

Evaluating the Process of Ambulatory Electrocardiographic Monitor Application and
Completion Rates

By

Anna S. Bhatnagar, R.N, B.S.N

University of Kansas School of Nursing 2019

Submitted to the School of Nursing and The Graduate Faculty of the University of Kansas in
partial fulfillment of the requirements for the degree of Doctor of Nursing Practice.

Kelly A. Bosak, Ph.D., ANP-BC

Faculty Project Committee, Chair

Carol Buller, DNP, APRN, FNP-C, GNP-C

Faculty Project Committee, Co-Chair

26 March 2019

Date Project Proposal Accepted

The DNP Project committee for **ANNA S. BHATNAGAR** certifies that this is the approved
version of the following DNP Project:

Evaluating the Process of Ambulatory Electrocardiographic Monitor Application and
Completion Rates

Kelly A. Bosak, Ph.D., ANP-BC

Co-Chair

*Carol Buller, DNP, APRN, FNP-C,
GNP-C*

Co-Chair

Date Approved:
26 March 2019

Abstract

Outpatient ambulatory electrocardiographic monitoring (AEM) is often used by practitioners to diagnose an arrhythmia. AEM devices can be mailed to the patient's home or applied in the office setting. A common barrier that decreases the diagnostic utility is failure to successfully complete the monitoring.

Objective: The purpose of this study is to compare the AEM completion rates between patients who self-apply the monitor at home and those who have the monitor applied in the office by clinical staff.

Methods: A cross-sectional retrospective chart review was used. The electronic health records were reviewed for billable codes before and after April 2018 when a new office policy of mailing monitors to patients was implemented. A random sample of 50 patients was obtained from each timeframe.

Results: The sample included the electronic medical records of adult patients (n=100) seen in the Cardiology clinic. Over half 63 (63%) were female, and the majority 88 (88%) were Caucasian, with 10 (10%) Black or African American, and 1 (1%) reporting Asian race. The average age was 59 (range 20-100). Most patients 98 (98%) had health insurance. The office application group had a significantly higher rate of successful completion 62 (62%) compared to the mail group 38 (38%). The average number of days that the AEM was worn was 18 days (range 7-30 days).

Conclusion: The results of this study indicate that professional support and application of AEM in the clinic setting may lead to an increase in completion rates.

Table of Contents

Introduction.....	3
Statement of the Problem.....	3
Definition of the Variables	5
Literature Review	5
Theoretical Framework	8
Methodology and Design	9
Assumptions.....	9
Design and Setting.....	9
Population Sample and Selection Process.....	10
Data Collection Protocol.....	11
Data Analysis.....	12
References	17

Introduction

Statement of the Problem

Ambulatory Electrocardiographic Monitoring (AEM) assists in the diagnosis and management of patients with a known or suspected cardiac conduction disturbance or arrhythmia. The number of AEM's being ordered for patients is on the rise (Kennedy, 2013). This is related to advances in technology and also the push to reduce costs by managing patient care outside of the hospital setting.

In the cardiology clinic selected for this study, there were a large number of monitors that were cancelled, not worn properly, terminated early or not activated. This resulted in a failure to obtain the rhythm monitoring data and the possibility of missing an important diagnosis. This project was designed to address the following questions: 1) Was there a significant difference in completion rates between patients who had the AEM applied in the office compared to those who had the monitor mailed to their homes; and 2) Did in-office application improve completion rates.

Common arrhythmias seen in clinical practice include premature atrial contractions (PAC's), premature ventricular contractions (PVC's), bradycardia, supraventricular tachycardia, atrioventricular (AV) block and ventricular tachycardia (VT). Symptoms of cardiac conduction disturbances can sometimes be vague and may include reports of syncope, palpitations, chest pain, dyspnea or dizziness. It can be difficult to identify the cause of such symptoms in patients presenting with these complaints.

Atrial fibrillation is the most common arrhythmia and is often seen in the elderly population and those with heart disease. The incidence and prevalence continues to rise, with some studies showing that by the year 2030 the number of people diagnosed with atrial

fibrillation will double to 12.1 million within the United States (Rosero et al., 2013). Atrial fibrillation can cause an irregular rapid heart rate and increases the risk of thrombotic events such as a stroke (NIH, 2018). The financial burden on the healthcare system related to treatment of atrial fibrillation is significant costing the United States about \$6 billion dollars each year. Patients who are diagnosed with atrial fibrillation have almost \$9000 more per year in health care costs than those who do not (CDC, 2018). In addition, syncope accounts for around one million emergency room visits per year in the United States with \$2.5 billion per year spent on hospitalizations leading to extensive inpatient testing with low diagnostic yield (Patel & Quinn, 2015). AEM's have become a popular method for outpatient management of suspected conduction disturbances and are generally cost-effective when compared to inpatient hospital stays. The devices are becoming more advanced with longer monitoring time and the ability to store more data. Longer monitoring times increases the diagnostic yield significantly but this requires patient compliance and an understanding of how to use the device (Solomon et al., 2016).

