conclusions were robust in wide sensitivity analyses. CTA was cost-effective if the proportion of LVO in all minor stroke patients was greater than 0.16%. Even when the cost of CTA was increased to $5,000 in sensitivity analysis, CTA was cost-effective if proportion of LVO was more than 1.32%. The literature reported prevalence of LVO in this patient population is significantly higher.

There is heterogeneity in reported outcomes after thrombectomy in minor stroke patients with some studies advocating immediate thrombectomy while others favoring best medical management and rescue thrombectomy in patients with neurologic deterioration [7,8]. Our results show CTA and immediate thrombectomy to be more cost-effective in the likely clinical scenarios given the literature (proportion of rescue thrombectomy between 0 and 25% and good outcome after rescue thrombectomy in 55 to 80% of patients). However, this area needs further study and current randomized clinical trials are underway for acute minor stroke patients.

**CONCLUSION**

Screening for large vessel occlusion with CT angiography in patients with acute, minor stroke is cost-effective. Our
study emphasizes the utility of early CTA detection of LVO to improve health outcomes and reduce overall costs. The costs incurred in faster and better selection of patients for EVT should be seen in the overall context of cost savings from better outcomes.

REFERENCES


**Book Review**

**Venous Interventional Radiology**

By Laura Findeiss

Pub by Thieme, July 2020; 230 pages; €119.99

The book Venous Interventional Radiology, by prominent interventional radiologist Laura Findeiss and an impressive group of contributors is a highly practical vascular interventional radiology reference that covers a full spectrum of venous disease. The richly illustrated book starts with an opening chapter on venous anatomy, physiology, and epidemiology. Disease-specific chapters cover common to complex disorders, from varicose veins and venous ulceration, to thromboembolic disease and pulmonary embolism. Each chapter presents the latest minimally invasive image-guided interventions for the diagnosis and management of a specific disease. Clinical cases provide discussion of patient presentation/symptoms, clinical evaluation, procedural and non-invasive management strategies, and follow-up, all of which are key to delivering comprehensive patient care.
ALARA: Evidence against the use of the radiation protection principle as used in the healthcare sector

By Paul A. Oakley & Deed E. Harrison

In this article we summarize the arguments against the use of the ‘ALARA’ (As Low As Reasonably Achievable) radiation protection principle [1]. Initially used in the nuclear energy sector, it was quickly implemented into the healthcare sector to caution doctors, radiologists and healthcare personnel to use radiological imaging judiciously because of the prevailing ideology borne from the linear no-threshold (LNT) model and its assumption that any and all ionizing radiation is harmful (i.e. carcinogenic), and that it is also cumulative (dose additivity).

Importantly, Calabrese has recently brought to light the fact that the LNT model was adopted for political rather than scientific reasons [2]. There has also been increasing criticisms of the continued use of the LNT model as used in radiation protection as it lacks scientific support in the low-dose range. Even recent analysis of the life span study data (LSS) on which the entire premise of the LNT rests, has been found to be better represented by a hormetic (linear-quadratic) model rather than a linear one. The LNT assumption for use in low-dose diagnostic imaging is receiving much criticism. Current evidence does not support the use of the LNT model for use in radiation protection in low-dose exposure ranges. Thus, the ALARA concept as used in the medical sector has no scientific basis. Here we provide examples where use of the ALARA principle does more harm than good as used in the delivery of health care [Figure 1].

DOCTORS RELUCTANT TO ORDER IMAGING

There are many current radiation limiting campaigns such as Image Wisely, Image Gently, and Choosing Wisely which target medical practitioners to avoid or limit subjecting their patients to radiation from medical imaging. Doctors and radiologists end up being ‘caught between a rock and a hard place’ as the practice of medicine often requires radiological imaging as a part of best practices.

Studies have shown that about 9 out of 10 medical providers/radiologists would reconsider radiological imaging when exposure history is considered in a risk-benefit decision making analysis. Also, many doctors are ill-informed in the ability to discuss the risks over radiation exposures to patients; they also have little time to delve into this lengthy conversation. This is why there is debate in the literature over whether to inform a patient of the perceived ‘risks’ prior to prescribing an X-ray/CT scan.

