SUMMARY OF SAFETY AND EFFECTIVENESS

A. GENERAL INFORMATION

Device Generic Name:	Implantable Pacemaker Pulse Generator
Device Trade Name(s):	Microny™ SR+ Model 2425T
PMA Number:	P970013
Applicant's Name and Address:	St. Jude Medical Cardiac Rhythm Management Division 15900 Valley View Court Sylmar, CA 91342
Date of Panel Recommendation:	Not applicable
Notice of Approval to Applicant::	December 21, 2000

B. Indications and Usage

The Microny™ SR+ is indicated for:

- Accepted Patient Conditions warranting chronic cardiac pacing which include:
  - sick sinus syndrome
  - chronic, symptomatic second- and third-degree AV block
  - recurrent Adams-Stokes syndrome
  - symptomatic bilateral bundle branch block when tachy-arrhythmia and other causes have been ruled out.
- Atrial Pacing in patients with sinus node dysfunction and normal AV and intraventricular conduction systems.
- Ventricular Pacing in patients with significant bradycardia and:
  - normal sinus rhythm with only rare episodes of A-V block or sinus arrest requiring short periods of pacing support
  - chronic atrial fibrillation
  - severe physical disability.
- Rate-Modulated Pacing in patients who would benefit from increased pacing rates concurrent with physical activity.

11

C. CONTRAINDICATIONS

The Microny™ SR+ is contraindicated for:

- Single-Chamber Ventricular Demand Pacing in patients who have demonstrated pacemaker syndrome, have retrograde VA conduction, or who suffer a drop in arterial blood pressure with the onset of ventricular pacing.
- Single-Chamber Atrial Pacing in patients who have demonstrated compromise of AV conduction.
- Rate-Modulated Pacing in patients who experience angina or other symptoms of myocardial dysfunction at higher sensor-driven rates.
- Unipolar Pacing in patients with an implanted cardioverter-defibrillator (ICD) since it may inhibit or trigger ICD therapy. The Microny™ SR+ is programmed to unipolar pacing and may be inappropriate for patients with an ICD.

D. Warnings and Precautions

PACEMAKER AND LEAD SELECTION

- Compatible Pacing Leads. Prior to implantation, make sure the pacing lead fits easily and snugly into the pulse generator's header.
- AutoCapture™ Pacing System Lead Compatibility. The AutoCapture™ Pacing System will operate only with a low polarization, bipolar pacing lead. Before implanting a lead, verify compatibility by conducting the E/R Sensitivity Test. For more information on AutoCapture-compatible leads, contact your St. Jude Medical Cardiac Rhythm Management Division representative or Technical Services.

PACEMAKER-DEPENDENT PATIENTS

- Emergency VVI. When programming the pulse generator to Emergency VVI settings, press the programmer's Emergency VVI or Programmer Reset button only once.
- Pulse Amplitude. If the AutoCapture™ Pacing System is not in use or if the lead is implanted in the atrium, determine the capture threshold before programming the Pulse Amplitude. Program Pulse Amplitude to yield a suitable safety margin for reliable, long-term capture. Reassess capture thresholds periodically.
- Recommended Replacement Time (RRT). At RRT, the nominal life of the pulse generator is three months.

When the pacemaker exhibits signs of RRT, it should be replaced expeditiously. RRT is indicated by:

- Magnet test rate below 81 ppm
- Test rate interval greater than 706 ms
- Cell impedance of 15 kΩ or greater
- battery voltage decrease to 2.65 volts
- the Sensor automatically programmed to Off.

Patient follow-up visits should be scheduled at an appropriate frequency so RRT can be detected well before EOL.

MEDICAL THERAPY

- Electrosurgery. Do not use electrosurgical devices in the vicinity of an implanted pulse generator. If electrocautery is necessary, use a bipolar cauterizer or place the indifferent electrode as far from the pulse generator as possible. The axis of the electrocautery should be perpendicular to the electrode axis.
- Lithotripsy. Do not focus a lithotripsy beam within six inches of the pulse generator. Program the pulse generator to Sensor Off prior to lithotripsy to prevent inappropriate increases in pacing rate. A thorough assessment of pulse generator function should be performed following exposure to lithotripsy.
- Therapeutic Radiation should not be used in the vicinity of an implanted pulse generator. Radiation therapy may damage the microprocessor circuitry of a pulse generator.
- Ultrasound Treatment. To avoid damage to the pulse generator, do not use therapeutic ultrasound within six inches of the pulse generator. Ultrasound energy may cause mechanical damage to the device.

