Pacemaker Longevity: The World's Longest-Lasting VVI Pacemaker

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Objective: To describe VVI-pacemaker longevity by model type at our institution and report on a long-lasting model and the longest-lasting pacemaker to be described in the literature.

Background: Cardiac pacemakers are becoming increasingly common in the United States. Presently their batteries are expected to last up to 12 years. Pacemaker generator change is associated with increased cost to the health care system and is inconvenient for patients.

Methods: After identifying a group of very long-lasting CPI Microlith 605 VVI pulse generators, we reviewed records on all patients who had either Guidant or Medtronic pulse generator explantation at our institution over a 10-year period. Average longevitys were calculated for all VVI pacemakers, four common VVI models, and the CPI Microlith 605.

Results: A total of 105 VVI-programmed pacemakers were identified. Their average longevity was 7.2 years. The two most common Medtronic VVI-programmed pacemakers explanted were the Thera (7.1 years) and Kappa (7.3 years). The two most common Guidant/CPI models were the Vigor (4.2 years) and Discovery (5.7 years). The CPI Microlith 605 (19.2 years) lasted more than 26 years in one patient before being explanted.

Conclusion: At a time when pacemakers are being used more frequently, pacemaker longevity may decrease as a result of the use of dual-chamber pacing systems. In our study, the CPI Microlith 605 had an average longevity more than twice that of all other VVI pacemakers. We also report on a pulse generator that lasted 26.3 years.

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Each year a growing number of Americans has a pacemaker implanted or replaced. In 1995 the number of implantations broke 600 per million people in the population, reaching 604 per 1,000,000 people. Of these implantations, 20% were replacements.¹ By industry estimates, approximately 324,000 pulse generators were implanted in 2005 (from correspondence with Guidant Corp. staff), suggesting that more than 60,000 replacements took place. Pulse generator replacement is associated with a risk of complication significantly higher than that of primary implantation, with increased incidence of infection and skin erosion, among other problems.² In addition, pulse generator battery depletion is associated with risks independent of replacement, including failure to capture, failure to output and inappropriate output, such as occurs in "run-away pacemaker."^{3,4} Undersensing also may occur in the setting of battery depletion.⁵ The costs of pac-

ing with long-lasting pacemakers is estimated to be \$424 million less per year than the cost of pacing with short-lived pacemakers.⁶ Longer-lasting pacemakers also make cardiac pacing more practical in the very old, as it allows for fewer office visits and procedures.⁷ Appropriately, the vast majority of patients prefer bulkier, longer-lasting pacemakers to thinner, shorter-lived ones.⁸

Various efforts have been made to understand the causes of pulse generator battery depletion and to improve pacemaker longevity. At present, pulse generator battery-life normally ranges from 7 to 12 years in single-chamber pacemakers and 5–10 years in dual-chamber models.^{3,9} Studies have shown increased battery longevity with use of steroid-eluting leads, increased lead impedance, pacemaker reprogramming, and modern pacing algorithms.^{8–12} Despite improving technologies, the move toward implanting

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dual-chamber pacemakers could decrease average pacemaker longevity when all paced patients are considered.

Review of the literature revealed a complete lack of reports of ultra-long-lasting pacemakers, although at least one observational study on pacemaker longevity does exist.¹³

Our group has noted a series of pacemakers that lasted well beyond the 7–12 years expected of single-chamber pacemakers. One of the authors (TA) noted that some Guidant/CPI Microlith 605 pulse generators were lasting beyond 20 years in his patients. Here we present a retrospective study of the longevity of VVI pacemakers explanted at Strong Memorial hospital that were implanted between 1970 and the end of 2004. During this period, our electrophysiologists explanted numerous VVI pacemakers. Below we consider two most common models from both the Guidant (Boston Scientific, Natick, MA) and Medtronic corporations (Fridley, MN), as well as the Guidant/CPI Microlith 605. Finally, we report on what we believe to be the longest-lasting pacemaker described in the literature to date.

METHODS

Using our transtelephonic monitoring database, we identified all patients who had either Guidant or Medtronic pulse generator explantation between 1996 and the present at our institution after implantation between December 1, 1970, and December 31, 2004. For the purposes of this study, we chose to limit our cohort to pulse generators programmed for VVI pacing. The two most common pulse generator models from both Guidant and Medtronic were identified, as was the model with the longest average lifespan. Pulse generators explanted 1 year or less after implantation were excluded from the study as their explantation was unlikely to have resulted from battery depletion. The lifetimes of the remaining pacemakers were calculated to the near-

est 0.1 years. Average pulse generator longevity and standard deviations (SDs) were calculated for all VVI pacemakers and for each of the model groups.

RESULTS

We identified 405 devices according to the criteria laid out earlier. Of these pulse generators, 228 were programmed for DDD pacing, 9 for AAI pacing. Sixty-three were DDD-capable, but with unknown program settings. VVI-programmed pulse generators accounted for 108 of the total number of devices, of which 3 lasted less than 1 year. The remaining 105 VVI-programmed pacemakers were included in this study. This group of devices had an average longevity of 7.2 years (SD ± 3.7 years). The two most common models of Medtronic VVI-programmed pacemaker explanted were the Thera (model numbers 7940, 7962i, 8942, 8960i, 8962i), and Kappa (model numbers SR706, DR401b, SR701, DR701, DR703, DR921, SR901). The two most common Guidant/CPI models were the Vigor (model numbers 1130, 1230) and Discovery (model numbers 1174, 1175, 1184, 1273, 1274, 1283). The number and average lifespan of each of these groups can be found in Table 1.

