ESC European Society of Cardiology

Europace (2019) **21**, 1360–1368
doi:10.1093/europace/euz140

Effect of remote monitoring on patient-reported outcomes in European heart failure patients with an implantable cardioverter-defibrillator: primary results of the REMOTE-CIED randomized trial

Henneke Versteeg[1]*, Ivy Timmermans[1,2], Jos Widdershoven[2,3], Geert-Jan Kimman[4], Sébastien Prevot[5], Thomas Rauwolf[6], Marcoen F. Scholten[7], Edgar Zitron[8], Philippe Mabo[9], Johan Denollet[2,10], Susanne S. Pedersen[11,12], and Mathias Meine[1]

[1]Department of Cardiology, University Medical Centre Utrecht, Heidelberglaan 100, PO box 85500 3508 GA Utrecht, Utrecht, The Netherlands; [2]Department of Medical and Clinical Psychology, CoRPS – Center of Research on Psychology in Somatic Diseases, Tilburg University, Tilburg, The Netherlands; [3]Department of Cardiology, Elisabeth-TweeSteden Hospital, Tilburg, The Netherlands; [4]Department of Cardiology, Noordwest Ziekenhuisgroep, Alkmaar, The Netherlands; [5]Department of Cardiology, Hôpital Privé Clairval, Marseille, France; [6]Department of Cardiology and Angiology, Otto von Guericke University, Magdeburg, Germany; [7]Department of Cardiology, Medisch Spectrum Twente, Enschede, The Netherlands; [8]Department of Cardiology, Universitätsklinikum Heidelberg, Heidelberg, Germany; [9]Department of Cardiology, Centre Hospitalier Universitaire, Rennes, France; [10]Department of Cardiology, Antwerp University Hospital, Edegem, Belgium; [11]Department of Psychology, University of Southern Denmark, Odense, Denmark; and [12]Department of Cardiology, Odense University Hospital, Odense, Denmark

Received 1 October 2018; editorial decision 24 April 2019; accepted 24 April 2019; online publish-ahead-of-print 5 June 2019

Aims The European REMOTE-CIED study is the first randomized trial primarily designed to evaluate the effect of remote patient monitoring (RPM) on patient-reported outcomes in the first 2 years after implantation of an implantable cardioverter-defibrillator (ICD).

Methods and results The sample consisted of 595 European heart failure patients implanted with an ICD compatible with the Boston Scientific LATITUDE® RPM system. Patients were randomized to RPM plus a yearly in-clinic ICD check-up vs. 3–6-month in-clinic check-ups alone. At five points during the 2-year follow-up, patients completed questionnaires including the Kansas City Cardiomyopathy Questionnaire and Florida Patient Acceptance Survey (FPAS) to assess their heart failure-specific health status and ICD acceptance, respectively. Information on clinical status was obtained from patients' medical records. Linear regression models were used to compare scores between groups over time. Intention-to-treat and per-protocol analyses showed no significant group differences in patients' health status and ICD acceptance (subscale) scores (all $Ps > 0.05$). Exploratory subgroup analyses indicated a temporary improvement in device acceptance (FPAS total score) at 6-month follow-up for secondary prophylactic in-clinic patients only ($P < 0.001$). No other significant subgroup differences were observed.

Conclusion Large clinical trials have indicated that RPM can safely and effectively replace most in-clinic check-ups of ICD patients. The REMOTE-CIED trial results show that patient-reported health status and ICD acceptance do not differ between patients on RPM and patients receiving in-clinic check-ups alone in the first 2 years after ICD implantation.
ClinicalTrials.gov Identifier: NCT01691586.

Keywords REMOTE-CIED • Implantable cardioverter-defibrillator • Heart failure • Remote monitoring • Patient-reported outcomes • Health status

* Corresponding author. Tel: +31 88 755 6184; fax: +31 88 755 5471. *E-mail address*: h.versteeg-2@umcutrecht.nl

What's new?

- The multicentre REMOTE-CIED trial including 595 European heart failure patients with an implantable cardioverter-defibrillator (ICD) was the first randomized trial primarily designed to examine the effect of remote patient monitoring (RPM) on patient-reported outcomes.
- Results showed that patient-reported heart failure-specific health status and ICD acceptance did not differ between remotely and in-clinic-monitored patients in the first 2 years after implantation.
- Results of the REMOTE-CIED study support use of RPM in clinical practice, but future research is warranted to optimize handling of remotely gathered data as this may enhance clinical and patient-reported outcomes.

Introduction

Remote patient monitoring (RPM) of patients with cardiovascular implantable electronic devices (CIEDs) is gaining acceptance in clinical practice. The Heart Rhythm Society stated in 2015 that RPM is preferred over a calendar-based schedule of in-clinic check-ups alone, and recommended that it should be offered to all patients with CIEDs.[1] Meta-analyses of randomized controlled trials suggest that RPM is at least comparable to in-clinic check-ups alone with regard to clinical outcomes like mortality and hospital admissions.[2,3]

However, evidence on the effects of RPM on patient-reported outcomes is limited and inconclusive. Only a few randomized trials have included these outcomes, and to our knowledge never as primary endpoint.[4] Most trials found no absolute group differences in patient-reported health status, i.e. a composite score of patients' symptoms, function, and quality of life. One pilot trial on 151 patients from the USA showed that quality of life assessed with the EuroQol thermometer was significantly better in the In-Clinic arm than in the RPM arm at 6-month follow-up, although this difference disappeared at 12 months.[5] On the contrary, the Italian EVOLVO trial ($N = 200$) using the Minnesota Living with Heart Failure Questionnaire (MLHFQ) found significantly more health status improvement in the RPM group over 16 months' of follow-up.[6] Disease-specific measures like the MLHFQ and the Kansas City Cardiomyopathy Questionnaire (KCCQ) are often more relevant to patients than generic measures such as the EuroQol and 36-item Short Form Health Survey, and more sensitive in reflecting treatment-related changes.[7] Also, the beneficial effects of RPM may be less noticeable for patients in the first year after implantation, as they are still adjusting to living with an implantable cardioverter-defibrillator (ICD) and the associated check-ups during this period.

