Entrance of the Mannheim University Medical Center, Germany

Cardiac Imaging: Early Recognition of Coronary Heart Disease

Determination of vascular calcification as a sub-clinical indication of atherosclerosis and exclusion of coronary heart disease at a medium pretest probability: Computed tomography of the coronaries shows what it can do.

By Hildegard Kaulen, PhD

For years, it was not possible to create sharp, three-dimensional images of the beating heart. Cardiac and respiratory motion continued to set unsurpassed limits for computed tomography (CT). But since the date that CT images can be acquired within one-tenth of a second, the precise display of the coronary vessels and luminal narrowing has been possible. Since the recent, pioneering development of the SOMATOM® Definition Dual Source CT (DSCT), images of the highest quality and detail of fast and irregularly beating hearts are now routine – without having to reduce the heart rate with beta-blockers. Today, every patient arriving at the emergency room who is eligible for CT can be examined and no one needs to be turned away because of heart irregularities. Because of these technical advances, the importance of CT for cardiac diagnostics has increased rapidly. Two clinical applications are of paramount importance: proof of coronary calcifications and coronary CT angiography. Vascular calcification is an independent risk factor for subsequent angina pectoris, cardiac infarction, or cardiac death. For selected patients with suspected coronary disease, coronary CT angiography is already part of modern comprehensive diagnostic work-up. At the Mannheim University Medical Center, Germany, the clinical potential of cardiac CT is being closely researched by radiologists and cardiologists. The participating organizations are the Institute of Clinical Radiology and Nuclear Medicine headed by Prof. Schönberg, MD and the Medical Clinic I headed by Prof. Borggrefe, MD. In addition, the medical faculty Mannheim University is examining methods to reduce radiation exposure through intelligent protocols. For this purpose, Schönberg and his section chief for cardiothoracic imaging, Christian Fink, MD, have received a grant from the Federal Office for Radiation Protection. It is beyond question for Schönberg that imaging procedures are a core medical discipline, as well as an integral part of overall disease management. That's why close cooperation with clinical colleagues is so important for Schönberg. "We are looking

Indications for coronary CT angiography

Considered as appropriate indications for coronary CT angiography by U.S. medical associations:

- Diagnosis of coronary heart disease involving a symptomatic patient with a medium pretest probability, ECG cannot be interpreted or stress examination is not possible.
- Diagnosis of coronary heart disease involving a symptomatic patient. Stress examination cannot be interpreted or results are not explicit.
- Evaluation of coronary vessels with newly occurring cardiac insufficiency.
- Diagnostics for acute chest pain, ECG and cardiac enzymes are inconspicuous.
- Display of anomalies in the coronary vessels.

Source: J Am Coll Cardiol 2006; Bd.48:1475-1492

at the definition and implementation of the entire process, from diagnosis to treatment and follow-up. When coronary heart disease is suspected, the cardiologists first determine the risks of its presence. We then hold joint discussions about the diagnostic approach, arrive at the diagnosis and the cardiologists make the necessary interventions, if required."

Precise Diagnostics

Despite the progress made in diagnosis and treatment, cardiovascular diseases remain the number one cause of death in the western world. Although mortality has dropped down, morbidity has increased. Therefore, coronary artery disease (CAD) needs to be detected and treated earlier. Tim Süselbeck, MD interventional cardiologist and head of the Cath Lab at the University Medical Center Mannheim adds: "In patients presenting with stable chest pain stenosing CAD (stenosis >70%) has to be excluded or confirmed. In patients without symptoms the calcium score estimated by cardiac CT is representing a strong predictor for the occurrence of myocardial infarction and offers relevant information in addition to the classical score systems as PROCAM, Framingham or ESC scores."
In patients with acute symptoms a high pretest probability for stenosing CAD coronary angiography remains the gold standard. However the majority of patients who underwent coronary angiography reveal normal or coronary arteries without significant stenoses, that effort neither stent implantation nor bypass surgery. Therefore cardiac CT with sensitivity of over 95% for the detection of CAD should focus on patients with a medium pretest probability to exclude CAD non-invasively.
Furthermore CTA requires less time and cost, two factors that are steadily growing in importance in day-to-day clinical settings.

Cardiac Catherization or Coronary CT Angiography?

Patients' history, clinical and laboratory examination findings and stress ECG, are the basis for deciding who will be examined invasively by cardiac catheterization or coronary CT angiography when presenting typical or less typical symptoms of angina pectoris. US medical associations agree with this statement, according to their recently published consensus article. Pretest probability includes age, sex, results of the ECG at rest, and the values of cardiac enzymes. According to Sueselbeck: "If patients has a high risk for CAD coronary angiography remains the gold standard, because significant coronary stenoses can be treated by balloon dilatation and stent implantation within the same procedure. If the risk is of medium severity, coronary CT angiography is recommended to exclude relevant stenoses. In case of low-risk situations, conservative treatment should be continued. Under low risk we understand values under 10 percent; medium risk ranges between 10 and 90 percent. High risk is assigned to values over 90 percent."
"The strength of coronary CT angiography is its high negative pretest value", explains Fink. "If the data set is conclusive and no stenoses are present, higher-grade stensosing CAD can be excluded with a sensitivity of 95 percent."

