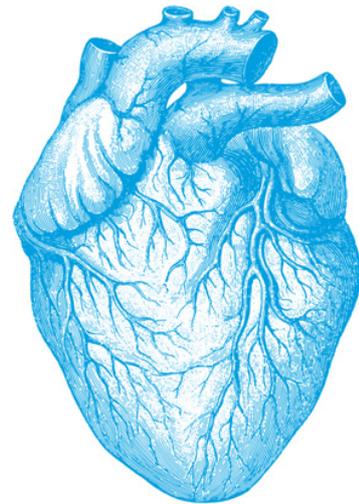


International Day of Radiology

CARDIAC IMAGING

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Interview on Cardiac Imaging Norway / Dr. Ylva Haig & Dr. Einar Hopp

Working as a radiologist is a great challenge as the technical developments are immense, and radiological examinations have become much more important for detailed diagnoses, preoperative assessment and follow-up, Dr. Ylva Haig and Dr. Einar Hopp from Oslo state

Both Dr. Ylva Haig and Dr. Einar Hopp are senior consultant radiologists at Oslo University Hospital. Dr. Haig works at Ullevål and Aker Hospitals which has combined local and secondary referral functions with some tertiary and national referral functions. Dr. Hopp works at Rikshospitalet which is a smaller part of the hospital with tertiary and some national referral functions. This combined similarity and diversity is the reason why Drs. Haig and Hopp chose to answer some questions separately and some as one.

European Society of Radiology: *Could you please give a detailed overview of when and for which diseases you use cardiac imaging?*

Ylva Haig: We perform cardiac imaging in both hospitalised patients mainly referred from our cardiac and thoracic departments, and patients referred from other hospitals in our health region and external cardiologists. The majority of our patients have clinical symptoms or suspicious signs of ischaemic disease, acute myocardial or pericardial affection, or cardiomyopathy.

Einar Hopp: In addition, at the tertiary referral centre at Rikshospitalet some patients are admitted because they are closely related to people with genetic cardiac disease, and there is a large patient group with congenital heart disease, both new-borns, older children and grown-ups.

ESR: *Which modalities are usually used for what?*

YH & EH:

In the Departments of Radiology at Ullevål and Rikshospitalet, we perform cardiac imaging with CT and MRI. The patients may

undergo other types of cardiac imaging such as echocardiography in the Department of Cardiology or cardiac scintigraphy and a PET scan in the Department of Nuclear medicine.

Over the last few years, CT has become an established method for the diagnostic investigation of coronary artery disease in patients classified at low to intermediate risk of coronary disease, with typical or atypical symptoms of angina. Coronary CT has to a large extent replaced invasive diagnostic coronary angiography. The modality is commonly used to detect atherosclerosis and stenoses and has a high negative predictive value. We also routinely perform cardiac CT preoperatively in patients prior to TAVI (transcatheter aortic valve implantation) and left atrial appendage closure procedures.

Cardiac MRI is commonly used in patients with ischaemia to characterise the extent and severity of myocardial involvement in addition to patients with arrhythmias prior to ICD implantation. MRI is used for the diagnostic workup when arrhythmogenic

right ventricular cardiomyopathy is suspected and is essential in the assessment of hypertrophic cardiomyopathy and different tissue deposition diseases for diagnostic purposes and risk stratification, but less so in dilated cardiomyopathy. Additionally, the modality is often central in visualising the anatomical distribution and character of cardiac tumours. However, cardiac CT may also be valuable here, and the modalities may be complementary. In the acute setting, cardiac MRI is performed on patients with suspected peri/myocarditis, and subacutely to detect and characterise cardiomyopathies. In the case of congenital heart defects both CT and MRI are used for different purposes at different stages. With MRI we assess intracardiac anomalies, myocardial tissue and flow. CT is still important for the assessment of vascular variants, even in some small children.

ESR: *What is the role of the radiologist within the 'heart team'? How would you describe the cooperation between radiologists, cardiologists, and other physicians?*

YH & EH: We meet regularly and discuss patients and optimal imaging methods and participate in each other's meetings weekly. The patients are usually referred by the cardiologists or the thoracic surgeons and the radiologist plays a central part in selecting the optimal imaging modality and protocol. Now we also have an increasing cooperation regarding MRI examinations of patients with a pacemaker or implantable cardioverter defibrillator.

