Optimizing Device Longevity

Advances in electronic circuitry and battery chemistry have enabled St. Jude Medical to design and produce pacemakers that can be implanted for many years without the need for replacement. Device longevity can be influenced by several factors, some over which the clinician may have little control (high or low lead impedances, elevated pacing thresholds, etc.) and others for which parameters may be programmed to optimize device longevity.

Nuts and Bolts of Pacemaker Technology

Pacemakers utilize microprocessor technology similar to a home computer. The microprocessor is used to provide accurate timing of the pacing events, and along with sense amplifiers, output circuitry and a battery, completes the basic building blocks of an implantable device. In order for the microprocessor and the other circuitry to run properly, a nominal amount of battery energy is used continuously, even when the pacemaker is fully inhibited. This battery energy is known as "quiescent" or housekeeping current. The typical housekeeping current for a St. Jude Medical pacemaker is approximately 7 microamps, and the typical pacemaker battery has a capacity of 0.5 to 1.2 amp-hours. Therefore, taking only the housekeeping current into consideration, we can roughly calculate expected longevity for a device that has a 7 microamp current drain and a useable battery capacity of 1.0 amp-hour (1,000,000 microamp-hours) to be 16.3 years. This estimate, however, is unrealistic as it represents the expected longevity for a pacemaker that never paces for the duration of its implant. When the device paces, additional battery current is used to supply the energy to stimulate the heart. This current is added to the housekeeping current and will therefore decrease the longevity of the device.

Parameters that Affect Device Longevity:

Output Settings

Pulse Amplitude and Pulse Width are two of the most important parameters influencing device longevity. Increasing the Pulse Amplitude or Pulse Width increases battery current drain and decreases overall device longevity. In St. Jude Medical pacemakers, when the Pulse Amplitude is programmed above 2.5 V, a voltage doubler is used in the circuitry of the device. This doubler is used to "pump-up" the output voltage above the nominal 2.8 volts supplied by the lithium iodine battery. Engaging this voltage doubler can significantly increase the battery current drain. Similarly, when the Pulse Amplitude is set above 5.0 V, a voltage tripler is used to achieve the desired output and results in a further increase in battery current drain.

Adjusting the output settings to a lower Pulse Amplitude and a higher Pulse Width may disengage the voltage doubler or tripler and reduce battery current drain while still providing adequate capture. For example, if a patient's capture threshold is 1.5 V at a pulse width of 0.4 ms, the Pulse Amplitude is often set to 3.0 V at 0.4 ms to ensure an adequate safety margin. Increasing the Pulse Width to 0.6 ms may lower the threshold to 1.25 V. Programming the

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Pulse Amplitude to 2.5 V with a Pulse Width of 0.6 ms reduces the current drain (amplitude is below where the voltage doubler kicks in) while maintaining an adequate safety margin and increasing the device longevity.

Utilizing Autocapture is a great way to conserve battery current drain as it constantly maintains a pacing output just above the patient's capture threshold and therefore eliminates the need to permanently program the typical 2:1 safety margin. Additionally, when AutoCapture is enabled, the pacemaker adjusts the Automatic Pulse Amplitude to provide low energy settings while monitoring and adjusting to changes in the ventricular capture threshold beat-by-beat.

Intrinsic Activity

To promote intrinsic activity and thereby extend longevity, St. Jude Medical offers features that help reduce the percentage of paced events in one or both chambers. Enabling Hysteresis can help reduce atrial pacing in dual chamber modes and reduce ventricular pacing in single chamber modes. When Hysteresis is active, the pacemaker allows the intrinsic rate to drop to the programmable Hysteresis Rate. Hysteresis with Search lowers the rate to the Hysteresis Rate periodically to search for intrinsic activity.

St. Jude Medical's AutoIntrinsic Conduction Search (AICS) and Ventricular Intrinsic Preference (VIP) also encourage intrinsic activity. Both features minimize ventricular pacing in the DDD(R) mode by periodically extending the AV and PV delays by a programmable delta to search for intrinsic conduction. When conduction is present, the delays remain extended. If conduction is not present, ventricular pacing is always available at the extended AV or PV delay. By utilizing AICS, VIP, and Hysteresis, pacing in one or both chambers is minimized, increasing overall battery longevity. Intrinsic activity can also be promoted by simple programming of longer AV/PV delays in patients without AV block.

AF Suppression

Enabling AF Suppression in patients with active sinus nodes will increase the atrial paced rate 5-10ppm over the detected sinus rate. Depending on the intrinsic heart rate, device longevity can be affected as a result of the increase in pacing rate.

Rate Responsive Pacing (Sensor Drive)

Rate Responsive pacing, when properly set up using Auto settings, provides a small average increase over base rate pacing (~ 2 ppm) over the life of the device. Taking into consideration that most patients' "daily activities" are limited to relatively short periods, this generally represents less than a 5% change in the paced current over the life of the device.

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By utilizing some of these tips, it is possible to significantly increase a pacemaker's longevity. Pacemakers introduced to the market since 2001 offer the Estimated Remaining Longevity diagnostic. The estimate accounts for the mode, rate, pulse amplitudes, pulse widths, lead impedances, battery current drain, battery impedance, and the total number of paced events since the device was last cleared.

The user can easily assess the impact of programmed parameter changes on the longevity by looking at the remaining longevity display. This allows the user to optimize the device to obtain the best clinical outcome and longevity.

If you have any questions please contact Abbott Technical Services.

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