The European REMOTE-CIED study is the first and largest randomized ICD trial primarily designed to evaluate the effects of RPM on disease-specific health status and ICD acceptance in the first 2 years after ICD implantation.[8] In addition, we explored whether the effects of RPM on these patient-reported outcomes differ for specific patient groups, based on their socio-demographic, clinical, and psychological characteristics.

Methods

Participants and study design

Consecutive patients receiving an ICD between April 2013 and January 2016 at one of the 32 participating hospitals in five European countries (i.e. France, Germany, Spain, Switzerland, and The Netherlands) were screened for study participation by local investigators. Patients were eligible to participate when they (i) were implanted with a first-time ICD (single chamber/dual chamber/biventricular) compatible with the LATITUDE® Patient Management system from Boston Scientific and (ii) suffered from symptomatic heart failure [LVEF ≤35% and New York Heart Association (NYHA) functional Class II or III] at the time of implantation. Patients were excluded if they (i) were younger than 18 or older than 85 years of age, (ii) on the waiting list for heart transplantation, (iii) had a history of psychiatric illness other than affective/anxiety disorders, or (iv) were unable to complete the questionnaires due to cognitive impairments or (v) had insufficient knowledge of the language. The study conforms to the principles outlined in the Declaration of Helsinki and the medical ethics committees of the participating centres approved the study protocol. All patients provided written informed consent.

Participating patients received a set of baseline questionnaires to complete at home 1–2 weeks after implantation. After returning the completed questionnaire, patients were randomized in a 1:1 fashion to the RPM group or In-Clinic group with the use of a blocked randomization procedure. To ensure that the relative percentage of ICD and cardiac resynchronization therapy defibrillator (CRT-D) patients was equal in both groups, a separate randomization procedure within these two subgroups of patients was used.

Four to 8 weeks after implantation, patients in the RPM group received the LATITUDE® RPM system, including weight scale and blood pressure cuffs from their local hospital staff. Subsequently, they had scheduled in-clinic ICD check-ups once a year, while intermediate check-ups were performed remotely at least every 6 months (including a real-time electrocardiogram, tests of battery status, lead impedances, and sensing amplitude). During and in-between these scheduled check-ups, the clinics were notified when predefined RPM alerts (e.g. low life battery, low/high shock lead impedance, device malfunction, arrhythmias, and weight change) or patient-initiated data transmissions were detected. The gathered data were accessible 24/7 via the secured LATITUDE® website and reviewed and responded to by nurses, cardiologists, and/or ICD-technicians according to the centres' clinical routine. Patients in the In-Clinic group visited the clinic for ICD check-up every 3–6 months according to the standard schedule at the participating centre.

All patients completed a set of follow-up questionnaires at 3-, 6-, 12-, and 24 months post-implantation. When the completed baseline or follow-up questionnaires were not returned within 2 weeks, patients received a reminder telephone call from their local hospital staff. More detailed information on the study design, randomization procedure, and LATITUDE® system is published elsewhere.[8]

Primary outcomes

Patient-reported health status

The KCCQ was used to assess heart failure-specific health status. The KCCQ is a 23-item, validated self-report questionnaire that quantifies physical limitations, symptoms, social functioning, and quality of life of patients with heart failure.[9] These four health status subscales can be combined into a single overall summary score. The (sub)scale scores are transformed into a score from 0 to 100, with higher scores representing better health status. Poor health status is defined as a KCCQ overall summary score <50 points, and a 5-point difference represents a clinically meaningful difference between the groups and within individual patients.

This scale has good internal consistency, with a Cronbach's alpha of 0.98 in the current sample.

Implantable cardioverter-defibrillator acceptance

Patients' acceptance of their device was assessed with the 12-item Florida Patient Acceptance Survey (FPAS).[10] Items (e.g. 'My device was my best treatment option') contribute to three four-item subscales: (i) device-related distress; (ii) return to function; and (iii) positive appraisal. Total and subscale scores are linearly converted into a score between 0 and 100. A high score on the total scale and the 'return to function' and 'positive appraisal' subscales means better acceptance, while a high score on the 'device-related distress' subscale means less acceptance. Cronbach's alpha of this scale was 0.71 in this sample, indicating satisfactory internal consistency.

Sample characteristics

Socio-demographic and clinical characteristics

Information on patients' socio-demographic characteristics was obtained via the baseline questionnaire. Information on patients' ICD and heart failure characteristics, medication, comorbidities, ICD shocks, and cardiac-related hospital visits and admissions were extracted from their medical records, and entered into an electronic case report form by the local investigators at the participating centres. Finally, in the questionnaire patients were asked about the average travel time to their hospital, their satisfaction with cardiovascular care (0–100), and if they attend(ed) a cardiac rehabilitation programme.

Lifestyle factors

Information on patients' lifestyle (i.e. body mass index, smoking status, and use of alcohol) was obtained from the baseline questionnaire. In addition, patients completed the 12-item European Heart failure Self-care Behavior Scale (EHFScBS-12),[11] with a higher score (range 12–60) indicating worse self-care behaviour.

Psychological characteristics

In the baseline questionnaire, patients were asked if they currently use psychotropic medication or are treated for psychological problems. The *distressed (Type D) personality* was measured using the 14-item Type D Scale.[12] Type D personality is defined by a score of ≥10 on both 7-item subscales: negative affectivity and social inhibition.[12] *Anxiety and depressive symptoms* were assessed using the 7-item Generalized Anxiety Disorder scale and the 9-item Patient Health Questionnaire, respectively.[13,14] For both scales, a cut-off of ≥10 points was used to classify patients with moderate to severe anxiety or depression.[13,14] The 8-item brief Illness Perception Questionnaire measured *patients' beliefs about their heart failure*.[15] An overall score ranging from 0 to 80 was computed with a higher score reflecting a more threatening view of heart failure. *Patients' concerns regarding the ICD giving a shock* were assessed using the 8-item ICD Patients Concerns questionnaire.[16] The total score ranges from 0 to 32, with a higher score indicating a higher level of concerns.