The monitoring timeframe for AEM ranges anywhere from 24 hours to as long as 3 years or more. It can be used to monitor patients with a known arrhythmia to evaluate effectiveness of medications and interventions, such as whether to increase or decrease a beta blocker or initiate anticoagulation for stroke prevention prophylaxis. AEM is medically indicated in patients with symptoms of cryptogenic stroke to determine if asymptomatic atrial fibrillation is an underlying cause (Zimetbaum & Goldman, 2010).

The AEM has the ability to be most useful when it is worn properly for the prescribed amount of time. Appropriate diagnosis and treatment of patients is more likely to be achieved among patients who complete the monitoring period successfully.

Definition of the Variables

Ambulatory Electrocardiographic Monitor (AEM) refers to cardiac rhythm monitoring over an extended period of time in the outpatient setting. AEM's were used in this project to describe the practice of recording the cardiac rhythm of a patient in an outpatient setting for a prescribed amount of time.

Mobile Continuous Outpatient Telemetry (MCOT) is a cardiac rhythm monitoring device worn by a patient that continuously records for up to 30 days. The MCOT can be triggered by the patient when an event/symptom occurs, or automatically for certain rhythms (new onset atrial fibrillation, ventricular tachycardia and other serious arrhythmias). The ordering provider can then be notified of the event.

Event Monitors are cardiac rhythm devices worn by a patients that only records when the patient triggers the monitor, or automatically when a serious arrhythmia is detected.

Diagnostic Yield is defined as the number of significant diagnoses identified from cardiac monitoring. This is usually obtained once the AEM is completed when a final report is generated and sent to the ordering provider for interpretation and diagnosis.

Mail Group in this project refers to the sample of patients who had monitors mailed to their home for self-application.

Office Group refers to the sample of patients who had monitors applied by a healthcare professional at a scheduled office visit.

Literature Review

AEM is a valuable tool that has the potential to influence medical management by detecting arrhythmias. It can rule out an electrical conduction disturbance as a likely source of symptoms such as excessive fatigue, pre-syncope, syncope or palpitations. The American

College of Cardiology/American Heart Association (ACC/AHA) recommends the use of AEM to: assess symptoms that may be related to rhythm disturbances; assess risk of cardiac events in patients without symptoms; monitor the efficacy of antiarrhythmic medications; evaluate pacemaker and internal cardiac defibrillator function; and monitor for signs myocardial ischemia (ACC/AHA, 1999). The guidelines are used to classify which patients with or without symptoms may benefit from cardiac monitoring.

AEM has become the most common technological tool ordered by health care providers to identify conduction disturbances (Kennedy, 2013; Zimetbaum & Goldman, 2010; Barrett et al., 2014; Smith, Riddell, Madon & Gleva, 2017; Solomon et al., 2016). There are several types of AEM devices, including 24 and 48-hour Holter monitors, looping and non-looping event monitors, real time mobile telemetry, and more recently, implanted loop recorders. With advances in technology these devices have become easier and more efficient to use.

Holter monitors have long been considered ‘the gold standard’ using either three-lead or twelve-lead configuration. They are the least expensive of the AEM devices and usually covered by most insurance companies. The timeframe of 24-48 hours may not capture an arrhythmia that is occurring less frequently, therefore it is recommended that Holter monitoring is limited to those who are having frequent symptoms or have a high probability of an arrhythmia within a short timeframe (Ruwald & Zareba, 2013). Event monitors are worn 7-30 days and require that the patient is symptomatic, recognizes the symptoms, and is able to manage activation of the device correctly (Zimetbaum & Goldman, 2010). Mobile Cardiac Outpatient Telemetry (MCOT) provides continuous ‘real-time’ monitoring. The MCOT is either triggered by the patient or automatically based on a pre-determined algorithm decided by the ordering clinician (eg. sustained ventricular tachycardia, >6 second pauses, complete heart block, atrial fibrillation).

