

## Substrate Mapping for Ventricular Tachycardia: Assumptions and Misconceptions

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### Summary

Substrate mapping was developed to treat poorly tolerated, infarct-related ventricular tachycardias (VT). The concept of substrate mapping was based on 30-year-old data derived from surgical and percutaneous mapping during sinus rhythm and VT, which demonstrated specific electrograms (EGMs) that characterized the “arrhythmogenic substrate” of VT. Characteristics of these EGMs included low-voltage, fractionation, long duration, split signals, and isolated late potentials as well as adjacent early and late activation.

Introduction of electroanatomical mapping (EAM) systems during the mid-1990s has allowed investigators to record EGMs in three dimensions and to identify sites assumed to represent the central common pathway (isthmus) during reentrant VTs. However, currently used substrate mapping techniques are based on assumptions that have not been validated, which limits our ability to accurately define the true arrhythmogenic substrate.

These assumptions include:

- Reentrant circuits are produced by fixed barriers of immutable, “inexcitable” scar tissue; hence, barriers forming the isthmus during VT are present during sinus rhythm
- Low-voltage amplitude ( $\leq 0.5$  mV) implies dense “inexcitable” scar, and the bipolar amplitude is a reflection of the underlying tissue
- Isthmuses identified in patients with tolerated VTs using entrainment mapping are both valid and provide an accurate depiction of isthmuses in less hemodynamically tolerated VTs
- Current mapping tools and methods can delineate specific electrophysiologic features that will determine the barriers forming channels during reentrant VTs

Despite acute success of ablation strategies based on the assumptions above, the VT recurrence rate at one year remains unacceptably high, ranging 50–60%. In addition, recent experimental and human data using high-resolution mapping with very small electrodes cast doubt on the validity of those assumptions.

These data call for re-evaluation of substrate-mapping techniques to characterize the arrhythmogenic substrate of post-infarction VT. Many of the limitations of current recording techniques can be overcome with the use of new catheters with small electrodes and closer interelectrode spacing, which markedly improves resolution. Standardization of recording techniques including electrode size, interelectrode spacing, tissue contact, catheter orientation and wavefront activation must be taken into consideration.

No limitations were identified by the author in this publication.

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## RHYTHMIA™ MAPPING SYSTEM INTENDED USE/INDICATIONS FOR USE

The Rhythmia™ Mapping System and accessories are indicated for catheter-based atrial and ventricular mapping. The mapping system allows real-time visualization of intracardiac catheters as well as display of cardiac maps in a number of different formats. The acquired patient signals, including body surface ECG and intracardiac electrograms, may also be recorded and displayed on the system's display screen.