Sample size calculation

Originally, we expected a trivial between-group effect (Cohen's $d = 0.20$) leading to a required sample size of 900 patients.[8] However, during our recruitment period, two randomized trials were published showing a positive effect of RPM on heart failure-specific health status.[6,17] In order to detect a clinically meaningful difference of ≥5 points in KCCQ scores with 85% power and an alpha of 0.05 (two-sided test), assuming a mean KCCQ score of 60 in the In-Clinic group and a standard deviation of 21 in both groups, 600 patients would be sufficient (i.e. 300 patients per group).

Statistical analyses

Data were analysed by the first two authors (I.T. and H.V.) in consultation with a statistician from the University Medical Centre Utrecht. H.V. and I.T. had full access to all the data in the study and take responsibility for its integrity and data analysis. Patient characteristics are reported as frequencies with percentages [*N* (%)] for categorical variables, and medians with interquartile ranges [median (IQR)] for continuous variables, as our data were not normally distributed. The Pearson's χ^2 tests (or the Fisher's exact tests if appropriate) and Mann–Whitney *U* tests were used to detect group differences in categorical and continuous variables, respectively.

We compared KCCQ and FPAS total and subscale follow-up scores between randomization groups using linear regression models with unstructured residual (i.e. generalized estimating equation type) covariance matrices to avoid unnecessary elimination of patients with missing values during follow-up. The model included treatment (RPM), all follow-up assessments over time (Time), baseline KCCQ or FPAS scores, and RPM-by-Time interaction. Baseline corrections were performed in part to control for potential imbalances between the groups, and in part to optimize power. Considering the number of crossovers in both arms, we decided to perform additional per-protocol analyses excluding all crossovers.

Finally, we performed a series of exploratory subgroup analyses to examine whether the effect of RPM on health status and ICD acceptance over time was different for patients with different nationalities, men vs. women, younger (<60) vs. older patients, patients with vs. without a partner, lower vs. higher educated patients, ICD vs. CRT-D patients, patients with a primary vs. secondary ICD indication, NYHA II vs. NYHA III patients, patient with any ICD shock(s)—appropriate or inappropriate—vs. patients without shocks during follow-up, patients with vs. patients without any cardiac-related visits to the emergency room, patients with vs. patients without any cardiac-related hospital admissions, patients with vs. without comorbidities, anxious vs. non-anxious patients, and depressive vs. non-depressive patients. For the RPM group, we also examined whether compliance with (daily) weight and (weekly) blood pressure measurements influenced health status and ICD acceptance.

All tests were two-tailed, and a *P*-value ≤0.05 was chosen to indicate statistical significance. Analyses were performed with SPSS 22.0 (SPSS Inc., Chicago, IL, USA), and SAS 9.4 (SAS Institute, Cary, NC, USA).

Results

Sample characteristics

Figure 1 displays the REMOTE-CIED enrolment, allocation, and follow-up numbers. The final study sample for the intention-to-treat analysis consisted of 595 patients. Baseline characteristics of the total sample, and stratified by randomization group are shown in *Table 1*.

Impact of remote patient monitoring on heart failure-specific health status

Table 2 and *Figure 2* show the effects of RPM on the KCCQ total score over 24-month follow-up. We observed no significant influence of RPM on patients' health status, and the course of health status over time was not different between groups. There was a significant effect of time ($P < 0.001$), indicating a health status decrease from 3 to 24 months post-implantation that is probably caused by heart failure progression. As expected, the baseline health

