Received: 20 January 2018 | Accepted: 23 April 2018

DOI: 10.1002/joa3.12072

ORIGINAL ARTICLE

WILEY Journal of Arrhythmia Open Access

Stability of intrinsic rhythm in pacemaker-dependent patients during pacemaker replacement: Can we predict the need for temporary pacing?

Yuki Kimura MD[1] | Masataka Sumiyoshi MD[1] | Kenji Inoue MD[1] | Masayuki Shiozaki MD[1] | Kentaro Fukuda MD[1] | Yasumasa Fujiwara MD[1] | Haruna Tabuchi MD[2] | Hidemori Hayashi MD[2] | Gaku Sekita MD[2] | Takashi Tokano MD[3] | Yuji Nakazato MD[3] | Hiroyuki Daida MD[2]

[1]Department of Cardiology, Juntendo University Nerima Hospital, Tokyo, Japan

[2]Department of Cardiology, Juntendo University School of Medicine, Tokyo, Japan

[3]Department of Cardiology, Juntendo University Urayasu Hospital, Urayasu, Japan

Correspondence
Masataka Sumiyoshi, Department of Cardiology, Juntendo University Nerima Hospital, Tokyo, Japan.
Email: sumi@juntendo.ac.jp

Abstract

Background: In pacemaker-dependent patients, the risk of asystole must be managed during device replacement. This study aimed to examine whether we could predict the indication for temporary pacing (TP) during the generator replacement.

Methods: We studied 105 consecutive patients who underwent pacemaker replacement due to battery depletion at Juntendo Nerima Hospital between September 2005 and December 2016. We examined the relationship between the stability of the intrinsic rhythm (IR) during pacemaker replacement and several clinical factors including age, gender, sick sinus syndrome or atrioventricular (AV) block, duration of pacing, structural heart disease, use of anti-arrhythmic drugs, and the presence/absence of a stable IR (>40 bpm) at the outpatient clinic (OPC) just before pacemaker replacement.

Results: Of the 105 patients, we excluded 1 patient who required TP because of bradycardia-dependent torsades de points. Therefore, we evaluated 104 patients for the indication for TP. TP was underwent in 19 patients (18%) because of an absence or instability of the IR during pacemaker replacement. The indication for TP was significantly correlated with AV block (84% vs 48%, $P = .0044$) and the absence of a stable IR at the last OPC visit (89% vs 24%, $P < .0001$). For predicting the indication for TP, the following values of no stable IR at the last OPC visit were obtained: 89% sensitivity, 77% specificity, 46% positive predictive value, and 97% negative predictive value.

Conclusions: The presence of a stable IR at the last OPC visit was a good predictor (97%) of no indication for TP during pacemaker replacement.

KEYWORDS

pacemaker replacement, pacemaker-dependent patients, stability of intrinsic rhythm, temporary pacing

1 | BACKGROUND

In pacemaker-dependent patients, the risk of asystole must be managed during device replacement. The use of temporary pacing (TP) is safe, but TP adds time and cost to the replacement procedure, as well as risks inherent to another venous access and lead placement within the heart. If patients who will need TP before the replacement procedure could be identified beforehand, we could prepare the TP system and explain the additional procedure to the patients before the operation. However, there have been few studies concerning the stability of the intrinsic rhythm (IR) in pacemaker-dependent patients.[1–3] The purpose of this study was to determine whether we could predict the indication for TP during the generator replacement in pacemaker-dependent patients.

2 | METHODS

The study population was 105 consecutive pacemaker-dependent patients (average age 80.0 years, range 39-99 years; 53 men and 52 women) who underwent pacemaker generator replacement due to battery depletion at Juntendo University Nerima Hospital between September 2005 and December 2016. All 105 patients had implanted cardiac pacemaker for symptomatic bradyarrhythmias. We examined the relationship between the stability of the IR during pacemaker replacement and several clinical factors including age at pacemaker replacement, gender, atrioventricular block (AVB) or sick sinus syndrome (SSS), the duration of pacing, structural heart disease, use of anti-arrhythmic drugs, and the presence/absence of stable IR (>40 bpm) at the pacemaker outpatient clinic (OPC) examination conducted just before the patient's pacemaker replacement (ie, the "last OPC visit"). The stable IR at the last OPC visit was defined as the rate of IR >40 bpm, which was examined in a sitting position while the pacemaker was programmed to 40 bpm.