The information is wirelessly transmitted to a central hub and if the rhythm meets notification criteria the ordering clinician is notified (Ruwald & Zareba, 2013). This device captures the most data with minimal patient activation over a longer period of time and provides real time data. In this project, the only devices that were mailed to patients were the MCOT's and event monitors. Holter monitors continued to be applied in the office.

In reviewing the literature, no information was found specifically related to the method of AEM application and how it affects completion rates. However, there are studies comparing completion rates and factors such as type of monitor that is worn, appropriateness of order (Benditt et al., 2018), length of monitoring and ease of use (Barrett et al., 2014, Rosenberg et al., 2012, Smith et al., 2017, Solomon et al., 2016), however these factors are beyond the scope of this paper to investigate.

Several studies showed that patch monitors were easier to apply compared to Holters, which have electrodes and leads that need to be attached. Bansal and Joshi (2017) reviewed current AEM technology specifically looking at the ease of use and accuracy of patch monitors. The findings indicated that the use of a continuous single lead patch improved outcomes for all of the evaluated endpoints. Patient compliance was excellent with a median wear time of 13.6 days (Reed et al., 2018). There have been several other studies comparing adhesive patch devices to other types of monitoring such as Holter, resting ECG and MCOT. The general outcomes from these preliminary studies show that the adhesive patch monitors are well tolerated, improve compliance, increase diagnostic yield and have higher ratings in patient satisfaction and ease of use compared to the traditional three or five lead Holter monitoring (Smith et al., 2017; Barrett et al., 2014; Rosenberg et al., 2012).

Within the biomedical research field there are studies that investigated factors known to influence ease of use and comfort with wearing a monitor or sensor. Results from these studies indicated that it was important for sensors to be simple to operate and not affect normal behavior or daily activities which improves length of monitoring and completion rates (Bergmann & McGregor, 2011; Bergman, Chandaria & McGregor, 2012).

Theoretical Framework

The theoretical framework that will be used to help guide this project is Donabedian's Model for measuring the quality of care. In 1966 Donabedian's ground-breaking article "Evaluating the Quality of Medical Care" was published in the Millbank Memorial Fund Quarterly where he provided a framework that can be used to assess healthcare quality.

The model has three integral parts; structure, process, and outcome. The structure is the environment in which the health care delivery is applied such as the type of facility (clinic, hospital) or the type of electronic health record (EHR) that is used. The process measures are the actual actions of the health care workers within the structure. Some examples of process measurements are the length of time a provider spends with the patient or the thoroughness of instructions for outpatient monitoring. Outcomes, such as AEM completion rates are the quantifiable measurements that can be used to evaluate the impact of the healthcare delivery (AHRQ, 2018).

The Donabedian model organizes the components of this project. The office structure includes personnel and staffing, patient flow and average daily census. The process of how AEM's are ordered and managed is key to this project. This includes determining how and where

the AEM is applied, origination and follow up of the AEM order, and insurance prior authorization. The outcome measurement is AEM completion.

Methodology and Design

Assumptions

- 1) Patients who receive cardiac monitors are able to read and comprehend the directions
- 2) The AEM ordered was the appropriate type of monitor based on symptoms and diagnosis.
- 3) All patients within the practice who wore an AEM were entered into the EHR billing database.
- 4) Patients in the project received either an event monitor or an MCOT that functioned properly.

Design and Setting

The project took place in a busy cardiology practice located in a suburb of a Midwestern metropolitan city. The practice had experienced rapid growth over the past three years with the most recent report of an annual growth of 27% since the prior year (S.S, Director of Cardiology Practice Operations, personal communication, July 8th, 2018). Five new cardiologists and two nurse practitioners joined the practice since moving into a new office space in 2016. The majority of patients seen were insured with many of them on Medicare or Medicare replacement plans. The clinic had on average of 4-5 four to five providers seeing 75-100 patients daily with over 9000 patients checked in for visits during the first quarter of 2018. One of the many services that the cardiology department offered was the reading and interpretation of cardiac testing including AEM reports.

Orders for AEM devices were generated from inpatient hospital stays, emergency department visits and outpatient clinic visits. The order was then sent to a prior authorization specialist who is responsible for verifying insurance coverage and obtaining authorization if

indicated. Once the insurance authorization had been obtained, the order was sent to the AEM company and indicated whether it was to be mailed to the patient or placed in the office. It was left to the discretion of the physician group whether it was preferred to mail monitors or stock an office supply to allow application in the clinic.

