

Post-Diagnosis Complications in Adults with Major Arrhythmia: Impact of Ambulatory Cardiac Monitoring

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ABSTRACT

Ambulatory cardiac monitoring (ACM) is recommended for the evaluation of unexplained symptoms, and its value has traditionally been assessed primarily by diagnostic yield. Far less attention has been paid to whether monitoring before the diagnosis of a major arrhythmia, such as atrial fibrillation, atrial flutter, supraventricular tachycardia, or ventricular tachycardia, influences subsequent patient outcomes. Our real-world claims analyses across commercially insured populations, Medicare beneficiaries, and disease-specific cohorts have consistently shown associations between ACM, particularly longer-duration continuous monitoring, and fewer subsequent hospitalizations, readmissions, and emergency department visits, as well as lower health care costs after arrhythmia is diagnosed. These studies evaluated health care utilization rather than clinical complications, and in one large Medicare comparison, differences in diagnostic yield did not translate into differences in subsequent outcomes. This editorial place these findings in the context of guideline-based indications for ACM and trials of atrial fibrillation screening, while examining the potential biases that could account for the observed associations. We further quantify the robustness of these associations to unmeasured confounding using E-values. The definitive question, however, remains unresolved: does earlier diagnosis of major arrhythmias, particularly atrial fibrillation, reduce the risk of heart failure, myocardial infarction, stroke, and cardiac death? Answering this question will require additional evidence from rigorous target-trial emulation and pragmatic randomized trials.

Keywords: Ambulatory electrocardiography; Atrial fibrillation; Arrhythmia; Real-world evidence; Health care utilization

DIAGNOSTIC YIELD IS NOT THE END POINT

Ambulatory cardiac monitoring is among the most frequently ordered cardiovascular tests, and the guidance that governs it is symptom driven. The 2017 ISHNE-HRS expert consensus statement and the 2017 ACC/AHA/HRS syncope guideline frame ambulatory electrocardiography as a means of correlating symptoms with rhythm, with the modality chosen by symptom frequency,^{1,2} and the 2023 ACC/AHA/ACCP/HRS atrial fibrillation (AF) guideline addresses monitoring chiefly for AF detection after cryptogenic stroke and for burden assessment.³ In each document the test is judged by what it finds. Comparative studies have accordingly focused on diagnostic yield, which rises with monitoring duration: among 287,789 Medicare beneficiaries undergoing first-time monitoring, long-term continuous monitors detected an arrhythmia in 33.8% compared with 22.7% for Holter monitors.⁴

Yield, however, is an intermediate outcome. The question that matters to patients and payers is whether making the diagnosis earlier, in an outpatient setting and before a complication, changes what follows. An estimated 13.1% of AF cases in the United States, about 0.7 million people, were undiagnosed in 2009, more than half of them at

moderate or high stroke risk,⁵ and in a Finnish cohort of 3,623 patients with a first stroke or transient ischemic attack, AF was newly diagnosed during the index hospitalization in 20.8%.⁶ For many patients the arrhythmia is discovered by its complication. Since EAST-AFNET 4 showed that early rhythm control, begun within a year of AF diagnosis, reduced a composite of cardiovascular death, stroke and hospitalization for heart failure or acute coronary syndrome,⁷ the timing of diagnosis also has a plausible therapeutic consequence.

WHAT REAL-WORLD DATA HAVE SHOWN

Over the past three years our group has examined this question in several U.S. claims populations (Table 1). Three patterns recur. First, among patients who developed an arrhythmia, those monitored before or at diagnosis used less acute care than those never monitored. In chronic obstructive pulmonary disease (COPD), an entropy-balanced comparison of 24,423 monitored and 47,162 unmonitored patients with arrhythmia found rate ratios of 0.71 (95% CI 0.69–0.72) for hospitalization, 0.63 (0.60–0.67) for 30-day readmission and 0.83 (0.82–0.85) for emergency department (ED) visits, with annual costs of \$35,504 versus \$42,403 per patient.⁸ In type 2 diabetes, patients monitored with a long-term continuous patch at arrhythmia detection had 64 versus 215 hospitalizations per 1,000 patients per month compared with matched never-monitored patients.⁹ Second, across modalities, longer continuous monitoring has been associated with higher yield, fewer repeat tests and lower downstream costs in commercially insured¹⁰ and Medicare^{4,11} populations. Third, and deserving equal weight, not every comparison favors one strategy: among 441,792 diagnosis-naïve Medicare beneficiaries receiving alert-based monitors, 90-day diagnostic yield differed across platforms but hospitalizations, ED visits, heart failure and costs did not.¹² Differences in yield do not automatically become differences in outcomes.

