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Case Report

Assessment of Myocardial Viability in Chronic Myocardial Infarction Using the Dual-Energy Computed Tomography Myocardial Extracellular Volume Fractionation Technique: A Case Report ☆

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ABSTRACT

Assessment of myocardial viability in patients with myocardial infarction is critical to identify residual ischemic tissue in areas of reduced function and to determine the need for revascularization. We present the case of an 80-year-old man with chest pain and a history of hypertension. Initial evaluation revealed abnormal electrocardiogram findings, and subsequent studies suggested chronic anteroseptal myocardial infarction with reduced cardiac function. Dual-energy cardiac computed tomography was performed to evaluate the coronary arteries and myocardium. Late iodine enhancement images obtained by dual-energy computed tomography showed mixed plaques and severe proximal left anterior descending artery stenosis. Conventional late iodine enhancement imaging was inconclusive, prompting extracellular volume fraction analysis using iodine density imaging. Extracellular volume fraction assessment indicated viable anterior myocardium, leading to successful coronary revascularization. Follow-up demonstrated improved wall motion and ejection fraction. Our study highlights the utility of late iodine enhancement with dual-energy computed tomography in assessing myocardial viability as a noninvasive alternative to magnetic resonance imaging, particularly in patients with contraindications to magnetic resonance imaging. This approach aids in treatment planning, evaluation of efficacy and determination of prognosis in cases of ischemic heart disease.

☆ Competing Interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Introduction

Measurement of myocardial extracellular volume (ECV) fraction by cardiac magnetic resonance (CMR) has been widely accepted as a reliable parameter for the assessment of various cardiac conditions [1]. ECV quantification from late iodine enhancement (LIE) using dual-energy computed tomography (DECT) is a valid alternative to ECV assessment by CMR due to the similar pharmacokinetics of iodine and gadolinium contrast agents [2]. Conversely, cardiac CT has been used primarily for the diagnosis of coronary artery disease. The ability to evaluate coronary arteries and myocardium rapidly and simultaneously is a major advantage.

Myocardial viability is an indicator of the viability and function of the myocardium. Assessment of myocardial viability helps determine whether a specific area of the myocardium has been damaged by ischemia and whether that area can return to normal function [3]. Assessment of myocardial viability is very important in evaluating the effectiveness of coronary revascularization procedures and treatments. Especially in diseases such as coronary artery disease and myocardial infarction, knowing whether ischemia-damaged myocardium has the potential to regain normal function is key to determining treatment strategies. The ECV obtained from CMR can reflect the severity of microvascular damage and myocardial viability [4]. We report a case in which myocardial viability was assessed by ECV obtained from DECT and improved cardiac function.

Case Report

An 80-year-old man (height: 155.5 cm; weight: 54.9 kg) was referred to our hospital after an abnormal electrocardiogram