It was the responsibility of the Pacemaker Clinic staff to monitor the patients who are on the AEM service. This department was staffed by four registered nurses, two of whom were full-time and two who work part-time. If a recorded rhythm met the urgent criteria, which was decided by the cardiologists, the AEM company notified the office or on-call provider after hours. The pacemaker nurses triage the incoming calls and monitoring data. Upon AEM completion, a final report was generated in the EHR. The pacemaker RN forwarded the report to the ordering provider for interpretation and further recommendations.

The growth and expansion of the cardiology department had been recognized and celebrated, but with it came many challenges. The healthcare leaders and administrators had to reassign duties and workflow to meet the demands of the increased patient volume and workload. Due to staffing shortages and lack of patient room availability, it was decided shortly before April 2018 that heart monitors would be mailed to the patients' home rather than having a scheduled appointment for application of the monitor in the office by a medical assistant (MA). There were many patients who did not wear the monitor, then came to their 30-day follow-up without the necessary data available to review. It was not uncommon for the patient to stop wearing the monitor, fail to transmit data, fail to keep a diary of symptoms which may be related to a lack of understanding of the purpose of the AEM and how to operate the device.

Population Sample and Selection Process

A cross-sectional retrospective chart review was used for this quality improvement project to answer the proposed research questions. The population sample for this project was randomly selected from a chart review of the billable codes for AEM devices that were entered into the EHR. The codes were obtained from August 1, 2017 to October 31, 2017 and then from August 1, 2018 to October 31, 2018. These timeframes were selected for data collection before and after the implementation of mailing monitors to the patient's residence. The average number of AEM orders processed per month was around 150. A random sample of fifty patients from each of the two time points was selected. This provided a total sample size of 100. Exclusion criteria included anyone younger than 18 years of age and patients with implanted loop recorders or Holter monitors. Holter monitors were not included in the study because they were applied in the office. This project did not include human research therefore the IRB designated it as exempt with approval to proceed with the project. Approval was also obtained from the management within the clinic.

Data Collection Protocol

Data on the population sample was collected from the available billing and coding reports generated from AEM orders and the office EHR. This included the patient demographics, diagnosis/ICD codes, CPT codes for the type of monitor ordered, insurance information, length of monitoring period, days that monitor was worn, successful completion, and order source. Also included in the data collected was whether the monitor was mailed to the patient or placed in the office. Daily reports from the EHR, in addition to the billing and coding reports showed monitoring of patient wear times and cancellations. No sensitive patient identifiers were recorded such as date of birth, social security numbers or addresses. The AEM data was entered into

Research Electronic Data Capture (REDcap), a secure web application designed for building surveys for data collection and creating a database that resided on a secure server.

Data Analysis

Data was transferred from REDcap to IBM SPSS 25 (IBM Corp, Armonk, NY, 20113). Descriptive statistics were used to analyze the data results and patient characteristics. A *Chi Square* test was used to assess the differences in completion rates between the mail group and office group.

Table 1

Sample Characteristics. n=100

Age Mean	59 years (range 20-100)
Male	37 (37%)
Female	63 (63%)
Caucasian	88 (88%)
African American	10 (10%)
Asian	1 (1%)
Hispanic	3 (3%)
Other/Not Reported.	1 (1%)
Health Insurance	98 (98%)

Results

The study sample consisted of 100 patients, 50 of whom had the AEM mailed to their home and 50 who had the monitor applied in the office (see Table 1). The average age was 59

years (range 20-100). Most of the patients were female 63 (63%), white 88 (88%), and had insurance coverage 98 (98%). There were two types of monitors used in this study, mobile outpatient telemetry 42 (42%), and event monitors 58 (58%). The ordered length of time was, on average, 18 days (range 7-30 days).

Out of the total sample ($n=100$), 62 (62%) successfully completed monitoring for the prescribed amount of time and 38 (32%) failed to complete monitoring, as shown in Table 2. The highest rate of non-completion was within the mail group 26 (26%) compared to the office group 12 (12%). Three patients did not wear the monitor for any of the prescribed days. A contingency table was created using the observed number of completions and non-completions between the two groups. A Chi Square test showed a significant difference between the mail group and office group supporting a correlation between how the monitors are applied and completion rates (see Table 2).

Table 2

Comparison of Completion Rates Between Mail Group and Office Group

AEM Completion

Application Method	Completed	Not Completed	Total
Office	38 (38%)	12 (12%)	50 (50%)
Mail	24 (24%)	26 (26%)	50 (50%)
Total	62 (62%)	38 (38%)	100 (100%)

$$\chi^2 = 8.319, df = 1, p = .005$$

Most of the orders 72 (72%) originated from the office and the rest of the orders 28 (28%) were generated from ER visits or inpatient stays. The electronic medical records revealed that seven patients required intervention, including two atrial fibrillation ablations, two loop recorder implants, two pacemaker implants and one internal cardiac defibrillator. The most frequent diagnosis used when ordering the AEM was palpitations 43 (43%) (see Table 3).

