

MRI Safety: Level 2 MR Personnel

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“Published initially in 2002, the ACR MR Safe Practice Guidelines established de facto industry standards for safe and responsible practices in clinical and research MR environments.”

JMRI 2013, Pg 1



Level 2 Personnel

Level 2 MR personnel: Those who have been more extensively trained and educated in the broader aspects of MR safety issues, including, for example, issues related to the potential for thermal loading, burns, proper hearing protection and a solid understanding of how to handle implants and devices...

- ⌘ MR Technologists
- ⌘ MR Radiologists / Medical Director

Patient Screening

ACR Guidance Document on MR Safe Practices: 2019
Expert Panel on MR Safety: Emanuel Kanal, MD, PhD, A, James Suckow, MD,
Christy Liu, MD, Catherine H. Reynolds, MD, Jennifer G. Bradley, MD, PhD,
John W. Frank, MD, PhD, Daniel S. Jaffe, MD, PhD,
Ellie Auerbach, MD, PhD, Paul A. Larson, MD, PhD, James W. Lister, Jr, MD, PhD,
John H. Barkley, MD, PhD, Daniel J. Borsook, PhD, Elizabeth A. Sider, PhD, BSBA,
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Lorenz L. Lohr, MD, PhD, and John H. Barkley, MD, PhD

“Non-emergent patients should be MR safety screened on site by a minimum of 2 separate individuals. At least one of these individuals should be level 2 MR personnel. At least one of these 2 screens should be performed verbally or interactively.”

Patient Screening

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Emergent patients should be MR safety screened by a level 2 MR Personnel on a case by case situation, keeping in mind the following should be assessed:

- Patient Medical Record
- Any previous radiographs
- Physical/Visual inspection of the patient for any markings indicating a previous procedure
- Consult with the Radiologist

**** Final determination is decided by the radiologist to image the patient in MRI****

Lenz's Forces in MRI



Keith Prince
Sharp and Children's MRI Center
<http://www.youtube.com/watch?v=liDj459-FY>

Implants and Devices



<http://www.thehelmcenter.com/images/Interventional/320/magnets/implantable-pumps.jpg>

http://www.sdfpm.com/wp-content/uploads/2011/08/notes_mriafety02.jpg

Gradient Magnetic Fields

Two types of gradient fields

- ⌘ Time-varying Magnetic Field Gradients dB/dt
 - produced by the gradient coils: Inside
 - vary in amplitude over time
- ⌘ Static Magnetic Field Gradient dB/dx
 - produced by the magnet itself: Outside

PNS

- ⌘ FDA Limit: No Painful Stimulation
- ⌘ Greatest further from isocenter
- ⌘ Varies with patients
- ⌘ Normal Operating Mode: 80% of the peripheral nerve stimulation mean
- ⌘ 1st Level Controlled: 100% of the peripheral nerve stimulation mean

PNS

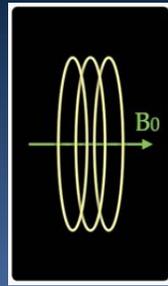
- ⌘ More likely to be seen when using sequences with very high slew rates
 - ⌘ Echo Planar Imaging
 - DWI
 - ⌘ Ultra-short TR Gradient Echoes
 - Localizer
 - Body imaging / MRA



Extra Caution

- ⌘ Patients with implanted or retained wires in anatomically or functionally sensitive areas (e.g. myocardium, epicardium or brain) **should be considered at higher risk**
- ⌘ Decision to limit the dB/dt and maximum strength of the gradient subsystems during imaging should be reviewed by the level 2 MR personnel-designated attending radiologist supervising the case or patient

Acoustic Noise



Acoustic Noise

ϵ_{PI}

Painful Acoustic Trauma	140	Shotgun blast
	130	Jet engine 100 feet away
	120	Rock concert
Extremely Loud	110	Car horn, snowblower
	100	Blow dryer, subway, helicopter, chainsaw
	90	Motorcycle, lawn mower, convertible ride on highway
Very Loud	80	Factory, noisy restaurant, vacuum, screaming child
Loud	70	Car, alarm clock, city traffic
	60	Conversation, dishwasher
Moderate	50	Moderate rainfall
Faint	40	Refrigerator
	30	Whisper, library
	20	March tickling
	0	dB levels

