REMOTE PATIENT SURVEILLANCE

VIABLE ALTERNATIVE TO TELEMETRY IN LOWER-RISK PATIENTS

KEY POINTS

- While cardiac telemetry can provide critical arrhythmia detection in at-risk patients, the technology can be overused in lower-risk patients.
- In lower-risk patients, clinically significant telemetry-monitored events are rare. The use of telemetry in these patients does not often change clinical management.
- The overuse of telemetry in lower-risk patients contributes to hospital overcrowding along with increased length of stay and cost of care.
- The implementation of "smart alert" systems that provide integrated ECG along with monitoring of other variables such as heart rate and respiration rate may provide a viable alternative to telemetry in lower-risk patients.

BACKGROUND

Cardiac disease or suspected cardiac disease remains one of the most common reasons for hospital admission for adults.[1,2] Currently, many of these patients are placed on continuous ECG monitoring (telemetry). The underlying belief supporting the use of telemetry in these patients is that it will enable early identification of potentially life-threatening cardiac arrhythmias. In fact, the widespread implementation of cardiac telemetry over the past 50 years has been credited with a reduction in mortality following acute myocardial infarctions.[3] During this time, telemetry has progressed from the simple tracking of heart rate and basic rhythm analysis to the diagnosis of complex arrhythmias, detection of myocardial ischemia, and identification of a prolonged QT interval.[4] While telemetry can be highly valuable in high-risk patients, the use of telemetry has gradually expanded to lower-risk patients, for whom such monitoring may not provide substantial clinical benefit. Additionally, the overuse of telemetry can contribute to delayed admission, emergency

GENERAL GUIDELINES FOR CARDIAC MONITORING

1. There must be adequate human surveillance of the monitors 24 hours a day by medical, nursing, or paramedical personnel. Personnel must be trained and qualified in the ECG recognition of clinically significant cardiac rhythm disturbances.
2. Appropriately trained physicians and nurses must be responsible for decisions regarding the use of cardiac monitoring in each hospital clinical area with these devices in use. Qualified healthcare professionals must determine: a) the specific degree of monitoring surveillance that is appropriate for each clinical area, b) the minimal qualification and training standards of personnel assigned to monitor surveillance duties, c) the protocols and procedures for responding to common arrhythmias, and d) the unit-specific indications for initiation and discontinuation of cardiac monitoring.
3. Adequate numbers of trained medical personnel must be present or immediately available to treat important, life-threatening arrhythmias detected by the system. The lack of available personnel to promptly detect or treat arrhythmias expeditiously should raise questions concerning the indications for surveillance.

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department (ED) over-crowding, increased cost of care, and alarm fatigue.[5] As with any monitoring technology, telemetry must be adequately integrated into clinical practice so that there are appropriate resources to properly evaluate and act on any identified abnormalities.

INDICATIONS

In 1991, the American College of Cardiology released general guidelines for use of telemetry, which were later updated by the American Heart Association.[4,6] These guidelines divide patients into three basic classes depending on clinical condition: Class I, patients at significant risk for life-threatening arrhythmia for whom telemetry is indicated; Class II, patients for whom some cardiac monitoring may be beneficial; and Class III, patients at low risk who are unlikely to benefit from telemetry. (See Table 1.)

BURDEN OF OVERUSE OF TELEMETRY

Despite these recommendations, studies have shown three of the top diagnoses of patients admitted to telemetry units, including hemorrhage, sepsis and pulmonary disease / respiratory distress, are not clinically indicated per AHA guidelines.[7] In 2014, Dresser et al reported that prior to a quality improvement program, nonindicated telemetry monitoring accounted for ~35% of patient telemetry days in their facility.[8] In a 2014 retrospective analysis of remote telemetry monitoring practices, Curry et al reported nearly half of the telemetry monitoring days in the study were of doubtful clinical utility.[9] Additionally, both Dressler et al and Curry et al reported that 17% of prescribed telemetry monitoring periods continued beyond the 48-hours shown to provide clinical benefit.[8,10]

Over the last decade, as the population ages and the acuity level of hospitalized patients rises, the demand for telemetry beds has been increasing[11], despite the fact that there are surprisingly few rigorous studies demonstrating its ability to improve patient outcomes. In fact, at the time that the 2004 AHA guidelines for the use of telemetry were generated, there were no published, randomized clinical studies evaluating the impact of telemetry on patient outcomes.[11] While there is evidence that telemetry can provide benefit in high-risk patients,[4,14] a number of studies have indicated that in lower-risk patients, telemetry may not provide substantial clinical benefit.[12-15]

Along these lines, Durairaj et al conducted a prospective study of 1,033 adult patients admitted to an inpatient telemetry unit from the ED.[12] The authors used a prediction rule to classify patients as high, moderate, low, and very low risk.