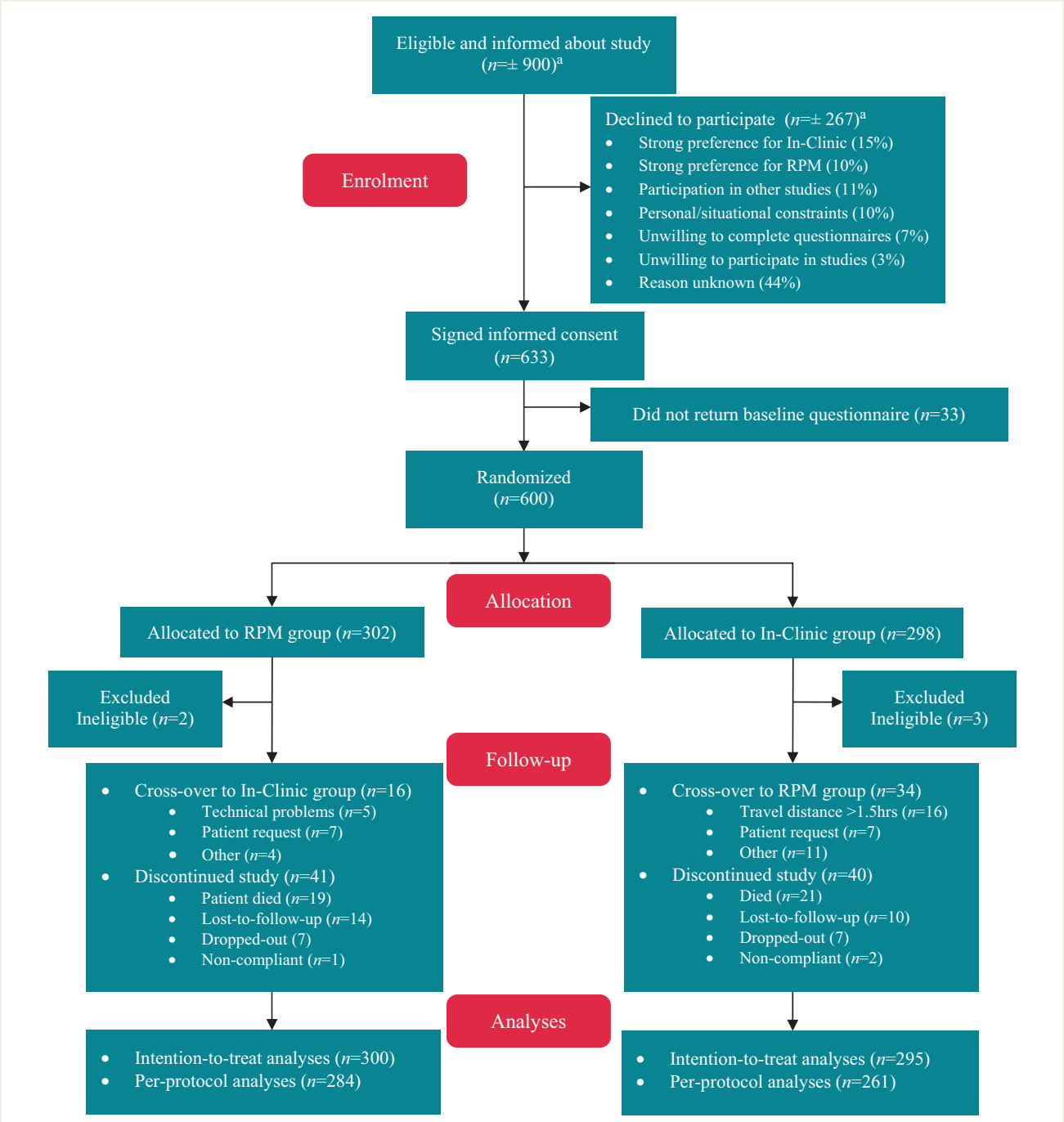


Figure 1 A flowchart of participants' enrolment, allocation, and follow-up. [a]Estimated numbers based on completed screening- and enrolment logs from 22 participating sites. RPM, remote patient monitoring.

status was significantly associated with health status during follow-up ($P < 0.001$). We repeated these analyses for all KCCQ subscales, yielding similar results (*Figure 2*). Per-protocol analyses produced comparable results. Finally, subgroup analyses did not show significant subgroup differences in the effect of RPM on health status over time (all *Ps* > 0.05).

Impact of remote patient monitoring on implantable cardioverter-defibrillator acceptance

In *Table 2* and *Figure 3*, the effects of RPM on the FPAS total score over the 24 months' follow-up period are displayed. We found no

Table 1 Baseline characteristics of the total sample, and stratified by randomization group[a]

	Total sample (*N* = 595)	RPM group (*N* = 300)	In-Clinic group (*N* = 295)
Socio-demographic characteristics			
Age (years)	65 (59–73)	66 (58–73)	65 (59–73)
Female	123 (21)	67 (22)	56 (19)
Having a partner	438 (74)	222 (74)	216 (73)
High educational level (tertiary or higher)	359 (60)	168 (56)	191 (65)
Employed	123 (21)	60 (20)	63 (21)
Device/heart failure characteristics			
Type of ICD			
Single chamber	256 (43)	126 (42)	130 (44)
Dual chamber	109 (18)	60 (20)	49 (17)
Biventricular	230 (39)	114 (38)	116 (39)
Secondary prophylactic ICD indication	86 (15)	42 (14)	44 (15)
Ischaemic heart failure aetiology	336 (57)	158 (53)	178 (60)
QRS duration (ms)	120 (102–156)	118 (102–157)	124 (102–154)
Ejection fraction (≤3 months pre-implantation)	27 (22–31)	27 (21–31)	28 (22–31)
New York Heart Association Class III	197 (33)	98 (33)	99 (34)
Cardiac medication			
ACE inhibitors + ARBs	525 (88)	267 (89)	258 (88)
Beta-blockers (excluding sotalol)	497 (84)	247 (82)	250 (85)
Diuretics	431 (72)	217 (72)	214 (73)
Aldosterone antagonists	370 (62)	177 (59)	193 (65)
Antiarrhythmic medication (including sotalol)	98 (17)	49 (16)	49 (17)
Comorbidities			
Diabetes mellitus	192 (32)	90 (30)	102 (35)
Chronic obstructive pulmonary disease	84 (14)	45 (15)	39 (13)
Renal disease (GFR <60 mL/min/1.73 m^2)	148 (25)	75 (25)	73 (25)
Atrial fibrillation	168 (28)	85 (28)	83 (28)
Hypertension	347 (58)	171 (57)	176 (60)
Anaemia (HB <8.6/<7.4 mmol/L—males/females)	63 (11)	29 (10)	34 (12)
Lifestyle			
Body mass index >30	134 (23)	61 (20)	73 (25)
Smoking	94 (16)	48 (16)	46 (16)
Use of alcohol	284 (48)	114 (48)	140 (48)
Self-care behaviour[b]	25 (20–32)	24 (20–32)	25 (19–32)
Psychological status			
Type D personality[c]	119 (20)	61 (21)	58 (20)
Anxiety[d]	91 (16)	37 (13)	54 (19)
Depression[e]	107 (19)	48 (16)	59 (21)
Illness perceptions[f]	41 (33–47)	39 (31–47)	43 (34–48)
ICD concerns[g]	9 (3–17)	9 (3–15)	9 (3–17)
Treatment			
Psychotropic medication[h]	123 (21)	62 (21)	62 (21)
Psychological treatment	28 (5)	12 (4)	16 (6)
Cardiac rehabilitation	123 (21)	58 (20)	65 (23)
Satisfaction with cardiovascular care	90 (85–100)	90 (85–100)	90 (80–100)
Travel time to hospital (min)	30 (20–45)	30 (20–45)	30 (20–45)

Results are presented as *N* (%) for categorical variables, and as median (interquartile range) for continuous variables. The differences between the groups were significant for educational level ($P = 0.03$), anxiety ($P = 0.05$), illness perceptions ($P = 0.004$), and satisfaction with cardiovascular care ($P = 0.04$).

ACE, angiotensin-converting enzyme; ARBs, angiotensin receptor blockers; GFR, glomerular filtration rate; HB, haemoglobin; ICD, implantable cardioverter-defibrillator; RPM, remote patient monitoring.

[a]Intention-to-treat.

[b]Self-care behaviour: total score European Heart Failure Self Care Behaviour Scale (range 12–60, higher score indicates worse self-care behaviour).

[c]Type D (distressed) personality: score of >10 on both negative affectivity and social inhibition subscales of Type D scale.

