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Presence of myocardial hypoenhancement on multidetector computed tomography after primary percutaneous coronary intervention in acute myocardial infarction predicts poor prognosis

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ABSTRACT

Background: Recent research has suggested that patients with greater delayed contrast-enhanced size by multidetector computed tomography (MDCT) are more likely to experience adverse cardiac events and have poor prognoses over the long term. The myocardial hypoenhancement area in the delayed contrast-enhanced effect suggests microvascular obstruction. The outcomes of patients with a hypoenhancement area detected by MDCT have not been clear. We examined the clinical importance of myocardial hypoenhancement detected by delayed contrast-enhanced MDCT after percutaneous coronary intervention (PCI) in patients with acute myocardial infarction.

Methods and results: In 80 patients with acute myocardial infarction, MDCT was performed immediately after primary PCI. We investigated the outcomes of the patients with hypoenhancement detected by MDCT. Myocardial hypoenhancement was observed in 14 patients (17.5%). All 14 of these patients with hypoenhancement had a transmural infarction, and their infarct volume was significantly higher than those of the patients without hypoenhancement ($n = 66$). During the median follow-up period of 309 days, the appearance of myocardial hypoenhancement was associated with the presence of slow flow/no-reflow, time from onset to reperfusion ≥ 6 h, aging, smoking, chronic kidney disease, and hyper-low-density lipoprotein cholesterolemia. The incidence of major adverse cardiovascular events (MACE) was significantly higher in the patients with hypoenhancement compared to those without hypoenhancement, regardless of the myocardial infarct volume.

Conclusions: These results indicate that the presence of myocardial hypoenhancement in delayed contrast-enhanced MDCT after PCI as well as the extent of infarct area is an important predictor of MACE.

1. Introduction

Percutaneous coronary intervention (PCI) has become the main method of reperfusion therapy contributing to improved prognoses in the treatment of acute coronary syndrome [1,2]. Reports indicate that the infarct size reflects the severity of the myocardial infarction and is relevant to long-term myocardial remodeling [3]. The most common methods used for determining infarct size are the measurement of peak myocardial enzyme values, the assessment of the degree of regional wall motion abnormalities, and single photon emission computed tomography (SPECT) imaging of the perfusion-defective region in chronic infarcts. It is now possible to visualize areas of myocardial ischemia and infarction through magnetic resonance imaging (MRI).

Recent advances in multidetector computed tomography (MDCT) have made the assessment of infarct areas and prognoses possible through delayed contrast-enhanced MDCT immediately after PCI for AMI [4,5]. Compared to MRI, which can only be performed in the stable period after an AMI attack, MDCT can be performed immediately after PCI, increasing its usefulness as a diagnostic tool.

Recently, circulatory disturbances at the microvasculature level are increasingly emphasized. The term "microcirculatory disturbance", also known as microvascular obstruction (MVO), refers to areas in the myocardium that have yet to return to the perfused state, even after blood flow to the epicardial coronary artery has returned. It was found that the presence of MVO can lead to myocardial remodeling and affect the long-term outcome regardless of the infarct size [6–8].

The presence of MVO, as determined by MRI, is known to be an independent, unfavorable prognostic factor for AMI [6,8], but it is difficult to

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obtain MRI images immediately after AMI. Delayed contrast-enhanced MDCT images obtained as myocardial hypoenhancement after PCI for AMI have similar MVO findings [9]. We investigated the prognoses of patients who were confirmed positive for myocardial hypoenhancement by MDCT taken after PCI.

2. Methods

2.1. Patients and protocol

We studied the cases of AMI patients who were transported to the Ogaki Municipal Hospital, and monitored the cases of 80 consecutive AMI patients who subsequently underwent MDCT immediately after primary PCI treatment. There were no exclusion criteria for patient background, and all patients were available for follow up. A variety of AMI patients were included in the study, such as patients with comorbid acute heart failure, patients receiving catecholamine treatment for circulatory failure, and patients whose coronary flow after PCI was less than the Thrombolysis in Myocardial Infarction (TIMI) grade 3. There were no patients without achievement of initial success of primary PCI.

Primary PCI was performed on all AMI patients. A physician specializing in cardiology inserted a 7-Fr catheter into the femoral artery to perform the PCI; an indwelling bare metal stent was used for all PCI procedures. The low-osmolar nonionic contrast medium iopamidol (Iopamiron-370; Bayer, Osaka, Japan) was used as the contrast agent. All patients underwent MDCT as soon as possible after the final PCI contrast without an additional contrast agent. Dual antiplatelet therapy with aspirin in combination with clopidogrel or ticlopidine was maintained during the study.

Iodine-123 BMIPP and 99mTc-tetrofosmin (TF) scintigraphy were performed 1 week and 3 months, respectively, after PCI (see Supplementary data online).

