2 Myocardial Infarction

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Abstract

Myocardial infarction (MI) is myocardial necrosis caused by myocardial ischemia. Pathologically, it is defined as myocardial cell death due to prolonged myocardial ischemia. Noninvasive imaging plays an important role in diagnosing known or suspected MI. Echocardiography and cardiac magnetic resonance imaging (CMRI) are used to assess cardiac structure and function, especially myocardial thickness and motion. Late enhancement in CMRI is associated with myocardial fibrosis and indicates the presence and extent of MI. Radionuclide imaging is the only commonly available method for evaluating myocardial viability and myocardial metabolism directly. Recently, the latest advances in CT scanner technique have opened a new era for cardiac imaging with MI patients. In this chapter, we will describe the characteristics of MI in cardiac CT imaging, and further discuss the application of new cardiac CT technology in patients with MI.

2.1 Case of MI

2.1.1 History

A 50-year-old male patient came to our hospital for routine physical examination without syndrome. He had hypertension for 10 years and a family history of coronary artery disease (CAD).

2.1.1.1 Physical Examination

- Blood pressure: 131/94 mmHg
- Breathing rate: 18/min
- Heart rate: 65 bpm without arrhythmia

2.1.1.2 Laboratory

The level of troponin is 1.205 μg/L.

2.1.2 Imaging Examination

2.1.2.1 CT Images

Coronary CT angiography and delay enhancement were performed to evaluate coronary artery and myocardium (Figs. 2.1 and 2.2).

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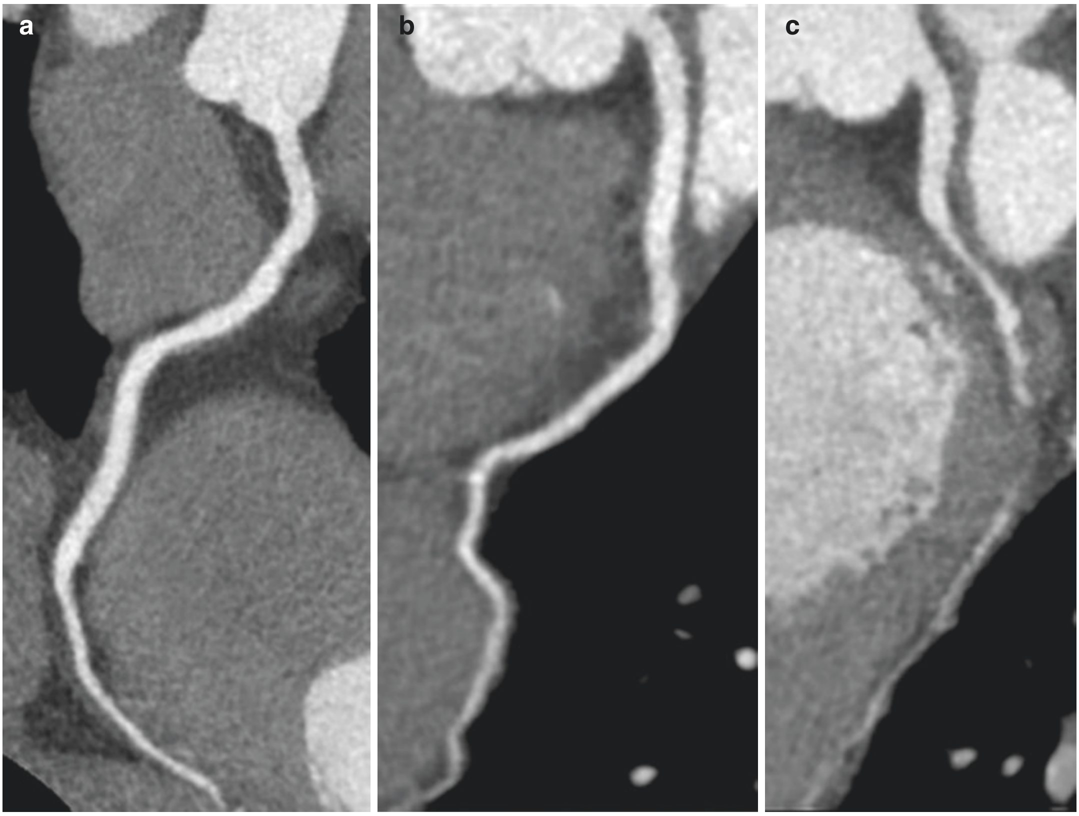