[d]Anxiety: score >10 on 7-item Generalized Anxiety Disorder Scale.

[e]Depression: score >10 on 9-item Patient Health Questionnaire.

[f]Illness perceptions: total score brief Illness Perceptions Questionnaire (range 0–80, higher score indicates more threatening view of heart failure).

[g]ICD concerns: total score on ICD concerns scale (range 0–32, higher score indicates higher level of concerns).

[h]Psychotropic medication: antidepressants, anxiolytics, and/or hypnotics.

Table 2 Effects of RPM on health status and ICD acceptance over 24 months' follow-up

	KCCQ total		FPAS total	
	Beta (95% CI)	***P*-value**	**Beta (95% CI)**	***P*-value**
RPM	−2.87 (−6.02 to 0.28)	0.29	1.23 (−0.61 to 3.07)	0.68
Time[a] (months)		**<0.001**		0.60
6	−2.39 (−4.47 to −0.31)		1.38 (−0.01 to 2.74)	
12	−5.65 (−7.94 to −3.35)		0.81 (−0.68 to 2.29)	
24	−10.05 (−13.17 to −6.91)		0.46 (−1.22 to 2.14)	
RPM × time[a] (months)		0.34		0.23
RPM × 6	1.58 (−1.41 to 4.46)		−1.62 (−3.56 to 0.33)	
RPM × 12	2.67 (−0.57 to 5.90)		−1.70 (−3.79 to 0.40)	
RPM × 24	0.69 (−3.71 to 5.09)		−0.40 (−2.76 to 1.97)	
Baseline KCCQ/FPAS score	0.59 (0.53 to 0.64)	**<0.001**	0.54 (0.48 to 0.59)	**<0.001**

Type III tests of fixed effects *P*-values are reported. Significant results ($P < 0.05$) are printed in bold.
CI, confidence interval; FPAS, Florida Patient Acceptance Survey; ICD, implantable cardioverter-defibrillator; KCCQ, Kansas City Cardiomyopathy Questionnaire; RPM, remote patient monitoring.
[a]Reference category for time is 3 months.

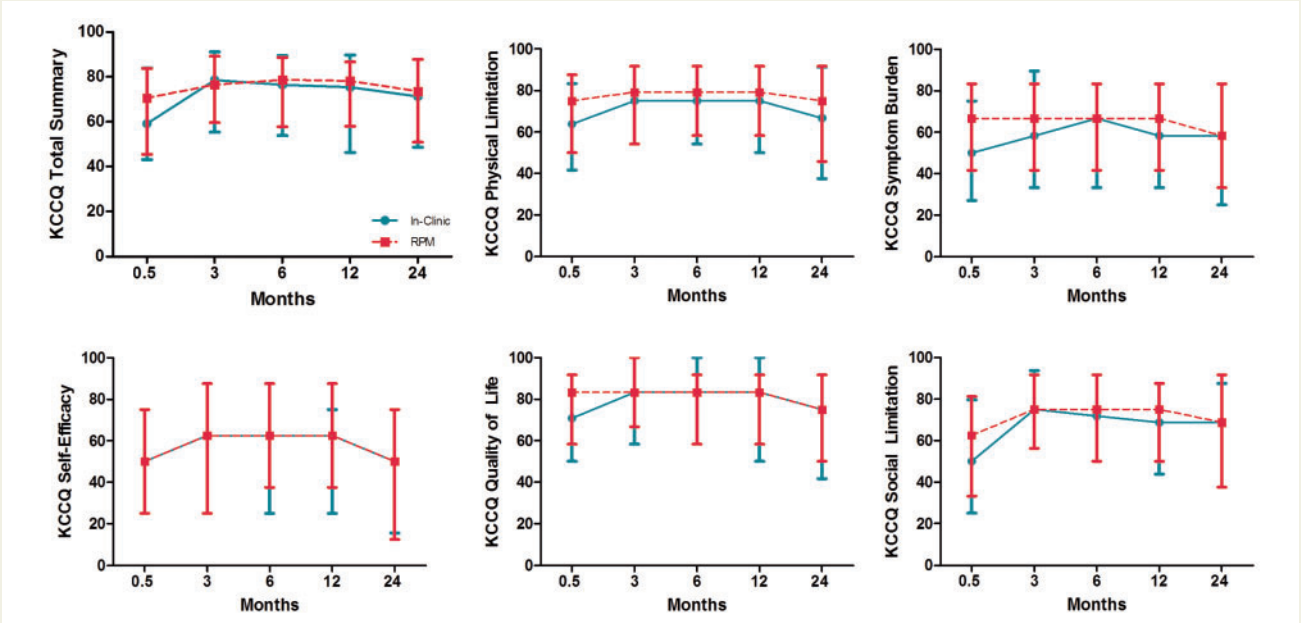


Figure 2 The KCCQ median scores (± interquartile range) over time. KCCQ, Kansas City Cardiomyopathy Questionnaire.

significant influence of RPM or time on patients' level of ICD acceptance, and the course of ICD acceptance over time did not differ between groups. Only the baseline FPAS score was significantly associated with ICD acceptance during follow-up ($P < 0.001$). Repeating these analyses for all FPAS subscales separately led to similar findings (*Figure 3*). Again, per-protocol analyses yielded comparable results.

Subgroup analyses indicated a difference in the effect of RPM on ICD acceptance over time between patients with a primary and secondary prophylactic ICD ($P = 0.006$). Between 3 and 6 months after implantation, ICD acceptance improved for In-Clinic patients with a secondary prophylactic ICD [beta −6.41 (95% confidence interval = −10.46 to −2.35), $P = 0.001$], while remaining stable in the other groups. This improvement appeared to be temporary, however, as the level of ICD acceptance in this group became non-significant again at 12 months. The largest observed difference in means between groups was 3.3 points. No other subgroup differences were observed (all *P*s > 0.05).

