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Case Report

Detecting a subendocardial infarction in a child with coronary anomaly by three-dimensional late gadolinium enhancement MRI using compressed sensing☆,☆☆

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ABSTRACT

Three-dimensional high-resolution late gadolinium enhancement (3D HR LGE) magnetic resonance imaging (MRI) using compressed sensing can help detect small myocardial infarcts. We discuss the case of an 11-year-old child with an anomalous aortic origin of the left coronary artery. Since he was suspected to have coronary stenosis due to anomalous aortic origin of the left coronary artery, cardiovascular MRI, including conventional two-dimensional (2D) LGE MRI and HR 3D LGE MRI, was conducted. Myocardial scars were not clearly observed via 2D LGE MRI; however, 3D HR MRI revealed subendocardial infarction of the anteroseptal wall, which corresponded to the left coronary artery. By applying the compressed sensing technique, 3D HR LGE, MRI enables a detailed assessment of small myocardial infarcts in a clinically feasible scan time.

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Introduction

Three-dimensional high-resolution late gadolinium enhancement (3D HR LGE) magnetic resonance imaging (MRI) is an effective tool for detecting small myocardial infarcts; however, its long scan time limits its clinical application [1]. Recently, compressed sensing with sparse sampling and iterative reconstruction has been applied to LGE MRI, which has helped drastically shorten its examination time [2]. We discuss a case where HR 3D LGE MRI using compressed sensing helped effectively detect a small subendocardial infarction.

Case report

An 11-year-old boy suffered an episode of loss of consciousness while running. An ST depression was identified through an electrocardiogram, and a left ventricular asynergy and an anomalous aortic origin of the left coronary artery (AAOLCA) were identified via echocardiography. A narrow anomalous left coronary artery from the right aortic sinus, with a course between the pulmonary artery and the aorta, was also identified via electrocardiogram-gated computed tomography angiography (Fig. 1). Then, stress/rest myocardial perfusion

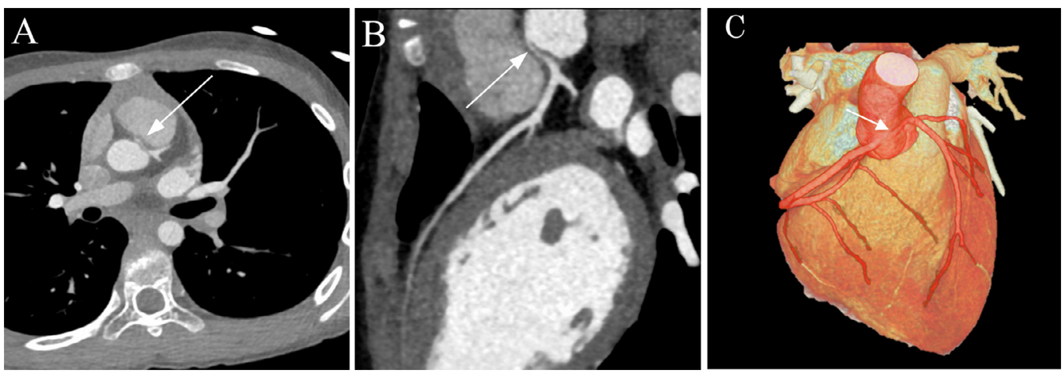

Fig. 1 – (A) Contrast-enhanced coronary CTA and (B) curved multiplanar reformatting image and (C) volume rendering image. A narrow anomalous left coronary artery from the right aortic sinus is running between the pulmonary artery and the aorta (A, B, and C, arrows).