PERFORM A THOROUGH ASSESSMENT OF PULSE GENERATOR FUNCTION FOLLOWING EXPOSURE TO ANY OF THE ABOVE STORAGE AND RESTERILIZATION

- For single use only.
- Do not implant or resterilize a pulse generator that has been contaminated by contact with body fluids.
- Do not resterilize the pulse generator more than once.
- Do not implant a pulse generator from a damaged package without resterilizing it.
- To sterilize the pulse generator, use ethylene oxide gas at temperatures not exceeding +50°C (122°F), according to the sterilizer manufacturer's instructions. Allow proper aeration per local and national ordinances.
- Do not sterilize the pulse generator with an autoclave, steam, gamma radiation, or ultrasonics.

- If you suspect the pulse generator has been damaged, do not implant it; return it to the manufacturer.
- Do not subject the pulse generator to temperatures above +50 °C (122 °F) or below 0 °C (32 °F). Exposure to low temperatures may cause a temporary high battery impedance reading until the device has returned to normal room temperatures.
- Do not incinerate the pulse generator.

PACKAGING

The Microny™ SR+ pulse generator is packaged one per package in a sterile package. Prior to opening the sterile package:

- Verify that the package contains the correct pulse generator.
- Verify that the pulse generator is operating properly by positioning the programmer telemetry head over the package and selecting "interrogate." The unit's Measured Data should indicate normal voltage and battery status, and the programmed parameters should be identical to the Shipped Settings on the package label.
- Verify that the package has not been opened or in any way compromised. If damage is suspected, return it to the manufacturer.
- Do not implant the pulse generator after the "use before" date printed on the label.

Observe complete sterile technique when opening the package's inner tray. The package's outer tray may be opened in non-sterile surroundings.

LEAD EVALUATION AND LEAD CONNECTION

- Connector compatibility. Do not use any lead with this pacemaker without first verifying connector compatibility.
- Set-Screw. When connecting a lead, exercise caution when turning the set-screw. A set-screw may back out of the terminal block if turned excessively counterclockwise.

PROGRAMMING AND PACEMAKER OPERATION

- Pre-Implant Testing. Test the device using a pacing system analyzer (PSA) with recently calibrated sensitivity and output settings. When the probe is attached to the pulse generator's connector, the programmed parameters should be identical to the Shipped Settings listed on the package label. . When performing the PSA test a constant voltage setting should be used.

- Capture/Sensing Thresholds. Determine capture and sensing thresholds with a PSA before implanting the pulse generator. When performing the PSA test a constant voltage setting should be used. Connect the negative (black) PSA terminal to the portion of the lead terminal pin corresponding to the tip electrode. The positive (red) terminal should be connected to the ring electrode portion of the lead pin for bipolar leads or to an indifferent electrode. For more information, consult the PSA technical manual and the programmer's Programming Guide.

- The Microny™ SR+ pulse generator limits the time at which the sensor-indicated rate will operate above 140 ppm to 15 minutes. The feature acts as a "watchdog" to prevent potentially dangerous high rates for extended periods of time.
- Programming. The Microny™ SR+ can be programmed with the APS® II, APS®µ, and the Model 3500 and Model 3510 programmers. For more information on programming the Microny SR+, refer to the programmer's Programming Guide.
- Unipolar Pulse Configuration. Implant the pulse generator with its uncoated (logo) side up to minimize the potential for pocket stimulation.

ENVIRONMENTAL AND MEDICAL THERAPY HAZARDS

- The Microny™ SR+ is equipped with special shielding and filters to reduce the adverse effects of electromagnetic interference (EMI) on the device.

- Patients should be directed to exercise reasonable caution in avoidance of strong electric or magnetic fields. If the pacemaker inhibits or reverts to asynchronous operation while in the presence of electromagnetic interference (EMI), the patient should move away from the EMI source or turn the source off.

- Advise patients to seek medical guidance before entering environments which could adversely affect the operation of the pulse generator, including areas protected by a warning notice preventing entry by pacemaker patients.

Hospital and Medical Environments

In general, pacemaker patients should not be exposed to hospital equipment that produces high electromagnetic field strength signals, such as diathermy machines and electrosurgical units. Certain hospital equipment may prompt the activity sensor to generate strong sensor signals which, may cause inappropriately high pacing rates.