During patient follow-up, the authors reported no major complications for the 318 very low risk patients with chest pain, for a negative predictive value of 100%.[12] Importantly, these authors also evaluated the effects of telemetry overuse in lower-risk patients on hospital bed availability. During the initial eight-week period, 168 ED patients were denied admission to the telemetry unit due to bed shortages, while during this same period, 70% of the patients admitted to the telemetry unit were very low risk patients who suffered zero major complications. Therefore, an average of three patients per day were denied admission to the telemetry unit, while at the same time, four of 12 telemetry beds were occupied by very low risk patients who demonstrated no apparent benefits from telemetry monitoring.[12]

Hollander et al found that arrhythmias were unlikely in patients with lower-risk ECG profiles. Of the 460 patients included in this study, only four had a notable arrhythmia, and in the 261 patients who presented with a normal or nonspecific ECG, there were no apparent benefits of telemetry.[13] Snider et al demonstrated no apparent benefit of telemetry in low-risk patients while there was an apparent benefit in higher-risk patients.[14] In this prospective study, none of the 101 low-risk patients had a clinically significant ECG abnormality during admission, while in high-risk patients, 29% had at least one significant monitored event.[14] Similarly, Saleem et al found that in low-risk patients, the use of telemetry neither altered the management of any patients nor did it identify patients at increased risk for poor long-term outcome.[15] The data of both Snider et al and Saleem et al indicate that simple risk-stratification in the ED could effectively identify patients who are unlikely to benefit from telemetry.[14,15] In a retrospective review of 8,932 patients admitted to a telemetry ward over a five-year period, Schull and Redelmeier found that of the 20 patients who suffered cardiac arrest, the telemetry monitors signaled the arrest in 56% of the cases.[3] Of these 20 arrest cases, only three patients survived to discharge, and two of the three patients had their arrest signaled by the monitor. In light of these data, the authors concluded: "Cardiac arrest is an uncommon event among telemetry ward patients, and monitor-signaled survivors are extremely rare. Routine telemetry offers little cardiac arrest survival benefit to most monitored patients, and a more selective policy for telemetry use might safely avoid ECG monitoring for many patients."[3]

In a prospective study of 467 telemetry patients, Estrada et al found that in 98.9% of the cases, telemetry added "no significant information," and that patients who deteriorated were identified clinically without "appreciable contribution" from the telemetry monitoring.[16] In a follow-up study, this same group determined that for 2,240 telemetry patients, monitor abnormalities resulted in transfer to the ICU in only

Table 1. Indications for Cardiac Arrhythmia Monitoring[4,6]

Class I: Cardiac monitoring is indicated in most, if not all, patients in this group.

- Patients who have been resuscitated from cardiac arrest
- Patients in the early phase of acute coronary syndromes (ST-elevation or non-ST elevation MI, unstable angina/rule out MI)
- Patients with unstable coronary syndromes and newly diagnosed high-risk coronary lesions
- Patients who have undergone cardiac surgery
- Patients who have undergone nonurgent percutaneous coronary intervention with complications
- Patients who have undergone implantation of an automatic defibrillator lead or a pacemaker lead and are considered pacemaker dependent
- Patients with a temporary pacemaker or transcutaneous pacing pads
- Patients with AV block
- Patients with arrhythmias complicating Wolff-Parkinson-White syndrome with rapid anterograde conduction over an accessory pathway
- Patients with long-QT syndrome and associated ventricular arrhythmias
- Patients receiving intra-aortic balloon counter pulsation
- Patients with acute heart failure/pulmonary edema
- Patients with indications for intensive care
- Patients undergoing diagnostic/therapeutic procedures requiring conscious sedation or anesthesia
- Patients with any other hemodynamically unstable arrhythmia
- Diagnosis of arrhythmias in pediatric patients

Class II: Cardiac monitoring may be of benefit in some patients but is not considered essential.

