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Putting down the phone: the obsolescence of transtelephonic monitoring for pacemaker follow-up

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Abstract

Purpose The evolution of heart rhythm monitoring technology over the past few decades has seen a decline in the use and need of transtelephonic monitoring (TTM). We sought to establish a predicted date for the sun setting of TTM at our institution, as well as establish the current demographics of the patients still using this technology.

Methods We retrospectively reviewed all patients with permanent pacemakers receiving routine device follow-up at our institution (Mayo Clinic—Rochester) between 2015 and 2018. From this cohort, we reviewed and analyzed patients using TTM for device follow-up and utilized projected battery longevity to determine cessation date. Pacemaker implantation date, underlying arrhythmia, and most recent device interrogation reports were also collected.

Results As of March 2018, a total of 3543 patients with permanent pacemakers were being followed at our institution and 289 (8.2%) are using TTM for monitoring device function (147 male, mean age 79.9 ± 12.0 years). Of those currently using TTM, by January of 2020, only 122 (42.2%) are predicted to be using this technology for device follow-up, 40 (13.8%) by January 2022, with zero patients by November of 2024.

Conclusions The use of TTM will continue to significantly diminish over the next few years. Based on battery longevity estimates, we predict that by the end of 2024 TTM will no longer be used for device follow-up at our institution.

Keywords Transtelephonic monitoring · Remote monitoring · Cardiovascular implantable electronic devices · Pacemaker · Arrhythmia

1 Introduction

Transtelephonic monitoring (TTM) refers to the analog transmission of limited pacemaker information over a landline telephone and was introduced in 1971 as a novel method to evaluate transient cardiac rhythm disturbances [1]. It was later used to evaluate the function of permanent pacemaker devices, including battery status, electrocardiogram (ECG) rhythms, and information regarding sensing, capture, lead, and device malfunction [2, 3]. TTM had been widely adopted in the USA for evaluating remote pacemaker function until approximately the year 2000 when technological advances resulted in the introduction of web-based remote monitoring of cardiac implantable electronic devices (CIEDs) [4].

Although a useful means to follow patients, there were noteworthy challenges to the adoption and use of TTM, with initial broad adoption in the USA, though limited in Europe. Firstly, signal transmission requires the need to arrange phone calls and follow phone instructions, which may be particularly problematic for the visually impaired and those with hearing deficits. Additionally, the type of phone, such as cordless phones or use of speakerphone, may also present difficulties. Further, obtaining high-quality electrocardiogram rhythm tracings via TTM tracing may be challenging due to poor resolution. Assessment of atrial events is tremendously more difficult than ventricular events due to the small amplitude of the atrial signal, which can be overwhelmed by the pacemaker artifact. As a result of these limitations and more importantly the development of more sophisticated remote follow-up, the use of TTM technology has fallen out of favor, and its clinical use has been markedly diminishing in recent years.

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With significant technological advancement, pacemakers now have the ability not only to provide cardiac pacing support but also to collect numerous diagnostic parameters about cardiac and device function on a continual basis. Remote monitoring and interrogation (RM and RI) is now the standard of care for all CIEDs and is recommended over TTM because of the expanded collection of data, diagnostic parameters [5], and improved outcomes [4, 6–8]. That said, TTM still holds clinical value with regard to assessing the battery status and function of older pacemakers that lacked RM capability. With the shift of patients away from TTM use, we sought to investigate the number of patients and clinical characteristics of patients using TTM for device follow-up. Additionally, we aimed to predict the sun setting date for TTM at our institution.