- External Defibrillation. Do not place defibrillator paddles directly over the pulse generator or pacing lead Placing the defibrillator paddles too close to the pulse generator and the pacing leads could generate a high current into the leads and the pulse generator damaging the defibrillation protection circuit or other circuitry. Following defibrillation, ensure that the pacemaker is operating correctly.
- Magnetic Resonance Imaging (MRI). Before and after the patient is exposed to MRI, conduct a detailed assessment of the pacemaker. The extremely strong magnetic fields generated during MRI may cause the pulse generator to temporarily pace in the asynchronous mode (VOO or AOO) at the magnet test rate and reverts the device to Magnet mode. The magnet test rate is between 60 ppm and 100 ppm, depending on remaining battery capacity.
- Ionizing Radiation. Therapeutic ionizing radiation (e.g., used in linear accelerators and cobalt machines) can permanently damage the pulse generator's circuitry. The effect of ionizing radiation is cumulative; the potential for damage to the pulse generator is proportional to the patient's total radiation dosage. If the patient must be exposed to ionizing radiation, protect the pulse generator during the procedure with local radiation shielding. If tissue near the implant site must be irradiated, it may be necessary to move the pulse generator to another area. Before and after exposure to radiation, evaluate the pulse generator operation to identify any adverse consequences.
- Transcutaneous Electrical Nerve Stimulation (TENS). To reduce the possibility of interference with pacemaker function, place the TENS electrodes close to one another and as far from the pulse generator as possible. Monitor the patient's cardiac activity throughout the procedure.
- Therapeutic Diathermy. Avoid using diathermy equipment, including therapeutic ultrasound, in the vicinity of the pacemaker.
- Electrosurgical Cautery can induce ventricular arrhythmias and/or fibrillation or may cause asynchronous or inhibited pulse generator operation. If use of electrocautery is necessary, the current path and ground plate should be kept as far away from the pulse generator and leads as possible. The axis of the electrocautery should be perpendicular to the electrode axis. A bipolar cauterizer may minimize these effects. Following electrocautery, conduct a thorough assessment of the pulse generator.

Home and Occupational Environments

- High-Voltage transmission lines and equipment, arc or resistance welders, induction furnaces, and similar equipment may generate substantial EMI fields which may interfere with pulse generator operation.
- Communication Equipment such as microwave transmitters, linear power amplifiers, or high-power amateur transmitters may generate sufficient EMI to interfere with pacemaker operation. Advise patients to move away from this equipment to resume normal pacemaker operation.
- Home Appliances which are in good working order and properly grounded do not usually produce enough EMI to interfere with pacemaker operation. Electric vibrators, razors, and hand tools held directly over the pacemaker may disturb pacemaker function.
- Patient Activities which involve repetitive impacts or jarring (such as horseback riding, jackhammer use, etc.) may increase the pacing rate when the pulse generator's Sensor is programmed On. Caution patients against such activity and program Sensor parameters with these activities in mind. The sensor is mounted in such a way that the ball moves more freely and generates stronger signals when the patient is in an upright position, generating weaker signals when the patient is supine.
- Theft Detection Systems. Theft detection systems, such as those often located at the entrances and exits of stores and public libraries may disturb pacemaker function only if the patient pauses in the path of the beam.
- No Pacer Symbol. Caution pacemaker patients to be cognizant of labeling in EMI fields, such as with EAS detection.

Cellular Telephones

Studies indicate there may be a potential interaction between cellular phones and pacemaker operation. When the phone is within six inches of the pulse generator, effects could include inhibition or asynchronous pacing. Any effects resulting from an interaction between cellular phones and implanted pacemakers are temporary. Moving the phone away from the device will return it to its previous state of operation.

17

Because of the great variety of cellular phones and the wide variance in patient physiology, an absolute recommendation to cover all patients cannot be made. The following is a general guideline for patients with an implanted pulse generator who desire to operate a cellular phone:

- Maintain a minimum separation of six (6) inches between a hand-held cellular phone and the implanted device. Portable and mobile cellular phones generally transmit at higher power levels compared to hand-held models. For phones transmitting above three watts, a minimum separation of 12 inches between the antenna and the implanted device is advised.
- Patients should hold the phone to the ear opposite the side of the implanted device.
- Patients should not carry the phone in a breast pocket, or on a belt over or within six inches of the implanted device as some phones emit signals only when they are turned on but not in use).
- Storing the phone in a location opposite the side of the implant is recommended.

E. Adverse Events

The clinical study evaluating the Microny™ SR+ and Regency® SR+ pulse generators when used with the Passive Plus® DX (Model 1346T) and Tendril® DX (Model 1388T) steroid-eluting pacing leads involved 324 Regency® SR+ and 178 Microny™ SR+ devices implanted in 502 patients. The study's cumulative implant duration was 11,196 months with a mean implant duration of 678 ± 298 days (range of 0 to 1,093 days). A total of 72 deaths were reported during the course of the study. Investigators judged that none of the deaths were device-related. The Regency® SR+ device will not be marketed in the U.S.. The Regency® SR+ operates the same as the Microny™ SR+, except it has a larger capacity battery and therefore the clinical results using the Regency® SR+ can be used to support the safety of the Microny™ SR+.