It should be known that the practice of medicine often involves ruling out processes and that imaging provides essential information towards formulating the best likely diagnosis for many medical conditions. X-rays and particularly CT scans have transformed current medical practice, however, when radiophobia misinformation dissuades the doctor from taking warranted imaging, this affects diagnostic accuracy. Better diagnostic accuracy leads to better patient outcomes.

RESISTANCE OF PATIENTS TO RECEIVE RADIOLOGICAL IMAGING

On the other side of the doctor-patient encounter is the resistance of patients or parents of children who require X-rays. Radiophobia, or the fear of radiation stems from media-hyped misinformation about the dangers of radiation. This has led patients to avoid any and all radiation, even when requested from their doctors. This constrains the medical management of their condition.

It has been demonstrated that when patients are informed about theoretical cancers risks, about 1/5 are less likely to consent to the radiological imaging. What is not known is that there is scientific consensus that doses of 100-200mSv is universally accepted as harmless as there is no evidence of harm. An X-ray is only about 1-3mSv and a CT scan only about 10-30mSv. Further, there is an abundance of evidence that an upregulation of the body’s adaptive protection systems occurs at low-doses such as from CT scans [3]. Avoiding the ideal imaging (x-ray/CT) may lead to a ‘missed diagnosis,’ and even if this occurs infrequently, can lead to catastrophic outcomes. Finally, even when alternate imaging is an option (e.g. MRI), it may have other significant risks such as the need for general anesthesia for children.

Current medicine encourages ‘shared decision making’ or keeping the patient involved with their care. However, the more
the patient is aware of radiation risks, the less likely they are to consent to imaging. This presents greater risks for certain clinical scenarios. For instance, ER doctors routinely rely on X-ray and CT scans as they are unfamiliar with the patient’s medical history. Another example is in the assessment of non-traumatic, non-specific abdominal pain (NSAP), since it has been shown that a substantial proportion of these patients will continue to suffer, even years later. Therefore, initial CT imaging often aids to provide a definitive and timely diagnosis and often changes the intended medical triage. After imaging, patients with NSAP have up to a 65% reduction in hospital admittances and also reduced unnecessary surgical interventions. The reduction of hospital stays and surgeries reduces iatrogenic deaths [4].

Radiological reduction campaigns including ALARA lead to ‘racing to the bottom’ or the overly aggressive attempt to reduce exposures. This can lead to poor image quality and missed diagnosis. Further, use of ALARA tends to ‘amplify’ detrimental aspects of radiation without consideration of the benefits of the tests. In the media, this is referred to as ‘media-driven social amplification’ which stigmatizes radiation in medicine and fuels radiophobia and increases the reluctance of patients to receive necessary imaging. In reality any presentation of radiation risks should also be accompanied by its benefits from medical testing.

**INCREASED RADIATION EXPOSURES BY ALIGNING WITH ALARA**

Ironically, the attempt to implement ALARA often leads to increased radiation exposures rather than decreasing them. First, the use of ‘optimizing’ radiological imaging parameters to obtain quality images is encouraged, but the reduction of settings (i.e. kVp) to decrease patient exposures may lead to poor image quality which can either lead to a re-take (doubles the exposure) or a missed diagnosis. Either scenario is undesirable. “Missing a diagnosis due to poor image quality resulting from sub-optimal imaging parameters in the attempt to reduce patient exposures by an infinitesimal amount is practically negligence” [1].

Gonadal shielding used to protect radiosensitive tissues from radiation exposures are no longer recommended [5]. This is because the shielding cannot reduce patient radiation exposures as it does not stop the internal scatter which occurs from the exposure of anatomy desired to be viewed. Poorly placed shielding also leads to repeated imaging. Also, if the shielding covers too large of an area of the photo timing cells, the automatic exposure controls will increase the radiation output (up to 150%) to compensate.

Attempts to decrease patient radiation exposures discourage traditional X-ray screening for many conditions (e.g. hip dislocations; low back pain). Hip dislocation is a highly morbid injury; thus, prompt reduction is necessary. It has been shown that skipping the X-ray screening assessment and triaging straight to CT imaging leads to repeated CT-imaging and also, ironically, a delay in the time to fracture reduction. Studies also show that delayed X-ray imaging for back pains for those with degenerative spinal conditions, for example, can lead to more costly imaging and also deprive the doctor of important knowledge of biomechanical causes for the conditions and appropriate treatment options [6].