Fig. 2.1 Curved multi-planar (CPR) reconstructed images of the coronary CTA showed severe stenosis to occlusion at the proximal and middle left circumflex artery (**c**). No significant stenosis has been found in the left anterior descending artery (**a**) and right coronary artery (**b**)

2.1.2.2 Conventional Coronary Angiography (Fig. 2.3)

2.1.2.3 MRI Images (Fig. 2.4)

2.1.3 Imaging Findings and Diagnosis

At standard coronary CT angiography, 40-keV virtual monochromatic image and iodine density map showed focal hypo-enhancement in the inferolateral myocardial wall, which was corresponding to the left circumflex artery territory. Suspected myocardial ischemia existed in this area. Iodine density map showed an iodine content of 0.6 mg/mL in the suspected myocardial ischemia segment and an iodine content of 2.0 mg/mL in the remote normal myocardial segment. At late iodine enhancement imaging, the corresponding area (inferolateral myocardial wall) revealed focal transmural delay enhancement at 40-keV virtual monochromatic image and iodine density map, which showed clearly infarcted myocardium. Iodine density map in this stage found an iodine content of 2.2 mg/mL in the delay enhanced segment and an iodine content of 1.2 mg/mL in the remote unaffected myocardial segment. ECV calculated from the iodine density map for the infarcted and remote normal segments were 53% and 29%, respectively, which indicated severe myocardial fibrosis in the infarcted segment.