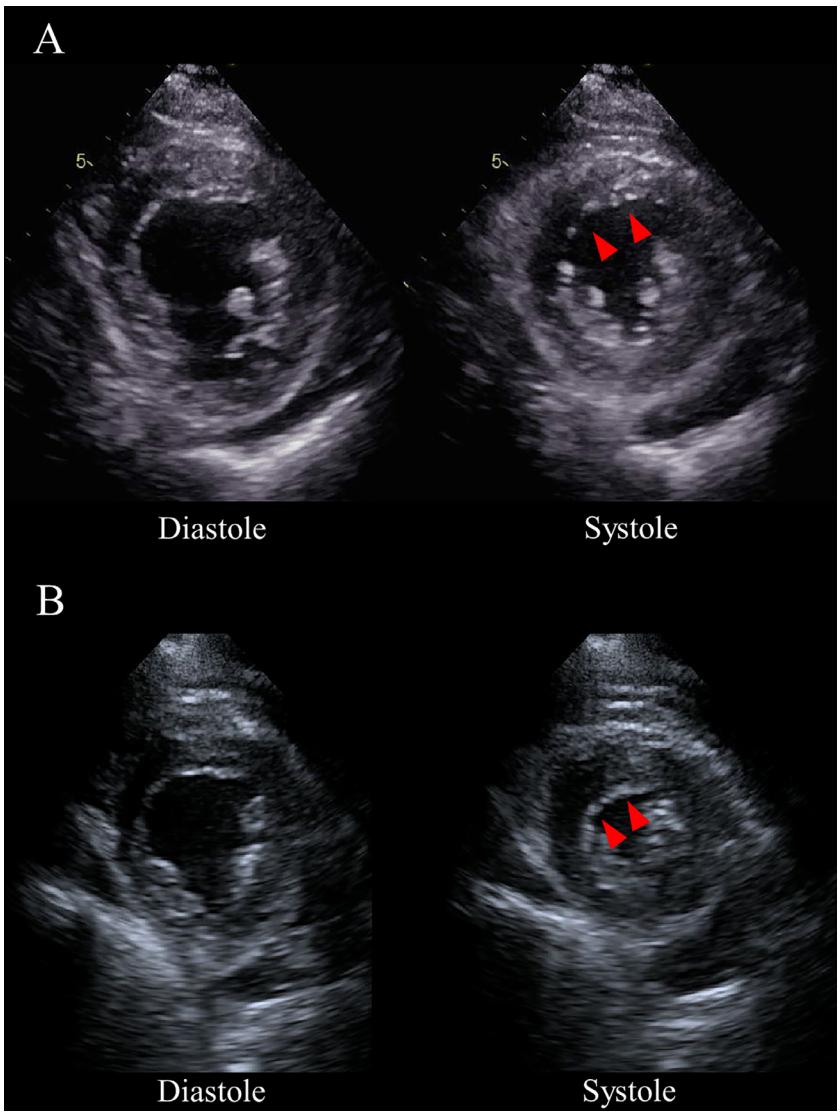

Fig. 1 – Echocardiogram. Paraventricular short-axis view at the level of the left ventricle at the time of the initial examination (A). One-year follow-up after percutaneous coronary intervention shows an improvement in anterior wall motion abnormalities (B).

was detected at another hospital. The patient attended the first hospital with a complaint of chest pain, and he had a medical history of hypertension. More than 1 month prior to detection of the abnormal electrocardiogram, he had an upset stomach and consulted a gastroenterologist who performed upper gastrointestinal endoscopy, which revealed no abnormalities.

Upon examination at our hospital, cardiac enzymes (troponin T, creatine kinase, and creatine kinase-MB) were normal. Twelve-lead electrocardiography showed T-wave negativity and Q waves in thoracic leads V1–V6. Transthoracic echocardiography showed akinesis in the anteroseptal region, suggesting chronic myocardial infarction (CMI) (Fig. 1A). The patient's ejection fraction (EF) was 45%, indicating reduced cardiac function.

Because of chest pain and hypertension, the patient underwent cardiac DECT (IQon Spectral CT; Philips, Best, the Netherlands) to evaluate the coronary arteries and myocardium. DECT was performed rather than coronary angiography at the patient's request and because the patient was elderly. First, a 15-second intravenous infusion of 450 mg iodine/kg of iodinated contrast medium (370 mg/mL iodine) was administered to perform routine CT angiography. LIE was acquired 7 minutes after administration of contrast medium. Coronary artery evaluation revealed mixed plaques and severe proximal left anterior descending artery (LAD) stenosis (Fig. 2A and B).

The myocardial assessment in the coronary phase did not reveal any ventricular wall thinning (Fig. 2C). Evaluation of myocardial viability using LIE images was difficult due to insufficient contrast on conventional images (Fig. 2D). Iodine density images provided adequate contrast, but the border between the left ventricular blood pool and the myocardium was unclear and could not be evaluated (Fig. 2E). To accurately assess myocardial viability from the LIE images, an ECV assessment was performed using a dedicated workstation (AZE VirtualPlace, Canon Medical Systems, Tochigi, Japan). This software can separate the left ventricular myocardium into two layers (endocardial and epicardial) and measure the ECV of each layer. Iodine density images were used for the ECV analysis (Fig. 2F), without the use of non-contrast CT images. The ECV analysis showed that the ECV on the endocardial side was extensively elevated from the cardiac base of the anterior wall to the apex, with a peak ECV of 49%, according to the segment evaluation (Fig. 2G). However, the ECV increase on the epicardial side was less pronounced than on the endocardial side, with a peak ECV of 39% (Fig. 2H). The area of LIE was also the area of abnormal wall motion on echocardiography, indicating that it was the perfusion area of the LAD (Fig. 2G and H). Based on the ECV assessment results, we concluded that the anterior myocardial wall was viable and indicated coronary revascularization the following day.

