Evaluation of Perfusion Area of a Coronary Artery Using Magnetic Resonance Imaging with High-Concentration Gd-DTPA Injection via Balloon Catheter

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Introduction:

Delineation of the perfusion area of a coronary artery is important in cardiovascular research in order to determine the "risk area" of myocardial infarction. A common and widely used method to evaluate this area involves the injection of Evens blue dye into a coronary artery, cutting the heart into slices, and examining the stained area in each slice. Though accepted as a golden standard, a problem associated with this method is the technical difficulty in delineating stained areas in each slice. Furthermore, perfusion areas in a live heart cannot be measured using this method. Injecting high-concentration gadolinium into a coronary artery via balloon catheter in an MRI suite, the perfusion area of the coronary artery was successfully delineated in both live and excised hearts. The perfusion areas measured by MRI corresponded well to those measured by Evens blue injection.

Method:

Six female Yorkshire pigs (35-50 kg) were used in this study. A 3.5-mm over-the-wire balloon catheter was advanced into either the left coronary descending artery (LAD), the left circumflex coronary artery (LCX) or the right coronary artery (RCA) via a 9 Fr Hockey Stick guiding catheter in a 1.5 T Signa Horizon CV/i MRI system (GE Medical Systems). Five milliliters of 40 mM gadolinium-diethylenetriamine pentaacetic acid (Gd-DTPA, Berlex Laboratories) was injected via the catheter followed by 5 ml of 5% Evens blue solution injection during balloon occlusion. Pigs were euthanized immediately after injection, and the heart was excised in order to evaluate perfusion areas. An inversion prepared 3D gradient echo sequence was used to acquire MR images with the following imaging parameters: IT= 200ms, TE/TR=2.9/6.1, FA=15°, slice thickness=2mm, NEX=3, matrix=256x256 and TA =8-10m. For evaluation of the perfusion area of live hearts, 5ml of 40mM Gd-DTPA was injected via the catheter during balloon occlusion for 60 seconds, and an ECG-gated inversion prepared 3D gradient echo sequence were used to acquire MR images with the following imaging parameters: IT = 200ms, TE/TR=3.1/6.5-6.6, FA=15°, slice thickness=3mm, NEX=1, matrix=192x192 and TA =40-60s. Perfusion area was determined as the area of Evans blue staining or Gd-DTPA enhancement. The percentage of Evans blue staining in a slice was calculated by comparing the weight of stained tissue cut from the slice with that of the remaining tissue. The percentage of Gd-DTPA enhancement was defined as the percentage of pixels having signal intensity 2 SD higher than non-enhanced pixels.

Results:

Perfusion area of the LCX is shown in Fig. 1. The regions of Gd-DTPA enhancement directly correspond to areas stained with Evens blue,

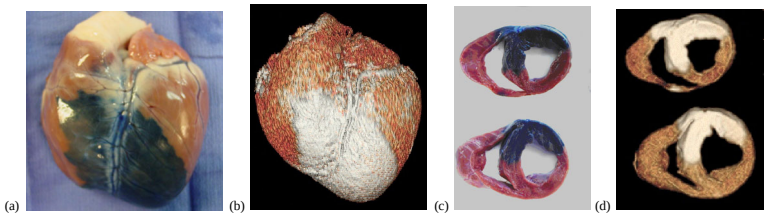

Fig. 1. (a) Excised heart. (b) 3D MRI reconstruction. (c) Slices of the heart. (d) MR image of heart slices.

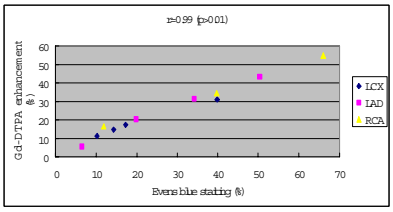

Fig. 2. Correlation between percentage of Gd-DTPA enhancement in each slice and percentage of area stained with Evens blue

as shown in the photographs and MR images. The percentage of Gd-DTPA enhancement and that of Evens blue staining were found to be strictly correlated. Figure 3 shows a 3D MR image of the perfusion area of the LAD in a live heart.

Conclusions:

Inversion recovery MR imaging with high concentration Gd-DTPA injection via balloon catheter was found to be able to determine the perfusion area of a coronary artery. Given the simplicity and accuracy of calculating Gd enhanced areas relative to calculating Evens blue stained area, the present method is a good replacement for Evans blue injection.

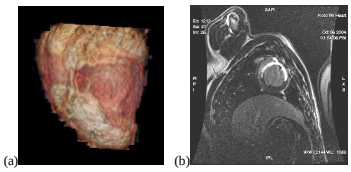

Fig.3 (a) 3D MR image of the perfusion area of the LCX of a live heart (b) 2D slice image of (a)