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Remote Monitoring of Implantable Cardioverter-Defibrillators

A Systematic Review and Meta-Analysis of Clinical Outcomes

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ABSTRACT

BACKGROUND Remote monitoring (RM) of implantable cardioverter-defibrillators (ICD) is an established technology integrated into clinical practice. One recent randomized controlled trial (RCT) and several large device database studies have demonstrated a powerful survival advantage for ICD patients undergoing RM compared with those receiving conventional in-office (IO) follow-up.

OBJECTIVES This study sought to conduct a systematic published data review and meta-analysis of RCTs comparing RM with IO follow-up.

METHODS Electronic databases and reference lists were searched for RCTs reporting clinical outcomes in ICD patients who did or did not undergo RM. Data were extracted from 9 RCTs, including 6,469 patients, 3,496 of whom were randomized to RM and 2,973 to IO follow-up.

RESULTS In the RCT setting, RM demonstrated clinical outcomes comparable with office follow-up in terms of all-cause mortality (odds ratio [OR]: 0.83; $p = 0.285$), cardiovascular mortality (OR: 0.66; $p = 0.103$), and hospitalization (OR: 0.83; $p = 0.196$). However, a reduction in all-cause mortality was noted in the 3 trials using home monitoring (OR: 0.65; $p = 0.021$) with daily verification of transmission. Although the odds of receiving any ICD shock were similar in RM and IO patients (OR: 1.05; $p = 0.86$), the odds of inappropriate shock were reduced in RM patients (OR: 0.55; $p = 0.002$).

CONCLUSIONS Meta-analysis of RCTs demonstrates that RM and IO follow-up showed comparable overall outcomes related to patient safety and survival, with a potential survival benefit in RCTs using daily transmission verification. RM benefits include more rapid clinical event detection and a reduction in inappropriate shocks. (J Am Coll Cardiol 2015;65:2591–600) © 2015 by the American College of Cardiology Foundation.

Implantable cardioverter-defibrillators (ICD) have become the standard of care therapy for primary and secondary prevention of sudden cardiac death (1). Conventionally, in-office (IO) follow-up on at least an every 3- to 6-month basis has been recommended for ICD interrogation, review of device data, and programmed parameters, as well as assessment of system function (2–4).

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ABBREVIATIONS AND ACRONYMS

CI = confidence interval

CRT = cardiac resynchronization therapy

CV = cardiovascular

HR = hazard ratio

ICD = implantable cardioverter-defibrillator

IO = in-office

OR = odds ratio

RCT = randomized controlled trial

RM = remote monitoring

Remote monitoring (RM) of ICD devices has been proposed as an alternative strategy to reduce the need for routine device follow-up visits while providing continuous surveillance and immediate problem notification (5). With this technology, ICDs can be interrogated automatically using wireless data transfer to the remote monitor. Patient diagnostic information is then transmitted to a central server that may be accessed by treating clinicians through an Internet-based interface or provide automatically generated clinician alerts (6).

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Recently, clinical data presented in the IN-TIME (Influence of Home Monitoring on Mortality and Morbidity in Heart Failure Patients with Impaired Left Ventricular Function) trial suggested that RM could potentially lead to a decisive survival advantage in ICD patients (7). This powerful survival benefit is supported by data from large-scale national device registries, showing that RM may lead to a significant survival advantage over patients not using RM (8–10). The ALTITUDE study, for example, followed a nonrandomized cohort of 69,556 patients implanted with ICD or cardiac resynchronization therapy (CRT) devices with defibrillator capability (CRT-D) (Boston Scientific Corporation, Natick, Massachusetts), and identified a striking 50% reduction in mortality (ICD hazard ratio [HR]: 0.56; CRT-D HR: 0.45; $p < 0.0001$) in remote networked patients, compared with nonnetworked device recipients (10). Similar mortality reductions with RM use have been seen in 2 other national device databases collectively enrolling more than 100,000 ICD patients (8,9).

Until recently, there has been insufficient randomized controlled trial (RCT) evidence to evaluate the overall impact of RM on clinical outcomes in ICD patients. In the current study, we conducted a systematic review and meta-analysis of RCTs comparing clinical outcomes in ICD patients undergoing RM with those receiving conventional IO follow-up. We specifically sought to evaluate the impact of RM on all-cause and cardiovascular (CV) mortality, hospitalization, unscheduled clinic visits, atrial arrhythmia detection, device shocks, and the time taken to clinical decision or clinical event detection.

METHODS

We conducted a systematic search of PubMed, Embase, Scopus, Web of Science, and the Cochrane databases to identify RCTs comparing RM with conventional IO follow-up in ICD patients. The search was conducted with the assistance of a research librarian, and the details of the search grid are outlined in the Online Appendix. Databases were last accessed on July 30, 2014 and results were updated after the publication of the IN-TIME trial on August 16, 2014.

Two authors (A.N.G., N.P.) reviewed titles and abstracts retrieved from our search strategy and selected RCTs reporting on clinical outcomes of home monitoring (treatment) of ICDs compared with conventional IO follow-up (control). RCTs were included if results were published in peer-reviewed journal articles or as published abstracts with extractable data. Studies were excluded if they provided outcome data only from nonrandomized cohorts or case series, evaluated ICDs but not RM, or evaluated RM in contexts other than ICD patients. **Figure 1** shows the number and reasons for exclusion of publications extracted from the search strategy. For included trials, all-cause mortality, hospitalizations, unscheduled visits, shock delivery, and atrial fibrillation detections were extracted by 2 authors (N.P., A.N.G.). Study quality was assessed on the basis of adherence to the Consolidated Standards of Reporting Trials (CONSORT) statement.

STATISTICAL ANALYSIS. Statistical analysis was performed with Comprehensive Meta-Analysis, version 2 (Biostat, Inc., Englewood, New Jersey). Odds ratios (OR) were used for dichotomous variables. The I^2 statistic was used as a measure of variability in observed effect estimates attributable to between-study heterogeneity (11). For variables exhibiting mild heterogeneity ($I^2 \leq 25\%$), pooled estimates were derived with fixed-effects models. For variables exhibiting more than moderate heterogeneity ($I^2 > 25\%$), pooled estimates were derived with random-effects models, according to the method of DerSimonian and Laird (12). For time to detection of clinical event/clinical decision data, variances were imputed from interquartile ranges and 95% confidence intervals (CIs) according to the method of Deeks et al. (13).

RESULTS

A total of 4,376 citations were retrieved after exclusion of duplicates, then 3,491 citations were excluded after initial screening of abstracts and titles on general criteria, as related to topics other than home monitoring of ICDs (**Figure 1**). Of 885 citations selected for a secondary review, we identified 20 journal articles referencing 8 published RCTs. An additional completed RCT, the EVATEL