**STIFLING OF LOW-DOSE RADIATION RESEARCH AND TREATMENT**

When radiophobia and low-dose radiation misinformation is the widespread narrative, acceptance for low-dose radiation medical treatment and research will be resisted. The fact however, there is an expansive historic evidence base for the use of low-dose irradiation (LDI) therapy for many diseases and conditions. Calabrese and colleagues have documented much of the historic evidence for the treatment of many common medical ailments (Figure 2) and found that LDI resulted in a 75-90% cure rate from exposures of 30-100 roentgen (263-877 mSv) [7]. Some diseases such as pneumonia respond well after a single treatment session. That is why there are many LDI clinical...
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**MEDICAL DOCTORS (respond below)**

1. What is your occupation? (check only one)
   - 50 ☐ Diagnostic Radiologist
   - 51 ☐ Other Physician (please specify)

1a. What is your radiology sub-specialty? (check only one)
   - 52 ☐ General Radiology
   - 04 ☐ Nuclear Medicine
   - 53 ☐ Nuclear Radiology
   - 54 ☐ Pediatric Radiology
   - 55 ☐ Neuroradiology
   - 56 ☐ Vascular & Interventional
   - 03 ☐ Cardiologvascular Diseases
   - 57 ☐ Other (please specify)

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

**NON-PHYSICIAN PROFESSIONALS (respond below)**

1c. What is your occupation? (check only one)
   - 50 ☐ Administrator/Manager:
   - 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 executive titles
   - ☐ Other (please specify)

2. In what type of facility do you work? (check only one)
   - ☐ Private Clinic
   - ☐ Hospital (check number of beds):
     - ☐ More than 500 beds
     - ☐ 200-299 beds
     - ☐ 100-199 beds
     - ☐ 300-399 beds
     - ☐ 0-99 beds

3. With what technologies or disciplines do you work? (check all that apply)
   - ☐ Diagnostic X-ray
   - ☐ MRI
   - ☐ Nuclear Imaging
   - ☐ Mammography
   - ☐ Interventional Radiology
   - ☐ Bone Density
   - ☐ CT
   - ☐ PACS/Teleradiology
   - ☐ Ultrasound
   - ☐ Cardiac Imaging

4. If you currently receive Diagnostic Imaging Europe, how many other people read your copy?
   - ☐ 0
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ 6 or more

5. Please describe your involvement in the decision to purchase medical imaging equipment/products for your department.
   - ☐ Approve purchase of product
   - ☐ Recommend purchase of product
   - ☐ Specify type of product to purchase
   - ☐ None of the above

**ALL RESPONDENTS reply to the questions below**

2. If you currently receive Diagnostic Imaging Europe, how many other people read your copy?
   - ☐ 0
   - ☐ 1
   - ☐ 2
   - ☐ 3
   - ☐ 4
   - ☐ 5
   - ☐ 6 or more

3. What is your involvement in the decision to purchase medical imaging equipment/products?
   - ☐ Approve purchase of product
   - ☐ Recommend purchase of product
   - ☐ Specify type of product to purchase
   - ☐ None of the above

4. Please describe your involvement in the decision to purchase medical imaging equipment/products.
   - ☐ Approve purchase of product
   - ☐ Recommend purchase of product
   - ☐ Specify type of product to purchase
   - ☐ None of the above

**PLEASE PRINT**

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trials currently being conducted for SARS-CoV-2. LDI therapy has also been shown to be effective for many cancers [Figure 2].

ALARA PROPAGATES RADIOPHOBIA

ALARA and the campaigns it underpins leads to the propagation of radiophobia. Radiophobia can be expressed as anxiety or can manifest as obsessive thinking or even phobias.

Also, recently a threshold for leukemia in this same population was reported to be 1100mGy (95% CI: 500-2600mGy) [10]. It becomes apparent that humans can tolerate surprisingly high levels of radiation without deleterious health consequences.