**CONTRAINDICATIONS** There are no known contraindications.

**WARNINGS AND PRECAUTIONS** The use of the Rhythmia Mapping System in conjunction with radio frequency ablation and other medical devices, as a part of the diagnosis and treatment of cardiac arrhythmias, may pose a risk of adverse events, such as cardiac perforation and arrhythmias (new and/or exacerbation of existing arrhythmias) that may require additional intervention. Do not operate the Rhythmia Mapping System near flammable anesthetics. System operation near flammable anesthetics may cause an explosion that could cause injury or death to the patient or user. All devices that are connected to the Rhythmia Mapping System must meet IEC 60601-1 requirements and any other relevant safety standards. When connected to other devices, the combined systems' configuration must meet the IEC 60601-1-1 safety standards. The use of the Rhythmia Mapping System with accessories and devices that do not comply with relevant standards may reduce the safety of the system, cause equipment damage or system malfunction, or harm to the patient or user. Only stimulators that are certified for IEC 60601 should be used with the Rhythmia Mapping System. Do not connect life-sustaining pacing through the Rhythmia Mapping System. The system is not intended to provide life-sustaining therapy and should not be used as such. In case of need for emergency pacing, or any failure of stimulator routing, directly connect the desired paced channel to the stimulator. The Rhythmia Mapping System is only designed to route the stimulation signal to the desired channel. To start or stop stimulation, always use the controls on the external stimulator. Use the Rhythmia Mapping System only with one of the following RF ablation generators: Maestro 3000™, Stockert™, or IBI™. Do not use the system with other RF ablation generators. Compatibility with other RF ablation generators has not been demonstrated. Do not apply RF energy larger than 150W to ablation catheters that are connected to the Maestro 3000 RF generator and the Rhythmia Mapping System. Do not apply RF energy larger than 70W to ablation catheters that are connected to the Stockert RF generator and the Rhythmia Mapping System. Do not apply RF energy larger than 50W to ablation catheters that are connected to the IBI RF generator and the Rhythmia Mapping System. To reduce the risk of electric shock or equipment damage, do not clean the Rhythmia Mapping System when it is plugged in, turned on, or connected to a patient. Cleaning the system while it is in use and connected to a power source may cause an electrical shock that could cause injury or death to the patient or user. To reduce the risk of electric shock, assure that any ECG cables and electrodes are not in contact with any other conductive parts, including ground. To reduce the risk of electric shock during defibrillation, assure that the exposed connector tips on the ECG output box are covered at all times with the protective, non-conductive material provided with the ECG output boxes. Do not use the ECG output box if the protective cover is damaged (see ECG Output Box). The system generates electrical impedance fields as part of its normal operation. Do not use other systems that also generate electrical impedance fields in the same procedure, as this may interfere with the system's normal operation and reduce the quality of catheter localization, and signals. Magnetic Localization System Do not operate the Localization Generator within 200 mm of installed cardiac implantable electronic devices (CIEDs). Doing so may affect pacing, temporarily suspend tachycardia therapy delivery, or lead to patient discomfort. Signal Station To minimize the risk of electric shock, connect the Signal Station only to supply mains with a protective ground (earth) connection. Use only a functioning, properly tested supply main with protective ground (earth) to power the Rhythmia Mapping System. The use of a faulty, ungrounded supply main increases the risk of electrical shock and system malfunction. To minimize the risk of electric shock, prior to using the Rhythmia Mapping System, connect the equipotential socket (located on the Signal Station rear panel) to a common ground. This connection grounds the Rhythmia Mapping System and must remain connected at all times (see Signal Station Setup in the DFU). The Signal Station requires a dedicated, 24V DC power supply, which is provided by Boston Scientific with the Signal Station. To reduce the risk of Signal Station damage, use only the power supply provided by Boston Scientific for use with the Signal Station. To reduce the risk of Signal Station damage, do not connect or disconnect the Signal Station to its power supply while the Signal Station is turned on. To minimize potential exposure to water or liquid, prevent fluids from entering air vents. Do not place beverages or containers of water or liquid directly on or near the Signal Station or other system components. Do not block the air vent on the Signal Station during Signal Station use. Blocking the air vent during Signal Station use can cause the Signal Station to overheat, which may affect system operation. Use only a flat stable surface to hold the Signal Station and Signal Station-related accessories. Workstation To minimize potential exposure to water or liquid, do not place beverages or containers of water or liquid directly on or near the Workstation or other system components. Use only a flat stable surface to hold or transport the Workstation and Workstation-related accessories. To prevent loss of data, frequently back up the data by archiving cases no longer needed for immediate access. Cables Use only the ECG cables supplied by Rhythmia™ Medical for use with the Rhythmia Mapping System. ECG cables provided by Rhythmia Medical are designed and tested to protect the Signal Station from defibrillation energy. Using other ECG cables may cause serious damage to the system hardware. Prior to using the Rhythmia Mapping System, inspect all external connections and cable connectors. Make sure all connections are secure. Tighten any loose connections prior to using the system. Do not use excessive force when connecting or disconnecting cable connectors. Excessive force can damage the connectors, which may cause system malfunction. Do not kink or sharply bend cables. Kinks and sharp bends can damage the cables, which may cause system malfunction. To minimize the risk of damage, store unused system cables in a clean, dry, and secure location, consistent with storage guidelines (see Equipment Storage & Transporting in the DFU). Electrical Never use ungrounded electrical outlets to power any system components. Do not use extension cords or adapters for ungrounded outlets. Using ungrounded outlets, extension cords, or adapters may cause equipment damage, system failure or malfunction. Body Surface Electrodes Use care when attaching the body surface electrodes to lead connectors. To minimize the risk of electric shock, make sure that electrodes and lead connectors do not contact one another or contact ground. To prevent low quality signals from body surface electrodes, properly prepare the skin prior to attaching the electrodes. Do not use excessive gel as this may lead to shorts between different electrodes. Environmental Do not immerse any cable connectors in water or liquid. Immersion in water or liquid may damage connectors, which may cause system malfunction. Magnetic Localization System Manually disabling the Localization Generator disables all catheter visualization and localization capabilities, including impedance tracking. Do not place the Localization Unit (SCU) or Sensor Interface Unit (SIU) within 1m of the Localization Generator. Doing so may lead to inaccurate tracking. Do not place cables used with the Rhythmia Mapping System within 30mm of the Localization Generator cable. If these cables are within 30mm or less, particularly if they are parallel to each other, inaccurate tracking or "noisy" signals may occur. Do not coil the Localization Generator cable. Doing so can disturb the magnetic field of the Localization Generator, which may lead to inaccurate tracking. Do not use the Magnetic Localization System in the presence of other magnetic fields or large metal objects. Doing so may lead to inaccurate tracking. Localization Generator Manually disabling the Localization Generator disables all catheter visualization and localization capabilities, including impedance tracking. During the Procedure To reduce catheter configuration mistakes, when connecting catheters to the system, always verify the signals by reviewing the signal display and recording system to ensure correct configuration of catheter electrodes to displayed channels. To ensure correct clinical decisions, use fluoroscopy, ultrasound, pace mapping or other visualization techniques to verify mapping results and catheter position. Always compare the anatomical map to the patient's expected anatomy. When a catheter localization error is encountered, use fluoroscopy or other visualization techniques to verify catheter location. Imported geometrical shells should only be used as a reference, for example to identify anatomical features in advance of mapping. Use other visualization tools, such as fluoroscopy or echocardiography to verify catheter location. During the mapping procedure, do not disconnect the Localization Unit from the Signal Station and/or the Localization Generator from the Localization Unit. Ensure caps are installed on Localization Unit SIU connection ports that are not in use. (Rev A)

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