Proof of Calcification and its Significance

Contrast-enhanced coronary CT angiography provides more than the inside diameter of vessels and therefore the degree of stenosis. With the CT Cardiac Engine it also allows for the evaluation of vessel walls. This method is able to prove calcified as well as non-calcified plaque. Süselbeck explains: "Vessel calcification speaks of a sub-clinical coronary atherosclerosis. While calcium is an independent risk factor for a subsequent coronary event, it has to be evaluated in relationship to the age and sex of the patient. Therefore, the calcium score provides important additional information with respect to risk stratification and whether prevention using acetylsalicylic acid and statins is necessary. However, the proof of vessel calcification alone does not justify a cardiac catheter examination."
To date, the prognostic value of non-calcified plaque has not been demonstrated. It has also not been possible to establish a close correlation between calcium score and risk of plaque rupture, that is, an acute coronary syndrome. Calcium in plaque is neither a sign of stability nor vulnerability. The calcium score is automatically determined with the complete solution for cardio-vascular

CT imaging, the CT Cardiac Engine, developed by Siemens Healthcare. Vessel calcification is determined without iodine containing contrast agents. Radiation exposure is reduced as compared to contrast-enhanced coronary CT angiography. With a patient-sparing exposure technique, for example, prospective triggering, radiation exposure is in the range of one mSv, that is, the same as the legally accepted exposure of the uterus during pregnancy."

Reducing Radiation Exposure

Radiation exposure is an important aspect as well. Using conventional computed tomography, exposure was higher with coronary CT angiography than with invasive coronary angiography. But with DSCT, it is now possible to perform coronary CT angiography with a comparable radiation dose than with invasive examinations. It is difficult, however, to assign an accurate exposure or number. They depend on the examination parameters used, such as tube current, tube voltage, and table feed. The patient's sex, build and weight play a significant role as well. Additionally, some tissues are more radiationsensitive than others, for example, the mammary gland. For this reason, Schönberg and Fink want to take a closer look at the radiation exposure of the various examinations. Fink: "Radiation exposure can vary by a factor of 10, given the variation of the examination parameters alone. Some scan strategies burden the patient with a considerably greater dose than others. This is why we want to define minimum requirements for the processes to keep the exposure as low as possible, independent of the user and the facilities. We are talking about a matrix based on accuracy and radiation exposure. For that purpose, we would like to compare the results of the different methods. That's why we received a grant from the state. We are eagerly awaiting the results."

***Hildegard Kaulen**, PhD, is a molecular biologist. After working at the Rockefeller University in New York and the Harvard Medical School in Boston, she has been a freelance scientific journalist for renowned newspapers and scientific magazines since the mid 90's.*

The team of the University Medical Center Mannheim (from left to right): Christian Fink, MD, associate chair for clinical operations and section chief of cardiothoracic imaging of the Institute of Clinical Radiology; Prof. Stefan Schönberg, MD, Chairmen of the Institute of Clinical Radiology and Nuclear Medicine; Theano Papavassiliu, MD, junior faculty of cardiac magnetic resonance imaging; and Tim Süselbeck, MD, Head of the cath lab.

Stefan Schönberg, MD, Professor and chair
Radiologist, studied medicine at the University of Heidelberg, worked at the University of Michigan in Ann Arbor, the German Cancer Research Center in Heidelberg and the Ludwig-Maximilians-University in Munich.
Since 2007, he has been Chairmen of the Institute of Clinical Radiology and Nuclear Medicine at the Mannheim University Medical Center. He is also a member of the executive board of the International Society for Magnetic Resonance in Medicine and is co-editor of Investigative Radiology magazine. In 2006, he was the recipient of the Holthusen Ring award of the German Roentgen-Ray Society.

Christian Fink, MD, Assoc. Professor
Radiologist, studied medicine at the University of Heidelberg, worked at the University of Heidelberg, the German Cancer Research Center in Heidelberg and the Ludwig-Maximilians-University in Munich. Since 2007, he has been associate chair for clinical operations and section chief of cardiothoracic imaging of the Institute of Clinical Radiology and Nuclear Medicine at the Mannheim University Medical Center. He is a co-editor of the book, "Screening and Preventive Diagnosis with Radiological Imaging."

Tim Süselbeck, MD, Assoc. Professor
Internist and interventional cardiologist, studied medicine at the University of Heidelberg. Since 1993, he has worked at the Mannheim University Medical Center, since 2005 head of the Cath Lab of the I. Medical Clinic at the Mannheim University Medical Center. Dr. Sueselbeck is constantly engaged in extensive interventional and clinical studies.

Theano Papavassiliu, MD, Assoc. Professor
Internist and cardiologist, studied medicine at the University of Wuerzburg. Since 1995, she has been employed at the Mannheim University Medical Center. Dr. Papavassiliu is junior faculty of the area of cardiac magnetic resonance imaging there.