The stability of the IR was evaluated at the replacement procedure: it was determined whether a stable IR was present or not when the basal pacing rate was programmed to 30 bpm for 30 s in a supine position. The stable IR during pacemaker replacement was defined as follows: (i) the rate of the IR was >30 bpm without any long pause (>2.0) or frequent premature ventricular contractions or torsades de points (TdP). (ii) Patients did not report any symptoms (eg, faintness, chest discomfort) during IR. If a stable IR at the pacemaker replacement was not obtained, TP was indicated and performed intravenously in all patients.

The protocol for this research project has been approved by the ethics committee of Juntendo University Nerima Hospital (approval No. 17-39), and it conforms to the provisions of the Declaration of Helsinki.

Continuous variables are presented as the mean ± SD and were compared by the unpaired Student's *t* test. Categorical variables were compared by the chi-square test or Fisher's exact test. To visualize and quantify other aspects of the prediction for the need for TP, we performed a recursive partitioning analysis (RPA) to make a decision tree model of the indication for TP. This nonparametric regression method produces a classification tree following a series of nonsequential top-down binary splits. The tree-building process starts by considering a set of predictive variables and selects the variable that produces 2 subsets of participants with the greatest purity. Two factors are considered when splitting a node into its daughter nodes: the goodness of the split and the amount of impurity in the daughter nodes. The splitting process is repeated until further partitioning in no longer possible and the terminal nodes have been reached.[4,5] A *P* value <.05 was considered significant.

3 | RESULTS

Of the 105 patients, we excluded 1 patient who required TP because of a history of bradycardia-dependent TdP. We thus evaluated 104 patients for the indication for TP. TP was underwent in 19 of the 104 patients (18%) without a stable IR during pacemaker replacement. We divided the 104 study patients into 2 groups: the TP (+) group (19 patients) and the TP (-) group (85 patients) (Figure 1), and we compared the several clinical factors between these 2 groups (Table 1). There were no significant group differences in age, gender, duration of pacing, structural heart disease, and use of anti-arrhythmic drugs. AV block was observed significantly more frequently in the TP (+) group than in the TP (–) group (84% vs 48%, $P = .0044$). The indication for TP was significantly correlated with the absence of a stable IR at the last OPC visit: TP (+) group 89% vs TP (–) group 24%, $P < .0001$. Figure 2 shows the results of the RPA to create an ideal prediction model for patients who indicate TP.

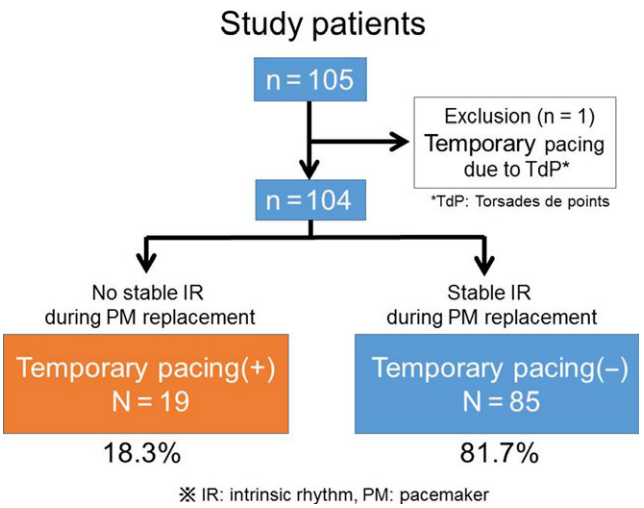

FIGURE 1 The study population was 105 consecutive pacemaker-dependent patients who underwent pacemaker generator replacement due to battery depletion. Of the 105 patients, we excluded 1 patient who required temporary pacing (TP) because of a history of bradycardia-dependent Torsades de points. We thus divided the 104 study patients into 2 groups: the 19 patients who underwent TP [TP (+) group] and the 85 patients who did not [TP (–) group]