Table 1 Ambulatory cardiac monitoring and downstream outcomes: real-world claims analyses from our group

Study	Population, data and design	Key finding
COPD with arrhythmia ⁸	MarketScan 2006–2024; 24,423 monitored vs 47,162 unmonitored patients with COPD and arrhythmia; entropy balancing	Hospitalization RR 0.71, readmission RR 0.63, ED RR 0.83; annual cost \$35,504 vs \$42,403 per patient
Type 2 diabetes with arrhythmia ⁹	MarketScan 2006–2023 and Symphony 2018–2023; incident arrhythmia, monitored (long-term continuous patch) vs never monitored; 1:1 exact matching	Hospitalizations 64 vs 215 per 1,000 patients per month; ED visits up to 50% lower
Commercially insured, first ACM ¹⁰	Commercial claims 2016–2023; 428,707 arrhythmia-naïve patients; IPTW	Long-term continuous monitoring associated with higher 90-day diagnosis, fewer retests, fewer CV events and lower costs
Medicare, first ACM ¹¹	MarketScan Medicare 2016–2024; 132,082 newly monitored beneficiaries; entropy balancing	12-month PPPM cost: LTCM \$2,678, AEM \$2,721, Holter \$2,873, MCT \$3,034
Medicare FFS, alert-based monitors (CAMELOT-ALERT) ¹²	100% Medicare FFS 2020–2022; 441,792 diagnosis-naïve beneficiaries (MCT, AEM); IPTW	90-day yield 39.1%–49.5% across platforms; no differences in hospitalizations, ED visits, heart failure or costs

ACM, ambulatory cardiac monitoring; AEM, ambulatory event monitor; COPD, chronic obstructive pulmonary disease; CV, cardiovascular; ED, emergency department; FFS, fee-for-service; IPTW, inverse probability of treatment weighting; LTCM, long-term continuous monitor; MCT, mobile cardiac telemetry; PPPM, per patient per month; RR, rate ratio.

All studies are retrospective and observational; arrhythmia and outcomes were ascertained from administrative claims.

WHAT THE EVIDENCE DOES NOT YET SHOW

The published record has a clear limit. Most outcomes in these studies are measures of health care use: hospitalizations, readmissions, emergency visits and costs. These matter to patients and payers, and an avoided admission is often an avoided decompensation, but they are not the same as complications. The commercially insured analysis did examine cardiovascular events, but as a comparison between monitor types rather than between monitored and unmonitored patients.¹⁰ Whether patients whose arrhythmia is found through monitoring go on to have less heart failure, fewer myocardial infarctions, fewer strokes and fewer cardiac deaths than comparable patients whose arrhythmia is found in the emergency department has not, to our knowledge, been established in a large, confounding-adjusted analysis. Nor has the question been examined specifically in the population in which it is most relevant: symptomatic adults with cardiovascular, metabolic or kidney risk factors, in whom monitoring is already indicated and the arrhythmic substrate is most active.

There is a plausible pathway from the one to the other. An outpatient diagnosis allows anticoagulation, rate or rhythm control and treatment of heart failure to begin before an acute event; an emergency diagnosis often coincides with one. In our COPD cohort, the average health care cost on the day of arrhythmia diagnosis was \$13,118 among monitored patients and \$17,943 among unmonitored patients,⁸ consistent with a shift in where, and in what clinical state, the arrhythmia is found. A plausible pathway, however, is a hypothesis to be tested, not a result.

