Title: PATIENT MONITORING DURING MAGNETIC RESONANCE IMAGING

Authors: J. L. Roth, M.D.; M. Nugent, M.D.; J. E. Gray, Ph.D.; P. R. Julsrud, M.D.; T. H. Berquist, M.D.; J. C. Sill, M.B.B.S.; D. B. Kispert, M.D.; D. L. Hayes, M.D.

Affiliation: Departments of Anesthesiology, Radiology, and Internal Medicine, Mayo Clinic, Rochester, Minnesota 55905

Introduction. Magnetic resonance* (MR) is a recently developed noninvasive diagnostic technique that employs a strong magnetic field and radio frequency pulses (RFP) to generate images.[1] It is being evaluated at several medical centers around the country. Patient monitoring during scanning poses problems because ferrous metal contained in most monitoring equipment may distort the magnetic field. In addition, wires attached to the patient and leaving the scanner act as antennae for stray radio frequency signals. Both these disturbances of MR function can result in image degradation. Currently at our institution patients are placed inside the MR scanner and monitored by closed circuit television and a two way intercom. However, seriously ill patients require more extensive monitoring. Here a monitoring system was assessed and its effects upon MR image quality were determined.

Methods. Twenty fully conscious patients without cardiovascular or respiratory support were studied. Patients with cardiac pacemakers, intravascular wires or neurovascular aneurysm clips were excluded as the scanner's strong magnetic field may have induced pacemaker dysfunction, cardiac arrhythmias, or clip twisting and dislodgement. Monitoring consisted of a blood pressure cuff with plastic connectors and ten feet of rubber tubing, an Aneuroid Chest Bellows chest-wall movement sensor (Coulbourn Instruments, Allentown, PA), a Hewlett-Packard 78 100A ECG telemetry system (Hewlett-Packard, Waltham, MA), and a Parks Model 811 Doppler (Parks Medical Electronics, Beaverton, OR). RFP produce artifacts on the ECG interferring with its interpretation when rapid RFP rates are used. During this time, the Doppler pulse was closely monitored. If irregularities in the Dopper pulse were detected, the MR radio frequency pulse could be stopped, and the ECG artifact would cease. Using a Picker 1500 Gauss MR imagining system (Picker International, Cleveland, OH), two scans were taken of the same anatomical area of each patient using identical scanning technique with and then without monitoring equipment. Three blinded observers independently evaluated the twenty pairs of scans to determine differences between the two scans in terms of image degradation and diagnostic quality. Agreement between two or more observers was necessary before image degradation was considered to have occurred.

Results. Satisfactory monitoring of BP, HR, ECG and chest wall motion was obtained on all twenty patients. All scans were assessed as being diagnostically adequate with and without monitoring devices. Evaluations of the twenty pairs of images by individual observers are listed in Table 1. Only two scans, both of unmonitored patients, met the criteria of degradation. None of the scans from monitored patients met the criteria. The monitoring technique described provided adequate physiological monitoring yet did not interfere with MR function nor produce image degradation.

Discussion. Results demonstrate that patient monitoring can be satisfactorily performed during MR scanning if monitoring equipment is carefully selected. Telemetric ECG and a battery-powered Doppler avoided the use of wires leaving the scanner and did not contain enough ferrous metal to cause significant image degradation. Fiberoptic transmission of ECG signals for gated cardiac imaging has been described[2] (Diasonics Inc., South San Francisco, CA), although this system is not commercially available for patient monitoring.[3] A laser-Doppler system (Medpacific Inc., Seattle, Washington) with fiberoptic signal transmission has been used to measure ear lobe or lip capillary blood flow during MR imaging.[2] This system is more expensive than the standard vascular Doppler and, as a routine monitoring device, offers no specific advantages. A monitoring system made up of commercially available components, permitting monitoring of BP, HR, ECG, and chest wall motion during MR scanning is described and is shown to be free of disturbances to MR scanning function.

References.

1. McCullough EC, Baker HL Jr: Nuclear magnetic resonance imaging. Radiol Clin North Am 20:3-7, 1982
2. Higgins CB, Lanzer P, Stark D, Botvinick E, Schiller NB, Crooks L, Kaufman L, Lipton MJ: Imaging by nuclear magnetic resonance in patients with chronic ischemic heart disease. Circulation 69:523-531, 1984
3. Personal communication, Diasonics, Inc.

Table 1
Observer Evaluation of Paired MR Images

Patient (numbered in order studied)	Observers		
	DBK	PRJ	THB
5	M	=	=
4	=	=	M
15	=	=	M
11	U	U	U
14	U	U	=
3	U	=	=
6	U	=	=
17	U	=	=
20	=	=	U
Remaining 11 patients	=	=	=

= Paired MR images of equal quality with and without monitoring.
M Image degraded when patient monitored.
U Image degraded when patient unmonitored.

* Previously called Nuclear Magnetic Resonance.