The longest-lasting pacemaker model was found to be the Guidant/CPI Microlith 605, with an average longevity of 19.2 years (SD ± 5.1 years). The longest-lasting single pacemaker was a Guidant/CPI Microlith 605 that was explanted after 26.3 years of use. Two others lasted 14.8 and 16.6 years. Further review of our records revealed the presence of three more Guidant/CPI Microlith 605 pacemakers with lifespans of 17, 21, and 21 years that did not meet inclusion criteria for this study.

The man whose pacemaker lasted more than 26 years was a married African American, type-II diabetic coin collector and former hospital janitor. He had pacemaker implantation in 1978, at the age of 48, after describing 50–60 episodes of syncope. Prior to implantation he was found to be

Table 1. Average Pacemaker Duration

Pacemaker Model	All VVI Pacemakers	Medtronic Thera	Medtronic Kappa	G/CPI Vigor	G/CPI Discovery	G/CPI Microlith
No. of devices	105	16	10	13	23	3
Average logevity (Y)	7.2	7.3	4.2	5.0	5.7	19.2
Standard deviation (Y)	3.7	1.8	1.8	1.6	0.9	5.1

G = Guidant, Y = Years.

bradycardic with episodes of complete heart block. In 1978 the patient had a medical history significant for episodes of atypical chest pain, which was not believed to be of cardiac origin. A CPI Microlith 605 was placed with a CPI 4210 right ventricular bipolar, porous, tined lead. The pacemaker was programmed to a demand rate of 60 ppm with a pulse width of 0.6 ms. His pacing threshold was recorded as "satisfactory" at implantation. He did continue to have atypical chest pain and at least one episode of syncope after implantation. He eventually developed hypertension and CHF. Transtelephonic monitoring reports showed the patient to consistently have had intrinsic rates greater than 60 bpm. He was never found to be pacemaker-dependent. When a magnet rate of 90 was found in October 2001, first-stage battery depletion was diagnosed. The patient's magnet rate returned to 100 until April 2002. On October 24, 2004, the patient had a syncopal episode while walking to bed. Explantation of the original pulse generator occurred on October 25, 2004, more than 26 years after its implantation.

DISCUSSION

This retrospective look at pacemaker longevity at our hospital suggests a great degree of variation in pulse generator longevity between models. Among the most common models implanted at our center, average longevity fell within one SD of the average longevity for all VVI-programmed pulse generators considered. In addition, average longevity for each of these models falls within two SDs of one and other. Our average longevity for all included VVI-programmed pulse generators falls at the low end of the expected longevity for VVI pacemakers.

At 19.2 years, the average longevity for the Guidant/CPI Microlith 605 falls greater than two SDs above that of the larger group of all VVI-programmed pacemakers. The Guidant/CPI Microlith 605 was a bipolar SSI pacemaker with a fixed amplitude of 5.0 V and factory set, but adjustable pulse width. In all of the patients we identified with long-lasting Microlith 605s, these pulse generators were coupled with Guidant/CPI porous, tined leads (CPI 4210 or 4230) that were placed in the apex of the right ventricle. This model, and all of the others considered here, employed a lithium iodide battery. The group of patients using these pacemakers was rarely found to be pacemaker-dependent at times of transtelephonic monitoring. The Microlith 605

was not capable of being interrogated, making it impossible to determine the true percentage of the time that these patients were artificially paced. Patients did have their pulse generators periodically reprogrammed. With its fixed amplitude, demand rate and pulse width were the only parameters programmable in the Microlith 605 that determine battery depletion. In at least one patient, the pulse width was lowered to 0.3 ms, although most were maintained at 0.5 or 0.6 ms.

The reason that the Microlith 605 so drastically outlasted the other pulse generators that were being explanted contemporaneously at our institution is not clear. Although we assume that all of our patients receive the same quality care, we noted that the Microlith 605s discussed here were favored by one of our electrophysiologists. Although this admission suggests that the longevity may be due to superior implantation or monitoring and reprogramming, we have no evidence to support that. In the absence of known factors causing the great disparity we observed between models, it is possible that the Microlith 605 coupled with Guidant/CPI porous tined electrodes had less current drain than the other pacemakers analyzed in this study.

We believe the 26.3-year lifespan of the pulse generator we described earlier to be the longest-lasting pacemaker to be reported. The longevity of this particular pacemaker may be due in part to infrequent pacing, although the actual incidence of pacing could not be accurately determined for reasons discussed earlier.

Limitations

This sample includes only pulse generators that were explanted. Further study would be required to determine what the effect on average longevity would be if devices lost to follow-up or lost as a result of patient death were included. Also, the longevities reported here represent clinical longevity, and so may underestimate battery longevity in these devices. Still, no individual pulse generator in the groups discussed earlier lasted as long as the average longevity of the Microlith 605.

CONCLUSION

Pacemakers are becoming increasingly common in this country. This increase is occurring at a time when the use of more complex pulse generators stands to lower average pacemaker longevity,

creating the need for greater numbers of replacement procedures. We have identified one model of pacemaker, the Guidant/CPI Microlith 605, which had drastically greater longevity than any of the other pacemaker models used during over 30 years at our hospital. We cannot definitively account for the differences in longevity we observed, but attribute the observed longevity to the pulse generator-lead combination used. We invite description of experiences with the Microlith 605 at other institutions.

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