- Patients with post-acute MI
- Patients with chest pain syndromes
- Patients who have undergone uncomplicated, nonurgent percutaneous coronary interventions
- Patients who are administered an antiarrhythmic drug or who require adjustment of drugs for rate control with chronic atrial tachyarrhythmias
- Patients who have undergone implantation of a pacemaker lead and are not pacemaker dependent
- Patients who have undergone uncomplicated ablation of an arrhythmia
- Patients who have undergone routine coronary angiography
- Patients with subacute heart failure
- Patients who are being evaluated for syncope
- Patients with do-not-resuscitate orders with arrhythmias that cause discomfort

Class III: Cardiac monitoring is not indicated because a patient's risk of a serious event is so low that monitoring has no therapeutic benefit.

- Postoperative patients who are at low risk for cardiac arrhythmias, such as young patients without heart disease who undergo uncomplicated surgical procedures
- Obstetric patients (unless heart disease is present)
- Patients with permanent, rate-controlled atrial fibrillation
- Patients undergoing hemodialysis (except for patients with a Class I or II indication who undergo dialysis in the hospital)
- Stable patients with chronic ventricular premature beats.

0.8% of patients.[17] Furthermore, in an observational study of 61 patients, Sivaram et al determined that only 12 of 297 (4%) telemetry events led to changes in patient management.[18]

A 2015 review by Crawford and Halm concluded the additional risks and safety concerns associated with the use of telemetry monitoring in nonindicated patients, including alarm fatigue, interruptions in workflows and overcrowding likely outweigh the often overestimated clinical value and give hospital staff a false sense of security.[26]

As noted above, a number of studies have revealed the burden of unnecessary telemetry on hospital resources.[5,12] Telemetry itself is expensive, requiring specialized equipment and trained personnel. While the estimates of the cost of telemetry vary across institutions, Henriques-Forsythe et al noted that in their hospital, the current (2009) cost of telemetry was at least $1,400 per patient per day.[7] Telemetry is also associated with a high alarm rate and is considered a major contributor to alarm fatigue.[11]

Furthermore, inefficient triage of patients with chest pain to monitored telemetry beds adds significant extra cost to the hospital. Bayley et al determined that the annual opportunity cost in lost hospital revenue for patients with chest pain waiting for a telemetry bed was $168,000 or about $204 for every patient who waited longer than three hours for a hospital bed.[19] Krochmal and Riley estimated that the total extra cost imposed on 26,020 ED patients admitted between 1988 and 1990 due to overcrowding was approximately $6.8 million. This extra cost was primarily attributed to patients who waited longer than 24 hours in the ED.[20]

Telemetry monitoring is also associated with a high alarm rate and is considered a major contributor to alarm fatigue.[12] Telemetry monitoring algorithms are typically maximized for sensitivity at the expense of specificity, resulting in high rates of false alarms.[21] In the ALARMED study, Atzema et al. reported cardiac telemetry in low-risk patients generated an average of 4.7 alarms an hour, most of which were false alarms (99.4%) and only 0.2% of which triggered a change in care management.[22]

BENFIT OF STANDARDIZATION OF CARDIAC TELEMETRY MONITORING

Cardiac telemetry standardization to the 2004 AHA recommendations has been shown to significantly reduce telemetry utilization and costs of care without increasing rapid response activations, codes, or deaths.[8,23] In 2014, Dressler et al reported that adherence to AHA guidelines for telemetry monitoring resulted in a 70% reduction in cardiac telemetry use without adversely affecting patient safety. The authors concluded that eliminating monitoring on non-indicated days could save a minimum of $53 per patient per day or $250K per year on average.[8] Catillon et al. demonstrated that implementation of education and EMR prompts to enable telemetry standardization was associated with a 15.5% telemetry unit census reduction with no associated increase in codes (122 vs 126 in the previous 13 months).[23] A nurse-led initiative to discontinue telemetry when it is no longer indicated resulted in an average decrease of 25 hours of telemetry monitoring per encounter and a 75% decrease in the likelihood of a patient remaining on telemetry until discharge.[24] Rayo et al implemented a quality improvement program including standardized telemetry order sets based on patient risk classifications and automatic discontinuation of telemetry monitoring unless explicitly renewed. When comparing pre- and post-implementation outcomes, the authors reported a 53.2% decrease in the average rate of cardiac telemetry monitoring, a 36.6% decrease in the ED boarding rate and a 48.9% decrease in false alarms with no observed changes in LOS or mortality.[25]

ALTERNATIVE SURVEILLANCE MONITORING STRATEGIES

Overall, available data indicate that reducing the incidence of unnecessary telemetry could increase bed availability and potentially shorten length of stay. These studies also highlight the financial benefit (and relatively low clinical risk) of allocating lower-risk patients to non-telemetry beds.

