Heparin dosing in uninterrupted anticoagulation with dabigatran vs. warfarin in atrial fibrillation ablation: RE-CIRCUIT study

Hugh Calkins1*, Stephan Willems2, Atul Verma3, Richard Schilling4, Stefan H. Hohnloser5, Ken Okumura6, Matias Nordaby7, Eva Kleine7, Branislav Bis8, and Edward P. Gerstenfeld9; on behalf of the RE-CIRCUIT investigators

1Johns Hopkins Medical Institutions, Baltimore, MD, USA; 2University of Hamburg, Hamburg, Germany; 3University of Toronto, Toronto, Ontario, Canada; 4St Bartholomew’s Hospital, London, UK; 5J.W. Goethe University, Frankfurt, Germany; 6Saiseikai Kumamoto Hospital, Cardiovascular Center, Kumamoto, Japan; 7Boehringer Ingelheim Pharma, Ingelheim am Rhein, Germany; 8Boehringer Ingelheim RCV, Vienna, Austria; and 9University of California, San Francisco, CA, USA

Received 27 September 2018; editorial decision 7 March 2019; accepted 18 March 2019; online publish-ahead-of-print 14 April 2019

Aims
To describe heparin dosing requirements in patients who underwent catheter ablation of atrial fibrillation with uninterrupted anticoagulation using dabigatran etexilate (dabigatran) or warfarin to attain therapeutic activated clotting time (ACT) in the RE-CIRCUIT® study. The RE-CIRCUIT study showed significantly fewer major bleeding events in the dabigatran vs. warfarin treatment group. Unfractionated heparin was administered during the procedure to maintain ACT >300 s.

Methods and results
Patients were randomly assigned to dabigatran 150 mg bid or international normalized ratio-adjusted warfarin. Ablation was performed with uninterrupted anticoagulation and continued for 8 weeks after the procedure. Heparin was administered after placement of femoral sheaths before or immediately after transeptal puncture. Ablation was performed in 635 patients (dabigatran, 317; warfarin, 318); data were available from 396 patients administered heparin (dabigatran, 191; warfarin, 205). Most frequent time window from last dose of study drug to septal puncture was 0 to <4 h in the dabigatran (41.3%) and 16 to <24 h in the warfarin arms (44.7%). Overall mean (standard deviation) heparin dose was similar between the dabigatran and warfarin groups [12 402 (10 721) vs. 11 910 (8359) IU, respectively]. Heparin dosing requirement to reach therapeutic ACT was lowest when the time from last dose of dabigatran to septal puncture was 0 to <4 h.

Conclusion
Patients treated with dabigatran required a similar amount of unfractionated heparin as those treated with warfarin to achieve an ACT of >300 s during ablation. More heparin units were required when the time from the last dose of dabigatran to septal puncture was 0 to <4 h.

Keywords
Atrial fibrillation • Anticoagulation • Catheter ablation • Dabigatran • Heparin dosing • Warfarin

Introduction
Catheter ablation is a widely used and effective interventional treatment for atrial fibrillation (AF).1–4 However, periprocedural stroke or transient ischaemic attack and cardiac tamponade are serious complications associated with the ablation procedure.5 Periprocedural management of anticoagulation in patients undergoing ablation is critical to limit these complications.1 In patients with

* Corresponding author. Tel: +1 410 274 5581. E-mail address: hcalkins@jhmi.edu
© The Author(s) 2019. Published by Oxford University Press on behalf of the European Society of Cardiology.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact journals.permissions@oup.com
planned catheter ablation of AF, oral anticoagulation with a vitamin K antagonist (VKA) or non-vitamin K antagonist oral anticoagulant (NOAC) should be continued during the procedure, maintaining effective anticoagulation, and should be continued for at least 8 weeks afterwards. Uninterrupted VKA during the ablation procedure has a lower risk of periprocedural bleeding and stroke than interrupted VKA and bridging with low molecular weight heparin. In addition, the RE-CIRCUIT study observed a lower risk of bleeding with uninterrupted anticoagulation with dabigatran etexilate (dabigatran) compared with warfarin in patients undergoing catheter ablation for paroxysmal or persistent AF.

