Combining noninvasive anatomical imaging with invasive functional information: an unconventional but appropriate hybrid approach

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CT coronary angiography (CTCA) allows accurate noninvasive imaging of the coronary arteries. As illustrated by this case report, the three-dimensional information provided by this technique might be of value to resolve complex coronary pathology encountered in the cathlab. However, the limitations inherent to an anatomical test also apply for CTCA, and bring in the need for functional information to ensure adequate patient management. (*Neth Heart J* 2009;17:292-4.)

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Catheter-based coronary angiography (CCA) is considered the gold-standard technique to assess the presence of coronary artery disease. It has become the essential diagnostic tool for the interventional cardiologist and cardiac surgeon to decide upon the most optimal revascularisation strategy. The catheter-based approach allows an ad-hoc percutaneous coronary intervention or the acquirement of additional morphological or functional information, using intravascular ultrasound or measurement of the fractional flow reserve, in case of intermediate coronary stenosis.

In the last decade, computed tomography coronary angiography (CTCA) has developed into a robust noninvasive alternative providing detailed anatomical information on the coronary arteries. Difficult coronary anatomy can easily be resolved due to the three-

dimensional nature of the technique. However, for clinical decision making, functional information remains essential and complementary in addition to accurate anatomical data.

This report describes a case highlighting the limitations of CCA and documents the advantages of CTCA. Invasively obtained functional information was necessary to reach a correct therapeutic decision.

Clinical history

A 56-year-old man was referred to undergo aortic valve replacement because of severe symptomatic aortic valve stenosis. Before final acceptance for surgery, all cases are preoperatively discussed in our daily heart team meeting, which is attended by a cardiac surgeon, an interventional cardiologist and a member of the general cardiology staff. The patient received medical treatment for hypercholesterolaemia and arterial hypertension. Otherwise he had no significant medical history. He recently underwent further investigation in the cardiology department of a community hospital because of anginal symptoms. On transthoracic echocardiography a severe aortic valve stenosis was diagnosed based on severe calcifications of the valve with a mean gradient of 60 mmHg. Left ventricular systolic function was normal. Invasive coronary angiography revealed a left dominant coronary system. The right and left coronary artery were considered normal by the referring cardiologist (figure 1). However, due to poor contrast opacification the left coronary artery was difficult to assess. Although the angiographic report did not mention the presence of pressure dampening when the left coronary system was cannulated, the absence of backward contrast filling into the left sinus of Valsalva suggested the presence of an ostial left main abnormality. To clarify this issue, we performed a dual-source cardiac CT scan with a specific emphasis on evaluating the left main coronary artery. The cardiac CT scan revealed a large noncalcified plaque at the origin of the left main stem causing a narrowing of the vessel lumen of at least 50% (figure 2). Because of these findings the patient was scheduled again for a repeat

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Figure 1. Conventional coronary angiogram of the right (A) and left coronary artery (B). The left coronary system is difficult to evaluate due to poor contrast opacification.

Figure 2. Cardiac CT scan showing a large noncalcified plaque (arrow) with accompanying significant lumen narrowing of the left main coronary ostium (inset, arrow). The aortic valve is severely calcified (arrowheads). The CT image provides the coordinates of the projection (encircled) in which the coronary narrowing is clearly visible, in this case an RAO 141 projection with 25° degrees of caudal inclination.

invasive coronary angiogram in combination with measurement of the fractional flow reserve across the stenosis (figure 3). Using a 0.014" pressure sensor wire and intravenous adenosine (140 µg/kg/min for two minutes) the obtained fractional flow reserve was 0.68, confirming the functional severity of the coronary narrowing. Instead of isolated cardiac valve surgery

Figure 3. Nonspecific opacification of the left coronary artery showing the left main stem coronary stenosis (arrow). The coronary pressure sensor wire (arrowhead) is advanced in the left anterior descending coronary artery.

with implantation of a St. Jude mechanical valve prosthesis, the patient also received a venous jump graft to the intermediate branch and obtuse marginal branch of the circumflex artery and a left internal mammary graft anastomosis to the left anterior descending artery. He made an uneventful recovery and remains symptom-free at one-year follow-up.

Discussion

Currently, CTCA is preferably used as a rule-out test for the presence of clinically relevant coronary artery disease (CAD), generally defined as a coronary stenosis with more than 50% diameter obstruction. For the purpose of exclusion of CAD, CTCA is most effective when used for symptomatic patients who are at low or intermediate pre-test risk of CAD.¹ By contrast, patients with typical angina are in general not referred to diagnose CAD, but rather undergo the test with the aim to provide information on who best to treat medically and who to treat by revascularisation. These patients usually present with an advanced stage of atherosclerosis that is hallmarked by calcifications.² Severe vessel wall calcification is the main obstacle for the use of CTCA today as it prevents assessment of the integrity of the underlying coronary lumen or leads to overestimation of coronary stenosis severity. A major role in the assessment of patients with a high pre-test likelihood of CAD is therefore not to be expected. However, CCA has limitations that sometimes result in an incomplete assessment of the coronary anatomy. As illustrated by this case, CTCA offers a useful alternative, especially in patients with complex coronary anatomy.^{3,4} The accurate three-dimensional visualisation of cardiac structures with CTCA explains the phenomenon of 'reverse referrals', i.e. patients who initially underwent a CCA are sometimes referred for a CTCA to complement the catheter-based angiographic findings.

Both CCA and CTCA are anatomical imaging techniques that provide detailed information on the location and severity of possible coronary artery stenoses. Quantification of lesion severity using quantitative coronary angiography has limited value for predicting the haemodynamic impact of a coronary stenosis, especially for an intermediately severe luminal narrowing (approximately 40% to 70% diameter narrowing).⁵ Recently, this discordance between anatomical-based assessment of lesion severity and its functional importance has been reported in patients who undergo CTCA.^{6,7} The documentation of myocardial ischaemia is essential information to guide the therapeutic management of patients with anatomically significant CAD.⁸ It is therefore advisable to clarify the physiological relevance of obstructive CAD on a cardiac CT scan by using a combined approach with a functional test. For the patient who is referred to the cathlab, invasive measurement of the fractional flow reserve is

the recommended test as it provides functional information about an angiographic stenosis.

Alternatively, hybrid imaging, using a combination of CTCA with single-photon emission computed tomography (SPECT), is evolving as an attractive noninvasive alternative to identify functionally relevant CAD.^{9,10}

Conclusion

The present case is a nice illustration of the accurate anatomical details provided by CTCA. The three-dimensional information provided by this technique might be of value to resolve complex coronary pathology encountered in the cathlab. However, the limitations inherent to an anatomical test also apply for CTCA, and create a need for combined functional information to allow appropriate therapeutic handling. ■

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