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Successful coronary artery bypass grafting based solely on non-invasive coronary computed tomography angiography

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ABSTRACT

An 81-year-old female presented with chronic coronary disease (Canadian Cardiovascular Society angina severity grading III). The patient underwent coronary computed tomography angiography (CCTA) that revealed three-vessel coronary artery disease (3VD). This case illustrates that in a patient with 3VD, planning and execution of coronary artery bypass grafting (CABG) were successfully performed based solely on CCTA combined with fractional flow reserve derived from computed tomography angiography (FFR_{CT}). Coronary artery bypass grafting (CABG) was planned and executed as follows: left internal mammary artery grafted to the left anterior descending artery (LAD), saphenous vein graft (SVG) to the right coronary artery (RCA), and SVG to the obtuse marginal artery (OM). Repeat imaging assessment with non-invasive CCTA and FFR_{CT} at 30-day follow-up confirmed the safety of this approach. The FFR_{CT} values of the RCA and LAD were normalized, whereas a borderline pressure drop was observed in the distal run-off of the OM (FFR_{CT}=0.79). Notably, this is the first case in which post-CABG FFR_{CT} assessment was performed. Post-CABG FFR_{CT} is an investigational novel non-invasive tool for assessing the functional improvement of the epicardial conductance vessels following surgical revascularization.

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1. Introduction

This case report highlights a recent and important development in the field of cardiovascular non-invasive imaging. Due to recent technological advances, coronary computed tomography angiography (CCTA) may play an important role as a sole imaging modality to guide cardiac surgeons in planning and executing surgical coronary artery revascularization.

2. Case report

We describe the case of an 81-year-old female who presented with chronic coronary disease (Canadian Cardiovascular Society angina

severity grading III). The patient had multiple comorbidities including hypertension and dyslipidemia. At baseline, blood examination showed a hemoglobin of 15.4 g/dL and a creatinine clearance of 71.0 ml/min. On transthoracic echocardiogram, she had a left ventricular ejection fraction of 65%. Coronary artery evaluation was performed with CCTA.

CCTA revealed that the patient had three-vessel disease (3VD). CCTA images were reconstructed on the AW workstation (GE Healthcare, Milwaukee, WI, USA). The anatomical SYNTAX score (48.5) was obtained from three-dimensional (3D) volume rendering, maximal intensity projection (MIP) (Fig. 1, Panel A), and curved and straight multiplanar reconstructions (MPR) (Fig. 1, Panel B) [1]. The SYNTAX score II predicted a 4-year mortality of 16.5% with percutaneous coronary intervention and of 12.0% with coronary artery bypass grafting (CABG). Both treatments were considered to have an equipose risk of 4-year mortality [2]. Furthermore, the functional SYNTAX score (48.5) based on fractional flow reserve derived from computed tomography angiography (FFR_{CT}) analysis, performed at HeartFlow Inc. (Redwood city,

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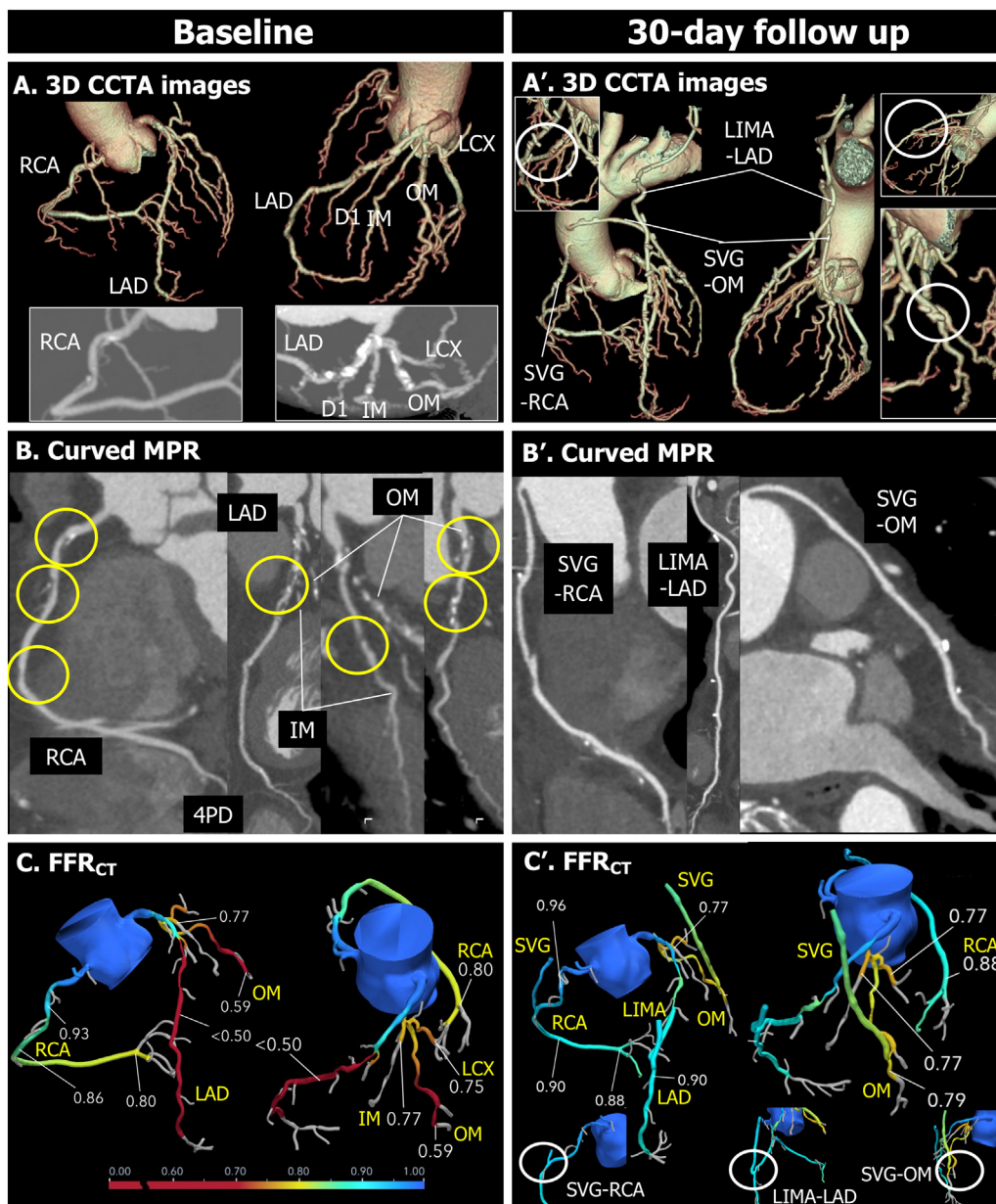