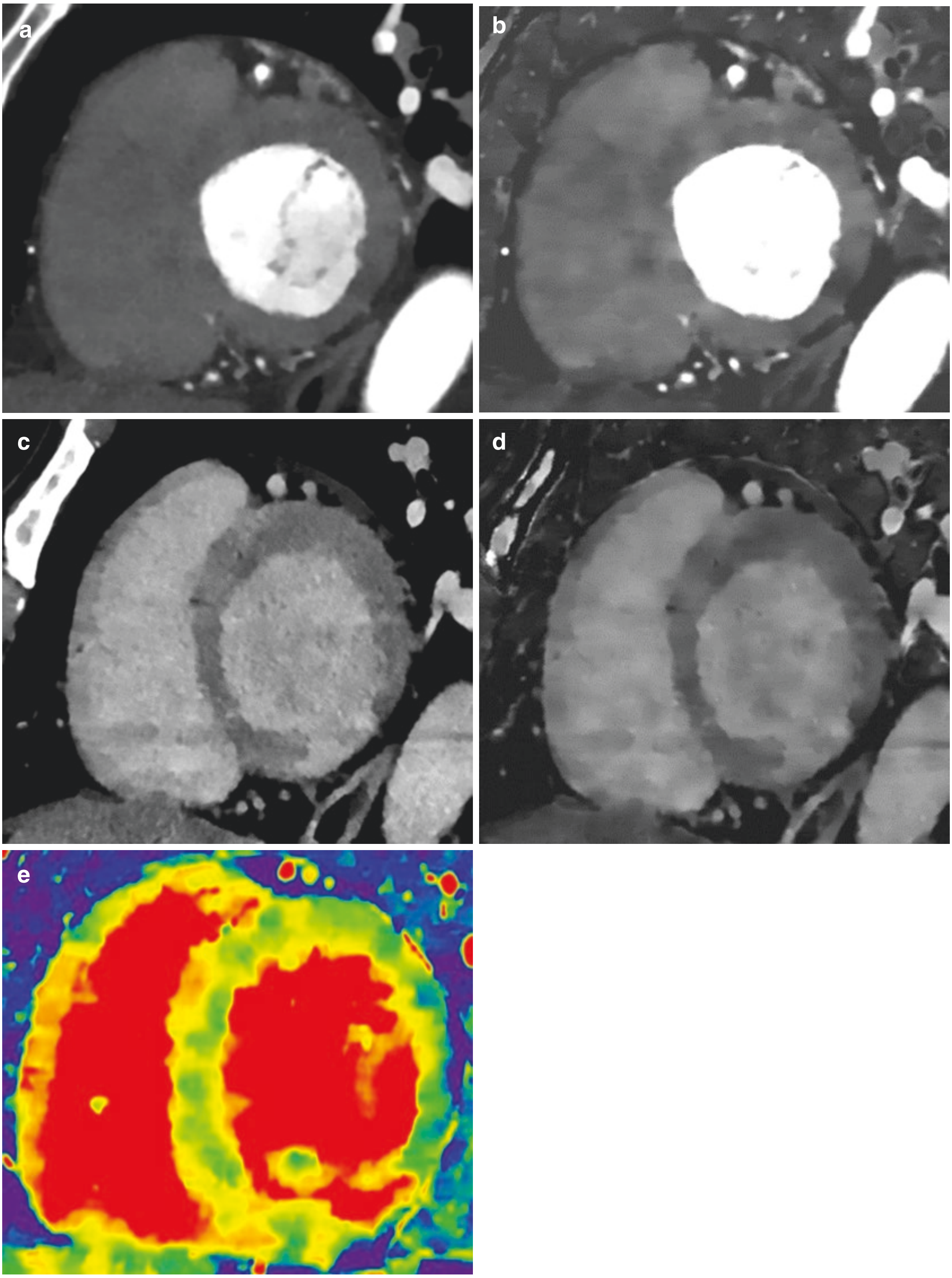

Fig. 2.2 At standard coronary CT angiography, 40-keV virtual monochromatic image (**a**) and iodine density map (**b**) showed focal hypo-enhancement in the inferolateral myocardial wall, which was corresponding to the left circumflex artery territory. At late iodine enhancement imaging, corresponding area (inferolateral myocardial wall) revealed focal delay enhancement at 40-keV virtual monochromatic image (**c**) and iodine density map (**d**). The extracellular volume (ECV) for the infarcted and remote normal segments were 53% and 29%, respectively (**e**)

2.1.4 Management

- Percutaneous coronary intervention operation therapy
- Conventional medical therapy for CAD

2.2 Discussion

MI is an event of heart attack due to an imbalance between oxygen supply and myocardial demand resulting in myocardial injury. According to electrocardiogram trace, MI is differentiated between non-ST-segment elevation myocardial infarction (NSTEMI) and ST-segment elevation myocardial infarction (STEMI). STEMI is the result of transmural myocardial ischemia that involves the full thickness of the myocardium, while NSTEMI does not spread across all the myocardial wall [1]. STEMI, NSTEMI, and unstable angina pectoris are formed in the concept of acute coronary syndrome [2]. The clinical symptoms of MI include chest and upper extremity diffuse discomfort, fatigue and shortness of breath during exertion or at rest. However, about 64% of people with MI have no obvious symptom, which is called silent MI [3].

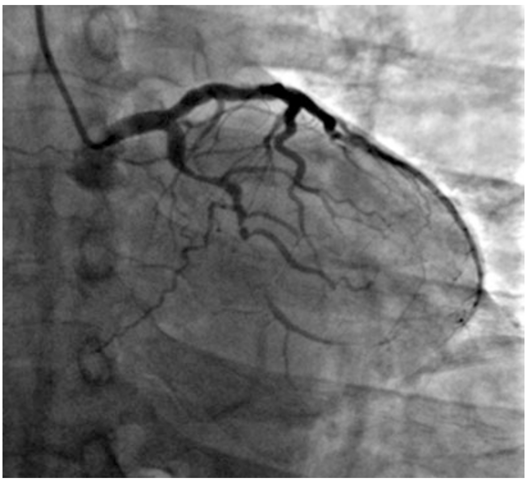

Fig. 2.3 Percutaneous coronary intervention showed severe stenosis to occlusion at the proximal and middle left circumflex artery

Noninvasive imaging acts as an important role in diagnosing and characterizing MI. Regional and global wall motion abnormalities induced by myocardial ischemia can be observed by echocardiography and CMRI. Tissue Doppler and strain imaging from echocardiography are used for quantification of regional and global function. Radionuclide imaging allows assessing myocardial viability and myocardial metabolism by radionuclide tracers. CMRI has the ability to assess myocardial perfusion and myocardial fibrosis of MI. In addition, CMRI also allows detection of the presence and extent of myocardial edema or inflammation to distinct acute or chronic MI.

