

HOW TO UTILIZE CORONARY COMPUTED TOMOGRAPHY ANGIOGRAPHY IN THE TREATMENT OF CORONARY ARTERY DISEASE

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Coronary computed tomography angiography (CCTA) has high negative predictive power for detecting coronary artery disease. However CCTA is limited by moderate positive predictive power in the detection of myocardial ischemia. This is not unexpected because the diameter of a stenosis is a poor indicator of myocardial ischemia and discrepancy between the severity of stenosis and noninvasive tests is not uncommon. The value of stenosis for predicting future development of acute coronary syndrome represented by plaque rupture has been questioned. CCTA identifies the characteristics of high-risk plaque including positive remodeling, low density plaque and spotty or micro-calcification. Also, additional evaluation of myocardial ischemia using computational flow dynamics, and luminal attenuation gradient are expected to increase both diagnostic performance for hemodynamically significant stenosis and the predictive power for future cardiovascular risk. Technical advances in CCTA would enable evaluation of both coronary artery stenosis and myocardial ischemia simultaneously with high predictive performance, and would improve vastly the clinical value of CCTA.

KEY WORDS: Coronary CT angiography · Prognosis · Coronary artery disease · Atherosclerosis · Functional ischemia · Myocardial mass.

INTRODUCTION

Coronary atherosclerosis is a chronic life-long progressive disease. Most clinical presentations of the disease are as a result of a critical narrowing of arterial lumen or a sudden thrombotic occlusion caused by the rupture of atherosclerotic plaque. Unfortunately prediction of such clinically adverse events is difficult by clinical judgement or symptoms alone.¹⁻³ Comprehensive approach of coronary atherosclerotic plaque including qualitative and quantitative analysis is necessary for the accurate lesion assessment and treatment planning as well as for the prediction of future outcome (Fig. 1).^{4,5}

Conventional invasive coronary angiography (CAG) has been regarded as the gold standard for coronary artery disease but has limitation for assessing the extent of mild to moderate coronary atherosclerosis.⁶ Intravascular ultrasound (IVUS) or optical coherence tomography (OCT) are needed to quantitate the burden of atherosclerosis. Coronary computed tomography

angiography (CCTA) can be considered as a non-invasive method that may substitute CAG and IVUS.^{7,8} CCTA is still limited by spatial and temporal resolution but enables non-invasive patient-friendly assessment of the extent of coronary atherosclerosis.⁹ Therefore it is expected that CCTA will be useful in overcoming limitations of the current diagnosis and treatment of coronary heart disease as shown below.

DEMONSTRATING THE PRESENCE OF CORONARY ARTERY DISEASE

CCTA has emerged as a new noninvasive tool for screening of coronary artery disease in place of conventional stress imaging or electrocardiography.^{10,11} Therapeutic strategy of coronary artery disease depends on the extent and severity of coronary artery disease. CCTA can visualize the extent of severity of coronary artery disease with good sensitivity and excellent specificity.^{12,13} The performance of CCTA for plaque detection