Fig. 1. Panel A. 3D CCTA (VR and MIP) images at baseline. Panel A'. 3D CCTA images at 30-day follow-up post CABG. LIMA-LAD, SVG-RCA, and SVG-OM were grafted. White circles indicate the anastomoses. Panel B. Curved MPR images of CCTA of RCA, LAD, and LCX at baseline. Yellow circles indicate the significant stenoses based on the anatomical SYNTAX score calculation. Panel B'. Curved MPR images of CCTA of RCA, LAD, and LCX at 30-day follow-up post CABG. All the grafted vessels were patent. Panel C. FFR_{CT} findings at baseline. FFR_{CT} indicated flow-limiting lesions of the distal RCA, LAD, IM, OM, and LCX. Panel C'. FFR_{CT} findings at 30 days post CABG. The FFR_{CT} values of RCA, LAD, and OM were 0.88, 0.90, and 0.79, respectively. White circles indicate the anastomoses of LIMA-LAD, SVG-RCA, and SVG-OM.

3D: three-dimensional; CCTA: coronary computed tomography angiography; VR: volume rendering; MIP: maximum intensity projection; CABG: coronary artery bypass grafting; LIMA left internal mammary artery; LAD: left anterior descending artery; SVG: saphenous vein graft; RCA: right coronary artery; OM: obtuse marginal artery; MPR: multiplanar reconstruction; LCX left circumflex artery; FFR_{CT}: fractional flow reserve derived from computed tomography angiography; IM: intermediate artery. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

California, USA) confirmed the functional significance of the anatomically diagnosed lesions [3,4]. FFR_{CT} indicated flow-limiting lesions of the distal right coronary artery (RCA), left anterior descending artery (LAD), intermediate artery (IM), obtuse marginal artery (OM), and left circumflex artery (LCX) (Fig. 1, Panel C).

The patient was enrolled in the FASTTRACK CABG trial (NCT04142021), an investigator-initiated single-arm, multicenter, prospective, proof-of-concept, and first-in-man study with feasibility and safety analysis (adequacy and patency of grafting documented by a CCTA at 30 days) that was approved by the investigational review board or ethics committee at each participating center [5,6]. In this trial, CABG strategy and its treatment planning are based solely on

CCTA and FFR_{CT} without knowledge of the anatomy defined by a prior invasive coronary angiography. Presently, the first 25 patients of this study have been enrolled without any request for unblinding by the heart team consisting of the investigating radiologist and the operating surgeon.

CABG was planned and executed as follows: the left internal mammary artery grafted to the LAD, saphenous vein graft (SVG) to the RCA, and SVG to the OM. Although the IM and LCX were anatomic-wise significantly stenosed according to the FFR_{CT} analysis [7], these vessels were not included in the grafting planning and therefore not bypassed. The patient was discharged 8 days after surgery.

At 30 days post CABG, CCTA was performed as planned in the study protocol. According to the assessment of 3D images (Fig. 1, Panel A'), curved and straight MPR images (Fig. 1, Panel B') of post-CABG CCTA, all three grafts were patent without anatomic stenoses. Furthermore, post-CABG FFR_{CT} assessment was performed. The FFR_{CT} values of the RCA (0.88) and LAD (0.90) were normalized, whereas a borderline pressure drop was observed in the distal run-off of the OM (0.79) (Fig. 1, Panel C').

3. Discussion

This case illustrates that in a patient with 3VD, planning and execution of CABG were successfully performed based solely on CCTA combined with FFR_{CT}. Repeat imaging assessment with non-invasive CCTA and FFR_{CT} at 30-day follow-up confirmed the safety of this approach. Notably, the present case suggests that post-CABG FFR_{CT} is an investigational novel non-invasive tool for assessing the functional improvement of the epicardial conductance vessels following surgical revascularization.

Declaration of competing interest

Dr. Taylor is an employee and shareholder of HeartFlow, Inc.

Dr. Serruys reports personal fees from SMT, Philips/Volcano, Xeltis, Novartis and Merillife.

All other authors have no conflict of interest to declare.

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