OBSERVED ADVERSE EVENTS

An Adverse Event was defined as any unfavorable clinical event which impacted or had the potential to impact the health or safety of a Clinical Study participant caused by, or associated with, a study device or intervention. An Adverse Event can occur during exposure to the procedure, exposure to the device, and/or at implant.

All adverse events have been classified as a complication or an observation. A complication was defined as any adverse event resulting in an injury or an invasive intervention (e.g., lead repositioning after lead dislodgment) which would not have occurred in the absence of the implanted device and/or system components. An observation was defined as any adverse event that was not associated with injury to the patient or an invasive intervention (e.g., reprogramming to adapt for an unusually high capture threshold).

Table 1 summarizes the adverse events reported and classified as complications during the study.

*Table 1. Complications**

Type of Complication	# of Patients†	% of Patients	# of Events	Events per Device-year‡	Events per Patient-Month**
Lead Dislodgement	9	1.8	9	0.00966	0.00080
Lead Replacement	2	0.4	2	0.00215	0.00018
Failure to Capture	2	0.4	2	0.00215	0.00018
Oversensing	1	0.2	1	0.00107	0.00009
High Lead Impedance	1	0.2	1	0.00107	0.00009
Premature Battery Depletion	1	0.2	1	0.00107	0.00009
Repositioning of Implant	1	0.2	1	0.00107	0.00009
Infection	1	0.2	1	0.00107	0.00009
No Venous Access	1	0.2	1	0.00107	0.00009
Pulse Generator Replacement	1	0.2	1	0.00107	0.00009

- All patients implanted (502 pulse generators out of 502 patients). Total 932 patient-years follow-up. Cumulative implant duration = 11,196 device months.

† One patient had more than 1 event reported.

‡ This rate is obtained by dividing the number of adverse events by the total device cumulative implant duration in years.

** This rate is obtained by dividing the number of adverse events by the total patient cumulative implant duration in months.

Table 2 on page 10 summarizes the adverse events reported and classified as observations during the study.

*Table 2. Observations**

Type of Observation	# of Patients†	% of Patients	# of Events	Events per Device-year‡‡	Events per Patient-Month**
Programmer Software Error	17	3.4	17	0.01824	0.00152
Undersensing	4	0.8	4	0.00429	0.00036
Blunted Sensor Response	3	0.6	3	0.00322	0.00027
Pocket Stimulation	3	0.6	3	0.00322	0.00027
Acute Lead Dislodgement/Instability	3	0.6	3	0.00322	0.00027
Intermittent Capture	3	0.6	3	0.00322	0.00027
High Capture Threshold	2	0.4	2	0.00215	0.00018
Low E/R Signal Amplitude	2	0.4	2	0.00215	0.00018
E/R Undersensing	2	0.4	2	0.00215	0.00018
No E/R Signal	1	0.2	1	0.00107	0.00009
Oversensing	1	0.2	1	0.00107	0.00009
No Sensor Response	1	0.2	1	0.00107	0.00009
Pacemaker Syndrome	1	0.2	1	0.00107	0.00009
High Polarization Value	1	0.2	1	0.00107	0.00009
Failure to Capture	1	0.2	1	0.00107	0.00009
Syncope	1	0.2	1	0.00107	0.00009
Reprogramming	1	0.2	1	0.00107	0.00009
Stripped Set-screw	1	0.2	1	0.00107	0.00009
Hematoma	1	0.2	1	0.00107	0.00009

* All patients implanted (502 pulse generators out of 502 patients). Total 932 patient-years follow-up. Cumulative implant duration = 11,196 device months.
† Four patients had more than 1 event reported.
‡‡ This rate is obtained by dividing the number of adverse events by the total device cumulative implant duration in years.
** This rate is obtained by dividing the number of adverse events by the total patient cumulative implant duration in months.

POTENTIAL ADVERSE EVENTS

Adverse events, including those reported in Table 1 on page 9, associated with the use of any pacing system include:

- Air embolism
- Bleeding/hematoma
- Body rejection phenomena
- Cardiac tamponade or perforation
- Formation of fibrotic tissue; local tissue reaction
- Inability to interrogate or program due to programmer or device malfunction
- Infection/erosion
- Interruption of desired pulse generator function due to electrical interference, either electromyogenic or electromagnetic
- Lead malfunction due to conductor fracture or insulation degradation
- Loss of capture or sensing due to lead dislodgment or reaction at the electrode/tissue interface
- Loss of desired pacing and/or sensing due to lead displacement, body reaction at electrode interface, or lead malfunction (fracture or damage to insulation)
- Loss of normal device function due to battery failure or component malfunction
- Pacemaker migration, pocket erosion, or hematoma
- Pectoral muscle or diaphragmatic stimulation
- Phrenic nerve stimulation
- Pneumothorax/hemothorax.