According to current guidelines, catheter ablation of symptomatic AF is a Class I or II recommendation depending on previous antirhythmic treatment and AF type. According to the Heart Rhythm Society, the European Heart Rhythm Association, the European Cardiac Arrhythmia Society, the Asia Pacific Heart Rhythm Society, and the Latin American Society of Cardiac Stimulation and Electrophysiology (Sociedad Latinoamericana de Estimulación Cardíaca y Electrofisiología) expert consensus statement, performing the ablation procedure without interruption of warfarin or dabigatran is a Class I recommendation. The currentguidelines also recommend systemic anticoagulation with heparin during the ablation procedure to maintain an activated clotting time (ACT) of more than 300 s to reduce the risk of thromboembolic events associated with the ablation procedure. Previous guidelines suggested that a loading dose of 100 U/kg heparin be administered, followed by heparin infusion at 10 U/kg/h in order to achieve ACT >300 s. The current guidelines do not recommend which heparin to use (e.g. unfractionated heparin, or low molecular weight heparin) or the dosage regimen to achieve ACT >300 s, with the suggestion that ACT levels be maintained every 10–15 min until >300 s, and then every 15–30 min for the remainder of the procedure. According to a European Heart Rhythm Association survey, the first loading dose of heparin was given after a transseptal puncture in the majority of centres (69.4%).

Dabigatran can prolong activated partial thromboplastin time (aPTT) and ACT in a dose-dependent manner. Previous evidence suggests that heparin dose requirements differ in patients receiving NOACs compared with VKAs. A single-centre Japanese study that assessed the differences in ACT and initial heparin dosing in patients receiving NOACs and warfarin showed the need for a higher initial bolus heparin dose for NOACs compared with warfarin (120–130 U/kg vs. 100 U/kg). A limited number of other single-centre studies that examined the heparin requirements and ACTs associated with NOACs and warfarin showed that NOACs require a higher dose of heparin and more time to reach the target ACT compared with uninterrupted warfarin.

In the RE-CIRCUIT trial, the rate of bleeding events was significantly lower with dabigatran compared with warfarin (risk difference −5.3%, 95% confidence interval −8.4 to −2.2; P < 0.001). In this post hoc analysis of the RE-CIRCUIT data, we evaluated the differences in heparin dosing between the dabigatran and warfarin treatment groups.

### Methods

#### Study design

RE-CIRCUIT was a prospective, randomized, open-label, blinded adjudicated-endpoint, multicentre, controlled study in patients scheduled for catheter ablation for paroxysmal or persistent AF (NCT02348723). The complete study design, methodology, and primary results were published previously. In brief, eligible patients were randomly assigned to anticoagulation with dabigatran 150 mg bid or international normalized ratio-adjusted warfarin. Ablation was performed with uninterrupted anticoagulation, which was continued for 2 months after the procedure. Unfractionated heparin was administered after placing femoral sheaths before or immediately after a transseptal puncture during AF ablation procedures. For the duration of the procedure when catheters were in the left atrium, it was recommended that weight-adjusted boluses of heparin should be adjusted to achieve and maintain an ACT >300 s. Investigators were instructed to measure ACT within 15 min after the administration of the bolus dose, and every 20 min subsequently.