The adoption of the ALARA principle in medicine was spawned by the original studies associating exposure from CT scans with increased cancers. These types of papers have continued to be published and unfortunately get sensationalized and amplified through the media. They also don’t typically get rebutted but are left unabated. These studies are flawed as they either predict (with no follow-up) future cancers by using the LNT model and theoretical weighting factors that are not applicable for low-doses exposures, or studies that do have follow-up, attribute the increased cancers and cancer deaths from previous radiation exposures, while the cohorts are more likely increased susceptibility in the first place (i.e. reverse causation).

The concept of reverse causation was proven in the study by Journy et al. who examined how cancer-predisposing factors (PFs) affected the assessment of radiation-related risk calculations [11]. They determined the relative risk of cancer incidence in patients who received CT scans prior to the age of 10 were reduced by up to 56% when adjusted for PFs including rare genetic defects and acquired immune deficiencies. Their conclusion was that “no significant excess risk (for cancer) was observed in relation to CT exposures” [11].

The choice for medical radiological imaging should always come down to a risk-benefit analysis. When there are no risks, then there is only a benefit for the patient in a risk-benefit ratio. Therefore, as long as an imaging procedure can provide meaningful data in terms of diagnosis, differential diagnosis, monitoring treatment progress, IIs (incidental findings), patient satisfaction, and so on, the benefit will always outweigh a risk of zero” [12].

Currently, we argue there is no solid evidence supporting the use of the LNT model as a surrogate for radiation risk in the low-dose exposure range such as from medical imaging. Therefore, use of the ALARA radiation protection principle as used in the medical sector is obsolete. As we recently stated: “Continued use of an outdated and erroneous principle unnecessarily constrains medical professionals attempting to deliver high quality care to patients by leading to a reluctance by doctors to order images, a resistance from patients/parents to receive images, sub-quality images, repeated imaging, increased radiation exposures, the stifling of low-dose radiation research and treatment, and the propagation of radiophobia and continued endorsement of ALARA by regulatory bodies” [1].

REFERENCES

4. Makary MA, Daniel M. Medical error-the third leading cause of death in the US. BMJ. 2016 May 3;353:i2339.
Taking X-ray radiography to a new level through AI

The new Ysio X.pree system from Siemens Healthineers is the world's first intelligent X-ray system with integrated artificial intelligence (AI) for optimizing the daily routine of image acquisition in radiography. To assist radiologists with the subsequent image post-processing, Siemens Healthineers also offers its new CE-labeled AI-Rad Companion Chest X-ray, an AI-supported software that aids clinical decision making on upright thorax images. "X-rays are still the most commonly used form of diagnostic imaging. By introducing AI technologies and other innovations into this area, we're taking traditional radiography to a new level," says Carsten Bertram, Head of X-ray Products at Siemens Healthineers.

The Ysio X.pree helps prepare for X-ray image acquisition using AI. Based on the images from a 3D camera, the AI-based algorithm automatically detects the thorax and thus sets the optimal acquisition area, or collimation. The radiation is focused only on the relevant area, with the goal being to acquire an image containing all the necessary information with the lowest possible radiation exposure. The user can make adjustments to the collimation area at any time on a live touch-screen image of the patient. AI functionality and other intelligent tools for image acquisition preparation are combined in the so-called myExam Companion. For full-spine and long-leg exposures, with the support of the live image of the 3D camera, the user can easily reduce the number of images needed and therefore reduce the dose. These new functionalities allow the user to utilize the device optimally every time and to concentrate more on the patient. Dr. Matthias May, Chief Physician of Radiology, University Clinic Erlangen, who is currently working with the device, says: “Thanks to the intuitively designed user interface of the Ysio X.pree, it was possible from day one to cover a wide range of examinations with high-quality results, even without intensive training. With the programmable robotics, the individual flavor settings for the image impression, the support of myExam Companion and the AI supported 3D camera, a wide array of technical solutions for the personalization of examination procedures is available.”

AI-Rad Companion Chest X-ray

DICOM X-ray images from devices such as Ysio X.pree are a very good basis for Siemens’ new AI clinical decision support software: AI-Rad Companion Chest X-ray. The newest member of the AI-Rad Companion product family complements the solutions already available for CT and MRI. Using artificial intelligence, it examines chest X-rays for abnormalities. The software acts as a kind of “concurrent reader” for example, highlighting nodules in the lungs or indicating the presence of a pneumothorax, with confidence scores.