Only 2 variables contributed to the final tree (Figure 2): the presence of a stable IR at the last OPC visit and the presence of AVB or SSS. The presence of a stable IR at the last OPC visit was the most significant factor to predict the indication for TP irrespective of the presence of AVB or SSS. For predicting the indication for TP, no stable IR at the last OPC visit showed 89% sensitivity, 77% specificity, 46% positive predictive value, and 97% negative predictive value.

TABLE 1 Comparison of clinical characteristics between patients with and without temporary pacing at pacemaker replacement

	Temporary pacing (+)	Temporary pacing (−)	*P* value
No. of patients	19	85	
Age at PM replacement, years	80.6 ± 6.9	79.8 ± 9.4	ns
Gender: male/female (male%)	9/10 (47%)	44/41 (52%)	ns
AVB/SSS (AVB%)	16/3 (84%)	41/44 (48%)	.0044
Duration of pacing, years	9.5 ± 3.3	11.0 ± 6.2	ns
Structural heart disease	4 (21%)	23 (27%)	ns
Ischemic	3	10	
Nonischemic	1	13	
Use of anti-arrhythmic drugs (%)	6 (32%)	48 (56%)	ns
Beta-blocker	6	29	
Calcium channel blocker	0	17	
Digoxin	0	8	
Sodium channel blocker	0	10	
Bepridil	1	14	
Amiodarone	0	1	
Absence of stable intrinsic rhythm at last OPC	17 (89%)	20 (24%)	<.0001

AVB, atrioventricular block; OPC, outpatient clinic; PM, pacemaker; SSS, sick sinus syndrome.

4 | DISCUSSION

The evaluation of a patient's IR at the OPC just before his or her pacemaker replacement seems to be useful for the prediction of the patient's indication for TP. Specifically, a stable IR at the last OPC visit was a good predictor (97%) for no indication of TP.

4.1 | The intrinsic rhythm (IR) in pacemaker-dependent patients

Stability of the IR is important for the safe generator replacement in pacemaker-dependent patients. The presence of a stable IR was reported as between 9.3% and 24%.[1–3] Rosenheck et al[1] studied that the presences of reliable ventricular escape rhythm in 74 patients who had a permanent pacemaker implantation due to complete AVB. In that study, the pacemaker was programmed to VVI mode at a rate of 40 bpm for 30 s, and the pacing was inhibited by using an external programmer. No IR was observed in 18 (24%) patients. Sumiyoshi et al[2] reported that no IR could be induced in 5 (9.3%) of 54 pacemaker-dependent patients with second- or third-degree AVB after programming the pacemaker to its lowest rate (30 or 40 bpm) or inhibiting the pacemaker by stimulating the chest wall. However, chest wall stimulation may be not commonly used clinically because of the need of an external pacemaker and some