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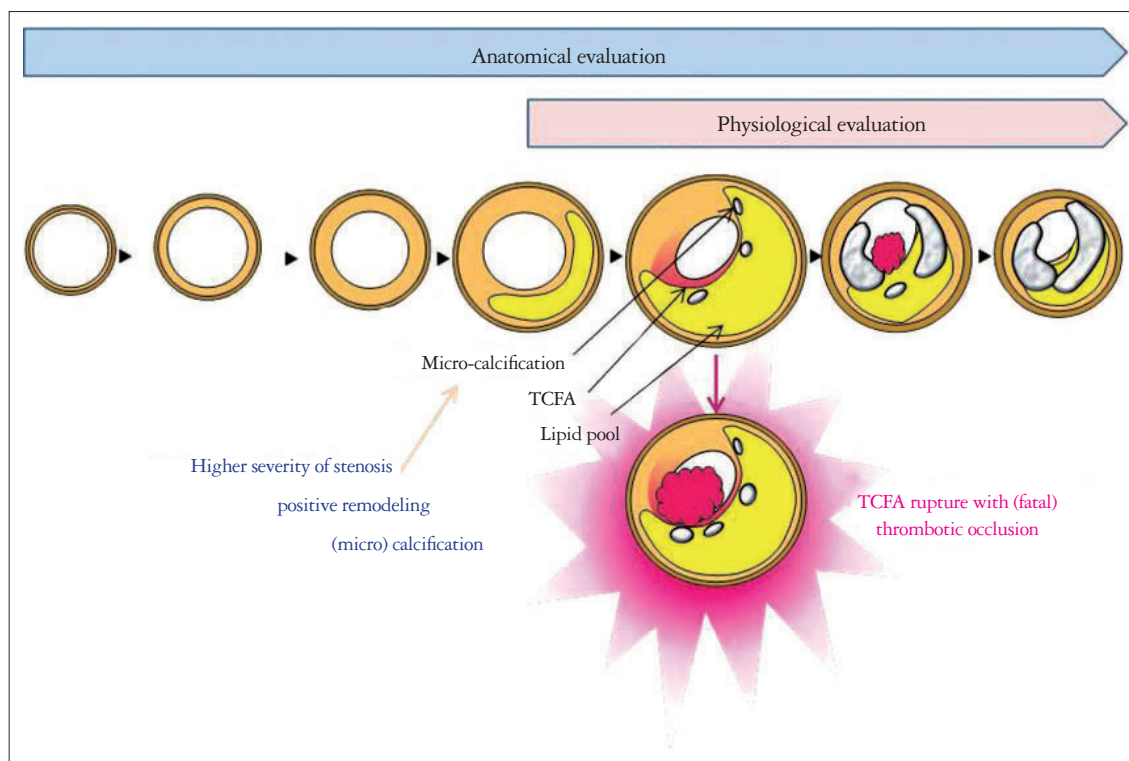


Fig. 1. Anatomical versus physiological evaluation of coronary atherosclerosis. TCEA: thin-cap fibroatheroma.

has been validated by IVUS and OCT.⁷⁽¹⁴⁾ Unlike stress imaging or invasive CAG, CCTA can detect a wide range of coronary artery disease from mild to severe disease.¹⁵⁽¹⁶⁾

PREDICTION OF FUTURE CORONARY HEART DISEASE INCIDENTS

It is difficult to predict future cardiac events through symptoms or clinical risk factors.¹⁷⁽¹⁸⁾ Clinical studies have shown that one-third of acute myocardial infarctions are asymptomatic prior to the event.¹⁹⁽²¹⁾ Most chronic total occlusions have infarct scar which is evidence of prior myocardial infarction but only half of them had a history of angina symptoms.²²⁽²³⁾

A CCTA is suitable to identify anatomical coronary stenosis, including calcified and non-calcified plaques, measure the atherosclerotic plaque burden and its response to treatment, and differentiate stable plaques from those that tend to rupture.²⁴⁾ Positive remodeling, low density (< 30 Hounsfield units) plaque, napkin-ring sign and spotty or micro-calcification detected by CCTA has been shown to have vulnerable plaque characteristics (Fig. 2).²⁴⁻²⁷⁾ These non-invasive findings have been validated by invasive IVUS and OCT studies.¹⁽²⁶⁾⁽²⁷⁾ Moreover, non-contrast coronary calcium CT scan is also useful to evaluate the risk of coronary artery disease using a coronary calcium score and it is well demonstrated to be related to long-term prognosis.²⁸⁾

Accordingly, CCTA can detect the presence of a coronary atherosclerosis most accurately and is one of the best non-invasive imaging modality to predict the clinical outcome of coronary artery disease as well.²⁹⁾

ROLES OF CCTA ON DETERMINING THE TREATMENT POLICY OF CORONARY ARTERY DISEASE

The treatment goal of coronary artery disease is the improvement of survival as well as relief of symptom. Revascularization by percutaneous coronary intervention or bypass surgery has relieved symptom but has been questioned for improved long-term outcome.³⁰⁽³¹⁾ Refinement of the need of revascularization strategy would be required to achieve improved clinical outcome after revascularization procedure including percutaneous coronary intervention or bypass surgery. The followings are proposed treatment strategy of coronary artery disease based on the CCTA.