AI-Rad Companion Chest X-ray is vendor agnostic and conforms with DICOM standards. The entire AI-Rad Companion product family benefits from the teamplay digital health platform. Its secure cloud environment provides high computing power, so no additional hardware resources are needed on-site.

New range of medical display controllers.

The new MXRT-x700 series of display controllers from Barco has been developed with the performance, longevity and workflow support required for diagnostic imaging workstations in mind. As quality and compliance are vital and demanding, and images often come from multiple modalities, both in color and in greyscale, choosing the right technological solutions is vital to ensure a smooth workflow.

Increased performance. The circuit boards support higher refresh rates and resolutions than their predecessors to ensure compatibility with evolving protocols and modality requirements. On top of that, their robust graphics processing engine will enhance workflow with faster image loading.

Reliable longevity. A 5-year warranty and extended availability meet the needs of long-term equipment management and avoids frequent system reconfiguration.

Workflow support

The display controller boards all support Barco’s Intuitive Workflow Tools, which were developed to enhance the radiologist’s productivity, accuracy and ergonomics. When paired with a Barco diagnostic display system, the boards guarantee the necessary performance and expected support for medical use.

BARCO, Kortrijk, Belgium
www.barco.com
Compressed speeder MR technology reduces scan time while maintaining image resolution

Physicians can now scan faster while maintaining MR image resolution using the Compressed SPEEDER technology from Canon Medical.

Scan times in MRIs have historically been a challenge in clinical practices, where shorter scan times are typically associated with lower resolution or decreased signal-to-noise ratio (SNR). To reduce acquisition time while maintaining image quality, Canon Medical’s innovative Compressed SPEEDER supports image acceleration and can be used to avoid unfolding error artifacts sometimes seen with standard parallel imaging, or can achieve higher resolution in 2D Fast Spin Echo (FSE) acquisitions. Reduced scan times also enhance patient comfort, which in turn may enable higher quality images by mitigating patient movement caused by patient discomfort during long scans.

Available on the company’s Vantage Galan 3T and Vantage Vantage Orian 1.5T, the technology speeds up MRI scan times by up to four times by reconstructing full resolution images from highly under-sampled data. The technology provides exceptional image quality and has great potential to help clinicians improve productivity. Reduced scan times also enhance patient comfort, which in turn produces higher quality images by mitigating patient movement caused by patient discomfort during long scans.

“In advanced imaging, generating high quality images and shortening scan times are paramount to success for both the patient and physician,” said Thierry Munier, Senior Manager of the MR Business Unit, Canon Medical Systems Europe B.V. “With the help of this new advanced imaging technology and Canon Medical’s innovative MR systems, health care providers can produce high resolution images, while providing a quick and comfortable exam experience for their patients.”

CANON MEDICAL SYSTEMS EUROPE, Zoetermeer, The Netherlands
https://eu.medical.canon/

Data show resumption in breast cancer screening

More than 75 percent of hospitals and imaging centers that perform mammography have now, post-COVID, resumed breast cancer screening operations and exam volumes are recovering rapidly, according to indications from Volpara Enterprise statistical data. The database of over 20 million aggregate, anonymized mammographic images is an invaluable tool for tracking utilization and monitoring image quality across Volpara’s global customer base.

Analysis of mammography services during the COVID-19 pandemic shows that as restrictions on non-emergency healthcare services are easing, imaging facilities are expanding their hours and offering weekend appointments to manage the backlog of patients who were unable to attend their regularly scheduled screening dates. Exam volumes in many sites have returned to within 10 percent of pre-pandemic levels. A small group of facilities, about five percent, are recording exam volumes higher than previous levels.

Mammography screening has been strongly impacted by shutdowns related to COVID-19, with estimates placing the downturn in overall outpatient imaging procedures at nearly 70 percent. Volpara is working with customers to help them prepare for increased patient volumes as they resume regular screening operations. During the shutdown, breast centers were able to remotely access Volpara Enterprise to analyze their center’s performance data and develop improvement plans prior to resuming screening operations. Technologists also accessed their positioning and compression data, giving them an opportunity to review educational videos to enhance their positioning skills. As facilities reopen, they are using the Volpara Enterprise data and the reporting tools in Aspen Breast to track utilization.

