Impact of remote monitoring on clinical events and associated health care utilization: A nationwide assessment ⓔ

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BACKGROUND Remote monitoring (RM) of cardiac implantable electronic devices (CIEDs) improves patient survival. However, whether RM reduces health care utilization is unknown.

OBJECTIVE The purpose of this study was to determine whether RM was associated with reduced hospitalization and costs in clinical practice.

METHODS We conducted a nationwide cohort study using the Truven Health Analytics MarketScan database. Patients implanted with a CIED between March 31, 2009, and April 1, 2012, were included. All-cause hospitalization events were compared between those using RM and those not using RM by using Cox proportional hazards methods with Andersen-Gill extension and propensity scoring. We also compared health care costs (payments >30 days after CIED implantation).

RESULTS Overall, there were 92,566 patients (mean age 72 ± 13 years; 63% men) with a mean follow-up of 19 ± 12 months, including 54,520 (59%) pacemaker, 27,816 (30%) implantable cardioverter-defibrillator, and 10,230 (11%) cardiac resynchronization therapy patients. Only 37% of patients (34,259) used RM.

Patients with RM had Charlson Comorbidity Index values similar to those not using RM but had lower adjusted risk of all-cause hospitalization (adjusted hazard ratio 0.82; 95% confidence interval 0.80–0.84; P < .001) and shorter mean length of hospitalization (5.3 days vs 8.1 days; P < .001) during follow-up. RM was associated with a 30% reduction in hospitalization costs ($8720 mean cost per patient-year vs $12,423 mean cost per patient-year). For every 100,000 patient-years of follow-up, RM was associated with 9810 fewer hospitalizations, 119,000 fewer days in hospital, and $370,270,000 lower hospital payments.

CONCLUSION RM is associated with reductions in hospitalization and health care utilization. Since only about a third of CIED patients routinely use RM, this represents a major opportunity for quality improvement.

KEYWORDS Remote monitoring; Hospitalization; Health care utilization; Cost; Comparative effectiveness; ICD; CRT; Pacemakers

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Introduction

The current health care environment in the United States emphasizes improvement in patient outcomes together with cost reduction and more efficient care. Information and telecommunication technologies have been promulgated as important tools to achieve these goals.[1,2] Overall, hospital admissions of patients with cardiovascular diseases such as heart failure (HF) and atrial fibrillation (AF) are potent drivers of health care costs.[3,4] However, telephone-based remote management failed to improve outcomes and/or decrease readmissions in this group.[5] In contrast, results with automatic remote monitoring (RM) using cardiac implantable electronic devices (CIEDs) have been more favorable, demonstrating improved patient outcomes.[6–8] RM provides several advantages including improved efficiency of outpatient clinical care and earlier detection of device/lead malfunction and/or changes in disease status (eg, HF and arrhythmias), enabling preemptive intervention.[9,10] This potentially reduces health care utilization and costs, but data are scant. The objective of the present study was to determine whether RM is associated with a decreased risk of hospitalization and lower health care costs in US clinical practice.

Methods

Data source

We conducted a retrospective, nationwide, observational cohort study using the Truven Health Analytics MarketScan Commercial and Medicare Supplemental Claims databases

with data from April 1, 2008, through March 31, 2013. The Truven database includes integrated inpatient, outpatient, and pharmacy data from privately insured and Medicare Advantage (supplemental) patients throughout the United States, including >150 million enrollees since 1995. The database has been used in nationwide health care utilization and outcome studies,[11,12] including patients with implanted cardiac electronic devices and patients undergoing cardiac electrophysiological procedures.[13,14]

Study population

Patients implanted with a permanent pacemaker (PM), implantable cardioverter-defibrillator (ICD), or cardiac resynchronization therapy with PM or defibrillator (CRT-P and CRT-D, respectively) from any manufacturer between March 31, 2009, and April 1, 2012, were included. Patients had to be ≥21 years of age and have ≥12 months of enrollment both before and after implant. To ensure fair comparisons, we restricted our analysis to patients maintaining regular follow-up by excluding patients with no follow-up and those without a clinic visit or RM follow-up within 120 days of implant (since these patients have worse outcomes[15]). RM utilization was identified with Current Procedural Terminology version 4 codes (93294, 93295, and 93296). The study was inclusive of all types of RM, including both inductive and wireless systems. The cohort selection is shown in Figure 1. Device implant procedures, follow-up procedures, and device type were determined from claims data Current Procedural Terminology codes, as shown in Online Supplemental Table S1.