First is to detect coronary atherosclerosis using CCTA. CCTA has the highest diagnostic power to find coronary atherosclerosis among non-invasive imaging modalities and hence very high negative predictive value.¹⁽¹⁶⁾

Second is to assess myocardial ischemia non-invasively with CCTA. The presence of myocardial ischemia is the most important factor for making a prognosis and for the decision to perform a revascularization.³¹⁾ However less than half of coronary arteries with a diameter stenosis $\geq 50\%$ cause myocardial ischemia in most clinical studies.³¹⁻³³⁾ It would be greatly preferable to find the functional significance of a stenosis as well as the presence of a stenosis by single CCTA test. Myocardial computed tomography perfusion imaging could be utilized in clinical practice.³⁴⁻³⁶⁾ Computational fractional flow reserve based on computed fluid dynamics analysis³⁷⁽³⁸⁾ and contrast gradient

analysis^{39/40} are being investigated.⁴¹⁻⁴³

Third, it would be important to evaluate the amount of ischemic myocardial mass. Several studies have investigated the relationship between the angiographic severity of stenosis and the amount of perfused myocardial tissue. Duke jeopardy score,^{44/45} myocardial jeopardy index,⁴⁶ and Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) lesion score^{44/47} have been used to evaluate the

burden of myocardium-at-risk based on angiographic extent of stenosis. However these scoring systems are limited by semi-quantitative grading of the severity of coronary artery disease and myocardium-at-risk. Detailed anatomical variations of individual vessels, myocardial mass, and location of stenosis is not taken account in these semi-quantitative scores. Nuclear perfusion studies have shown that the clinical benefit of revascularization became evident when the ischemic burden ex-