Hearing protection must be provided for everyone in the scan room during an exam

Hearing Protection

FDA

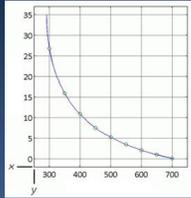
...instructions from manufacturers of MR equipment should state that hearing protection is required for all patients studied on MR imaging systems capable of producing sound pressures that exceed 99 dB

IEC 60601-2-33

...for all equipment capable of producing more than an A-weighted rms sound pressure level of 99dB, hearing protection shall be used for the safety of the patient and that this hearing protection shall be sufficient to reduce the A-weighted r.m.s. sound pressure level to below 99 dB

Spatial Field Gradient at a given distance from the wall

GE Optima MR450w
70 cm bore



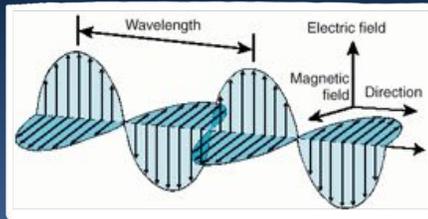
x = Spatial gradient, G/cm
y = Distance, cm

Spatial gradient (G/cm)	Distance D (cm)
<291	35*
300	26.8
350	15.9
400	10.9
450	7.5
500	5.3
550	3.5
600	2.1
650	1.0
700	0.1
≥710	0

*Since this is the radius of the bore, there is no path into the bore that does not pass through at least this spatial gradient.

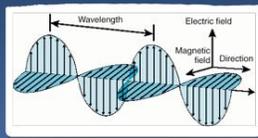
GE User Manual 000085-01A (05/01/04 Rev)

Radio Frequency (RF) Field



Electromagnetic Energy

- ⊗ Magnetic (B-field)
- ⊙ Electric (E-field)



www.mrisafety.com

“Various underlying health conditions may affect an individual’s ability to tolerate a thermal challenge including **cardiovascular disease, hypertension, diabetes, fever, old age, and obesity**. In addition, medications including **diuretics, beta-blockers, calcium blockers, amphetamines, and sedatives** can alter thermoregulatory responses to a heat load. Importantly, certain medications have a synergistic effect with RF radiation with respect to tissue heating. The **environmental conditions** (i.e., ambient temperature, relative humidity, and airflow) that exist in the MR system will also affect tissue temperature changes associated with RF energy-induced heating.”

SED: Specific Energy Dose

Specific to the body part and tissue

Energy of the RF

Dose into the body

Units of Joules/kg

*Also referred to as SAE (Specific Absorbed Energy)

SED: Specific Energy Dose

240 W-min/kg (14440 J/kg)*

Research shows that this level will produce a temperature rise to 43^o C (109^o F) above which patient with **normal thermal regulation** may suffer tissue damage¹

¹IEC 60601-2-33 edition 3 (2010) requirement

²Magn Reson Med, 71, 421-431, 2014

RF Burns

Avoid contact with the bore wall at all times



Padding should be between 0.5 cm and 1.0 cm

RF Burns

Avoid skin-to-skin contact

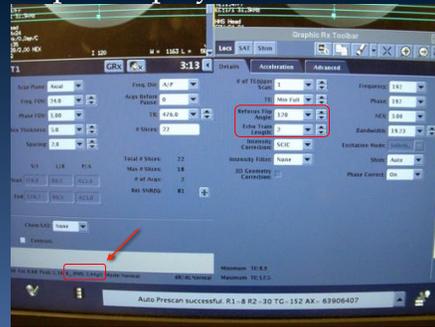


RF Burns



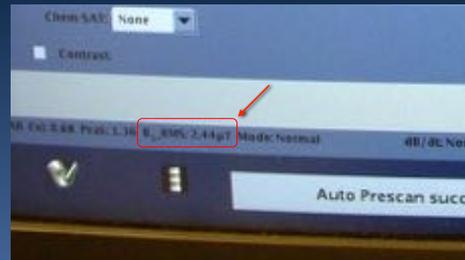
Do not create loops with coil wires

Example Display



Sample shown from a GE system

Example Display



Sample shown from a GE system

$$B_1 + \text{rms}$$

The magnetic field generated by the RF transmit coil

Root-mean-square
Time average over all RF pulses

The positively rotating component of the B_1 field useful for imaging
