

**AMBER BOLER:** Greetings. I'm Dr. Amber Boler, cardiology fellow at Mayo Clinic. During today's recording, we'll be discussing noninvasive imaging for suspected coronary artery disease. I'm joined by my colleague, Dr. Nandan Anavekar, who specializes in this area. Welcome, Dr. Nandan Anavekar.

**NANDAN ANAVEKAR:** Hi, Amber, and thank you so much for having me here and for the chance to chat about imaging in coronary artery disease.

**AMBER BOLER:** So let's get started. What are some of the noninvasive imaging studies available to assess for coronary artery disease?

**NANDAN ANAVEKAR:** Well, there are several noninvasive tests that are available for the assessment of coronary artery disease, and all are aimed at helping the risk stratification process. As you know, the mainstay tests that we are all familiar with are echocardiography, which uses ultrasound technology to produce images, and nuclei cardiac imaging, which uses radiation to produce images. Echocardiography provides information regarding function and hemodynamic parameters, whereas the strength of nuclear cardiac imaging is in its ability to demonstrate function, perfusion, and metabolic phenotypic features of myocardial performance.

Now, not so new is cardiac MRI and cardiac CT. However, these are not typically mainstay imaging modalities used in practice. MRI is magnetic resonance imaging and uses the magnetic properties of protons to produce images. And it provides useful information regarding cardiac function, potentially hemodynamic abnormalities. But most importantly, it is able to help distinguish ischemic from non-ischemic forms of ventricular dysfunction. Cardiac CT uses X-rays to produce images, and its major strength is in its ability to noninvasively delineate coronary anatomy.

So briefly, to summarize what we just talked about, the noninvasive imaging modalities available to assess coronary artery disease includes echocardiography and nuclear imaging as the mainstays. And centers with advanced cardiac imaging technologies, both cardiac MRI and cardiac CT, become an option as well.

**AMBER BOLER:** And when would you choose a noninvasive imaging test to evaluate for coronary artery disease?

**NANDAN ANAVEKAR:** Amber, that's a great question, and it pertains to the underlying disease. As you know, coronary artery disease is an important diagnosis to be aware of since it is related to both major morbidity and mortality. However, both primary and secondary preventive strategies, as well as contemporary treatment of acute coronary artery disease, have improved outcomes in the ischemic heart disease overall.

And this is something that the wider cardiovascular community can really be proud of. When to choose a noninvasive test for suspected coronary artery disease, in reality, depends on the type of practice that one operates in. For example, my inpatient practice is in the nature of cardiac intensive care, and therefore, essentially all of my patients with ischemic heart disease present with an acute ischemic syndrome.

In this situation, the goal of imaging, for me, is to assess left ventricular function, to assess the structural complications of ischemic heart disease, and to assess for alternative diagnostic possibilities for the presentation. In the outpatient setting, the goals are intuitively different, and the two major considerations are the evaluation of a patient presenting with symptoms and the evaluation of the asymptomatic patient who is at risk of coronary events.

In these settings, most often, imaging is undertaken to facilitate restratification and the decision to pursue invasive and geographic assessment. In the majority of instances, this may be in the form of functional cardiac imaging, in the form of a stress test on the one hand, or anatomic imaging in the form of noninvasive cardioangiography with CTA on the other hand.

**AMBER BOLER:** And how do you choose a noninvasive study for these patients?

**NANDAN ANAVEKAR:** Well, that's another really important question, and there are really two important factors that determines one's choice for that noninvasive test. The first is the availability of the technology and the second is the availability of the expertise. If both these are present, then the choice depends upon the acuity of illness and the goal of testing.

Let's first consider the acute coronary syndrome in the inpatient setting. In most instances, one doesn't need imaging to make the diagnosis. However, when it may become necessary is when there may be diagnostic ambiguity, and we do not see this infrequently.

The major diagnoses in the acute setting beyond myocardial infarction includes, for example, stress cardiomyopathy, myocarditis and pericarditis, pulmonary embolism, and the acute aortic syndromes. If there is any doubt in the diagnosis, then imaging may become very important in the evaluative process. In the inpatient setting, the two important modalities that are available in most places, essentially 24/7, would be echocardiography and CT imaging.

Echocardiography, in particular, is very useful since it is a technology that can be brought to the bedside, which is important in the care of our unstable patients. Once the diagnostic goal has been established, most imaging in acute coronary syndromes takes place after ischemia has been eliminated. And it is focused, thereafter, upon the assessment of ventricular function and to monitor for complications of disease, which can include both acute structural complications, but also chronic changes of size and shape of the pumping chambers that holds prognostic relevance.