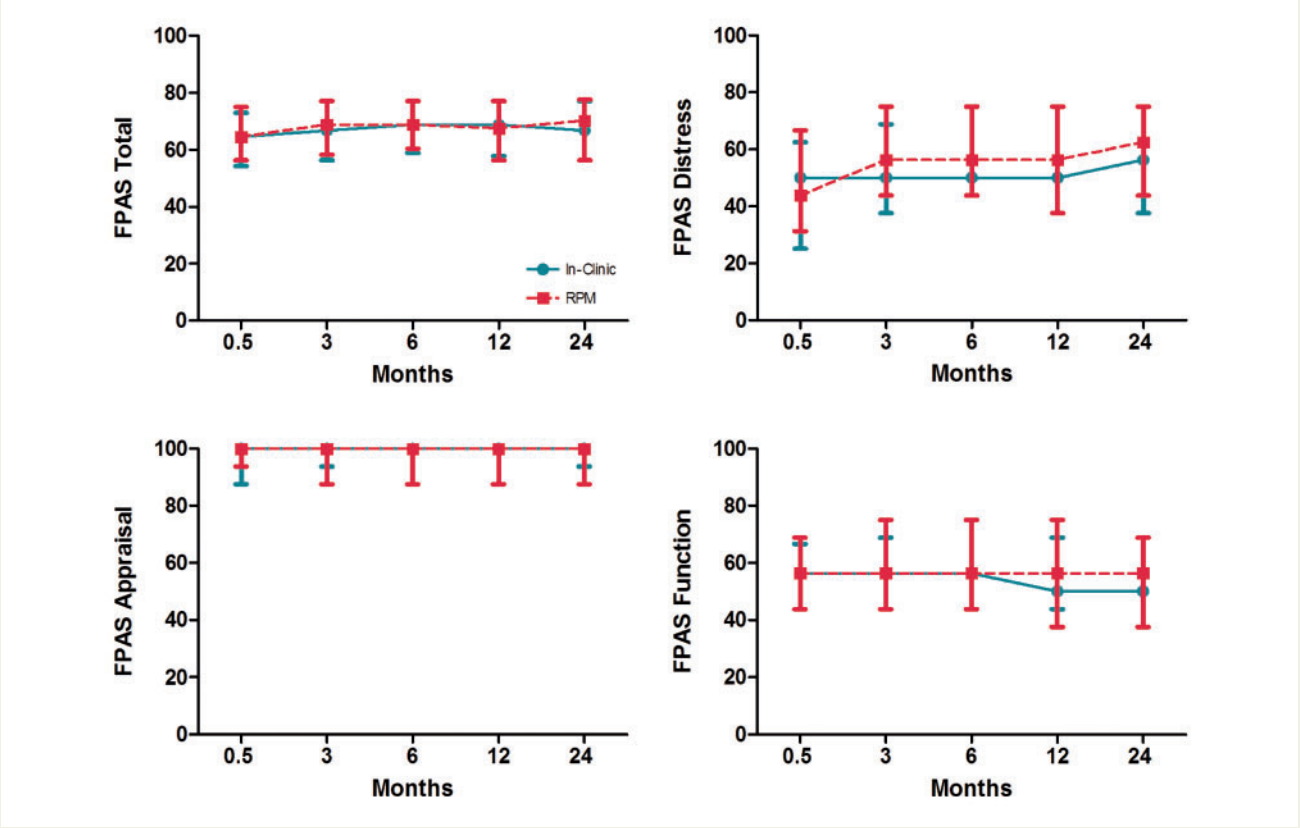


Figure 3 The FPAS median scores (± interquartile range) over time. FPAS, Florida Patient Acceptance Survey.

Discussion

Over the past years, the European Society of Cardiology and the American Heart Association have emphasized the incorporation of patient-reported outcomes to assess the quality of cardiovascular care.[7,18] Patient-centred measures provide important insights into the effect of a disease and treatments on patients' daily lives, and are essential for shared decision-making and patient-centred care. Large clinical trials have already shown that RPM is safe and effective in ICD patients,[2,3] yet patient-reported outcomes have received only little attention so far. The REMOTE-CIED study is the first randomized trial primarily designed to examine the effect of RPM on patient-reported outcomes in ICD patients. Intention-to-treat and per-protocol analyses showed that patients receiving RPM do not report significantly different heart failure-specific health status and ICD acceptance scores compared with patients on regular in-clinic ICD follow-up during the first 2 years post-implantation. These results are in line with most previous randomized trials examining health status as a secondary endpoint.[4] The non-significant and clinically irrelevant group differences found in the current and previous studies suggest that RPM is not different to in-clinic follow-up alone with respect to patient-reported health status, supporting its use in clinical practice. To our knowledge, this is the first trial that explored whether the effect of RPM on patient-reported outcomes differs for specific subgroups of patients. We only found that ICD acceptance scores were significantly yet slightly higher in secondary prophylactic ICD patients in the In-Clinic group at 6-month follow-up. It is important to emphasize that the subgroup analyses were of explorative nature and most probably lacked sufficient power, for instance only 15% of the patients had a secondary prophylactic ICD indication. Nevertheless, the analyses were valuable in ruling out the existence of very large subgroup effects, and could provide directions for further research.

Patients in the current study received an RPM system including a weight scale and blood pressure cuffs for additional heart failure monitoring. A recent ICD cohort study showed that the addition of weight and blood pressure transmissions was not associated with lower risk of mortality or hospitalizations.[19] The REMOTE-CIED study was not designed to differentiate between the effects of monitoring ICD vs. heart failure data, yet compliance with weight and blood pressure measurements did not influence health status and ICD acceptance scores. Accordingly, randomized trials on non-invasive telemonitoring of heart failure data found no or only small (subscale) differences in health status scores between groups.[20] Trials on heart failure telemonitoring with structured telephone support including e.g. clinical consultation or self-management education yielded more promising results.[20] Maybe RPM of heart failure data may be beneficial only when it is used for tailored therapy optimization and with more sophisticated alert algorithms predicting heart failure events.[20]

