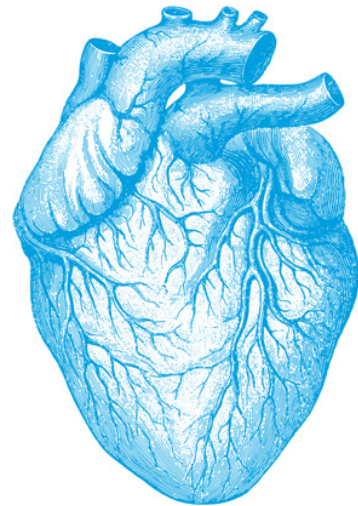


International Day of Radiology

CARDIAC IMAGING

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Interview on Cardiac Imaging Croatia / Dr. Maja Hrabak Paar

Cardiac imaging should be used in every teaching hospital, and every radiology resident should learn the basics of cardiac imaging, believes Dr. Maja Hrabak Paar from Zagreb

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

Maja Hrabak Paar: I work in the largest hospital in Croatia, and patients are referred to our department for a cardiac CT or MRI examination from departments of cardiology, cardiac surgery, and paediatric cardiology at our hospital, but also from other institutions that do not have cardiac imaging facilities. We use cardiac CT and MRI for evaluation of a wide spectrum of cardiac diseases. In the evaluation of coronary artery disease, we use CT mostly for its exclusion or for evaluation of coronary artery bypass grafts (CABG) patency, and MRI for assessment of myocardial viability and significance of coronary artery stenosis. We also use both techniques for evaluation of complex congenital heart disease, CT as a faster technique with fewer artefacts mostly in young children and non-cooperative patients, and MRI in others. For patients with cardiomyopathies, we regularly perform cardiac MRI, usually soon after it presents itself, but sometimes also for follow-up of patients.

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

MHP: At our institution, we use cardiac CT mostly for the exclusion of coronary artery disease in patients with atypical chest pain

and inconclusive stress ECG, and those who require cardiac non-coronary surgery. Other common questions that we answer using cardiac CT include CABG patency, evaluation of cardiac masses, the presence of coronary artery anomalies, the depiction of post-occlusive segments of coronary arteries before CABG and detection of a relationship between the sternum and cardiovascular structures in patients who require re-do cardiac surgery. We also use cardiac CT for evaluation of complex congenital heart disease in children who are too young to cooperate during cardiac MRI, and for emergent examinations.

The most common indication for cardiac MRI at our institution is the evaluation of cardiomyopathies, including their dilated, hypertrophic and restrictive/infiltrative forms, arrhythmogenic right ventricular cardiomyopathy (ARVC) and left ventricular non-compaction (LVNC). We use a stress cardiac MRI for a comprehensive evaluation of ischaemic heart disease. The most common emergent indications for cardiac MRI are myocarditis and evaluation of patients with arrhythmia before emergent ICD implantation. Our institution is the national referral centre for grown-up congenital heart disease (GUCH), so we have an increasing number of GUCH patients that we examine using cardiac MRI. Another important group of patients who need cardiac MRI are those referred by the

electrophysiological specialists before or after their intervention.

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

MHP: Adult and paediatric cardiologists usually assess cardiac morphology and function using echocardiography or invasive vascular techniques, whereas cardiac CT and MRI at our institution are mostly performed by radiologists in close cooperation with the referring physicians. The indication for the examination and specific clinical question are usually well defined by the referring adult or paediatric cardiologists and cardiac surgeons, and the indications and contraindications are routinely checked by radiologists. Preparation of the patients for the exam is mainly done by cardiologists, and a radiologist selects the proper scanning protocol, performs post-processing, analyses images and writes the report. In case of any doubt, the referring physician is consulted, and the conclusion is made together. Cardiac surgeons often come to the radiological department before surgery if they have some specific questions that can be answered through mutual assessment of the examination. Furthermore, there are interdisciplinary team meetings where cardiologists, paediatric cardiologists, cardiac surgeons and radiologists meet together to determine the best solution for further patient care. Today a cardiac radiologist is an important peer in the 'heart team' and helps to deliver optimal healthcare to cardiological patients.

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

MHP: Close cooperation between radiographers and radiologists is more important in cardiac imaging than in other segments of radiology. Radiographers involved in cardiac imaging require dedicated theoretical and practical education, not only from a technical but also from a clinical point of view. They are familiar with cardiac scanning protocols selected by the radiologists, and with possible issues during examination

including arrhythmias, atypical anatomy in patients with congenital heart disease or after cardiac surgery, adverse reactions to premedication or contrast media administration and also radiation protection. At our institution, a cardiac radiologist is always available to radiographers during cardiac imaging examinations, he/she is usually even present at the control room, and good interaction between a radiographer, radiologist and cardiologist helps to get high-quality images without harm to the patient.

