A gentle look at the heart

Coronary artery disease is one of the major causes of death in the Western population, mainly because of the potential risk of a heart attack. The latter often occurs out of the blue and the only chance to survive it is to find immediate medical assistance. Sometimes, however, a heart attack is preceded by typical symptoms: Patients suffer from chest pain during physical or emotional stress. The coronary arteries, the vessels that supply the heart muscle with blood and oxygen, are diseased and narrowed by so-called coronary artery plaques. During an increased oxygen demand of the heart during stress, the narrowed vessel cannot supply enough blood to the heart muscle. It screams in pain. This is your body telling you that you should consult a cardiologist. So, what can the cardiologist do at this point?

A 63-year-old male with high cholesterol complains about chest pain whenever he goes for a walk. The cardiologist referred him for exclusion of coronary artery disease. CT revealed severe narrowing of his left anterior descending artery (white arrow). Subsequently, SPECT demonstrated reduced blood flow to the heart (violet). The patient underwent cardiac catheterization and a stent was placed.

After thoroughly evaluating your symptoms and your cardiovascular risk factors, he will perform a physical examination and most likely an ultrasound examination of your heart. If he suspects coronary artery disease to be the cause of the symptoms, he has several options to look for reduced blood flow to the heart. The first option is a treadmill or bicycle test. It is a non-invasive (that is, no surgery or interventions are performed) test and the patient is neither exposed to

radiation nor to a contrast agent. This is a significant advantage since very high radiation exposure may potentially induce malignancies and exposure to contrast medium carries the risk of allergic reactions or kidney injury. The drawback of such exercise testing, however, is its limited accuracy. A much more accurate technique is invasive cardiac catheterization where the interventional cardiologist advances a catheter through the leg artery up to the heart and visualizes the coronary arteries with x-rays and contrast agent. If a significantly narrowed vessel is seen, the interventionalist has the possibility to dilate the narrowed section and place a stent. Nevertheless, due to its invasive nature, this intervention bears non-negligible risks aside from exposure to radiation and contrast medium, namely vessel injuries, stroke or even death. In view of the fact that in the majority of cases there is no need for dilatation and stenting because the symptoms are not due to coronary artery disease, such an invasive approach may be inappropriate and should only be performed if there is a proof that coronary artery disease really is present. This is why non-invasive alternatives should always be performed first. Cardiac hybrid imaging constitutes such an alternative. It combines computed tomography (CT) coronary angiography and single-photon-emission-computed-tomography (SPECT). With the use of CT coronary angiography plaques in the coronary arteries can be very acutely detected without the need for catheters or any other invasive procedures, reducing the potential risks to radiation (usually around 2 to 3 mSv) and contrast agent (usually 60 to 100 mL) exposure. As a comparison: flight attendants are annually exposed to about 2 mSv of additional cosmic radiation. If narrowed vessels are detected by CT, blood flow to the heart can then be evaluated by SPECT as a next step. SPECT allows visualization of blood flow to the heart by means of radioactive molecules which are injected intravenously and accumulate in the heart according to the regional blood flow. However, the use of radioactivity in the past has led to an additional radiation exposure of up to 10 to 15 mSv. Combination of the morphological information from CT and the functional information from SPECT results in a comprehensive clinical evaluation of suspected coronary artery disease – but at the cumulative expense of up to 100 mL of contrast agent and up to 20 mSv of radiation exposure.

This is where our research makes a tremendous difference. Latest-generation CT scanners, combined with novel reconstruction algorithms and sophisticated acquisition protocols allow shorter acquisition times with reduced radiation and contrast medium exposures as low as 0.5 mSv and 45 mL. In addition, SPECT cameras have recently seen milestones in technical advancement, rendering them much more sensitive to radioactive signals. Thus, SPECT can now be performed with much less radioactive molecules, resulting in an average radiation exposure well below 4 mSv. Thanks to these radiation- and contrast-sparing techniques, the combination of CT and SPECT for the assessment of coronary artery disease now results in a cumulative amount of contrast agent of less than 50 mL and with a radiation dose exposure of well below 5 mSv while offering a comprehensive non-invasive work-up with an excellent diagnostic accuracy.

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