2 Methods

2.1 Study cohort

We retrospectively examined the medical records of 3543 patients with permanent pacemakers being followed for routine device follow-up at the Mayo Clinic (Rochester, MN) as of March 1, 2018. From this population, a list of patients using TTM for device follow-up was gathered from 2015 to 2018. To be considered eligible for inclusion, subjects must have been ≥ 18 years of age, had a permanent pacemaker placed, and had at least one device follow-up encounter. Patients were excluded if TTM was not the remote follow-up method utilized, if they did not provide research consent, or failed to have at least one device encounter. From this population, we extracted data from the most recent device interrogation reports that reported projected battery longevity. Patients who did not have a predicted battery longevity recorded within the electronic medical record were excluded from the predicted date of cessation of TTM. No pacemakers equipped with solely TTM technology have been implanted at our institution since October 2012 and we do not anticipate further implantations will utilize TTM. The study was approved by the institutional review board at the Mayo Clinic.

2.2 CIED device information

Each participant's medical record was reviewed to obtain basic device information, demographic information, indications for pacemaker implantation, pacemaker battery longevity as well as the most recent device interrogation date.

2.3 Statistical analysis

Continuous variables were reported with mean values and standard deviations. Categorical variables were reported with absolute numbers and corresponding percentages.

3 Results

3.1 Baseline demographics

As of March 1, 2018, there were 3453 patients with permanent pacemakers being followed with routine device checks, 289 of which were using TTM for follow-up. Of these 289, 147 (50.9%) of the subjects were male with an average age of 79.9 ± 12.0 years. The most common indications for

Table 1 Baseline characteristics of patients utilizing transtelephonic monitoring

Characteristic	*n*	Percentage (%)
Gender		
Female	142	49.1
Male	147	50.9
Lead location		
Single lead	40	13.8
Dual lead	249	86.2
Company		
Boston Scientific (Marlborough, MA)[a]	204	70.6
Medtronic (Minneapolis, MN)	51	17.6
Abbott (Chicago, IL)[b]	32	11.1
Sorin Group USA (Arvada, CO)[c]	1	0.3
Telectronics pacing systems (Englewood, CO)	1	0.3
Implantation indication		
High-grade/complete atrioventricular block	110	38.1
Sinus node dysfunction	87	30.1
Atrial fibrillation	76	26.3
Carotid hypersensitivity	16	5.5
Original implantation year		
1986	1	0.3
1992	1	0.3
2003	4	1.3
2004	6	2.1
2005	5	1.7
2006	13	4.5
2007	17	5.9
2008	44	15.2
2009	58	20.1
2010	62	21.4
2011	57	19.7
2012	21	7.3

[a] Boston Scientific (Marlborough, MA) has acquired Guidant, for which 33 patients in our cohort had a Guidant device implanted.

[b] Abbott (Chicago, IL) has acquired St. Jude Medical, for which 31 patients in our cohort had a St. Jude Medical Device implanted. Additionally, one patient in our cohort had a Pacesetter device implanted, which was acquired by St. Jude Medical and subsequently by Abbott.

[c] Sorin Group USA (Arvada, CO) has acquired ELA Medical, for which one patient in our cohort had an ELA device implanted.

