Cine Magnetic Resonance Imaging of Myocardial Ischemia and Reperfusion in Mice

Zequan Yang, MD, PhD; Brent A. French, PhD; Wesley D. Gilson, MS; Antwone J. Ross, MS; John N. Oshinski, PhD; Stuart S. Berr, PhD

Studies of acute myocardial ischemia/reperfusion injury in genetically manipulated mice have been impeded by the technical challenges of instrumenting small animals (<40 g) and assessing cardiac function at such rapid heart rates (>500 bpm). To address these problems, 4 C57BL/6 mice (28 to 30 g) were anesthetized with pentobarbital and intubated for surgical instrumentation of the major left coronary artery with pneumatically controlled balloon occluders. The distal end of the tubing from the balloon occluder was exteriorized at the back of the neck. One week later, each mouse was anesthetized with pentobarbital and fitted with surface ECG electrodes, and an extension tube was added to the balloon occluder. Mice were imaged on a Varian Inova 4.7T MR scanner using a Helmholtz radiofrequency coil. An ECG-triggered, 2D gradient echo sequence with an echo time of 3.9 ms and a flip angle of 20 degrees was used to obtain 12 phases per cardiac cycle at a final resolution of 100×100×1000 μm³.

Baseline cine images consisted of a series of 7 contiguous, 1-mm-thick, short-axis slices spanning the heart from apex to base. A myocardial stunning protocol consisting of a series of four 4-minute coronary occlusions interspersed with 4 minutes of reperfusion was then executed from a remote position outside of the magnet. Contiguous, short-axis cine MR images were successively acquired in the midventricular to apical regions of the left ventricle during each of the 4 balloon inflations. As shown in the Figure and the accompanying cine images, the use of remotely controlled coronary occluders, combined with high-field MRI for the noninvasive assessment of cardiac function, should prove valuable for elucidating the role of specific genes in the pathophysiology of ischemia/reperfusion injury using genetically manipulated mice.

Short-axis cardiac MR images of a mouse heart at end-systole before, during, and after ischemia imposed by inflating a coronary occluder while the animal was within the magnet. Left panel shows a 1-mm-thick, midventricular, short-axis slice acquired at baseline before ischemia. Same midventricular slice is shown during third transient coronary occlusion (middle) and 16 minutes after completion of final occlusion (right). In this mouse, coronary occlusion caused an immediate deficit in anterolateral left ventricular wall thickening, marked acute left ventricular dilation, and a dramatic decline in ejection fraction from 54% before ischemia to 20% during ischemia (as calculated from the chamber volumes imaged at end-systole and end-diastole). Ejection fraction recovered to 36% within 16 minutes of last occlusion. Repeat cardiac MRI performed 7 days later confirmed full recovery of contractile function (ejection fraction, 56%). Cine images of this figure can be found Online at www.circulationaha.org
Cine Magnetic Resonance Imaging of Myocardial Ischemia and Reperfusion in Mice
Zequan Yang, Brent A. French, Wesley D. Gilson, Antwone J. Ross, John N. Oshinski and Stuart S. Berr

Circulation. 2001;103:e84
doi: 10.1161/01.CIR.103.15.e84

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/103/15/e84

Data Supplement (unedited) at:
http://circ.ahajournals.org/content/suppl/2001/03/23/103.15.e84.DC1

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/