The REMOTE-CIED study protocol did not include standard procedures on in-clinic follow-up schedules and handling of RPM data, reflecting real-world daily practice and resulting in high ecological validity. However, pooled data-analyses of previous RPM trials indicate that daily verification of transmitted data and predefined response mechanisms to RPM-alerts may be essential in producing maximal benefit from this technology.[3] The only randomized trial (IN-TIME) that showed a significant positive effect of RPM on mortality used a central monitoring unit that reviewed all RPM-data on a daily basis and transmitted any predefined medical events and safety notifications to the investigational clinics.[21] The integration of such a workflow in clinical practice remains challenging, especially when centres use RPM systems from various manufacturers and face inadequate reimbursement. Future studies are warranted investigating the possibilities and effects of risk-stratification algorithms that automate the identification of actionable events and of delivering RPM-data directly to patients allowing them to respond promptly when properly educated.[22]

Limitations

Other potential limitations should be kept in mind when interpreting the results of this study. First, the relatively high number of dropouts and crossovers has negatively affected the statistical power of our analyses. However, linear modelling allowed patients with one or more missing outcome values to remain in the analyses, and correcting for baseline KCCQ and FPAS scores may have led to a substantial increase in power. Also, additional per-protocol analyses excluding all crossovers did not yield other conclusions on the effects of RPM. Second, our study sample was relatively young with a median age of 65 years and the majority (67%) of patients suffered from mild NYHA Class II heart failure symptoms. Hence, our results may not be generalizable to older patients with more severe heart failure. Future RPM trials with longer follow-up periods are needed to see whether RPM is particularly beneficial when patients approach their end of life. Third, data on the number and character of RPM alerts were not collected. Finally, the LATITUDE® RPM system from Boston Scientific was used in our study, and results may be not generalizable to other manufacturers as differences exist between the various available systems.[22] Yet, our health status results were similar to those of previous trials using other RPM systems.[4]

Conclusion

In conclusion, the REMOTE-CIED study results show that patient-reported health status and ICD acceptance do not differ between patients on RPM and patients receiving in-clinic check-ups alone in the first 2 years after ICD implantation. Previous analyses of qualitative REMOTE-CIED data showed that patients in the RPM group were highly satisfied with the RPM system (median score of 9 out of 10), yet a subgroup of patients (19%) preferred in-clinic follow-up.[23] Future RPM studies considering both physicians' and patients' needs and preferences are warranted to find ways to optimize (i) the handling of ICD and heart failure data and (ii) patients' active involvement in managing their health. This may improve clinical and patient-reported outcomes and lower costs.

Acknowledgements

The authors acknowledge Nicolaas P.A. Zuithoff from Julius Support for Research and Trials, University Medical Centre Utrecht, for his statistical consultation.

Funding

This work was supported by a research grant from Boston Scientific to support independent investigator-initiated research (http://www.bostonscientific.com/en-US/investigator-sponsored-research.html).

Conflict of interest: none declared.

References

1. Slotwiner D, Varma N, Akar JG, Annas G, Beardsall M, Fogel RI *et al.* HRS Expert Consensus Statement on remote interrogation and monitoring for cardiovascular implantable electronic devices. *Heart Rhythm* 2015;**12**:69–100.
2. Klersy C, Boriani G, De Silvestri A, Mairesse GH, Braunschweig F, Scotti V *et al.* Effect of telemonitoring of cardiac implantable electronic devices on healthcare utilization: a meta-analysis of randomized controlled trials in patients with heart failure. *Eur J Heart Fail* 2016;**18**:195–204.
3. Parthiban N, Esterman A, Mahajan R, Twomey DJ, Pathak RK, Lau DH *et al.* Remote monitoring of implantable cardioverter-defibrillators: a systematic review and meta-analysis of clinical outcomes. *J Am Coll Cardiol* 2015;**65**:2591–600.
4. Timmermans I, Meine M, Zitron E, Widdershoven J, Kimman G, Prevot S *et al.* The patient perspective on remote monitoring of patients with an implantable cardioverter defibrillator: narrative review and future directions. *Pacing Clin Electrophysiol* 2017;**40**:826–33.
5. Al-Khatib SM, Piccini JP, Knight D, Stewart M, Clapp-Channing N, Sanders GD. Remote monitoring of implantable cardioverter defibrillators versus quarterly device interrogations in clinic: results from a randomized pilot clinical trial. *J Cardiovasc Electrophysiol* 2010;**21**:545–50.
6. Landolina M, Perego GB, Lunati M, Curnis A, Guenzati G, Vicentini A *et al.* Remote monitoring reduces healthcare use and improves quality of care in heart failure patients with implantable defibrillators: the evolution of management strategies of heart failure patients with implantable defibrillators (EVOLVO) study. *Circulation* 2012;**125**:2985–92.
7. Rumsfeld JS, Alexander KP, Goff DC Jr, Graham MM, Ho PM, Masoudi FA *et al.* Cardiovascular health: the importance of measuring patient-reported health status: a scientific statement from the American Heart Association. *Circulation* 2013;**127**:2233–49.
8. Versteeg H, Pedersen SS, Mastenbroek MH, Redekop WK, Schwab JO, Mabo P *et al.* Patient perspective on remote monitoring of cardiovascular implantable electronic devices: rationale and design of the REMOTE-CIED study. *Neth Heart J* 2014;**22**:423–8.
9. Green CP, Porter CB, Bresnahan DR, Spertus JA. Development and evaluation of the Kansas City Cardiomyopathy Questionnaire: a new health status measure for heart failure. *J Am Coll Cardiol* 2000;**35**:1245–55.
10. Versteeg H, Starrenburg A, Denollet J, Palen J, Sears SF, Pedersen SS. Monitoring device acceptance in implantable cardioverter defibrillator patients using the Florida Patient Acceptance Survey. *Pacing Clin Electrophysiol* 2012;**35**:283–93.
11. Jaarsma T, Arestedt KF, Martensson J, Dracup K, Stromberg A. The European Heart Failure Self-care Behaviour scale revised into a nine-item scale (EHFScB-9): a reliable and valid international instrument. *Eur J Heart Fail* 2009;**11**:99–105.
12. Denollet J. DS14: standard assessment of negative affectivity, social inhibition, and Type D personality. *Psychosom Med* 2005;**67**:89–97.
13. Kroenke K, Spitzer RL, Williams J. The PHQ-9—validity of a brief depression severity measure. *J Gen Intern Med* 2001;**16**:606–13.
14. Spitzer RL, Kroenke K, Williams JB, Lowe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med* 2006;**166**:1092–7.
15. Broadbent E, Petrie KJ, Main J, Weinman J. The brief illness perception questionnaire. *J Psychosom Res* 2006;**60**:631–7.
16. Frizelle DJ, Lewin B, Kaye G, Moniz-Cook ED. Development of a measure of the concerns held by people with implanted cardioverter defibrillators: the ICDC. *Br J Health Psychol* 2006;**11**:293–301.
17. Madigan E, Schmotzer BJ, Struk CJ, DiCarlo CM, Kikano G, Pina IL *et al.* Home health care with telemonitoring improves health status for older adults with heart failure. *Home Health Care Serv Q* 2013;**32**:57–74.
18. Anker SD, Agewall S, Borggrefe M, Calvert M, Jaime Caro J, Cowie MR *et al.* The importance of patient-reported outcomes: a call for their comprehensive integration in cardiovascular clinical trials. *Eur Heart J* 2014;**35**:2001–9.
19. Al-Chekakie MO, Bao H, Jones PW, Stein KM, Marzec L, Varosy PD *et al.* Addition of blood pressure and weight transmissions to standard remote monitoring of