F. DEVICE DESCRIPTION

1. Microny™ SR+ Pulse Generator

   The Microny™ SR+ is a rate-responsive pacemaker and features AutoCapture™, a collection of related algorithms that function together to pace a cardiac patient at a level slightly higher than the current physiological capture threshold.

The Microny™ SR+ measures 6 x 33 x 33 mm and weighs 12.8 gm. The "T" connector top is compatible with IS-1 standard 5841-3.3 1991/04. The Microny™ requires a bipolar lead. A single set-screw secures the lead within the pacemaker connector and ensures contact with the lead connector pin (cathode). An annular spring makes contact with the proximal ring (anode). It uses a lithium-iodine battery with a capacity of 0.37 Ah. The patient-contacting materials include a titanium can and Hysol epoxy connector top. The pacer is coated with parylene except for a "window" around the logo.

The pulse generator can be programmed with the St. Jude Medical programmer using Model 3204a or higher software, the APSμ hand-held programmer and Models 3500 and 3510 programmers.

2. "Casino" Sensor

The activity-based sensor in the Microny™ SR+ pulse generator consists of a magnetized ball within a plastic ellipsoidal capsule. The sensor responds to motion in three dimensions. A copper-wire coil surrounds the plastic housing and generates electric signals in response to movement of the magnetic ball.

3. AutoCapture™

The AutoCapture™ feature available in the Microny™ SR+ pulse generator operates only in VVI or VVIR. It tracks the threshold and automatically sets the pulse amplitude 0.3V above the measured threshold. AutoCapture™ verifies capture after every pacing stimulus. If a pulse fails to capture, a 4.5V back-up pulse is delivered 63 milliseconds after the normal pulse.

AutoCapture™ operates by detecting an evoked response (ER). The sense amplifier sends a signal to the ER Detection Logic which, measures the incoming signal to determine if ventricular depolarization occurred. The following algorithms allow detection and response:

Automatic Capture Confirmation – Capture is confirmed when an ER occurs during the ER detection interval. This interval begins 15 msec after a pacing pulse and lasts for 47.5 msec.

Automatic Back-Up Safety Pulse -- When capture is not confirmed, the pacer discharges a back-up safety pulse at the end of the ER detection interval. The amplitude of the safety pulse is 4.5V.

Automatic Stimulation Threshold Search – Two circumstances initiate the threshold search. Two consecutive stimuli resulting in non-capture activate the search sequence and raise the pulse amplitude until confirmation of capture. Otherwise, the search sequence begins after the passage of eight hours.

Automatic Output Regulation – This function sets the pulse amplitude 0.3V above the measured threshold.

G. ALTERNATIVE TREATMENTS

Other pacemaker systems may meet the needs of patients with diseases and conditions for which the Microny™ SR+ cardiac pacing system is indicated.

H. MARKETING HISTORY

The Microny™ SR+ pulse generator is approved for commercial release in Europe, Japan, Canada and Australia. The Microny™ SR+ device has not been withdrawn from any country for safety and/or efficacy reasons.

I. SUMMARY OF STUDIES

1. *In vitro* Studies - Microny™ SR+ Pulse Generator

A series of *in vitro* tests were performed on the Microny™ SR+ pulse generator to verify that these devices meet all requirements of their respective design specifications. The qualification program consisted of a series of mechanical, connector top, shipping, sterilization, and electrical tests. A complete qualification testing program was performed for each of these topics.

a. Mechanical

A total of nine pulse generators (six uncoated, three coated) underwent the mechanical tests. The following series of tests were performed on the uncoated pulse generators: functional testing, visual inspection of the outside of the pacer, x-ray, temperature cycling, shock test, vibration test, and cut-open evaluation for visual inspection of the inside of the pacer. The following were performed on the coated pulse generators: functional test to test the pacer parameters, visual inspection, and temperature storage to exceed storage temperature from +55 °C to –25 °C. All acceptance criteria were fulfilled.

b. Connector Top

A total of five pulse generators underwent the connector top test. The following series of tests were performed: visual inspection, connector cavity dimensions, temperature cycling, leakage in IS1 connector test, insertion/extraction force test, torque test, push test, and destructive physical analysis to cross section the connector for analysis. All acceptance criteria were fulfilled.