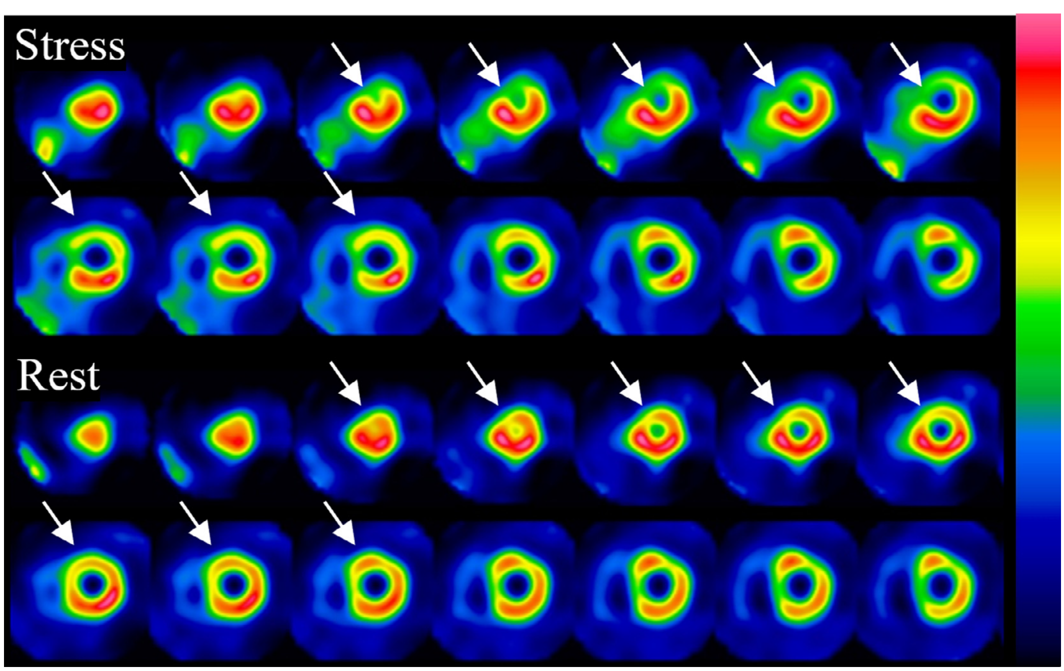

Fig. 2 – Stress/rest myocardial SPECT showing reduced uptake of the tracer under stress (upper row, arrow) and fill-in at rest (lower row, arrow). These findings indicate a LAD territory ischemia and a subendocardial infarction.

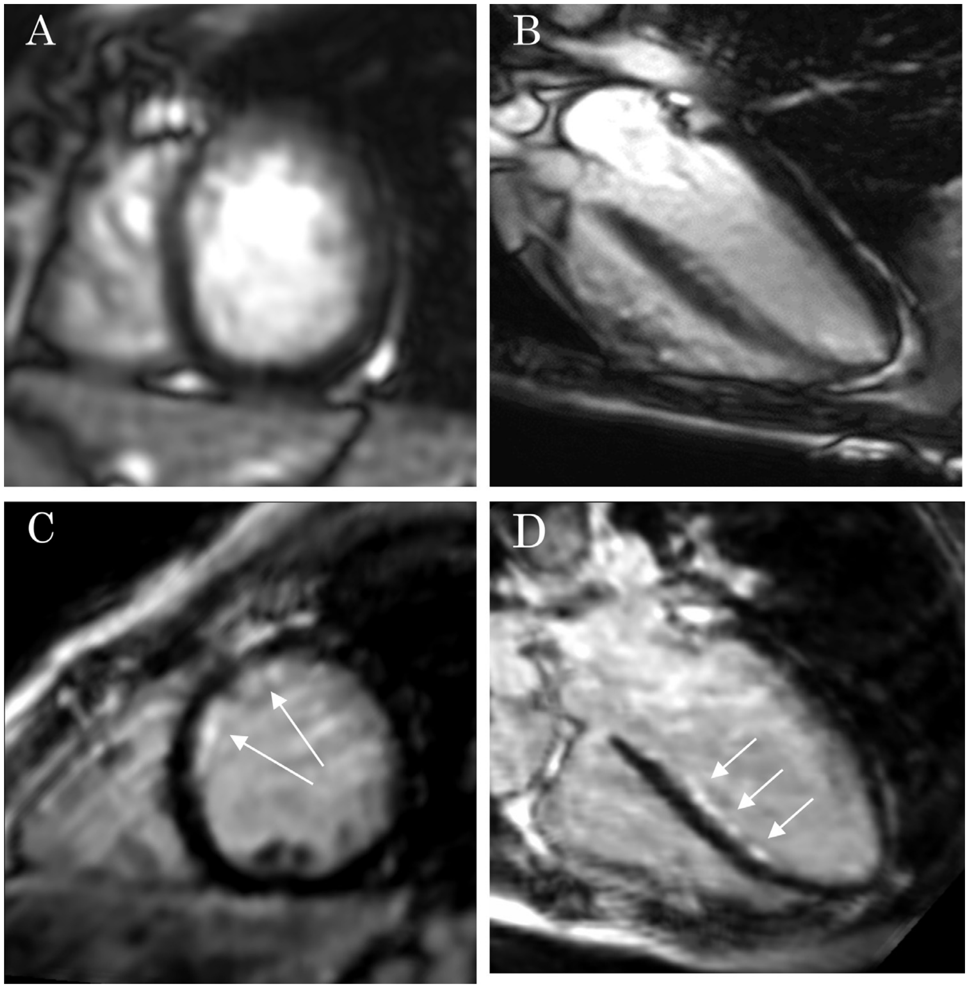

Fig. 3 – (A, B) Conventional 2D LGE images of the short and long axes. (C, D) Multiplanar reformatting created from 3D LGE with an orientation corresponding to 2D LGE. LGE is not clear in the 2D LGE image (A and B); however, 3D HR LGE with compressed sensing shows LGE in the anterior and septum (C and D, arrows), indicating a LAD territory subendocardial myocardial infarction.