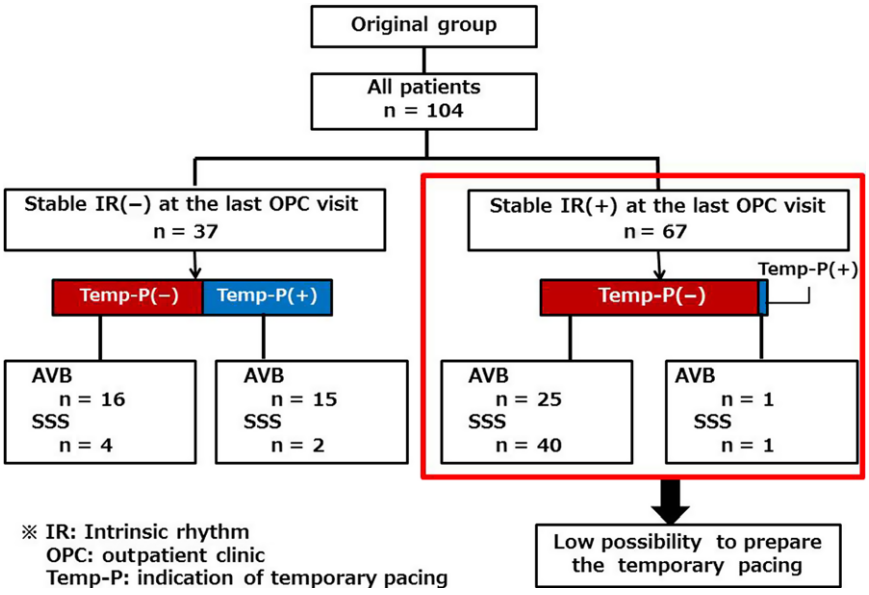

FIGURE 2 Decision tree obtained from the recursive partitioning analysis (RPA) for predicting the indication for temporary pacing (TP) during pacemaker replacement. Only 2 variables contributed to the final tree: the presence of a stable intrinsic rhythm (IR) at the last outpatient clinic (OPC) visit and the presence of atrioventricular block (AVB) or sick sinus syndrome (SSS). The presence of a stable IR at the last OPC visit was the most significant factor to predict the indication for TP irrespective of the presence of AVB or SSS

additional electrodes. Chihrin et al[3] reported that 41% of 100 pacemaker-dependent patients could not achieve an IR after programming the pacemaker to 30 bpm for 1 min. Finally, 13% of the patients had failed to demonstrate an IR even after an isoproterenol infusion protocol. However, that study population included various indications for cardiac pacing; for example, complete AVB in 31 patients, syncope in 20, post-AV node ablation in 10, and sinus bradycardia in 9 patients. In addition, with the use of isoproterenol provocation, there are concerns about the induction of ischemia and ventricular arrhythmias, instability of the effect, and the time-consuming nature of the protocol, along with the need for additional instruments and drugs.

Considering the above reports, we speculate that 10%-40% of pacemaker-dependent patients require TP for safe pacemaker replacement without the use of isoproterenol or chest wall stimulation. Thus, our result seems to be reasonable: TP was needed in 18% of the pacemaker-dependent patients due to the absence or instability of the IR. Pacemaker dependency is known to be depend on the pacing rate: a higher pacing rate tends to induce more depression of the escape foci or diseased AV conduction system and a less stable IR.[6,7] The average heart rate of the IR in pacemaker-dependent patients with advanced or complete AVB was reported as 26 bpm,[1] 37-40 bpm,[2] and 30 bpm.[7] Therefore, it is important to program the pacemaker to 30 bpm for >30 s to obtain a stable IR.[1–3,8]

4.2 | Prediction of a stable IR during pacemaker replacement

Several factors were reported to influence the presence of a stable IR. The absence of a stable IR was seen more frequently in patients with AVB compared to patients with SSS.[8,9] Longer follow-up duration [9] and treatment with digitalis [10] or anti-arrhythmic drugs [1] were reported to be factors that suppress the IR. In addition, Edhag et al[10] reported that a reliable IR was identified during generator replacement in all patients who had had a spontaneous IR at a routine follow-up, whereas 43% of the patients who had had a pacing rhythm at the follow-up had asystole at their generator exchange.

In the present study, AVB was significantly correlated with an absence of stable IR, but the follow-up duration and the use of anti-arrhythmic drugs after pacemaker implantation were not related to the stability of the IR during pacemaker exchange. Our analyses revealed that the presence of a stable IR at the last OPC visit is the most significant factor to predict a stable IR during pacemaker replacement. AVB seems to be a significant factor but the results of our RPA showed that the presence of AVB or SSS is not significant compared to the presence of a stable IR at the last OPC visit. Our findings thus demonstrated that the indication for TP was predictable at the last OPC visit with good sensitivity and specificity (89% and 77%, respectively) and an excellent negative predictive value (97%). Although a stable IR is not completely predictable even in patients with transient high-grade AVB,[11] our results may provide useful information to physicians and staff concerning the pacemaker replacement.