The first post-procedural dose of dabigatran was administered in the evening of the procedure at the scheduled dosing time, with a minimum delay of 3 h after removal of the sheath and achievement of haemostasis. In this post hoc analysis, we compared heparin dosing, and the relationship between ACT, heparin dosing, and the time elapsed from morning administration of the study drug to transseptal puncture in the dabigatran and warfarin treatment groups. The study was performed in accordance with

### Table I: ACT (ablation set)

| ACT (ablation set) | Dabigatran | Warfarin | Total |
|-------------------|------------|----------|-------|
| Patients ablated, n | 317 | 318 | 635 |
| Individual mean ACT | | | |
| N | 312 | 308 | 620 |
| Mean (SD), s | 330 (81.0) | 342 (74.0) | 336 (77.8) |
| ACT categories | | | |
| Maintained >300 s, n (%) | 101 (31.9) | 96 (30.2) | 197 (31.0) |
| Dropped <300 s, n (%) | 213 (67.2) | 213 (67.0) | 426 (67.1) |
| Missing, n (%) | 3 (0.9) | 9 (2.8) | 12 (1.9) |

ACT, activated clotting time; SD, standard deviation.
the provisions of the Declaration of Helsinki and the International Conference on Harmonisation Good Clinical Practice Guidelines. The study protocol and procedures were approved by the relevant institutional review boards and ethics committees.

Consent

All patients provided written informed consent before entering the study.

Statistical analysis

Heparin doses administered and ACT values in both treatment groups are presented descriptively.

Results

Study population

A total of 635 patients were administered at least one dose of the study drug and underwent the ablation procedure (dabigatran, 317; warfarin, 318 patients). In this randomized trial, baseline demographic and clinical characteristics were well balanced between the treatment groups. The mean age of patients was 59.2 years overall, and the mean CHA2DS2-VASc score was 2.0 in the dabigatran and 2.2 in warfarin treatment groups. Mean ACT during the ablation was similar between the dabigatran and warfarin groups (330 and 342 s, respectively), as was the percentage of patients who maintained a
therapeutic ACT >300 s during ablation between these treatment groups (31.9% and 30.2%, respectively) (Table 1).

### Heparin Dose

Data on heparin doses on the day of ablation were available from 396 patients (dabigatran, 191; warfarin, 205), with baseline demographic and clinical characteristics well balanced between treatment groups (Table 2). Of the 396 patients who received heparin, almost three quarters were male (72.7%), and the mean age was 59.2 years. The mean CHA2DS2-VASc score was 1.9 and 2.1 in the dabigatran and warfarin groups, respectively. Almost twice as many patients receiving warfarin had coronary artery disease vs. those

**Table 3** Heparin dose requirements in patients with ACT <300 s vs ≥300 s (ablation set)

|                      | Dabigatran 150 mg, bid | Warfarin | Total |
|----------------------|------------------------|----------|-------|
|                      | N                      | Heparin dose (IU), mean (SD) | N               | Heparin dose (IU), mean (SD) | N               | Heparin dose (IU), mean (SD) |
| Overall              | 191                    | 12 402 (10 721)               | 205             | 11 910 (8359)                 | 396             | 12 147 (9562) |
| First ACT            |                        |                                     |                 |                              |                 |                              |
| <300 s               | 80                     | 14 822 (13 743)                | 89              | 13 485 (9634)                 | 169             | 14 118 (11 742) |
| ≥300 s               | 108                    | 10 699 (7534)                  | 107             | 10 864 (7289)                 | 215             | 10 781 (7396) |
| Maximum ACT          |                        |                                     |                 |                              |                 |                              |
| <300 s               | 13                     | 7554 (3269)                    | 16              | 7381 (2828)                   | 29              | 7459 (2979) |
| ≥300 s               | 175                    | 12 817 (11 067)                | 180             | 12 469 (8727)                 | 355             | 12 641 (9937) |
| Minimum ACT          |                        |                                     |                 |                              |                 |                              |
| <300 s               | 126                    | 13 956 (12 401)                | 136             | 12 501 (8963)                 | 262             | 13 201 (10 758) |
| ≥300 s               | 62                     | 9399 (5264)                    | 60              | 11 042 (7363)                 | 122             | 10 207 (6410) |
| Mean ACT             |                        |                                     |                 |                              |                 |                              |
| <300 s               | 54                     | 12 358 (9046)                  | 46              | 10 026 (7154)                 | 100             | 11 285 (8273) |
| ≥300 s               | 134                    | 12 492 (11 450)                | 150             | 12 676 (8816)                 | 284             | 12 589 (10 127) |
| ACT missing          | 3                      | 9167 (3884)                    | 9               | 8778 (1889)                   | 12              | 8875 (2317) |

ACT, activated clotting time; SD, standard deviation.

