DOES SAR MATTER?
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What is SAR (Specific Absorption Rate)?
- SAR (Specific Absorption Rate) is a measure of the rate at which energy is absorbed by the body when exposed to a radiofrequency (RF) electromagnetic field. It is measured in units of Watts per kilogram of body weight.
- There are two SAR modes allowed for clinical operation of an MRI: Normal and First Level Controlled. For the head, both Normal operating mode and First Level Controlled are less than or equal to 3.2W/kg. Given the SureScan™ pacing, defibrillation (ICD) or cardiac resynchronization therapy defibrillation (CRT-D) systems have a head SAR limit of less than or equal to 3.2W/kg (both Normal and First Level Controlled for head SAR), the remainder of this document will be addressing whole body SAR.

For whole body SAR:
- Normal operating mode: Less than or equal to 2W/kg. In the normal operating mode, no physiologic stress is expected.
- First level controlled operating mode: Greater than 2W/kg up to 4W/kg. In the first level controlled mode, some patients who are unable to tolerate a thermal challenge may experience physiologic stress. Examples include: elderly, frail, obese, diabetic etc.
- Second level controlled operating mode: Greater than 4W/kg. Second level controlled mode is not unitized in clinical imaging and currently would require research protocols (IRB approval).

For patients with a SureScan pacing, ICD or CRT-D system, the SAR limit is less than or equal to 2W/kg for whole body scans and less than or 3.2W/kg for head scans. Therefore, patients with a SureScan pacing, ICD or CRT-D system should be scanned in the Normal Operating Mode.

What is “image quality”?
“Image quality” is a somewhat subjective term. The question to ask is “can I provide a diagnostic study based on the clinical condition of a given patient?” As long as the image produced allows for proper diagnosis, the image quality has not been compromised.

Scanning at a reduced SAR level could result in reduced temporal resolution (i.e., reduces # phases per cycle). However, this does not mean that the study is non-diagnostic.

“As an MR technologist, I have often modified the protocol (including scanning at a lower SAR level) to meet the clinical needs of the patient. This does not mean they received a less than optimal study.”
—Wm. Faulkner, BS, RT (R) (MR) (CT), FSMRT

Does higher SAR produce a higher image quality?
- More power or higher SAR does not produce a better image. SAR is not directly related to image quality.
- All patients can be scanned in the Normal Operating Mode with no impact on image quality.
- The main effect is that some scans (depending on the particular sequence) may take from a few seconds to a few minutes longer.

In what cases is it necessary to scan a whole body at an SAR above 2W/kg?
There is no instance known when a scan cannot be acquired without going into First Level Control Mode. In some instances, certain types of sequences may not have as short a scan time in Normal Operating Mode. This, however, does not mean they cannot be performed.

How to stay within the 2W/kg SAR limit?
When selecting the Normal Operating Mode on some systems, the operator CANNOT exceed 2W/kg. On other systems, if the 2W/kg limit is reached, the system will prompt the operator to change certain parameters (TR, flip angle, # of slices) and provide the values for each which will keep the system in the Normal Operating Mode.
A knowledgeable and trained operator can easily stay at or below 2W/kg without negatively impacting image quality. The negative impact can be a slightly longer scan time.

Are there other cases when the SAR is limited to 2W/kg?
At 2W/kg (normal operating mode) no physiologic stress is expected. Physiological stress can occur above 2W/kg (1st level controlled). There are many instances when normal mode should be maintained for patients who do not have a pacemaker, ICD or CRT-D system. The 2W/kg condition is not a big problem and should not be an issue. Basically, due to other clinical conditions or medications, patients with pacemakers, ICDs and CRT-D systems should be scanned at 2W/kg anyway.

“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.”
—Frank Shellock, PhD

What is the downside of an SAR limit at 2W/kg?
Slightly increased scan times in some instances.

Why is there an SAR limit for SureScan pacing, ICD or CRT-D systems?
Testing was performed at 2W/kg and no physiologic stress is expected.
SUMMARY TABLE

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<td><strong>Disadvantages</strong></td>
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<td>No physiologic stress is expected. Patients are more comfortable in that they are able to easily dissipate heat resulting from exposure to RF.</td>
<td>Some sequences in certain patients will have slightly longer scan times.</td>
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<tr>
<td>Certain sequences will have shorter scan times.</td>
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<td>“Various underlying health conditions may affect an individual’s ability to tolerate a thermal challenge.” —Frank Shellock, PhD1</td>
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**Contraindications**

The SureScan pacing systems are contraindicated for implantation with unipolar pacing leads (Revo MRI™ only), concomitant implantation with another brady/atrial device or an implantable cardioverter defibrillator. Rate-responsive modes may be contraindicated in those patients who cannot tolerate pacing rates above the programmed Lower Rate. Dual chamber sequential pacing is contraindicated in patients with chronic or persistent supraventricular tachycardias, including atrial fibrillation or flutter. Asynchronous pacing is contraindicated in the presence (or likelihood) of competition between paced and intrinsic rhythms. Single chamber atrial pacing is contraindicated in patients with an AV conduction disturbance. ATP therapy is contraindicated in patients with an accessory antegrade pathway.