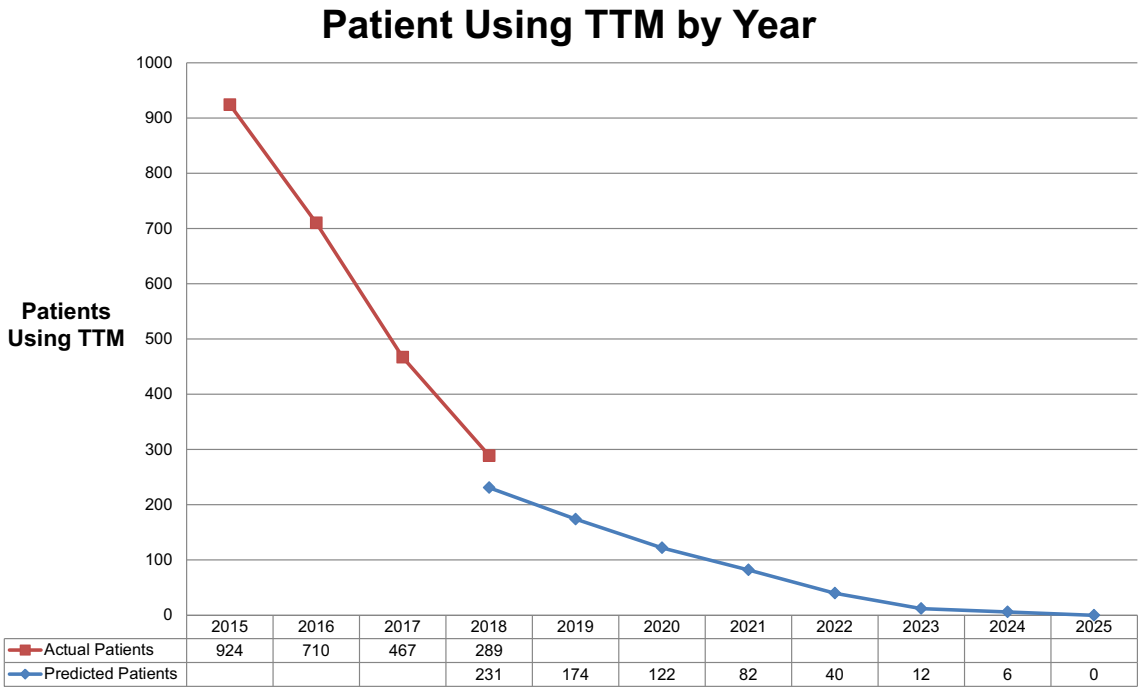

Fig. 1 Graphical depiction of patients using TTM by year. From years 2015–2017, this number of the *x*-axis reflects the number of patients using TTM by the beginning of the year (e.g., January 1). For the year 2018, the number reflects the number of patients as of March 1, 2018. Red squares: documented number of patients using TTM. Blue squares: predicted number of patients using TTM based on battery longevity data (for whom battery longevity data was available)

pacemaker implantation were high-degree AV block (38.1%), sinus node dysfunction (30.1%), and atrial fibrillation (26.3%). The most commonly followed devices were manufactured by Boston Scientific (Marlborough, MA) (70.6%) and Medtronic (Minneapolis, MN) (17.6%). Of the CIEDs, 40 (13.8%) were single-chamber and 249 (86.2%) were dual-chamber. A full list of baseline demographics, indications for implantation, and device characteristics is reported in Table 1.

3.2 TTM usage

As of January 2015, we identified 924 patients using TTM for pacemaker device follow-up. From January 2015 to March 2018, there was a precipitous drop in the number of patients using TTM. Between these 3 years, 635 patients ceased use of TTM, largely due to pulse generator change and patient deaths. Between January 2015 and 2018, there were 215 patient deaths and 317 patients who underwent pulse generator change. Of the 289 patients presently being followed, 231 were found to have battery information recorded. By 2020, only 122 patients are predicted to continue follow-up with TTM. A total of six remaining patients are projected to be using TTM for device follow-up by January 2024, with the last patient's battery life estimated to reach replacement in November of 2024. The number of patients using TTM for device follow-up by calendar year is depicted in Fig. 1.

4 Discussion

Our study is unique in that, to the best of our knowledge, we are the first to evaluate temporal trends in TTM use, with predictions for future utilization. TTM has served a fundamental role in the remote evaluation of pacemakers since its inception in the 1970s and was largely used throughout the United States. National surveys showed that in 1981, roughly 85% of patients were followed by TTM and that rose to 94% of patients with a pacemaker implant by 1985 [9, 10]. The general adoption of RM and RI has significantly reduced the proportion of patients using TTM for follow-up. Data from TTM is limited to battery life assessment, ECG rhythms, and information about device capture and sensing versus remote monitoring which allows full interrogation of the device as well as alerts for events that may be clinically significant. RM and RI has shown high satisfaction among patients and clinicians and more readily identified clinically actionable events as compared to in person evaluation with TTM-based follow-up [4].