ESR: *Radiographers/radiological technologists are also part of the team. When and how do you interact with them?*

YH & EH: We have dedicated and experienced radiographers who perform all the cardiac MRI imaging, whereas most of the radiographers have training in coronary CT imaging. They always contact us when in doubt.

YH: In my daily work in the angio suite I also have close teamwork with our interventional radiographers.

ESR: *Please describe your regular working environment (hospital, private practice). Does cardiac imaging take up all, most, or*

only part of your regular work schedule? How many radiologists are dedicated to cardiac imaging in your team?

YH: Cardiac imaging is one of many tasks and accounts for less than half of my time at work. We are approximately ten radiologists involved in the evaluation of the coronary CT imaging and two who handle all the cardiac MRI.

EH: Cardiac MRI constitutes approximately half of my radiological practice, but has a larger share of my research schedule. At Rikshospitalet we are building a team of four radiologists performing both cardiac CT and MRI in grown-ups, and we have a similar number of paediatric radiologists performing the examinations in congenital heart defects.

ESR: *Do you have direct contact with patients and if yes, what is the nature of that contact?*

YH & EH: Regarding the cardiac imaging patients we always choose appropriate protocols before the examination. As for the cardiac CT, I attend the CT lab on request from the radiographers, usually for the administration of medication, and sometimes to review the examination before the patient is taken from the lab. I am more closely involved in cardiac MRI imaging. Depending on the purpose of the examination I may be present during the examination or just be consulted along the way.

ESR: *If you had the means: what would you change in education, training and daily practice in cardiac imaging?*

YH: As coronary CT has become a routine examination and to a large extent replaced invasive coronary angiography, I believe it is important that training in cardiac and especially coronary CT is implemented in doctors' radiological specialty training programme.

EH: I strongly support that point of view. Even in routine thoracic CT scans, some cardiac diagnoses are readily made, calling for deeper knowledge among general radiologists. Probably, cardiac MRI will stay sub specialised, but the need for general knowledge in MRI for every radiologist is obvious.

ESR: *What are the most recent advances in cardiac imaging and what significance do they have for improving healthcare?*

YH: The trend towards more non-invasive diagnostic examination with coronary CT is a major change with fewer complications and costs involved. The development of combined CT and fractional flow reserve (FFR) to measure the haemodynamic significance of a stenosis is another interesting and valuable technique; however, the software is not yet commercially available in today's CT scanners.

Cardiac MRI techniques are further developing and will likely provide us with additional information and stratification on cardiomyopathies and tumours in the future.

EH: Technological improvement is obvious both for CT and MRI examinations. For CT, broader detectors, higher speed and the possibility for lower and even numerous voltages increase quality. For MRI, the numerous different improvements of different sequences, higher speed and a number of recently available methods both increase the number of relevant parameters. Most importantly: for both methods, the advances have increased our ability to examine a broader range of the population. Analysis software has become quicker, more stable, and more advanced. Still, there seems to be potential for further implementation and further improvement. Some advances in other medical disciplines influence imaging: development in genetics has provided more precise recruitment for cardiomyopathy assessment. Improved cardiological knowledge and work-up has increased the demand for better risk assessment in cardiac disease.

Demand for advanced imaging seems to have increased. Probably this is a combined effect from increased availability and the advances mentioned above.

ESR: *In what ways has the specialty changed since you started? And where do you see the most important developments in the next ten years?*

YH: Radiology as a specialty has and is changing at great speed. Working as a radiologist is a great challenge as the technical development is immense,

continuously leading to improved imaging with more and more information. It is challenging to keep up to date with the new available techniques and all the possible advantages they bring. Simultaneously, as new medical treatments are introduced, the demand for radiological assessment is increasing.