single-photon emission computer tomography (SPECT) with a technetium-99m labeled tracer was conducted to assess myocardial ischemia. SPECT showed a reduced uptake of the tracer in the anteroseptal wall under stress and fill-in at rest (Fig. 2). As the patient was suspected to have severe myocardial ischemia at the left anterior descending (LAD) territory, cardiovascular MRI, including conventional two-dimensional (2D) LGE MRI and 3D HR LGE MRI with compressed sensing, was conducted using 3 Tesla scanner (MAGNETOM Skyra, Siemens Healthcare, Erlangen, Germany) to rule out myocardial infarction.

Myocardial infarcts were not be clearly observed via conventional 2D LGE MRI (1.6 × 1.6 × 5 mm spatial resolution, 4 mm slice gap, 882.4 ms repetition time, 2.7 ms echo space, 1.12 ms echo time, and 55° flip angle). However, 3D HR LGE MRI (1.4 × 1.4 × 1.4 mm spatial resolution, gapless, 460.4 ms repetition time, 3.3 ms echo space, 1.6 ms echo time, and 20° flip angle) using compressed sensing revealed a small subendocardial infarct in the septal and anterior myocardium, which corresponded to the LAD territory (Fig. 3). As a result, surgical repair was conducted using the unroofing procedure based on the symptoms and imaging diagnosis of severe myocardial ischemia with subendocardial infarction. The patient recovered well following the procedure.

Discussion

An anomalous aortic origin of a coronary artery from the opposite sinus of Valsalva is a rare congenital anomaly, known as an anomalous aortic origin of the right or left coronary artery (AAORCA or aortic origin of the left coronary artery, respectively) [3]. Although the detection of myocardial infarctions occurring due to anomalous aortic origin of a coronary artery has been achieved using SPECT [4], MRI features a higher spatial resolution than SPECT and offers the advantage of being free from radiation exposure [5]. Wagner et al reported that

47% of the segments with small subendocardial infarcts on LGE MRI could not be detected when using SPECT [6]. 2D LGE MRI is widely used to evaluate myocardial infarction. However, owing to the slice thickness and the gap between slices in 2D LGE MRI, small lesions can be missed. In contrast, 3D LGE MRI features a higher spatial resolution and is capable of detecting small infarctions because it covers the entire heart, without any gaps. In addition, 3D LGE MRI can evaluate myocardial infarctions in more detail via multiplanar reformatting. 3D LGE MRI can also be performed under free breathing, which is useful for patients who have difficulty holding their breath, such as children.

Therefore, 3D HR LGE MRI, which achieves better diagnostic performance than 2D LGE MRI, is recommended for detailed evaluations of small myocardial scars [7]. In this case, myocardial infarcts were not clearly observed via 2D LGE MRI; however, 3D HR LGE using compressed sensing clearly showed a small myocardial infarction in the anterior and septal endocardium, indicating a subendocardial infarction corresponding to the LAD territory. In general, 3D HR LGE MRI requires a long scan time, which has limited its clinical application. Compressed sensing is a novel fast imaging technology with sparse sampling and iterative reconstruction [8]. It enables high-resolution and high-speed imaging, unlike the conventional method. Applying compressed sensing to 3D LGE MRI improves the detectability of small myocardial infarcts and enables shorter scan times to complete imaging, while maintaining the contrast effect. It has been reported that the average scan time of conventional 3D LGE with a SENSE factor of 2 was approximately 16 minutes [1]. However, we could complete 3D HR LGE MRI within approximately 6 minutes by applying compressed sensing with an undersampling factor of 7, while maintaining high resolution and diagnostic performance.

Further, multiplanar reformatting allows for the detailed assessment of myocardial infarction with confidence (Fig. 3 C and D). We could detect small subendocardial infarctions, and we also assessed myocardial viability. Myocardial viability can be assessed based on the transmural extent of LGE. Transmural extent indicates the percentage of hyperenhanced area in each myocardial segment. It has been reported that revascularization does not improve cardiac function when this transmural extent of hyperenhancement exceeds 50% [9]. In this case, the transmural extent of LGE was almost 25%; hence, revascularization was expected to improve cardiac function.

3D HR LGE MRI using compressed sensing is faster and offers higher resolution than conventional 3D LGE; it could clearly detect a small infarct that was not clear on the 2D LGE MRI. Since 3D HR LGE using compressed sensing can be performed under free breathing with a clinically feasible scan time, it can be a useful tool, especially for patients who have difficulty holding their breath, such as children or poor health condition.

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