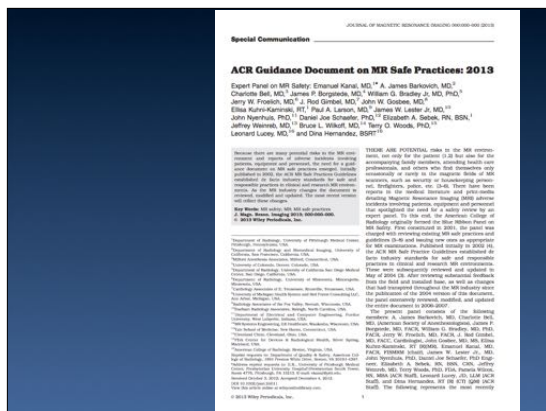


# MRI Safety: Level 2 MR Personnel

Wm. Faulkner, BS,RT(R)(MR)(CT), FSMRT, MRSO (MRSC)  
Kristan Harrington, MBA,RT(R)(MR)ARRT, MRSO (MRSC)



ACR Guidance Document on MR Safe Practices: 2013

Expert Panel on MR Safety: Elizabeth Rens, MD,<sup>1,2</sup> James Barkness, MD,<sup>3</sup> Charlotte Bell, MD,<sup>4</sup> James P. Bergshtein, MD,<sup>5</sup> William G. Bradley, Jr, MD, PhD,<sup>6</sup> Jerry B. Franks, MD,<sup>7</sup> Paul L. Garwood, MD,<sup>8</sup> John W. Gurnea, MD,<sup>9</sup> Elina Kuviniemi-Karola, RT,<sup>10</sup> Paul A. Larson, MD,<sup>11</sup> James W. Lester, Jr, MD,<sup>12</sup> John Nardiak, PhD,<sup>13</sup> Daniel J. Reardon, PhD,<sup>14</sup> Elizabeth A. Selzer, RN, BSN,<sup>15</sup> Jeffrey Weiss, MD,<sup>16</sup> Bruce L. Wilcutt, MD,<sup>17</sup> Terry O. Woods, PhD,<sup>18</sup> Leonard Lundy, MD,<sup>19</sup> and Dina Hernandez, BSMT<sup>20</sup>

“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: 2013**

Expert Panel on MR Safety: Emanuel Kanal, MD,<sup>1\*</sup> A. James Barkovich, MD,<sup>2</sup> Charlotte Bell, MD,<sup>3</sup> James P. Borgardt, MD,<sup>4</sup> William G. Bradley Jr, MD, PhD,<sup>5</sup> Jerry W. Froelich, MD,<sup>6</sup> J. Fred Gimbel, MD,<sup>7</sup> John H. Goske, MD,<sup>8</sup> Elissa Kohn-Kaminski, RT,<sup>9</sup> Paul A. Larson, MD,<sup>10</sup> James H. Lester Jr, MD,<sup>11</sup> John Nyenhuis, PhD,<sup>12</sup> Daniel Joe Schaefer, PhD,<sup>13</sup> Elizabeth A. Setak, PhD,<sup>14</sup> Jeffrey Walcott, MD,<sup>15</sup> Bruce L. Wilford, MD,<sup>16</sup> Terry O. Woods, PhD,<sup>17</sup> Leonard Laine, MD,<sup>18</sup> and Oana Hernandez, BSRT<sup>19</sup>

“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

**ACR Guidance Document on MR Safe Practices: 2013**

Expert Panel on MRI Safety: Emanuel Kanal, MD,<sup>1\*</sup> A. James Barkovich, MD,<sup>2</sup> Charlotte Bell, MD,<sup>3</sup> James P. Borgstede, MD,<sup>4</sup> William G. Bradley Jr, MD, PhD,<sup>5</sup> Jerry W. Froelich, MD,<sup>6</sup> J. Rod Gimble, MD,<sup>7</sup> John H. Gosbee, MD,<sup>8</sup> Elias Kuhn-Kamrinski, RT,<sup>9</sup> Paul A. Larson, MD,<sup>10</sup> James H. Lester Jr, MD,<sup>11</sup> John Nyenhuis, PhD,<sup>12</sup> Daniel Joe Schoeller, PhD,<sup>13</sup> Elizabeth A. Sebek, PhD,<sup>14</sup> Jeffrey Walcott, MD,<sup>15</sup> Bruce L. Wilford, MD,<sup>16</sup> Terry O. Woods, PhD,<sup>17</sup> Leonard Lubitz, MD,<sup>18</sup> and Ome Hernandez, BSRT<sup>19</sup>

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=liDj439-fY>

## Implants and Devices



<http://www.theholocenter.com/images/Interventional/320Images/Implantable-pumps.jpg>

[http://www.safem.com/wp-content/uploads/2011/06/inter\\_implantable2.jpg](http://www.safem.com/wp-content/uploads/2011/06/inter_implantable2.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

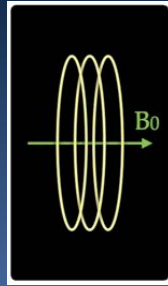
- ⌘ More likely to be seen when using sequences with very high slew rates
  - ⌘ Echo Planar Imaging
    - DWI
  - ⌘ Ultra-short TR Gradient Echoes
    - Localizer
    - Body imaging / MRA



## 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

$\epsilon PI$

Painful Acoustic Trauma	140	Shotgun blast
	130	Jet engine 100 feet away
	120	Rock concert
Extremely Loud	110	Car horn, siren/blower
	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 ticking
	dB levels	

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

## Hearing Protection

### FDA

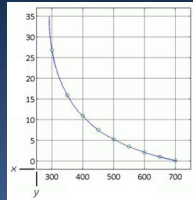
...instructions from manufacturers of MR equipment should state that hearing protection is required for all patients studied on MR imaging systems capable of producing sound pressures that exceed 99 dB

### 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



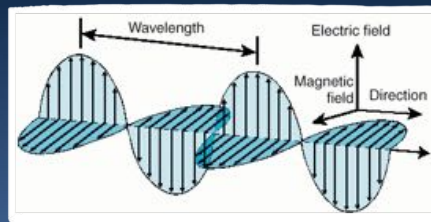
x = Spatial gradient, G/cm  
y = Distance, cm

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.

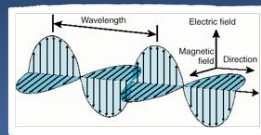
GE User Manual 000085-000-0001-0 Rev 1

## 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° C (109° F) above which patient with normal thermal regulation may suffer tissue damage<sup>1</sup>

\*IEC 60601-2-33 edition 3 (2010) requirement

<sup>1</sup>Magn 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

---

---

---

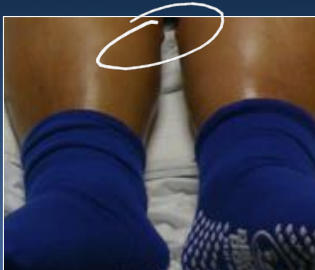
---

---

---

## RF Burns

Avoid skin-to-skin contact



---

---

---

---

---

---

## RF Burns



Do not create loops with coil wires

---

---

---

---

---

---

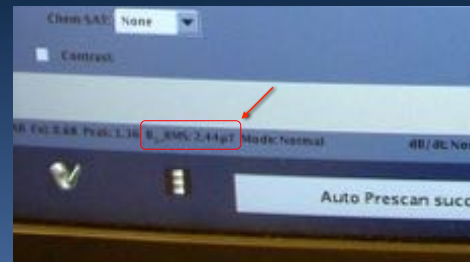


## Example Display



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