Invasive coronary angiography was performed, which revealed similar results to cardiac CT, with 99% proximal LAD stenosis. Percutaneous coronary intervention was performed (Fig. 3A and B) using the Xience Sierra 3.25 × 23 mm stent (Abbott Vascular, Santa Clara, CA, US), and the patient's

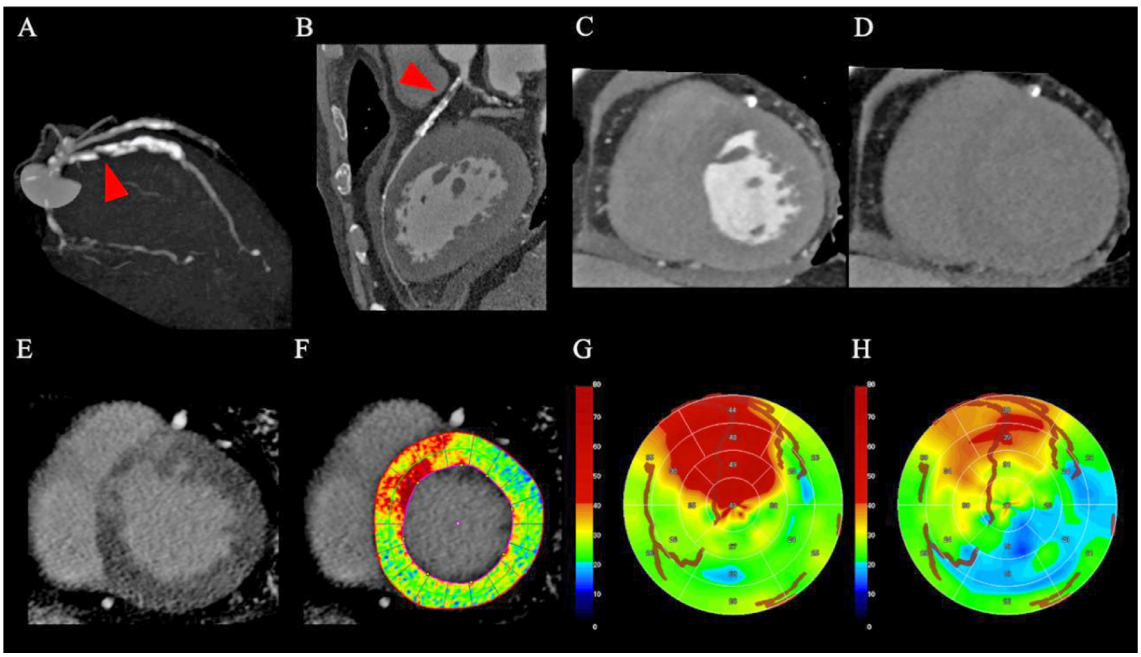

Fig. 2 – Cardiac computed tomography (CT) angiography and extracellular volume fraction (ECV) assessment. Cardiac CT angiography shows severe proximal left anterior descending artery stenosis (arrow; A and B). The short-axis images of the coronary phase (C) and delayed phase (D) of the conventional image. Iodine density imaging was inadequate to assess myocardial viability (E). The results of the ECV assessment (F) can be automatically evaluated in two layers: endocardial and epicardial. The ECV assessment of the myocardium shows a high ECV at the anterior wall (G). The ECV results of the epicardial side show that the anterior wall tended to have a high ECV, as did the endocardial side, but no areas exceeding 40% were observed (H).