4.3 | Limitations

There are several limitations in this study. The policy and indication of TP during pacemaker replacement may differ among hospitals or institutions. TP needs additional time and adds costs to the pacemaker replacement procedure, with some risks including venous access and lead placement in the heart. However, there will inevitably be patients with no stable IR or bradycardia-induced TdP at the time of their pacemaker replacement. TP is thus important in such cases to ensure a safe replacement procedure.

This study was a retrospective analysis and was conducted at a single institution with a limited number of the patients. Greater numbers of patients and a multicenter study are necessary to confirm our results.

5 | CONCLUSIONS

Evaluation of the IR at the patient's outpatient clinic visit just before the generator replacement seems to be useful for predicting the indication for TP in pacemaker-dependent patients. We observed that a stable IR at the last outpatient clinic visit was a good predictor (97%) of no indication for TP during pacemaker replacement.

CONFLICTS OF INTEREST

Authors declare no conflict of interests for this article.

ORCID

Masataka Sumiyoshi http://orcid.org/0000-0002-2644-6356

REFERENCES

1. Rosenheck S, Bondy C, Wess A, et al. Comparison between patients with and without reliable ventricular escape rhythm in the presence of long standing complete atrioventricular block. Pacing Clin Electrophysiol. 1993;16:272–6.
2. Sumiyoshi M, Nakata Y, Yasuda M, et al. Changes of conductivity in patients with second- or third-degree atrioventricular block after pacemaker implantation. Jpn Circ J. 1995;59:284–91.
3. Chihrin SM, Mohamed U, Yee R, et al. Utility of isoproterenol in unmasking latent escape rhythm in pacemaker dependent patients undergoing pacemaker replacement. Am J Cardiol. 2008;101:631–3.
4. Panageas KS, Reiner AS, Iwamoto FM, et al. Recursive partitioning analysis of prognostic variables in newly diagnosed anaplastic oligodendroglial tumors. Neuro Oncol. 2014;16:1541–6.
5. Komatsu T, Takahashi E, Mishima K, et al. A simple algorithm for predicting bacteremia using food consumption and shaking chills: a prospective observational study. J Hosp Med. 2017;12:510–5.
6. Schmidinger H, Probst P, Weber H, et al. Rate dependent depression of subsidiary ventricular impulse formation – cause of Stokes-Adams attacks in patient with rate modulated pacing. Pacing Clin Electrophysiol. 1988;11:1095–7.

7. Rosenheck S, Bondy C, Weiss AT, et al. The effect of overdrive pacing rate and duration on ventricular escape rhythms in patients with chronic complete atrioventricular block. Pacing Clin Electrophysiol. 1994;17:213–21.
8. Nagatomo T, Abe H, Kikuchi K, et al. New onset of pacemaker dependency after pacemaker implantation. Pacing Clin Electrophysiol. 2004;27:475–9.
9. Staessen J, Ector H, De Geest H. The underlying heart rhythm in patients with an artificial cardiac pacemaker. Pacing Clin Electrophysiol. 1982;5:801–7.
10. Edhag O, Rosenqvist M. Heart rhythm during permanent cardiac pacing. Br Heart J. 1979;42:182–5.
11. Rosenqvist M, Edhag O. Pacemaker dependence in transient high-grade atrioventricular block. Pacing Clin Electrophysiol. 1984;7:63–70.

How to cite this article: Kimura Y, Sumiyoshi M, Inoue K, et al. Stability of intrinsic rhythm in pacemaker-dependent patients during pacemaker replacement: Can we predict the need for temporary pacing?. *J Arrhythmia*. 2018;34:450–454. https://doi.org/10.1002/joa3.12072