READING THE SIGNAL CORRECTLY

The utilization associations are large, consistent across populations and biologically plausible. They are not proof of benefit, and four cautions apply to them and to any future analysis of complications.

First, lead time and diagnostic setting. Patients who are never monitored are more likely to be diagnosed in acute care, often during the event that revealed the arrhythmia. Their post-diagnosis window therefore begins to become sicker and closer to decompensation. Part of any difference is the intended effect of monitoring; part is an artifact of when follow-up starts. The two cannot be separated unless follow-up is anchored at the presenting symptom rather than at the diagnosis.

Second, confounding by access and engagement. Patients who are monitored may differ in insurance, access to cardiology and health-seeking behavior. Entropy balancing¹³ and inverse probability weighting removed imbalance, but claims do not capture ejection fraction, frailty, health literacy or the clinician's judgment about whom to monitor. An exposure defined over the interval between symptom and diagnosis also invites time-related biases¹⁴ that a formally specified target-trial emulation would address.¹⁵

Third, robustness. Applying E-value¹⁶ to the entropy-balanced COPD estimates,⁸ an unmeasured confounder would need to be associated with both monitoring and the outcome by a risk ratio of about 2.2 (2.1 for the confidence limit nearest the null) to explain away the hospitalization association, 2.6 (2.4) for readmission and 1.7 (1.6) for emergency visits. These values indicate moderate robustness: a confounder of the strength of frailty or poor access to care could plausibly account for part, though not obviously all, of the effect.

Fourth, the null results matter. CAMELOT-ALERT found that higher yield did not translate into fewer hospitalizations,¹² and the AF screening trials temper expectations: implantable loop recorders in LOOP more than tripled AF detection without a significant reduction in stroke,¹⁷ and the U.S. Preventive Services Task Force found the evidence insufficient to recommend screening asymptomatic adults.¹⁸ The question raised here concerns a different population, symptomatic patients for whom monitoring is already indicated, but the lesson that detection alone does not change outcomes still applies.

WHAT SHOULD HAPPEN NEXT

We suggest three steps. First, symptomatic adults with cardiometabolic risk factors should receive monitoring that current guidance already supports; the issue is timely use of an indicated test, not a new indication. As we argued previously, cardiometabolic burden should lower, not raise, the threshold for acting on symptoms.¹⁹

Second, claims and electronic health record analyses should be designed as explicit target-trial emulations, with time zero at the qualifying symptom, a defined grace period for monitoring, intention-to-treat and per-protocol contrasts, negative-control outcomes, prespecified clinical endpoints (heart failure, myocardial infarction, stroke and cardiac death) and measurement of the downstream treatments, namely anticoagulation, rhythm control and heart-failure therapy, through which any benefit would have to pass. Associations that survive that design would be much harder to dismiss.

Third, the question deserves a pragmatic, randomized trial in which symptomatic adults with cardiometabolic risk are allocated to protocolized early monitoring or usual care, with heart-failure hospitalization, major adverse cardiovascular events and acute-care use as endpoints. Monitoring is inexpensive, already reimbursed and already indicated in this population, which makes such a trial feasible; the gap between utilization and complication data makes it necessary.

CONCLUSION

For two decades ambulatory cardiac monitoring has been judged by what it finds. Published real-world evidence from several national claims cohorts suggests that monitoring patients before or at arrhythmia diagnosis is associated with less emergency and hospital care and lower costs afterwards. Whether it also prevents the complications that make major arrhythmias dangerous remains unproven. The next step is to test whether finding the rhythm earlier changes what happens next.

CONFLICTS OF INTEREST

PR and Ramaa Nathan are employees of EVERSANA, that has received funding from iRhythm Technologies for the real-world studies cited. KB, EH and BW are employees of iRhythm Technologies, a manufacturer of ambulatory cardiac monitors, and own stock in the company. No funding was received for the writing of this editorial.

ETHICAL APPROVAL

Not applicable. The cited analyses used retrospective, de-identified administrative claims data.

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