Our data shows that between January 1, 2015 and March 1, 2018, there was a precipitous drop (68.7%, $n = 635$) in the number of patients using TTM for device follow-up. Based on the battery longevity reports recorded for 231 patients in our study, only 35.5% of the current TTM users will have battery life to extend beyond the end of 2020. By the end of 2022, 5.9% will continue with TTM, and its use will be completely obsolete by the end of 2024. Interestingly, for those patients whose battery

longevity is set to last until 2024, their current age range (as of March 2018) is 77–92 years of age, with half this group above 90 years of age. Further, we must note that these predictions assume no new users of TTM enter or leave our cohort and that patients transition to another method for device follow-up following the expiration of their battery life. Once battery life reaches less than 6 months, we begin performing monthly checks, with plans to transition to a new device capable of RM and RI. Since the development of RM and RI around the year 2000, our institution has transitioned away from TTM and has not implanted a pacemaker equipped solely with TTM since October 2012. Since that time, there have been 4173 pacemaker implantations with RM and RI technology.

The further gradual decline in TTM will not have a noticeable impact on work flow within our pacemaker follow-up unit. Patient satisfaction with RM, cost-savings [11], lower mortality, and identification of a greater number of actionable findings are well-documented in the literature [4]. The majority of patients at our institution use RM and RI combined with a yearly in office visit for device follow-up. As of March 2018, 91.6% of patients with pacemakers in our study were conducting device follow-up with means alternative to TTM.

5 Limitations

Limiting the predictability of the study is that patients' true battery end date may under or overestimate the true battery life [12]. Further, the average age of the patients in our cohort using TTM for device follow-up is 79.9 years of age, higher than the national life expectancy average (78.8) in the United States [13]. Death may precede battery longevity and our predicted date of TTM cessation does not incorporate anticipated deaths. Hence, the actual date of TTM cessation may be sooner than the end of 2024. Additionally, this retrospective study did not assess other comorbidities that may affect life expectancy. Our study also excluded patients ($n = 58$, 20.0%) who did not have a predicted battery longevity recorded in a device interrogation note. The study also does not account for patients who move in and out of our device follow-up pool due to physical relocation or being lost to follow-up. Given that our institution is a large tertiary care facility with a large practice group transitioning patients away from this technology, these results may not be generalizable to other institutions but provide a better understanding for the future of TTM.

6 Conclusion

As advancement in device interrogation continues to progress, TTM will be completely replaced by alternative methods for pacemaker follow-up by the end of 2024. Web-based RM and RI will continue to replace most existing TTM users following the end of their battery longevity, though TTM use will vary based on geographic and institutional practices.

Authors' contributions SAS was involved in the concept/design, data collection, analysis and interpretation, and drafting of the article.

AS was involved in the data collection, analysis and interpretation, drafting of the article, and critical revision.

NYT was involved in the data collection, analysis and interpretation, and revision of the article.

SA was involved in the concept/design of the project, analysis and interpretation, and critical revision of the article.

DLH was involved in the concept/design of the project, analysis and interpretation, and critical revision of the article.

Compliance with ethical standards

Conflicts of interest Drs. Samuel Shabtaie, Alan Sugrue, and Nicholas Tan have no conflicts of interest to disclose. Dr. Samuel Asirvatham has received compensation for services from Aegis Medial, ATP, Nevro, Sanovas, Sorin Group, and FocusStart, LLC. He has been a speaker for Abiomed, AtriCure, Inc., Biotronik, Boston Scientific Corp., Medtronic, Inc., Medtelligence, Spectranetics Corporation, St. Jude Medical, Sanofi Aventis, Wolters Kluver, Elsevier, and Zoll Medical Corporation. He has received royalties from Nevro and Aegis Medial. Dr. David Hayes has served as a speaker for Medtronic, Boston Scientific, Biotronik, LivaNova. He has served on research oversight committee from Abbott Medical. He has received royalties from UpToDate, Wiley, and Cardiotext.

Ethical approval This study was approved by the institutional review board at the Mayo Clinic (Rochester, MN).

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