c. Shipping and Sterilization Tests

The Microny™ SR+ package is virtually identical to those of other pacemakers manufactured by Pacesetter AB (Veddesta, Sweden, formerly Siemens Elema), including those approved in the U.S.: Sensolog III; Dialog II; and Multilog. The only difference is that the "pocket" in the molded tray is formed specifically for the various models. Therefore only limited testing was performed on the Microny™ SR+ model in which three packaged pulse generators were subjected to sterilization and functional testing. One packaged pulse generator was subjected to the shipping and functional tests. All acceptance criteria were fulfilled.

d. Electrical

A total of six coated Microny™ SR+ pulse generators underwent electrical tests. The following tests were performed on three of the six pulse generators: functional test, electrical neutrality test, protection from spurious injected current, protection from malfunction due to EMI, protection against sensing EMI, behavior in a static magnetic field, HF test, demodulation from Pulse generator during HF, defibrillation test, ESD test, and electrical neutrality test. All acceptance criteria were fulfilled.

e. Biocompatibility Testing

The following materials used in the Microny™ and Regency® pulse generators come in contact with the patient's blood and/or tissue while the pulse generator is implanted:

Titanium
Silicone rubber
Parylene
Epoxy

These materials have a long history of successful use in long term implants and are identical to those used in other pulse generators manufactured by St. Jude Medical.

In addition to the extensive implant experience with these materials, standard biocompatibility testing (cytotoxicity, intracutaneous toxicity, acute systemic toxicity, intramuscular implantation tests, hemolysis, and material-mediated pyrogenicity) have been performed for all blood/tissue contact material. Tests have shown the materials to be biocompatible and suitable for this intended use.

Clinical Studies

The "Microny SR+ and Regency SR+ Clinical Trial" was conducted using the Microny™ SR+ Model 2425T and Regency® SR+ Model 2400L pulse generators along with the Passive Plus® DX model 1346T and Tendril® DX model 1388T. The Regency® SR+ device will not be marketed in the U.S. Regency® SR+ operates the same as the Microny™ SR+, except it has a larger capacity battery and therefore the clinical results using the Regency® SR+ can provide supporting evidence of safety of the Microny™ SR+. The Microny and Regency pacing system was evaluated in a multicenter (37 U.S. centers and 7 Canadian centers) clinical trial involving 502 patients.

The primary objectives of the clinical trial were to: 1) evaluate the safety and efficacy of the ventricular AutoCapture™ Pacing System algorithm, and 2) to evaluate the rate-modulation capability of the device's activity sensor during Chronotropic Assessment Exercise Protocol (CAEP) treadmill test. The clinical study was conducted in two parts, one for evaluating the AutoCapture™ Pacing System and the other, to evaluate the Casino sensor. Results of these two evaluations are presented separately below under the appropriate headings.

PATIENT POPULATION

The overall study population consisted of 502 enrolled patients. All patients were evaluated for safety, 137 patients were evaluated for AutoCapture™ effectiveness and 46 patients were evaluated for Sensor performance. Of these patients, 291 (58%) were males and 211 (42%) were females. The mean age at implant was 71 ± 17 years. Indications for pulse generator implantation in the study population are summarized in Table 3. As some patients had more than one indication, the total number of indications exceeds the number of patients in the study. The mean duration of implant for all patients in the study was 22.3 months, ± 9.8 months (minimum duration: 0 months; maximum duration: 36 months).

Table 3. Indications for Implantation

Indication	Number of Patients
Persistent or Intermittent AV Block	172 (34%)
Bradycardia-Tachycardia Syndrome	122 (24%)
Sick Sinus Syndrome	96 (19%)
Sinus Bradycardia	62 (!2%)
Atrial Fibrillation/Atrial Flutter	37 (7%)
Sinus Node Arrest or Exit Block	9 (2%)
Chronotropic Incompetence	4 (0.8%)
Not Reported	15 (3%)

AutoCapture™ Pacing System Evaluation

The AutoCapture™ Pacing System was evaluated in a multicenter (15 U.S. centers and 7 Canadian centers) clinical trial involving 137 patients implanted with 138 devices.
The purpose of this part of the study was to assess the ability of the AutoCapture™ Pacing System to correctly identify loss of capture and to deliver an appropriate backup safety pulse to ensure 100% pacing as verified by a surface ECG and 24-hour Holter monitoring data.

PATIENT POPULATION

Of the 137 patients enrolled in the study, 80 (58.4%) were males and 57 (41.6%) were females. The age at implant ranged from 22 to 96 years with a mean of 73 (± 13) years.

Indications for implantation in the study population are summarized in Table 4. Because some patients had more than one indication, the total number of indications exceeds the number of patients in the study.