implantable defibrillators and its association with mortality and rehospitalization. *Circ Cardiovasc Qual Outcomes* 2017;**10**. doi:10.1161/CIRCOUTCOMES.116.003087.
20. Inglis SC, Clark RA, Dierckx R, Prieto-Merino D, Cleland JG. Structured telephone support or non-invasive telemonitoring for patients with heart failure. *Heart* 2017;**103**:255–7.
21. Hindricks G, Taborsky M, Glikson M, Heinrich U, Schumacher B, Katz A *et al*. Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): a randomised controlled trial. *Lancet* 2014;**389**:583–90.
22. Ono M, Varma N. Remote monitoring to Improve long-term prognosis in heart failure patients with implantable cardioverter-defibrillators. *Expert Rev Med Devices* 2017;**14**:335–42.
23. Timmermans I, Meine M, Szendey I, Aring J, Romero Roldán J, van Erven L *et al*. Remote monitoring of implantable cardioverter defibrillators: patient experiences and preferences for follow-up. *Pacing Clin Electrophysiol* 2019;**42**:120–9.

EP CASE EXPRESS

doi:10.1093/europace/euz124
Online publish-ahead-of-print 3 June 2019

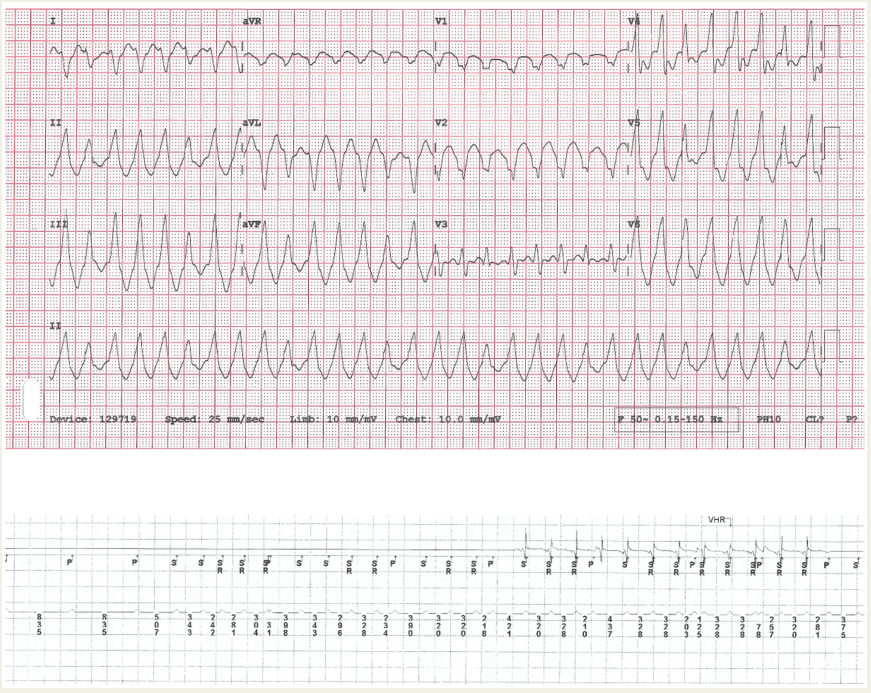
A case of wide complex tachycardia with regular fusion beats

Debjit Chatterjee*

Cardiology Department, Medway Maritime Hospital, Windmill Road, Gillingham, ME7 5NY, UK

* Corresponding author. *E-mail address*: debjit.chatterjee@hotmail.com

A 90-year-old man was admitted with palpitation and chest tightness for 2 h. He was known to have persistent atrial fibrillation (AF) and had a single chamber pacemaker (VVIR) implantation 9 years ago. His echocardiogram, about a year ago, showed moderate left ventricular dysfunction and moderate aortic stenosis.



This was ventricular tachycardia (VT) at a rate of 187 b.p.m. Every 4th beat was a fusion of pacing beat and intrinsic ventricular rhythm. He was known to have persistent AF and hence any regular supraventricular rhythm was very unlikely. Rarely in presence of AF, VT can show evidence of fusion but in that case fusion beats will be irregular.

After interrogation of the pacemaker we saw, the tachycardia cycle length was less than ventricular refractory period (which in this case was 330 ms), so the pacemaker went into noise reversion mode. Hence sensing during refractory period was restarting another cycle of refractory period. This resulted in asynchronous pacing and pacemaker was delivering a pacing stimulus 857 ms from the last sensed event here (lower rate of 70 b.p.m.) and every 4th beat was a fusion of pacing beat and intrinsic VT beat.

This is an interesting case of wide complex tachycardia with regular fusion beats. Fusion beats were product of pacing stimuli and intrinsic rhythm of VT. In spite of tachycardia, pacing stimuli were delivered because of noise reversion mode.

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