2.2. Calculation of the delayed contrast-enhanced MDCT area and hypoenhancement area

Scanning was performed with a 16 × 1.0-mm slice collimation CT scanner (Aquilion 16, Toshiba, Tokyo) with a gantry rotation speed of 400 ms/rotation. Scanning was performed using a tube energy of 120 kV and an effective tube current of 300 mA with a beam pitch of 0.18 and radiation dose of CTDIvol 62 mGy. Acquisition of CT data and an ECG trace were automatically started during an around 20-second breath-hold. CT images were obtained during the end-diastolic phase. First, multi-planar reconstruction images of the minor axis of the myocardium were constructed from 5-mm slices. In each slice, a histogram of normal myocardium with no delayed contrast was constructed; the largest CT number was defined as the cut-off and we defined any area above the cut-off as a delayed contrast-enhanced area. A recent review shows that 16-slice MDCT is as accurate as 64-slice MDCT for the assessment of left ventricular morphology [10].

As shown in Fig. 1, we color-coded normal myocardium with a CT number below the cut-off. For every slice, we used the workstation (Synapse Vincent, Fuji Film Corp., Tokyo) to determine the area of the entire myocardium and the delayed contrast-enhanced areas, calculated the volume of each area based on a width of 5 mm, and added all the volumes together to determine the volume of the entire left ventricular myocardium and the corresponding delayed contrast-enhanced area. The percentage of delayed contrast enhanced area (%DE) was calculated by dividing DE volume by the volume of the entire left ventricular myocardium.

Hypoenhancement areas with a CT number less than the cut-off described above in delayed contrast-enhanced areas were considered to represent MVO (Fig. 2). These areas were calculated manually to determine a final volume for the hypoenhancement area in the same manner described above. Advances over 75% were classified as transmural, whereas anything less than 75% was classified as a non-transmural infarct. The myocardial infarct volume by MDCT is the volume of the hypoenhancement area added to the delayed contrast-enhanced area. We sometimes observe hypoenhancement areas in the LV apex and the interventricular septum without a delayed contrast-enhanced area, and they were excluded from the calculation because they were fat [11,12].

We selected 10 cases of MDCT with hypoenhancement at random for the assessment of the delayed contrast-enhanced volume and hypoenhancement volume by three trained radiology technicians,

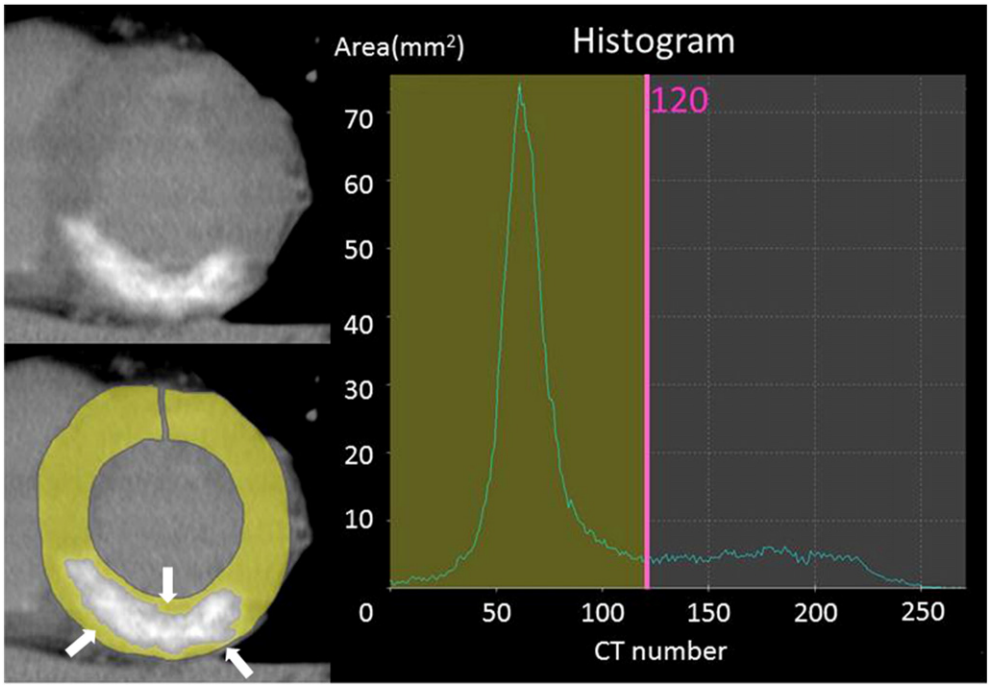

Fig. 1. Definition of delayed contrast-enhanced MDCT area. We defined the areas with a CT number more than the maximum CT number of normal myocardium as delayed contrast-enhanced myocardium areas (arrows). MDCT, multidetector computed tomography.