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?*

MHP: I work in a university hospital, and cardiac imaging takes up only about a third of my work schedule, during other time I do mostly body imaging. At our institution, there are two more radiologists who also perform both body and cardiac imaging. The number of referrals for cardiac CT and MRI is growing, but currently the number of cardiac imaging examination is limited by the lack of radiologists and MRI scanners.

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

MHP: Patients are regularly in direct contact with radiographers who scan the patients, and cardiologists who select the premedication for patients. However, there are instances when I as a radiologist also get in direct contact with the patient, either before the examination to get additional data important for protocol selection or image analysis, or after the examination, usually to explain the findings to the patient.

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

MHP: If I had the means I would introduce cardiac imaging in at least every teaching hospital and every radiology resident should learn the basics of cardiac imaging, and be able to perform and interpret a cardiac CT and MRI examination. Furthermore, level III education and official

subspecialisation in cardiac imaging recommended by ESR should be accepted in each European country, and more cardiac imaging fellowships should be offered to provide excellence in education. In my country, unfortunately, CT and especially MRI equipment is old, and if I had the means, I would invest in new generation scanners and post-processing software that would improve the diagnostic procedure.

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

MHP: In my opinion, the most important advances in cardiac MRI during last few years were multiparametric myocardial mapping techniques that enable precise tissue characterisation, even without the use of contrast media, and detection of diffuse myocardial diseases that was very limited using late gadolinium enhancement. In cardiac CT, relevant reduction of radiation dose to submillisievert values led to a large increase in its use. The future addition of functional testing, such as FFR-CT or CT perfusion, into clinical routine could further improve the positive predictive value of the technique, and support its use as a one-stop-shop method for evaluation of coronary artery disease.

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?*

MHP: Today patients favour non-invasive imaging much more than ten years ago. If we compare cardiac radiology today and ten years ago, there is a huge improvement in technology. At that time cardiac CT was mostly performed on scanners with 64 detector rows, and today it is possible to scan the whole heart in a single heartbeat. The radiation dose in cardiac CT decreased up to 20 times, and iterative reconstruction was created that enabled imaging to be carried out with less noise. Furthermore,

improvement in post-processing techniques enabled faster and more automatised evaluation of both CT and MRI examinations. During the next ten years, I believe that functional testing during a CT examination, either as FFR-CT or CT perfusion, should become a clinical routine, and that MRI scans should be much faster with more quantitative data.

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

MHP: Post-processing software, both for cardiac CT and MRI, are already semi-automatised and really speed up the interpretation process compared to previous manual segmentation of images. However, all contours should still be checked by an experienced interpreter, because semi-automatised segmentation is far from perfect, especially for the right ventricle segmentation. Issues with semi-automatised segmentation are also present if images are of suboptimal quality or the cardiac anatomy is non-conventional. I believe that this segmentation process will be further improved in the future so that less manual correction will be needed, and there will be more quantitative data obtained using artificial intelligence, that could have a significant impact on patients' treatment and prognosis.

ESR: *Please feel free to add any information and thoughts on this topic you would like to share.*

MHP: I still feel some level of fear of cardiac radiology among general radiologists, even young ones. I am aware that the learning curve in cardiac imaging is pretty steep and that it requires additional efforts to become familiar both with technical and clinical aspects of the field. Nevertheless, I strongly support all young enthusiasts to enter it because it is one of the most prospective, rapidly developing and fascinating areas in radiology.



Dr. Maja Hrabak Paar is a cardiac and abdominal radiologist at the University Hospital Centre Zagreb, Croatia, where she finished her residency in 2008. Since 2016 she has been an assistant professor of radiology at the University of Zagreb School of Medicine. She introduced cardiac imaging in Croatia after training in cardiac radiology as a fellow of the European School of Radiology (ESOR) in AKH Vienna, Austria in 2007 (tutor: Christian Loewe). She spent the academic year 2014/2015 as a postdoctoral fellow in cardiac imaging at the University Hospital Basel, Switzerland (tutor: Jens Bremerich). She passed the European Board of Cardiovascular Radiology (EBCR) Diploma examination in 2018. She is president of the

Cardiac Section of the Croatian Society of Radiology that she established in 2016, a member of the Cardiac Subcommittee for the European Congress of Radiology (ECR) 2017–2019, and a member of the Education & EBCR Committee of the European Society of Cardiovascular Radiology (ESCR) 2017–2020. She has authored or co-authored 20 papers, three book chapters and 95 scientific posters and oral presentations.