Table. 4 Indications for Implantation

Indication	Number of Patients
Persistent or Intermittent AV Block	56
Bradycardia-Tachycardia Syndrome	33
Sick Sinus Syndrome	24
Atrial Fibrillation/Flutter	19
Sinus Bradycardia	8
Sinus Node Arrest or Exit Block	5

METHODS

The AutoCapture™ Pacing System's stored diagnostic data summarizing the number of capture losses and backup safety pulses were compared to the results of a surface ECG taken at the time of implant, pre-discharge, one-month follow-up, and three-month follow-up. The AutoCapture™ Pacing System's stored diagnostic data was also compared to the results of a 24-hour Holter monitor conducted on all patients within one month of the device implantation. Patients were also asked to record their activities during the monitoring period in a diary, and the Holter data was checked against the diary entries.

Table 5. ECG Analysis Results

Analysis Date	Patients (N)	Events Analyzed (N)	Paced Events (N)	Capture Losses (N)	Capture Losses Followed By A Backup Pulse (N)	Capture Losses Followed By A Backup Pulse (%)
Implant	134	4,719	4,472	176	176	100%
Pre-discharge	131	3,915	3,709	168	168	100%
One Month	116	2,832	2,721	232	232	100%
Three Month	60	1,526	1,314	133	133	100%

Table 6. Holter Monitoring Analysis Results

Time Recorded (Hours)	Events Analyzed (N)	Paced Events (N)	Capture Losses (N)	Capture Losses Followed By A Backup Pulse (N)	Capture Losses Followed By A Backup Pulse (%)
1,157	4,949,313	2,031,279	820	820	100%

RESULTS

In Table 5, the number of losses of capture threshold recorded by the ECG is compared to the number of capture losses followed by a backup safety pulse as recorded by the AutoCapture™ Pacing System. The analysis found that every instance of capture loss recorded by the ECG was recognized by the AutoCapture™ Pacing System. In addition, each loss of capture was followed by a backup safety pulse as required by the AutoCapture™ Pacing System.
Table 6 presents the results of the Holter monitoring analysis, taken at one-month follow-up. A total of 820 instances of loss of capture were recorded on Holter monitoring, and the same number (100% consistency) were recorded by the AutoCapture™ Pacing System. In addition, every instance (100%) of loss of capture was appropriately followed by a backup safety pulse.

SUMMARY

These results of ECG and Holter monitoring analyses demonstrate that the AutoCapture™ Pacing System can safely provide a pacing stimulus by accurately detecting loss of capture and delivering a backup pulse for each capture loss.

Sensor Evaluation

The objective of this part of the study was to evaluate the rate-modulation capability of the device's activity sensor. This was accomplished by performing both a hall-walk test and a Chronotropic Assessment Exercise Protocol (CAEP) treadmill test in study patients.
The hypothesis was to determine whether the activity sensor provides a rate-response (sensor-indicated rate or SIR) which is similar to the predicted heart rate response based on the Wilkoff model.

METHODS

SIR was evaluated using the pacing system's diagnostic data during hall-walk testing and exercise testing to generalized exhaustion using a modified Chronotropic Assessment Exercise Protocol (CAEP).

PATIENT POPULATION

A total of 46 patients were included in this study. Of those patients, 27 (58.7%) were male and 19 (41.3%) were female. The ages of the patient population at the time of implant ranged from 35 to 98 years with a mean of 72.4 ± 14.8 years.

Patient indications for implant were consistent with the overall study patient population and with patients who require single chamber pacing. The indications are summarized in Table 7. (Patients could have more than one indication.) All implants were pectoral. The mean duration of implant to the date the hall-walk and treadmill test was performed was 21.4 ± 9.6 months, ranging from 0.9 to 33.8 months.

Table 7. Indications for Sensor Evaluation

Indication	Number of Patients
AV Block	21
Bradycardia-Tachycardia Syndrome	16
Sick Sinus Syndrome	3
Atrial Fibrillation/Flutter	5
Sinus Bradycardia	2
Sinus Node Arrest	2

RESULTS

Of the 46 enrolled, 30 patients were used in the final analysis. Sixteen (16) patients were excluded from analysis because they did not complete the required minimum number of stages of CAEP (N=13) or because data was not available (N=3).

Hall-walk Analysis

The hall-walk test is routinely used by the clinician to optimize the sensor to the individual patient's activity level. The hall-walk optimization consisted of invoking the prediction model algorithm and performing a 2-3 minute (approximate) walk at the patient's normal walking speed on a level surface. The data from this hall-walk exercise was retrieved and the sensor output for the activity performed was modeled. The clinician then chose the appropriate sensor response for the level of activity performed. During the hall-walk test, an average SIR of 101 was achieved. The overall SIR/EHR ratio during the hall-walk was 0.93 with a 95% confidence interval of (0.863, 0.999). This hall-walk activity is considered to be similar to the activity requirements for the activities of daily living.

