What is SAR?

An MRI exam causes no known harm to patients or to the operator. That’s not the same as saying that there’s no possible way of being hurt by an MRI. After all, if you drop a magnet on your foot, you’ll be hurt.

It’s also not the same as saying that there are no known physiological effects of an MRI examination on the patient. The most obvious effect that an MRI has on human tissue is that it heats it up, a little bit. In some cases, the heating can be a lot, so the FDA places a limit for how much the MRI is allowed to heat up the patient.

How does the patient get heated?

The MRI has a powerful radio transmitter and a transmit coil (antenna) that is capable of heating the patient enough so that it’s noticeable and even bothersome to the patient. In effect, you’re microwaving the patient in a mild way; but this hasn’t been shown to be harmful in modest doses (and in fact your body absorbs infinitesimally small amounts of RF energy all the time). The RF receiver does not impart any energy into the patient and for the purposes of this discussion, neither do the gradient coils. You cannot hear the RF transmit pulse.

The heating that the MRI does is carefully monitored so that it stays below the prescribed limit. Even when operating safely, however, sometimes the patient can feel warm; this doesn’t necessarily mean that there’s an unsafe condition.
Here are the factors that can affect the amount of RF energy that the patient absorbs:

- High field magnets heat up the patient more than less powerful magnets.
- Faster sequences heat up the patient more than slower sequences (in many cases).
- Fat people heat up more than skinny people, and they tend to be less able to dissipate the heat that they absorb.
- Small coils heat up the patient less than large coils (in most cases).
- Transmit/Receive coils heat up the patient less than Receive Only coils.
- Adding more slices, or more presaturation slabs, heats up the patient more.

For many exams, especially faster sequences with relatively large flip angles on larger patients, the SAR limits can be exceeded in routine clinical work. In those cases, the most common way to reduce the heating is to slow down the acquisition sequence by increasing the TR, decreasing the number of slices, or by other means.

These techniques have the effect of spreading the same amount of energy absorbed over a longer period of time (lessening the heating effect), or by transmitting less RF power into the patient, or both.

It’s important to note that, unlike x-rays, there is no evidence showing that a lower RF dose is beneficial or lowers risk for cancer, etc. The guiding principle for x-ray radiation exposure during an exam is called ALARA, As Low As Reasonably Achievable. This does not apply to MRI RF exposure, and repeated MRI exams are not known to cause any harm. Pro Imaging’s field engineers are not permitted to act as a test dummy for calibrating a CT scanner, but they can be a test volunteer for MRI.

**How is SAR Dose Controlled?**

SAR stands for Specific Absorption Rate, which is the amount of energy per kg of tissue mass in a given time that can be transmitted into the patient. The amount of energy transmitted into the patient is determined by:

- The sequence parameters you’ve chosen especially the TR and flip angle, and whether or not it’s a multiple echo sequence.
- The coil you’ve chosen (in the case of transmit & receive coils)
- The amount of tissue inside the coil (which determines the amount of energy needed for a given flip angle)
- The field strength of your magnet. A 3T magnet creates four times the RF energy as a 1.5T MRI does, using the same sequences.
The amount of RF energy used is automatically calculated when the pre scan calibrations are done. If you manually adjust the RF transmit calibration to a lower than normal value, you’ll decrease the SAR, but you’ll in effect be lowering the flip angle, which will impact the signal/noise and will affect the image contrast weighting.

The software for all MRIs is set up more or less the same for SAR monitoring;

‘Normal’ SAR limits are the lowest level, considered safe for everybody

‘Level 1’ control is a higher limit, suitable if you know that the patient is not under medication, pregnant, or has some other medical condition that might affect their ability to dissipate heat

‘Level 2’ control is for experimental purposes, or when scanning phantoms

The MRI operator is not exposed to RF energy at all.

If the patient complains that they’re getting warm, turning on a fan to blow a slight breeze over them can make a difference in their perception.

The patient cannot feel when a certain slice is being acquired; for example, they cannot tell when you’re scanning anterior, or if the sequence is in the sagittal plane. The patient also cannot feel the magnetic field, unless they have metal in their clothing. Patients with high iron concentration will not be heated more in the MRI.

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