B$_{1+\text{RMS}}$ as a Condition for Use

Because B$_{1+\text{RMS}}$ is now recommended as a supplemental metric to SAR, Medtronic has begun to have device labeling approved with B$_{1+\text{RMS}}$ limits.

For a full list of devices and leads approved for the MRI environment, download our MR-conditional Cardiac Device Summary Chart, which can be found on MRISureScan.com.

SureScan™ cardiac device 3T labeling is a little different than 1.5T labeling in that it uses B$_{1+\text{RMS}}$ rather than SAR when landmarking/centering below C7. When scanning these devices at 1.5 T, SAR must be limited to the Normal Operating Mode. It is important to remember that the B$_{1+\text{RMS}}$ limit applies to 3T ONLY. When utilizing B$_{1+\text{RMS}}$ as a condition of use at 3T, one can utilize either Normal or First Level Controlled Mode for SAR. However, the displayed B$_{1+\text{RMS}}$ value for each scan is not to exceed 2.8 µT (micro Tesla) when landmarking/centering below C7. When landmarking/centering above C7, either Normal or First Level Controlled mode may be used for SAR and there are no restrictions regarding B$_{1+\text{RMS}}$. If your 3T MR system does not display B$_{1+\text{RMS}}$, then only studies may be performed which are landmarked/centered above C7. Centering/Landmarking and/or scanning below C7 is not allowed for 3T systems that do not display B$_{1+\text{RMS}}$.

At 3T, most of your current protocols will need little to no modification to comply with the 2.8 µT B$_{1+\text{RMS}}$ condition of use. As a rule of thumb, the higher the estimated SAR, the higher the likelihood that some modifications may need to be made. However at 3T, the likelihood that a sequence would need modification to comply with the 2.8 µT limit is still very low.

It should also be noted that there are no restrictions on the use of local transmit/receive coils for imaging of the head or the extremities, which includes no B$_{1+\text{RMS}}$ restrictions. For example, if one is using a knee transmit/receive coil with a sequence requiring > 2.8 µT, this would be acceptable since the whole body coil is not being used as the transmit coil.

GE 3T MR Systems

On the GE system, B$_{1+\text{RMS}}$ is displayed alongside the estimated SAR values as shown in Figure 1.

How one modifies scan parameters to affect the B$_{1+\text{RMS}}$ may vary slightly between MR system brands based on available options. However, in general, whatever you do to reduce SAR on your system will likely reduce the B$_{1+\text{RMS}}$. If your system displays B$_{1+\text{RMS}}$, you will find it in the same area in which you find SAR.

As previously mentioned, most parameters that affect SAR will affect the B$_{1+\text{RMS}}$. Also remember that once you have adjusted the parameters to obtain a B$_{1+\text{RMS}}$ value of 2.8 µT or less, you can save that sequence in your protocols. Unlike SAR, the B$_{1+\text{RMS}}$ value will be the same the next time you recall that sequence (provided none of the parameters are altered from when it was saved, including the number of slices).
Specific Examples for Modifying $B_{1+RMS}$ on GE 3T Systems

Reducing the number of slices without increasing the TR or increasing the TR without increasing the number of slices will reduce the $B_{1+RMS}$. Reducing the number of slices is often not practical so increasing the TR is the more likely choice between the two. Depending on other parameters, you may have to significantly increase the TR. Besides the impact on scan time, significant increases in TR are also not practical when T1-Weighted spin echo sequences are desired.

Fast spin echo series consist of a 90-degree pulse followed by a “train” of refocusing pulses, generally said to be 180-degree pulses. In reality these are rarely 180-degree pulses but rather 170-degrees or even less. The number of echoes generated by the refocusing pulses is often referred to as the **Echo Train Length (ETL)**. To reduce the $B_{1+RMS}$ you can reduce the ETL (leaving all other parameters unchanged). You may also have the option to alter the **Refocus Flip Angle** (depending on your particular version of software). The selection on DV24 software is shown in Figure 2.

As you reduce either the ETL or the refocusing flip angle, the $B_{1+RMS}$ will be reduced (yellow arrow). It should be noted that at some point, reducing the refocusing flip angle can result in reduced SNR and altered image contrast. As a general rule of thumb, use caution when selecting a refocusing flip angle below 130.

Low SAR Mode

GE has recently introduced what they refer to as “Low SAR Mode” option for patients with implants and devices. When selecting this option, specific conditions of use can be entered (Figure 3). It should be noted that in Low SAR Mode, the whole body SAR will automatically be limited to 2.0 W/kg (Normal Operating Mode for SAR). The 3T conditions of use for the SureScan™ cardiac devices do not require a 2.0 W/kg whole body SAR limit.