As mentioned previously, one of the top diagnoses of non-indicated patients admitted to a telemetry bed is pulmonary disease / respiratory distress. ECG events detectable by cardiac telemetry may represent secondary rather than primary events and may be a lagging indicator of deterioration in these patients.[3] Monitoring systems based on respiratory vital signs may provide a more appropriate surveillance solution for earlier detection of deterioration for cases in which physiological monitoring is desired but the patient does not meet the AHA criteria for cardiac telemetry.[3]

Recent advances in monitoring technology may allow for the comprehensive monitoring of key vital signs, provide for the early detection of patients who warrant increased attention, aid in ED triage, and improve overall caregiver workflow.[27] These newer surveillance monitoring technologies have the ability to monitor multiple variables at once, including vital signs parameters such as single-lead ECG and respiratory rate, and/or oxygen saturation.[27-30] These surveillance systems may provide the desired enhanced vigilance within the general medical/surgical floor without requiring patient transfer to a dedicated telemetry bed.

For example, in lower-risk patients, a simple, single-lead, chest-mounted ECG sensor may effectively replace telemetry while allowing for monitoring heart rate and cardiac

arrhythmias. In support of this, a single-lead ECG system has been shown to be surprisingly accurate for arrhythmia detection as compared to three-lead Holter, especially for longer (i.e., >24 hour) recording periods.[27] In fact, in this analysis, the single-lead sensor detected more arrhythmias than the Holter, and arrhythmias that were "missed" by the single-lead system in the first 24 hours were detected in the second 24 hours. Furthermore, 93.7% of patients found the adhesive monitoring patch comfortable to wear as opposed to 51.7% for the Holter monitor. Similarly, the adhesive patch monitor affected 10.5% of patients' activities of daily living as opposed to 76.2% of patients in the Holter group. When these patients were asked if they preferred to wear the adhesive patch monitor or the Holter monitor, 81% chose the adhesive patch monitor.[27]

Choi and Kim described the design and implementation of a wireless patient monitoring system for postoperative GCF patients in a 2000-bed tertiary hospital.[28] For this monitoring system, the authors aimed to better integrate peripheral oxygen saturation (SpO_2) surveillance into the existing network infrastructure to provide more effective postoperative monitoring on the GCF. Following implementation of the system, the authors concluded that the technology allowed for improved notification of patient deterioration and aided in clinician decision making. The authors also noted that the addition of more vital signs to the system could further enhance the delivery of healthcare services.[28] Similarly, Brown et al reported on the effects of continuous heart rate and respiration rate monitoring on unplanned ICU transfers and length of stay in a 33-bed medical-surgical unit vs. a `sister' control unit for a 9-month preimplementation period and 9-month postimplementation period.[29] The authors reviewed 7643 patient charts, including 2314 patients who had continuous monitoring and 5329 control patients. For this comparison, continuous monitoring resulted in a significant reduction in average length of stay (3.6 days vs. 4.0 days; $p<0.05$), a significant reduction in total ICU days (63.5 days vs. 120.1 days; $p=0.04$), and a significant reduction in the rate of code blue events (0.9/1000 patients vs. 6.3/1000 patients; $p=0.02$).[29]

Finally, Bellomo et al reported on a international study, involving ~ 20,000 patients at 10 hospitals, and found that the use of an automated surveillance system was associated with increased survival immediately after RRT treatment and a shorter median hospital length of stay in patients in the U.S. hospitals.[30]

CONCLUSIONS

While telemetry can provide lifesaving information in high-risk patients, its overuse in lower-risk patients can overburden the hospital system while providing limited clinical benefit. In lower-risk patients, clinically significant telemetry-monitored events are rare. The use of telemetry in these patients does not often change clinical management. The overuse of telemetry can contribute to hospital overcrowding and increase the length of stay and cost of care. The development of smart-alert monitoring systems capable of providing basic ECG monitoring in conjunction with concurrent vital sign monitoring (i.e., respiration rate) may provide valuable monitoring alternatives in lower-risk patients. In these patients, such alternative-monitoring strategies may provide acceptable clinical benefit while reducing hospital burden.

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