Outcomes

The primary outcome of interest in this analysis was all-cause hospitalization events and inpatient hospitalization payments occurring >30 days after device implantation. Outpatient and pharmacy payments were not evaluated as part of the present study. We prespecified the evaluation of *all-cause* hospitalization since arrhythmias and other device findings are often triggered by noncardiovascular triggers such as pneumonia. Secondary outcomes included cardiovascular hospitalizations, HF hospitalizations in patients with a previous diagnosis of HF, readmissions for HF, stroke hospitalizations in patients with a previous diagnosis of AF, and stroke hospitalizations in patients with new-onset AF within 1 year after CIED implant. *International Classification of Diseases, Ninth Revision, Clinical Modification* codes for all diagnoses and outcomes are shown in Online Supplemental Table S1 as described and validated by Quan et al[16] and Birman-Deych et al.[17]

Statistical analysis

Age, sex, and geography (state) were determined from implant event claims data. For descriptive analyses, the study population was dichotomized on RM follow-up use: those with clinic follow-up visits and RM constitute the RM group and those with only clinic visits constitute the no RM group. Characteristics of these 2 groups were compared, and data are represented as mean ± SD or median (quartiles). Diagnoses for 20 conditions were assessed using claims data from ≥12 months before CIED implant.

The primary end point for this study was hospitalization risk and payments. A Cox regression model for censored
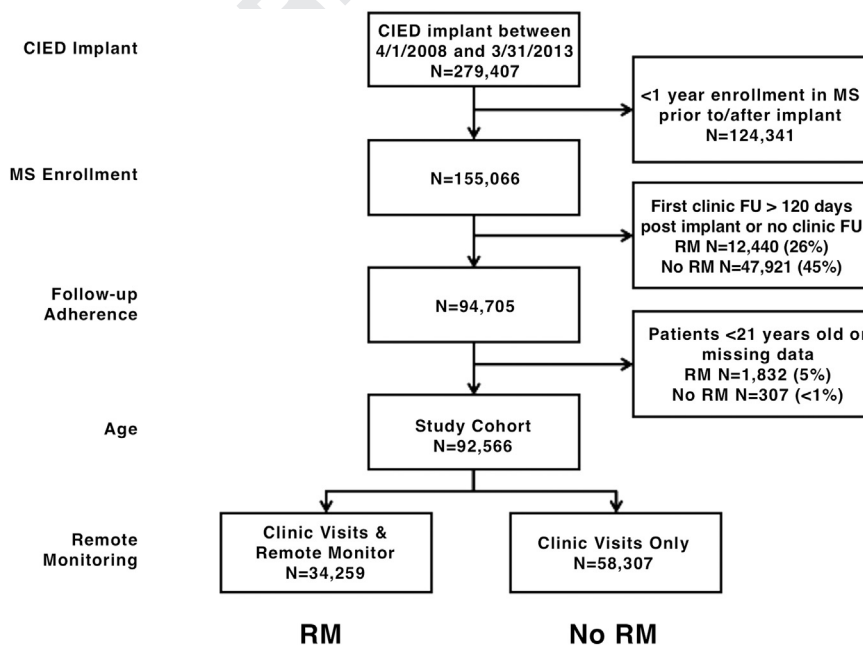
Figure 1 Flowchart of cohort selection. CIED = cardiac implantable electronic device; FU = follow-up; MS = XXXX; RM = remote monitoring.