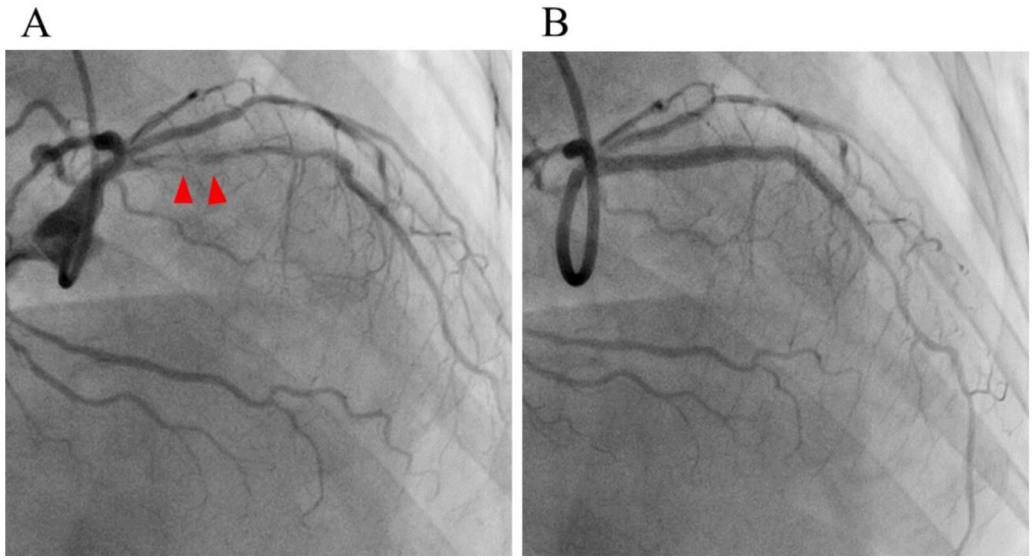

Fig. 3 – Coronary angiogram. The coronary angiogram shows severe proximal left anterior descending artery stenosis on cardiac computed tomography angiography (arrow; A), and percutaneous coronary intervention was performed (B).

symptoms improved. Follow-up echocardiography 1 year later showed that the anteroseptal wall motion abnormalities had improved to mild hypokinesis, and EF had increased to 54% (Fig. 1B). No adverse or unanticipated events occurred.

Discussion

Determining the myocardial characteristics of ischemic heart disease is important for subsequent treatment planning, evaluation of treatment efficacy, and assessment of prognosis. In particular, the determination of myocardial viability, which establishes whether there is residual ischemic myocardium in the area of reduced function, is important to ascertain whether revascularization is indicated. As well as providing information on coronary artery morphology, cardiac CT with the use of LIE provides information on the presence or absence of myocardial infarction and the location and site of infarction. CT with LIE has also been used in the context of myocardial fibrosis, heart failure, cardiomyopathy, and aortic valve stenosis [5,6].

LIE is a straightforward imaging technique that requires only electrocardiogram-synchronized imaging during the contrast-enhanced equilibrium phase, but it has not been widely used because of its lower contrast than CMR [7]. However, ECV assessment using iodine density images obtained from LIE with DECT is expected to provide comparable results to CMR [2,5]. In fact, a previous meta-analysis showed an excellent correlation between ECV derived from DECT and ECV derived from CMR[5]. LIE with DECT is also less time-consuming than MRI and can be used for people who are claustrophobic or who have implanted devices, such as pacemakers. Moreover, DECT allows simultaneous coronary artery and myocardial evaluation without the need for additional contrast medium. Therefore, LIE with DECT may be a useful technique to assess myocardial viability and to decide whether revascularization is indicated.

To our knowledge, this is the first case in which myocardial viability in a patient with CMI has been reliably determined by ECV assessment using DECT. The results of this study could provide a foundation for future studies on the usefulness of ECV assessment based on LIE with DECT to determine myocardial viability in the clinic.

Patient consent

The patient provided permission to publish the details of his case and for the future use and publication of his images, at the time the images were obtained.

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