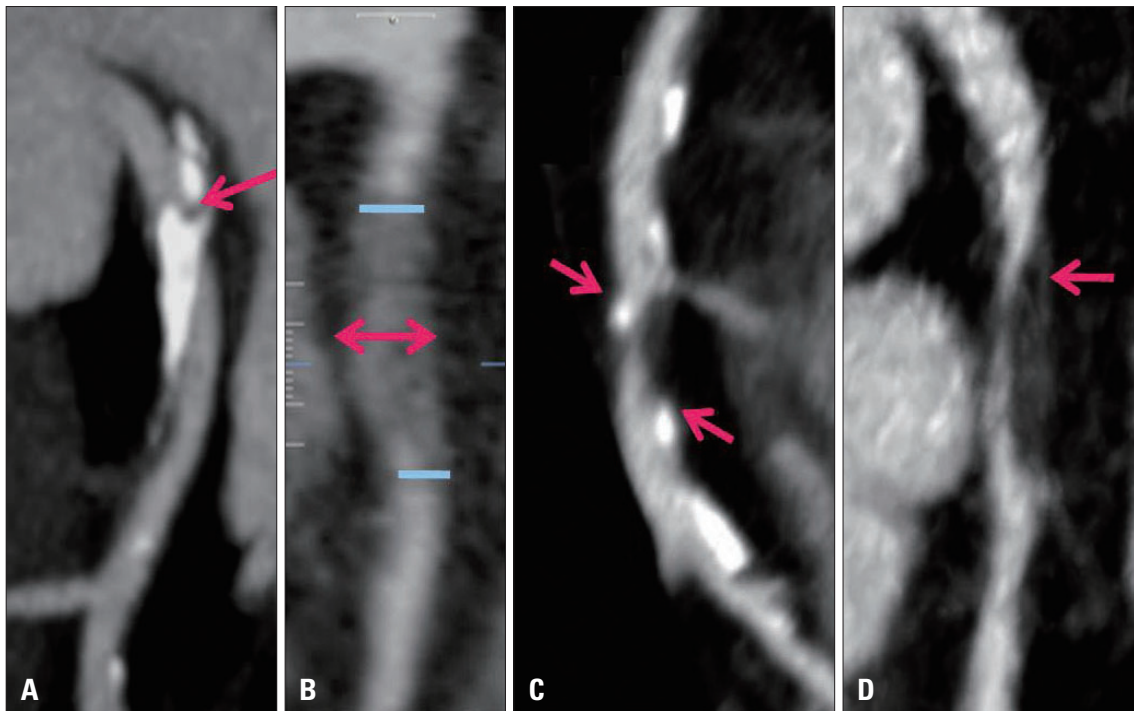


Fig. 2. Characteristics of coronary atherosclerotic plaque detected on CCTA. A: Severe stenosis. B: Positive remodeling. C: Partially calcified or “spotty” calcification. D: Low attenuated plaque (< 30 HU). CCTA: coronary computed tomography angiography, HU: Hounsfield unit.

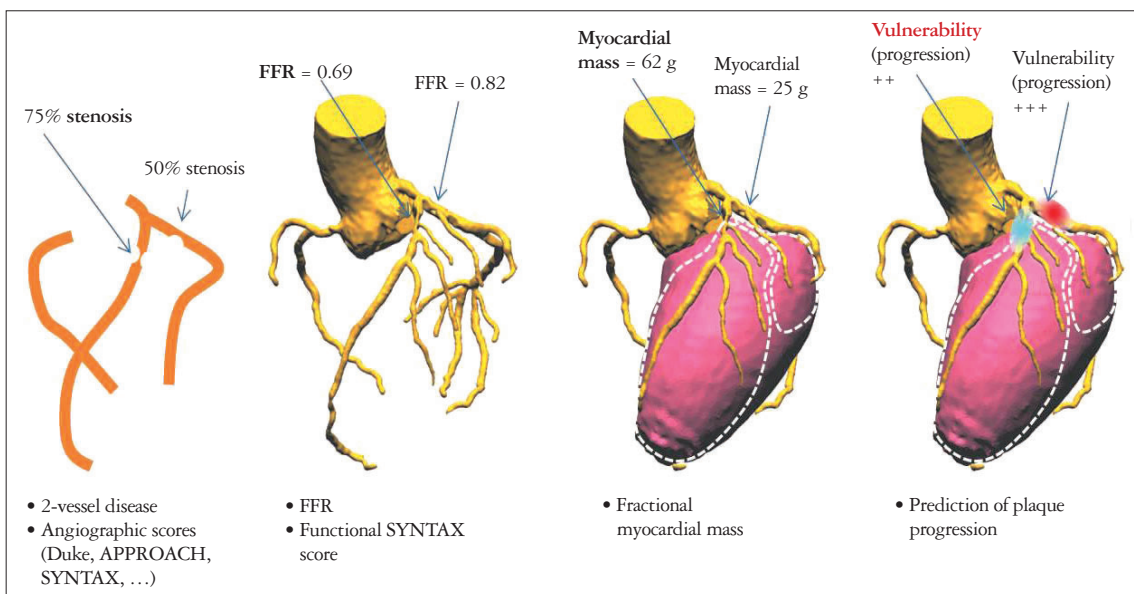


Fig. 3. Risk assessment of coronary artery disease in the future. APPROACH: Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease, FFR: fractional flow reserve, PCI: percutaneous coronary intervention, SYNTAX: Synergy between PCI with Taxus and Cardiac Surgery.

ceeds 12% to 15% of total myocardial mass.⁴⁸⁻⁵⁰ CCTA enables exact quantitative assessment of the burden of myocardium-at-risk and the extent of coronary artery disease (Fig. 3).

CONCLUSIONS

CCTA can find coronary artery disease, determine the significance of coronary artery disease, and guide treatment strategy including revascularization. Now it is time to validate and investigate the role of CCTA in clinical practice and the impact of CCTA on the clinical outcome. Further research on this area is warranted in the future.

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