VOLPARA, Wellington, New Zealand
https://volparasolutions.com/
Next-generation ultrasound system

The new Logiq E10 from GE Healthcare is the company’s most technologically-advanced ultrasound system ever and brings fast, precise and consistent performance in a broad range of applications.

By allowing the choice of a wide array of advanced imaging tools and robust productivity enhancers based on artificial intelligence, the new system has been designed to be able to adapt to current and future needs. The features are all on a scalable platform that allows the system to be configured specifically to individual practice requirements.

Among the system’s features are:

**New AI-based Tools.** By leveraging the power of artificial intelligence, the system improves the speed and ease of exams and reduces the number of steps needed to achieve excellent image optimization. These AI algorithm are powered by GE’s Edison suite to create advanced applications, from computer-aided diagnosis to virtual assistant. In general, AI is proving to be a powerful tool to improve the quality, efficiency, and cost of healthcare. In particular highly-assisted tools help transform the LOGIQ E10 Series ultrasound into an Intelligent Digital Assistant to help healthcare providers make clinical decisions quickly and confidently.

**Processing Power.** The Logiq E10 ultrasound system is powered by a proven, high-performance cSound architecture that delivers extraordinary image quality, so providing the clarity, consistency, and confidence needed for a wide range of clinical applications.

**Cyber Threat Protection.** SonoDefense helps protect patients’ data, the institution and its reputation, by enabling the successful implementation of cybersecurity policies, yet still allowing daily workflow to be managed efficiently.

**Cleanability.** Rugged materials are robust in the face of harsh cleaning chemicals for both console and probes. For more information about cleaning procedures, visit the GE Healthcare Cleaning Compatibility Website.

GE HEALTHCARE
Chicago, IL USA
www.gehealthcare.com

Advanced software for X-ray angiography

The mission of the Budapest, Hungary based company Kinepict Health, is to make x-ray angiography safer and more powerful by bringing to the angiography community a novel and proprietary technology, which can provide interventional radiologists and vascular surgeons high-quality angiography images in the operating room. In particular, the company’s mission is to reach a ten-fold reduction in radiation dose and a five-fold reduction — or complete elimination — of iodinated contrast media. This strategy is based on the use of the company’s patented kinetic imaging technology that enables more efficient following of contrast media from X-ray image series. The new technology represents the bolus movement as a new digital variance angiography (DVA) image.

The company has now announced that it has received US FDA 510(k) clearance for its Kinepict Medical Imaging Tool (KMIT) software. Kinepict’s DVA technology revolutionizes the calculation of X-ray angiography images, innovating a field in which the fundamental principles of data analysis have been unchanged in the past four decades. The proprietary DVA algorithm uses advanced statistical methods to visualize blood vessels by identifying contrast-induced changes in the X-ray angiography image series. First clinical validations show that DVA provides superior image quality compared to the state-of-the-art Digital Subtraction Angiography (DSA). The dramatically improved image quality provided by DVA has the potential to make X-ray angiography safer and more powerful.

The following indications have already been clinically validated, and several other clinical validations are underway:

- Using DVA instead of DSA greatly improves image quality (2.5 to 10 times better contrast-to-noise ratio) for both positive (iodinated) and negative (CO₂) contrast media.
- DVA allows a 70% X-ray dose reduction compared to DSA in imaging of the lower limb.
- DVA allows a 50% contrast agent reduction compared to DSA in imaging the carotid.
- DVA provides superior image quality compared to DSA when imaging blood vessels near metal implants.
- DVA provides superior image quality compared to DSA during prostate embolization.

KINEPICT HEALTH LTD.
Budapest, Hungary
https://kinepict.com/

Left Panel. Conventional DSA. Right Panel DVA
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1. ProFound AI for 2D Mammography is CE Marked. It is not available for sale in the U.S.
2. ProFound AI for Tomosynthesis is FDA Cleared, CE Marked and Health Canada Licensed.