**Indications**

SureScan CRT-D systems are indicated for rate adaptive pacing in patients who may benefit from increased pacing rates concurrent with increases in activity. Accepted patient conditions warranting chronic cardiac pacing include symptomatic paroxysmal or permanent second- or third-degree AV block, symptomatic bilateral branch block, symptomatic paroxysmal or transient sinus node-dysfunction with or without associated AV conduction disorders, or bradycardia-tachycardia syndrome to prevent symptomatic bradycardia or some forms of symptomatic tachyarrhythmias. Dual chamber SureScan pacing systems are also indicated for dual chamber and atrial tracking modes in patients who may benefit from maintenance of AV synchrony. Dual chamber modes are specifically indicated for treatment of conduction disorders that require restoration of both rate and AV synchrony, which include various degrees of AV block to maintain the atrial contribution to cardiac output. VVI intolerance (for example, pacemaker syndrome) in the presence of persistent sinus rhythm, or vasovagal syndromes or hypersensitive carotid sinus syndromes. Antitachycardia pacing (ATP) is indicated for termination of atrial tachyarrhythmias in bradycardia patients with one or more of the above pacing indications.

SureScan defibrillation systems are indicated to provide ventricular antitachycardia pacing and ventricular defibrillation for automated treatment of life-threatening ventricular arrhythmias. In addition, the dual chamber devices are indicated for use in the above patients with atrial tachyarrhythmias, or those patients who are at significant risk of developing atrial tachyarrhythmias.

SureScan CRT-D systems are indicated for ventricular antitachycardia pacing and ventricular defibrillation for automated treatment of life-threatening ventricular arrhythmias and for providing cardiac resynchronization therapy in heart failure patients on stable, optimal heart failure medical therapy if indicated, and meet any of the following classifications: New York Heart Association (NYHA) Functional Class III or IV and who have a left ventricular ejection fraction ≤ 35% and a prolonged QRS duration. Left bundle branch block is BBB with a QRS duration > 150 ms, left ventricular ejection fraction ≤ 30%, and NYHA Functional Class II. NYHA Functional Class I, II, or III and who have left ventricular ejection fraction ≤ 50% and atrioventricular block (AV block) that are expected to require a high degree of ventricular pacing that cannot be managed with algorithms to minimize right ventricular pacing. Optimization of heart failure medical therapy that is limited due to AV block or the urgent need for pacing should be done post-implant. Some CRT-D devices are also indicated for use in patients with atrial tachyarrhythmias, or those patients who are at significant risk for developing atrial tachyarrhythmias.

The RV Lead Integrity Alert (LIA) feature is intended primarily for patients who have a Medtronic ICD or CRT-D device and a Sprint Fidelis lead (Models 6949, 6948, 6931, and 6930), based on performance data. The RV LIA feature may not perform as well with a St. Jude Medical Rata/Durata lead or a Boston Scientific Endotak lead as it does when used with a Medtronic Sprint Fidelis lead. This is because different lead designs may have different failure signatures and conditions that may or may not be detected early by the RV LIA feature.

**Disadvantages**

In patients with certain atrial tachyarrhythmias, such as atrial fibrillation or flutter, asynchronous pacing is contraindicated in the presence (or likelihood) of competition between paced and intrinsic rhythms. Single chamber atrial pacing is contraindicated in patients with an AV conduction disturbance. ATP therapy is contraindicated in patients with an accessory antegrade pathway.

**Indications**

SureScan defibrillation and CRT-D systems are contraindicated for patients experiencing certain underlying arrhythmias with transient or reversible causes including, but not limited to, the following acute myocardial infarction, drug intoxication, drowning, electric shock, electrotye imbalance, hypoxia, or sepsis. The device is contraindicated for patients who have a unipolar pacemaker implanted. The device terminates arrhythmia episodes, acceleration of VT or VF. For patients with a dual chamber device, the device is contraindicated for patients whose primary disorder is atrial tachyarrhythmia. The SureScan system, which is a SureScan device with appropriate SureScan lead(s), is required for use in the MR environment. To verify that components are part of a SureScan system, visit http://www.mrissurescan.com/. Any other combination may result in a hazard to the patient during an MR scan.

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**Caution:** Federal law (USA) restricts these devices to sale by or on the order of a physician.