CAEP ANALYSIS

All patients who underwent CAEP treadmill testing had sensor optimization performed prior to the treadmill test. Figure 1 on page 19 shows the mean SIR vs. Expected (Wilkoff) SIR and the upper bound and the lower bound of the 95% confidence interval of the observed SIR for all 30 patients included in the analysis. The graph is normalized based on the CAEP workload (METs), with the mean of SIR calculated at each stage and its corresponding confidence intervals being plotted.

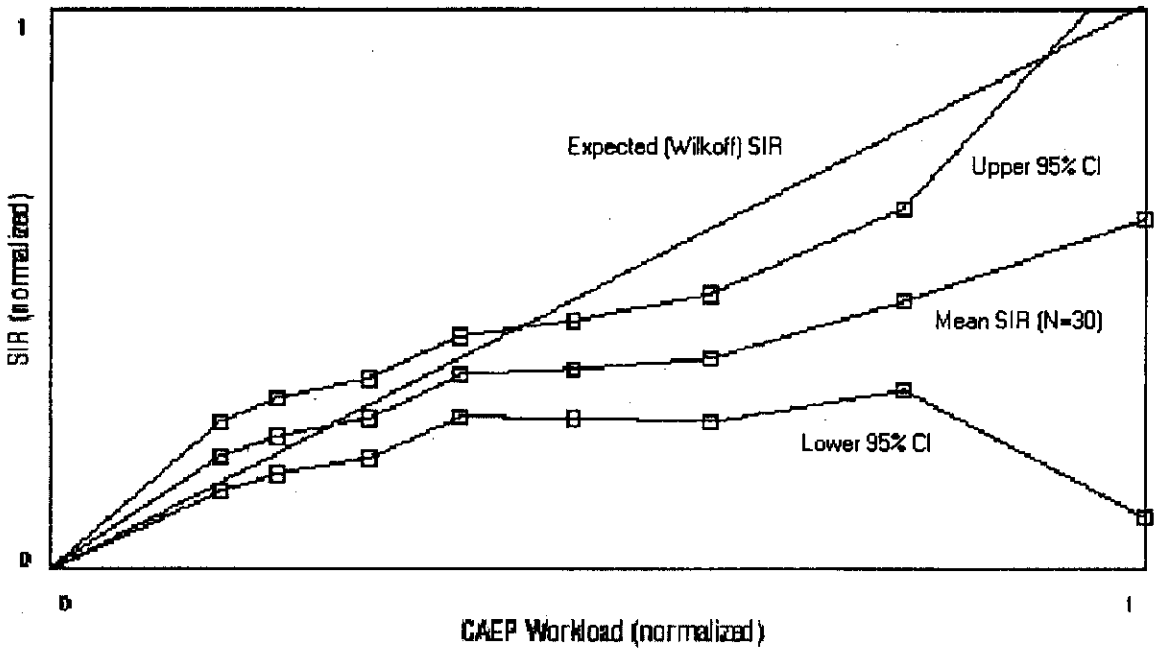

FIGURE 1. Mean Sensor-Indicated Rate (SIR) vs. Expected Sensor-Indicated Rate (SIR) During CAEP
The arithmetic mean of the 30 slopes derived directly from the 30 individual patient linear regression lines of SIR versus EHR is 0.495 with a 95% confidence interval (0.365, 0.625).

J. CONCLUSION DRAWN FROM THE STUDIES

Extensive *in vitro* and *in vivo* testing provide reasonable assurance that the proposed Microny™ SR+ Model 2425T cardiac pulse generator is safe and effective when used in accordance with the proposed device labeling.

K. PANEL RECOMMENDATION

Pursuant to section 515(f)(2) of the act as amended by the Safe Medical Devices Act of 1990, this PMA was not referred to the Circulatory System Devices Panel for review and recommendations because the information in the PMA substantially duplicated information previously reviewed by this panel.

L. FDA DECISION

FDA issued an approval order on December 21, 2000. The applicant's manufacturing facility was inspected and was found to be in compliance with the device Quality System Regulations, 21CFR Part 820.

M. APPROVAL SPECIFICATION

Directions for use: see attached labeling.

Conditions of approval: CDRH approval of this PMA is subject to full compliance with the conditions described in the attached approval order and the conditions of Approval for Cardiac Pacemakers and Programmers.