**Table 4** ACT and heparin dose according to the time from the last preprocedural dabigatran administration to septal puncture (ablation set*)

| Time from dabigatran dose to septal puncture | 0 to <4 h | 4 to <8 h | ≥8 h | NR | Total |
|--------------------------------------------|----------|----------|------|----|-------|
| N                                          | 79       | 74       | 33   | 5  | 191   |
| Median heparin dose (IU)                    | 9500     | 10 167   | 10 000 | 9008 | 10 000 |
| First ACT                                   |          |          |      |    |       |
| 0 to <100 s, n (%)                          | 0 (0.0)  | 0 (0.0)  | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| 100 to <200 s, n (%)                        | 12 (15.2)| 11 (14.9)| 10 (30.3) | 0 (0.0) | 33 (17.3) |
| 200 to <300 s, n (%)                        | 19 (24.1)| 19 (25.7)| 8 (24.2) | 1 (20.0) | 47 (46.4) |
| >300 s, n (%)                               | 47 (59.5)| 44 (59.5)| 15 (45.5) | 2 (40.0) | 108 (56.5) |
| Missing, n (%)                              | 1 (1.3)  | 0 (0.0)  | 0 (0.0) | 2 (40.0) | 3 (1.6)  |
| Mean ACT                                    |          |          |      |    |       |
| 0 to <100 s, n (%)                          | 0 (0.0)  | 0 (0.0)  | 0 (0.0) | 0 (0.0) | 0 (0.0)  |
| 100 to <200 s, n (%)                        | 0 (0.0)  | 0 (0.0)  | 0 (0.0) | 0 (0.0) | 0 (0.0)  |
| 200 to <300 s, n (%)                        | 19 (24.1)| 21 (28.4)| 14 (42.4) | 0 (0.0) | 54 (28.3) |
| ≥300 s, n (%)                               | 59 (74.7)| 53 (71.6)| 19 (57.6) | 3 (60.0) | 134 (70.2) |
| Missing, n (%)                              | 1 (1.3)  | 0 (0.0)  | 0 (0.0) | 2 (40.0) | 3 (1.6)  |

*Restricted to patients with documented heparin dosing.
ACT, activated clotting time; NR, not reported.

---

H. Calkins et al.
receiving dabigatran (14.1% vs 7.3%), while twice as many patients receiving dabigatran had a prior stroke vs. those receiving warfarin (4.2% vs. 2.4%). The overall heparin dose on the day of the ablation was similar between the dabigatran and warfarin groups [mean (standard deviation, SD) 12 402 (10 721) vs. 11 910 (8359) IU, respectively] (Table 3). Heparin dosing tended to be lower in patients with a first or minimum ACT measurement of >300 s vs. <300 s for all patients; mean (SD) heparin dose for first ACT <300 s vs. >300 s was 14 118 (11 742) IU vs. 10 781 (7396) IU, and for minimum ACT <300 s vs. >300 s it was 13 201 (10 758) IU vs. 10 207 (6410) IU, respectively. In addition, mean (SD) heparin dosing also tended to be lower in patients who did not achieve ACT >300 s [7459 (2979) IU] vs. those who did [12 641 (9937) IU] (P < 0.001). The mean ACT level attained was also lower in the rivaroxaban arm vs. the VKA arm (302 vs. 332 s; P < 0.001). The difference in heparin dosing between dabigatran and rivaroxaban may be attributed to their different modes of action. As a direct thrombin inhibitor, dabigatran can modify ACT and aPTT, whereas therapeutic doses of the factor Xa inhibitor rivaroxaban do not affect ACT or aPTT. Thus, patients treated with rivaroxaban require higher doses of heparin to maintain ACT.