![Figure 3](image-url)
Summary

- 3T labeling uses $B_{1+RMS}$ as the condition of use relative to RF power when landmarking/centering below C7.
- When landmarking/centering above C7, there are no restrictions for $B_{1+RMS}$ and either Normal or First Level Controlled mode for SAR may be selected.
- When landmarking/centering below C7, the displayed $B_{1+RMS}$ value should be less than or equal to 2.8 µT (micro-Tesla). Either Normal or First Level Controlled SAR mode may be selected.
- In the event your 3T system software does not display $B_{1+RMS}$, only studies in which the landmark is above C7 may be performed on a 3T system.

- The use of $B_{1+RMS}$ as a metric for RF heating provides for greater flexibility in pulse sequence and parameter selection.
- Most parameters which affect SAR will affect $B_{1+RMS}$.
- Once a sequence has been modified to have a $B_{1+RMS}$ value of 2.8 µT or less, it can be saved in the site’s protocols.
- As long as the parameters affecting $B_{1+RMS}$ are not modified, sequences saved with a specific $B_{1+RMS}$ value will remain unchanged patient-to-patient.
Brief Statement
Medtronic SureScan® Portfolio for 1.5T and 3T MR-Conditional Use
Medtronic SureScan products and systems are MR Conditional, and as such are designed to allow patients to undergo MRI under the specified conditions for use.

Pacing, ICD, CRT-P and CRT-D Systems: When programmed to On, the MRI SureScan feature allows the patient to be safely scanned while the device continues to provide appropriate pacing. A complete transvenous SureScan system, which is a SureScan device with appropriate SureScan leads, is required for use in the MR environment. For ICD and CRT-D Systems, when a single coil SureScan defibrillation lead is used, a Medtronic DF-1 pin plug must be secured in the SVC port to make a complete SureScan DF-1 defibrillation system. To verify that components are part of a SureScan system, visit www.misurescan.com. Any other combination may result in a hazard to the patient during an MRI scan.

Indications
The SureScan MRI transvenous pacing systems are indicated for rate adaptive pacing in patients who may benefit from increased paced rates concurrent with increases in activity. 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. The SureScan MRI 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.

The SureScan MRI 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 II and IV who have a left ventricular ejection fraction ≤ 35% and are admitted in acute decompensation.
- Left bundle branch block (LBBB) with a QRS duration ≥ 130 ms, left ventricular ejection fraction ≤ 50%, and NYHA Functional Class II.
- NYHA Functional Class III and IV who have left ventricular ejection fraction ≤ 50% and atrioventricular block (AV block) that are expected to require a high percentage 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 considered in these patients. Dual chamber and atrial tracking modes are also indicated for use in patients with atrial tachyarrhythmias, or those patients who are at significant risk for developing atrial tachyarrhythmias.

The SureScan CRT-P Systems are indicated for NYHA Functional Class III and IV patients who remain symptomatic despite stable, optimal heart failure medical therapy and have a LVEF ≤ 35% and a prolonged QRS duration and for NYHA Functional Class III, IV or NYHA III patients who have a LVEF ≤ 35% and atrioventricular block (AV block) that are expected to require a high percentage 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. Rate adaptive pacing systems for these patients developing a bradycardia indication who might benefit from increased pacing rates concurrent with increases in activity. Dual chamber and atrial tracking modes are indicated for patients who may benefit from maintenance of AV synchrony. Antitachycardia pacing (ATP) is indicated for termination of atrial tachyarrhythmias. The SureScan CRT-P Systems are indicated for patients with atrial tachyarrhythmias. Dual chamber and atrial tracking modes are also indicated for use in patients with atrial tachyarrhythmias, or those patients who are at significant risk for developing atrial tachyarrhythmias.

Potential Adverse Events
SureScan defibrillation and CRT-D systems are contraindicated for patients experiencing tachyarrhythmias with transient or reversible causes, or patients with incessant VT or VF. For dual chamber and CRT-D devices, the device is contraindicated for patients whose primary disorder is chronic atrial tachyarrhythmia with no concomitant VT or VF. For single chamber devices, the device is contraindicated for patients whose primary disorder is atrial tachyarrhythmia.

Reveal LINQ: There are no known contraindications for the implant of the Reveal LINQ ICM. However, the patient’s particular medical condition may dictate whether or not a subcutaneous or transvenous device should be selected. For further information, call Medtronic at 1-800-328-2518 and/or consult the Medtronic website at www.medtronic.com or www.misurescan.com.

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