EH: Radiological development is driven both by medical and by technological progress, and the mix is powerful. In general, the radiological role has changed, and radiological examinations have become much more important for detailed diagnoses, preoperative assessment and follow-up. Each examination calls for more detailed investigation, and even reporting has become more demanding. The radiologist herself is ever more central in multidisciplinary teams. Let us add the fact that every radiological exam now is several times larger than just a few years ago, and that the detailed imaging also has the potential for finding relevant, unknown disease in neighbouring organs. Thus, radiology has become increasingly interesting, and radiological labour increases very fast. Staff do not increase at the same speed. The next ten years we will have to follow and drive the upcoming progress, but we also have to reconsider the way we work in order to cope with the demands. Redefining workflow, roles and computer aid, and development of automated procedures are probably parts of this.

ESR: *Is artificial intelligence already having an impact on cardiac imaging and how do you see that developing in the future?*

YH: We have not implemented artificial intelligence in our hospital, but I think it has an immense potential in the future and will influence and change our work routines. However, with our existing IT system I do not see this in the near future.

EH: Artificial intelligence (AI) does not seem to directly influence cardiac CT or MRI diagnostics at our hospital, presently. The potential may be large and according to Q 9, the need as well, both from AI and more traditionally developed software. There is a magnitude of possibilities. Pre-exam text screening might have the potential to detect risks before contrast

medium administration or exposure to the magnetic field. Pre-exam image screening might influence protocol planning of the examination. Fusion with or subtraction from historical exams or other modalities might highlight relevant changes better than we are presently able to.

Better software may increase segmentation speed and accuracy, and even decrease the need for expert involvement. Reporting might be more standardised and content may improve with new, relevant parameters.

All these processes may become more automated than today, decreasing the

radiologist's work burden. We will have to rethink local and distant development, investment and risk. However, the cost is unknown and the benefit has to be defined. The test is the simple question: does it imply any benefit to the patient's health, for sufficiently low cost?

And we have to get into the black box of AI, and demand explainable AI. As always, the radiologists, clinical doctors, technical staff and scientists have a pivotal role in the development and testing of all new technology. I believe working roles will change, but tasks will continue to increase.



Dr. Ylva Haig is an interventional radiologist at the Department of Radiology at Ullevål and Aker in the unit of vascular, thoracic and intervention radiology, Oslo University Hospital, Norway. After completing medical school at the Karolinska Hospital in Stockholm, Sweden, Dr. Haig moved to Norway where she trained in general radiology and became a specialist in 2007.

During her specialty training, she developed a special interest in cardiac radiology and interventional work and was introduced to percutaneous coronary angiography and intervention procedures. She also participated in the first implementation of cardiac CT at Oslo University Hospital, Ullevål, and is now in charge of developing

and implanting new cardiac CT techniques at the hospital. In recent years she has also been a major contributor in the cardiac MRI activity at her hospital.

Her main research interest has also been within cardiac and interventional radiology and she completed her PhD thesis on *Catheter-directed thrombolysis in deep Venous Thrombosis (the CaVenT study)* in 2015 and is now the research group leader of vascular diagnostics and intervention at Oslo University Hospital and currently supervising a PhD thesis on cardiac CT imaging in high-risk patient groups.

In 2016 Dr. Haig was awarded at Oslo University Hospital for outstanding research and first authorship of a research paper selected as top 10% at CIRSE (Cardiovascular and Interventional Radiological Society of Europe) and nominated to the best-paper session at the American Venous Forum, 2017 in New Orleans. Since 2015 she is the treasurer in the Society of Interventional Radiology in Norway (NFIR) and in 2017 obtained the Swedish Interventional Radiologist certification (SCIR). She is author or co-author of 11 scientific papers.

Dr. Einar Hopp is Head of the Department of Radiology, Rikshospitalet, Oslo University Hospital (OUH). His PhD in cardiac MRI was defended in 2014. After focusing on paediatric radiology, his main diagnostic and research interests became non-invasive cardiac radiology and ENT radiology.

He has authored and co-authored 30 scientific papers, two book chapters and 48 scientific posters and presentations, and has given numerous invited lectures, tutorials and refresher courses at national and international meetings.

At Rikshospitalet, OUH, he is responsible for thoracic and ENT MRI, and he is head of the research group of non-invasive cardiac imaging at the Clinic of Radiology and Nuclear Medicine, OUH. He is a board member and treasurer of the Norwegian Society of Radiology.