Furthermore, in the RE-CIRCUIT study, the last dose of dabigatran was given very close to the ablation procedure, whereas patients in the rivaroxaban study took their last dose of rivaroxaban the evening before the day of the ablation procedure. The number of patients maintaining an ACT >300 s during ablation was low (~30%), suggesting that physicians may have been more conservative with heparin administration in the context of uninterrupted oral anticoagulant. However, the heparin requirement in the present study is comparable to that reported in a retrospective cohort study from a prospective AF ablation registry, the average heparin dose required to reach therapeutic ACT was 12 900 units in dabigatran-treated patients.

Intraprocedural ACT and heparin requirements were evaluated in 184 patients treated with dabigatran or warfarin (one dose of...
Dabigatran was withheld for 70 patients, two doses of dabigatran and warfarin were withheld for 63 and 51 patients, respectively. Patients receiving dabigatran who withheld one or two doses before the procedure had higher intraprocedural heparin requirements (mean ± SD 225.2 ± 64.4 U/kg and 239.0 ± 65.0 U/kg, respectively) compared with warfarin (164.9 ± 36.1 U/kg; P < 0.001) to achieve an ACT >350 s.12 These results support the concept mentioned above that, for patients for whom an uninterrupted dabigatran anticoagulation strategy has been decided, the heparin requirements may be similar to a comparable uninterrupted anticoagulation strategy with warfarin, owing to the ability of dabigatran to affect ACT in a dose-dependent manner.10

This post hoc analysis of RE-CIRCUIT showed that the closer the septal puncture was to the last anticoagulant dose, the lower the heparin requirement was to achieve the desired ACT. Limitations of the current analysis include the small sample size with documented heparin dosing, and the inherent shortcomings of post hoc analyses.

Conclusions

The data from the RE-CIRCUIT study showed that patients treated with dabigatran 150 mg bid required a similar amount of heparin as those treated with international normalized ratio-adjusted warfarin, and similar ACT was achieved in the treatment groups. It also suggests that the heparin units required to reach the desired ACT may be affected by the time from the last preprocedural dose of dabigatran.

Acknowledgements

We thank Corinna Miede and Wilfried Esken from HMS Analytical Software GmbH for providing support for statistical analyses. Medical writing assistance, funded by Boehringer Ingelheim, was provided by Anoop Joseph, MSc, of PAREXEL.

Funding

This work was supported by Boehringer Ingelheim.

Conflict of interest: H.C.: lecture honoraria from Abbot Medical, Boehringer Ingelheim and Medtronic; consultant to, Abbot Medical, AtriCure, Biosense Webster, and Medtronic. S.W.: honoraria as a consultant, advisor, or speaker from Abbott Medical, AtriCure, Biosense Webster, Medtronic; research grants and honoraria from Bayer, Boehringer Ingelheim, Daiichi Sankyo; consultant to, Bayer, Biosense Webster, Boehringer Ingelheim, and Medtronic. R.S.: research grants from Biosense Webster, Boston Scientific, Medtronic, and St Jude Medical; honoraria and travel sponsorship from Biosense Webster, Boston Scientific, Medtronic, and St Jude Medical. H.C.: consultant, advisor, or speaker for Bayer HealthCare, Bristol-Myers Squibb, Daiichi Sankyo, Johnson & Johnson, and Medtronic. M.N.: employee of Boehringer Ingelheim Pharma GmbH & Co. KG; E.K.: employee of Boehringer Ingelheim Pharma GmbH & Co. KG; B.B.: employee of Boehringer Ingelheim RCV, Vienna, Austria. E.P.G.: honoraria from Boehringer Ingelheim; research grant and honoraria from Biosense Webster; research grant and honoraria from St Jude Medical.