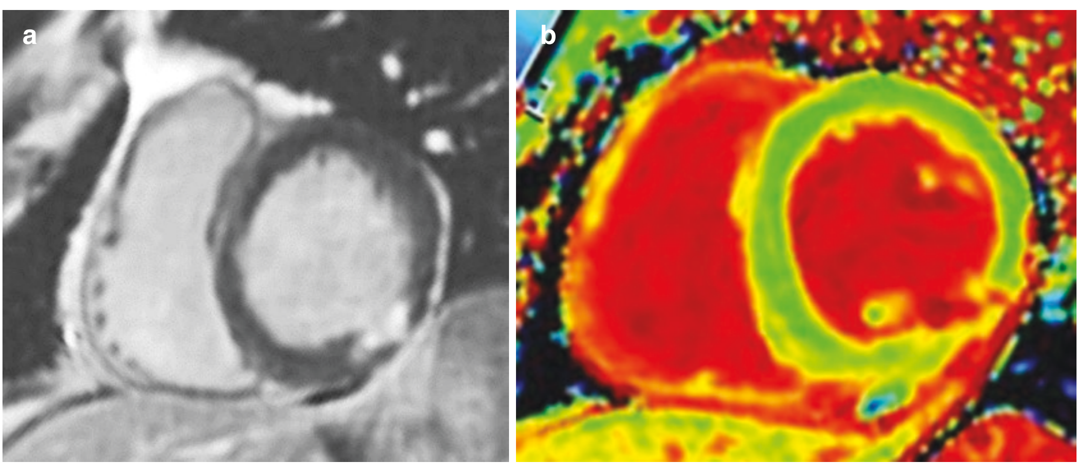

Fig. 2.4 Cardiac magnetic resonance imaging showed transmural lateral late gadolinium enhancement in the inferolateral myocardial wall (**a**). ECV in the infarcted and remote unaffected segments were 50% and 23%, respectively (**b**)

2.3 Current Technical Status and Applications of CT

Compared with invasive coronary angiography, conventional CT angiography has an advantage in assessing coronary stenosis with 95–99% sensitivity and 97–99% specificity [4]. However, myocardial analysis is limited by motion and beam-hardening artifacts [5]. With the advance of CT technique, dual-energy CT open new era for cardiac imaging in which attenuation data from different energies are used to characterize material properties. CT perfusion imaging, late iodine enhancement CT imaging, and CT strain imaging are now used for analyzing myocardial function.

Dual-energy CT technique not only corrects beam-hardening artifacts to improve image quality, but also generates iodine map to increase accuracy in evaluating MI. Iodine map reflects the distribution of iodine in myocardium, which is correlated with myocardial perfusion and blood flow [6]. CT perfusion imaging is used for evaluating fixed and reversible perfusion defects with myocardial injury. Qualitative and quantitative analysis can be obtained from myocardial perfusion imaging. In addition, the combination of coronary analysis and myocardial perfusion imaging provides a significant incremental value over coronary CT angiography alone for the detection of hemodynamically significant stenosis in CAD patients [7].

CMRI is used as the reference standard for evaluation of myocardial fibrosis or scarring. Meanwhile, myocardial extracellular volume fraction acquired from CMRI is now considered a reliable parameter for the assessment of diffuse myocardial fibrosis [8]. However, late iodine enhancement CT imaging is an alternative approach to late gadolinium enhancement MRI because the pharmacokinetics of iodinated contrast materials are similar to those of gadolinium-containing contrast materials [9]. Virtual monoenergetic from dual-energy CT can improve the image quality of late iodine enhancement [10]. In addition, myocardial ECV with dual-energy CT has good agreement and excellent correlation with MR ECV imaging [11, 12].

Myocardial strain imaging has emerged as a quantitative approach to assess regional cardiac function using cardiac CT [13]. Conventional myocardial strain imaging allows identification of MI by the degree of two-dimensional (2D) strain reduction, which mainly measured strain of three orthogonal directions of myocardial motion: longitudinal strain, circumferential strain, and radial strain. Recently, three-dimensional maximum principal strain acquired from cardiac CT can also be used for detecting regional cardiac dysfunction with MI [14].

Technological advancements in CT imaging have extended more potential for assessment of MI than conventional CT image, which is helpful for disease identification and clinical management.

2.4 Key Points

- The combination of coronary CTA with CT perfusion/late iodine enhancement imaging provides comprehensive information for patients with MI.
- New CT techniques offer more advantages than conventional CT techniques, particularly for myocardial viability analysis.

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