If we now consider imaging in the outpatient setting, the two important technologies that are probably current mainstay include echocardiography and nuclear cardiac imaging, just because there is such extensive global experience and availability of these technologies. Most of the outpatient assessment revolves around functional imaging. Cardiac MRI is evolving, a growing presence in the field of functional cardiac imaging, since it provides absolutely beautiful images in any plane, and the imaging resolution is so good that it allows for assessment of subtransmural perfusion defects.

CT is also developing a role in the assessment of individuals, where alternative diagnoses are being considered and where the manifestation of ischemia may be due to another etiology. For example, myocardial bridging or the detection of congenital coronary artery abnormalities. Another controversial area is viability imaging, and in my personal practice, I've utilized echo, PET imaging, and cardiac MRI.

Although my preferential bias-- that's my personal bias-- is towards PET imaging since I feel, in my personal experience, that at Mayo, we tend towards PET imaging for viability assessment. Now, having said all of that, it is extremely important to be cognizant of the relative paucity of data supporting routine viability testing, and the lack of data regarding the role of the different imaging modalities in viability testing.

So again, I've been rambling, quite a long answer to your question. But if we were to summarize, my choice of imaging in the inpatient setting, in the majority of cases, utilizes echocardiography and CT imaging. In the outpatient setting, my practice preferences has been echo and nuclear cardiac imaging. I utilize cardiac CT if I'm considering alternative diagnosis for chest pain or for screening. And I consider cardiac MRI, echo, or nuclear if I'm considering an assessment of myocardial viability in a patient with established coronary artery disease with significant left ventricle dysfunction.

**AMBER BOLER:** This is fascinating. Can you discuss some of the pertinent limitations for each of the studies you just mentioned?

**NANDAN ANAVEKAR:** Yes, of course. So I think to answer this question, let's take this by imaging modality. So let's first consider echocardiography. Remember, echo depends upon ultrasound to develop images. Therefore, if there are limited acoustic windows, then we will have limited image quality, and this will certainly impact the interpretive sensitivity of the test. I would consider this to be the major limitation of echo choreography.

With nuclear cardiac imaging, the major limitation is radiation exposure, which becomes of particular importance, especially in our younger patients with coronary artery disease. For cardiac MRI and CT, the major limitation remains access to technology. Beyond that, for MRI, there are both patient and technology-related limitations. For example, in a patient with claustrophobia, MRI would probably not be a good choice. In a patient with renal disease, one has to be cognizant of the fact that this represents a contraindication to the administration of gadolinium-based contrast agents.

Although over the last five years or so, we've been able to image individuals with MRI who have cardiac devices, I personally still see this as a relative contraindication to cardiac MRI, especially if alternative imaging strategies are available. For cardiac CT, there are several important factors to consider. First is that CT uses radiation to produce images. Most cardiac CT scans in contemporary practice use dose reducing protocols to minimize X-ray exposure. But having said that, this remains an important consideration.

Cardiac CT imaging requires electrocardiogram gating, therefore the presence of arrhythmias may impact the quality of images that are produced. Finally, iodine-based contrasting agents are used, and this is a contraindicated in individuals who have iodine allergies, and is relatively contraindicated in those with significant renal disease.

**AMBER BOLER:** This is a rapidly evolving field. Can you discuss some of the ongoing research in this area?

**NANDAN ANAVEKAR:** I think this is a really challenging question to answer, but an important question. Simply, there is a large volume of research in the field of ischemic heart disease. In the context of cardiac imaging, areas of interest relates to the performance of one modality against another in diagnostic and prognostic capacities. These goals must also be pitted against the phase of the disease that one is interested in, acute versus chronic and symptomatic versus asymptomatic.

If I were to comment on one or two areas that are of interest to me, the first would be CT perfusion imaging, which is rapidly becoming an important adjunct to coronary CT and geography, for both anatomic and functional assessment of coronary artery disease using a single modality. The second air of interest, for me personally, would be viability imaging since it pertains to the evaluation of a group of patients who are at the highest risk of poor outcomes, but who, paradoxically, have the greatest to gain from potential revascularization strategies.

Viability imaging has the potential to connect different modalities of cardiac imaging and provides us the opportunity to understand the different phenotypic manifestations of coronary heart disease. There are just so many other research areas in coronary artery disease that it would take a symposium to just touch upon. So beyond my personal practice interests, I would say, stay tuned for more to come.

**AMBER BOLER:** Well, thank you, Dr. Anavekar, for this excellent discussion of these very important insights into noninvasive imaging for suspected coronary artery disease.

**NANDAN** Thank you, Amber, for the chance to be here today.

**ANAVEKAR:**

**AMBER BOLER:** And thank you all for joining us on the heart.org on Medscape cardiology.