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MYOCARDIAL INFARCTION AND SCAR

Myocardial Scarring Caused by Left Ventricular Assist Device (LVAD) Insertion Demonstrated by Cardiovascular Magnetic Resonance

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ABSTRACT

We report three cases of dilated cardiomyopathy treated with left ventricular assist devices (LVAD), subsequently explanted. These mechanical devices are being increasingly used to support left ventricular function in the short and long term. We used cine and gadolinium-enhanced cardiovascular magnetic resonance (CMR) to examine the consequences of previous LVAD implantation. In all cases, there was apical akinesis and tethering on cine imaging. Early (<5 minutes) imaging after gadolinium demonstrated apical hypo-enhancement, an avascular area of scar or thrombus, while late (>10 minutes) imaging demonstrated transmural apical infarction which in one case extended into the inferior wall. The findings suggest that LVAD insertion may cause permanent myocardial fibrosis at the site of ventricular insertion, and the cases demonstrate the use of contrast-enhanced CMR in this scenario of iatrogenic ventricular scarring.

Key Words: Magnetic resonance; Left ventricular assist device; Scarring; Gadolinium-DTPA.

INTRODUCTION

The use of mechanical circulatory support in heart failure is gaining in popularity both in the acute setting as a bridge to recovery, as a bridge to transplantation and increasingly as a long term therapeutic option (Hunt and Rose, 2002; Rose et al., 2001). One of the principal classes of the device are the implantable left ventricular

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assist device (LVAD), a mechanical pump that pumps blood from a vent at the apex of the left ventricle to the aorta. However, the use of LVADs is still associated with short-and long term complications (Piccione, 2000).

We present three cases in which cine and gadolinium cardiovascular magnetic resonance (CMR) was performed after the removal of a left ventricular assist device (LVAD) after functional ventricular recovery. Our aim is to examine the consequence of previous LVAD implantation using a combination of cine imaging and gadolinium-DTPA tissue characterisation by CMR.

Cases

Case 1: A 24-year-old woman with acute dilated cardiomyopathy for which a Heartmate I (Thermo Cardiosystems, Inc.) LVAD was inserted and remained in situ for 16 months before explantation because of left ventricular functional recovery; imaging occurred 10 days after explantation.

Case 2: A 42-year-old man with acute dilated cardiomyopathy for which a Heartmate II LVAD was inserted and remained in situ for 5 months before explantation because of left ventricular functional recovery. Imaging occurred 3 months after explantation.

Case 3: A 21-year-old man with acute dilated cardiomyopathy for which a Heartmate I LVAD was inserted and removed after 2 months following infection. Imaging occurred 19 days after explantation.

CMR Findings

In all three patients, there was residual LV dilatation, with impaired systolic function in two patients (EF 45%,47%, 57%). All patients had apical akinesis with tethering of the apex and loss of the normal planes between fat, pericardium, and myocardium. (Fig. 1a, diastole; 1b, systole)

Early imaging (<5 minutes after the bolus) after Gadolinium-DTPA (0.1 mmol/Kg) was performed using segmented inversion-recovery FLASH using an inversion time of 400–440 ms, so that tissues such as thrombus or microvascular obstruction, without gadolinium penetration (hypo-enhancement) are nulled and appear black (Simonetti et al., 2001). In all patients, there was focal apical hypo-enhancement that extended to the outside of the ventricle. (Fig. 1c)

Late imaging (>10 minutes after the bolus) was performed using the same sequence but with the inversion time meticulously adjusted to null remote

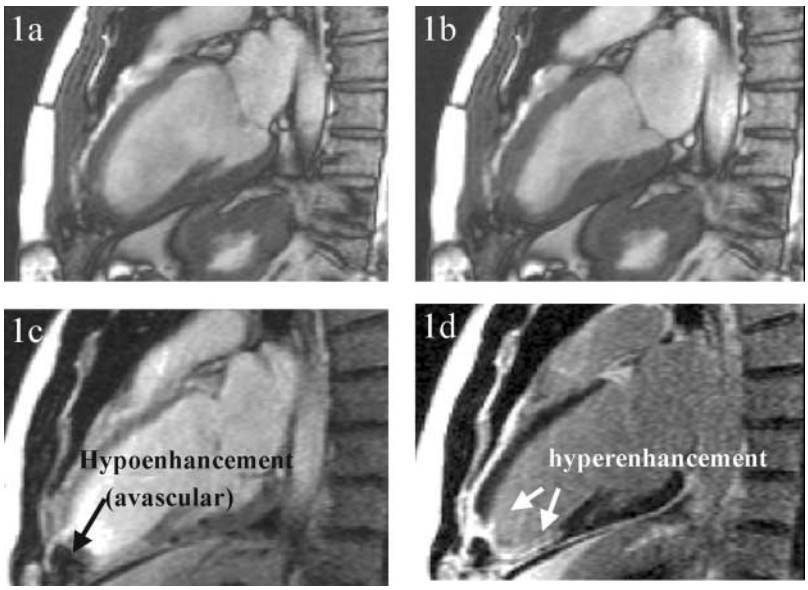

Figure 1. a (diastole) and b (systole): Gradient-echo cine image (true FISP sequence) of case 2 demonstrating loss of normal planes apically. There is also inferoapical thinning in this case (Case 2). c (early) and d (late): Inversion-recovery imaging demonstrating apical early hypo-enhancement representing an avascular zone and late hyper-enhancement representing infarction, which extends along the inferior wall of the LV (Case 2).

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myocardium (TI 330–400), with fibrosis and myocardial infarction demonstrating hyper-enhancement. In all patients there was a localized area of apical transmural hyper-enhancement surrounding the area of early hypo-enhancement. In patient two, the area of hyper-enhancement was larger, extending transmurally along the apical inferior wall and associated with a larger wall motion abnormality on cine imaging (Fig. 1d). No remote myocardial hyper-enhancement was found in any patient.

INTERPRETATION

These three patients had left ventricular functional recovery after LVAD implantation and the device was removed after having operated as a bridge to recovery. However, the cine and contrast MRI demonstrates that while there was remote myocardial recovery, the procedure results in significant apical scarring. The implication is that after LVAD insertion, the ventricle can never subsequently be normal even if there is complete recovery from the initial myopathic process. In one patient this scarring extended to the apical inferior wall, suggesting that the device had interrupted the LVAD wrapping around the apex.

Gadolinium-DTPA is a small molecule that diffuses into the extracellular fluid making the tissue appear bright on CMR. It does not cross intact cell membranes. Myocardial infarction and fibrosis, because of myocyte death, has an increased volume of extracellular fluid and slower gadolinium kinetics than normal myocardium, so in the late phase (>10 minutes) after a bolus, appears bright and hyper-enhanced (Flacke et al., 2001; Judd et al., 1995). In some tissues, gadolinium may fail to diffuse because of either capillary collapse and microvascular obstruction or avascularity, and this is best seen in the early phase (<5 minutes); such tissues include thrombus and microvascular obstruction, regions of no reflow.

The cases demonstrate the use of early and late gadolinium imaging to image myocardial scarring in unusual circumstances. The combination of CMR-functional cine imaging and contrast enhancement at different phases after a bolus results in high contrast images with transmural resolution by CMR which in these cases, demonstrates potential adverse long term consequences of previous albeit lifesaving LVAD insertion.

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