References

1. Calkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA et al. 2012 HRS/EHRA/ESC expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design. Europace 2012;14:528–606.
2. January CT, Wann LS, Alpert JS, Calkins H, Cigarroa JE, Cleveland JC et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol 2014;64:1e–76.
3. Kirchhof P, Benussi S, Köchel D, Ahlsson A, Atar D, Casadei B et al. 2016 ESC guidelines for the management of atrial fibrillation developed in collaboration with EACTS. Europace 2016;18:1609–78.
4. Calkins H, Hindricks G, Cappato R, Kim YH, Saad EB, Aguina L et al. 2017 HRS/EHRA/ECAS/APHRS/LSHACEC expert consensus statement on catheter and surgical ablation of atrial fibrillation. Europace 2018;20:61–160.
5. Di Biase L, Burkhart JD, Santangeli P, Mohanthy P, Sanchez JE, Horton R et al. Periprocedural stroke and bleeding complications in patients undergoing catheter ablation of atrial fibrillation with different anticoagulation management strategies from the role of Coumadin in Preventing Thromboembolism in Atrial Fibrillation (AF) Patients Undergoing Catheter Ablation (COMPARE) randomized trial. Circulation 2014;129:2638–44.
6. Gage SP, Siddiqui MS, Finlay M, Hunter RJ, Abrams D, Dhinora M et al. Catheter ablation for atrial fibrillation on uninterrupted warfarin: can it be done without echo guidance? J Cardiovasc Electrophysiol 2011;22:65–70.
7. Calkins H, Willems S, Gerstenfeld EP, Verma A, Schilling R, Hohnloser SH et al. Uninterrupted dabigatran versus warfarin for ablation in atrial fibrillation. N Eng J Med 2017;376:1627–36.
8. Calkins H, Brugada J, Packler DL, Cappato R, Chen SA, Crijns HJ et al. HRS/EHRA/ESC expert consensus statement on catheter and surgical ablation of atrial fibrillation: recommendations for personnel, policy, procedures and follow-up. A report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation developed in partnership with the European Heart Rhythm Association (EHRA) and the European Cardiac Arrhythmia Society (ECAS); in collaboration with the American College of Cardiology (ACC), American Heart Association (AHA), and the Society of Thoracic Surgeons (STS). Endorsed and approved by the governing bodies of the American College of Cardiology, the American Heart Association, the European Cardiac Arrhythmia Society, the European Heart Rhythm Association, the Society of Thoracic Surgeons, and the Heart Rhythm Society. Europace 2007;9:335–79.
9. Chen J, Todd DM, Hocini M, Larsen TB, Bengtorn MG, Blomstrom-Lundqvist C. Current periprocedural management of ablation for atrial fibrillation in Europe: results of the European Heart Rhythm Association Survey. Europace 2014;16:1637–41.
10. van Ryn J, Stangier J, Haertter S, Liesenfeld KH, Wienen W, Feuring M et al. Current periprocedural management of ablation for atrial fibrillation in Europe: results of the European Heart Rhythm Association Survey. Europace 2014;16:1637–41.
11. Yamaji H, Murakami T, Hina K, Higashiya S, Kawamura H, Murakami M et al. Adequate initial heparin dosage for atrial fibrillation ablation in patients receiving non-vitamin K antagonist oral anticoagulants. Clin Drug Investig 2016;36:837–48.
12. Bassoumy M, Saliba W, Rickard J, Shao M, Seyer A, Diab M et al. Use of dabigatran for periprocedural anticoagulation in patients undergoing catheter ablation for atrial fibrillation. Circ Arrhythm Electrophysiol 2013;6:460–6.
13. Nagao T, Inden Y, Yanagisawa S, Kato H, Ishikawa S, Okumura S et al. Differences in activated clotting time among uninterrupted anticoagulants during the periprocedural period of atrial fibrillation ablation. Heart Rhythm 2015;12:1972–8.
14. Konduru SV, Cheema AA, Jones P, Li Y, Ramza B, Wimmer AP. Differences in intraprocedural ACTs with standardized heparin dosing during catheter ablation for atrial fibrillation in patients treated with dabigatran vs. patients on interrupted warfarin. J Interv Card Electrophysiol 2012;35:277–84.
15. Calkins H, Gerstenfeld EP, Schilling R, Verma A, Willems S. RE-CIRCUIT study—randomized evaluation of dabigatran etexilate compared to warfarin in pulmonary vein ablation: assessment of an uninterrupted periprocedural anticoagulation strategy. Am J Cardiol 2015;115:154–5.
16. International Conference on Harmonisation. ICH harmonised tripartite guideline. Guideline for good clinical practice E6(R1) 1996. https://www.ich.org/fileadmin/Public_Web_Site/ICH_Products/Guidelines/Efficacy/E6/E6_R1_Guideline.pdf (25 March 2019, date last accessed).

17. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA 2013;310:2191–4.

18. Cappato R, Marchlinski FE, Hohnloser SH, Naccarelli GV, Xiang J, Wilber DJ et al. Uninterrupted rivaroxaban vs. uninterrupted vitamin K antagonists for catheter ablation in non-valvular atrial fibrillation. Eur Heart J 2015;36:1805–11.

19. Heidbuchel H, Verhamme P, Alings M, Antz M, Diener HC, Hacke W et al. Updated European Heart Rhythm Association practical guide on the use of non-vitamin K antagonist anticoagulants in patients with non-valvular atrial fibrillation. Europace 2015;17:1467–507.

20. Armbruster HL, Lindsley JP, Moranville MP, Habibi M, Khurram IM, Spragg DD et al. Safety of novel oral anticoagulants compared with uninterrupted warfarin for catheter ablation of atrial fibrillation. Ann Pharmacother 2015;49:278–84.

Safety and usefulness of a second Micra transcatheter pacemaker implantation after battery depletion

Paula Sánchez, Jose Apolo, Rodolfo San Antonio, Eduard Gusach, Lluís Mont, and José María Tolosana*

Arrhythmia Section, Cardiology Department, Thorax Institute, Hospital Clinic and IDIBAPS (Institut d’Investigació Agustí Pi i Sunyer), University of Barcelona, Barcelona, Catalonia, Spain

*Corresponding author. Tel: + 34 93 2271778; fax: + 34 93 4513095. E-mail address: tolosana@clinic.cat

Techniques to manage the end of life of the Micra transcatheter pacing system (Medtronic Micra TPS) are not well standardized. It has been suggested that the best option is to leave the old device in the heart and implant a new one. Nevertheless, to date no double implant has successfully been reported in humans.

We present the case of a 78-year-old man who had reached the elective replacement time of the pacemaker after having received a Micra TPS in 2014 due to atrioventricular block. Reasons for early battery depletion were high right ventricular pacing threshold and 100% right ventricle (RV) pacing. A new Micra TPS was implanted through right femoral vein access. The new pacemaker was placed in the mid-septum of the RV, distant from the first pacemaker (Figure). The parameters of the new device (sensing, impedance, and threshold) were achieving within acceptable limits. No interactions were observed between the two devices. An echocardiography ruled out a negative impact of RV function by the implantation of the two devices. To our knowledge, this study is the first successful case of multiple implants of a Micra TPS with correct sensing and capture and no negative effects on RV function.

The full-length version of this report can be viewed at: https://www.escardio.org/Education/E-Learning/Clinical-cases/Electrophysiology

Published on behalf of the European Society of Cardiology. All rights reserved. © The Author(s) 2019. For permissions, please email: journals.permissions@oup.com.