Table 3

ICD 10/Diagnosis Codes Frequency for AEM Orders

<i>Diagnosis</i>	<i>ICD 10 Code</i>	<i>Frequency (%)</i>
Palpitations	R00.2	43 (43%)
Syncope/Collapse	R55	17 (17%)
Bradycardia	R00.1	5 (5%)
Transient Ischemic Attack	G45.9	3 (3%)
Atrial Fibrillation	I48	18 (18%)
Supraventricular Tachycardia	I47.1	3 (3%)
Dizziness/Giddiness	R42	6 (6%)
Ventricular Tachycardia	I47.2	2 (2%)
Cerebrovascular Infarction	I63.9	2 (2%)
Atrioventricular Block	I44	1 (1%)
Other Conduction Disorder	I45.9	1(1%)

Discussion

This retrospective chart review found that patients with monitors applied in the office had a significantly higher rate of completion compared to those who had the AEM mailed to their home. A variety of reasons could explain these findings. Patients may feel more comfortable with the device when they receive instructions face to face in the clinic setting and have the opportunity for their questions and concerns to be answered along with support as well as proper initiation by trained personnel. The office staff can clearly explain the importance of the AEM as a tool that assists providers in making important healthcare decisions.

Patients who have an AEM ordered after a hospital stay receive a large amount of education and sometimes a new diagnosis. Having an AEM arrive by mail could be confusing for some patients especially when it was prior to the follow-up appointment after hospital discharge. Wearing an AEM requires active participation of the patient. Encouraging and supporting patients who are wearing these monitors by providing instruction by medically trained staff is an intervention that could be implemented in the outpatient clinic setting to increase completion rates.

The longer the monitor is worn and operating correctly, the more rhythm data is generated. This leads to greater confidence in clinical decision making. The AEM reports are often used to help determine medication management or rule out an arrhythmia. A report showing 100% sinus rhythm for 30 days provides greater confidence in ruling out a conduction disturbance compared to a report showing 100% sinus rhythm for a patient who only wore the monitor for 3 days. It is especially useful for the symptomatic patient to record events so that it can be correlated with the rhythm at that time.

An interesting finding in this project was the high number of female patients 63 (63%) compared to males who had an AEM ordered. The most frequent ICD 10 diagnosis code overall was palpitations (43%) and the second most frequent reported ICD 10 diagnosis code was syncope (16%). Palpitations and syncope are symptoms associated with disorders common in females such as thyroid disease, menopause, or depression and anxiety. It is also known that women are more likely than men to present with atypical symptoms (abdominal pain, dyspnea, extreme fatigue, syncope) in acute coronary syndrome (Mehta et. al., 2016). Whether there is a correlation between the high rate of AEM's ordered in this patient population and these reported symptoms was not established in this project but could be an area of interest for future studies.

Currently the clinic continues to mail the monitors to the patient's home. Presenting the results of this study to health care administrators within the organization would support a decision to re-implement the policy of placing the AEM on patients in the clinic. A cost benefit analysis may show potential financial gains looking at the number of tests, procedures, interventions and new patient consults generated by AEM completion.

In summary, AEM is an important tool used to manage, treat and diagnose patients who may have underlying cardiac conduction disturbances. The popularity of outpatient monitoring technology continues to expand providing extensive rhythm data, with more responsibility placed on the patient to ensure success of the intervention. Further research is needed to explore interventions that increase AEM completion with the potential to significantly improve the care and management of patients suspected of having a conduction disturbance.

References

- American College of Cardiology/American Heart Association. (1999). 1999 Executive summary and recommendations on practice guidelines for ambulatory electrocardiography. *Circulation*, 100(8), 886-893.
- Bansal, A., & Joshi, R. (2018). Portable out of hospital electrocardiography: A review of current technologies. *Journal of Arrhythmia*, 34(2), 129-138.
- Barrett, P. M., Komatireddy, R., Haaser, S., Topol, S., Sheard, J., Encinas, J., Fought, A.J., & Topol, E. J. (2014). Comparison of 24-hour Holter monitoring with 14-day novel adhesive patch electrocardiographic monitoring. *The American Journal of Medicine*, 127(1), 95-e11.
- Bergmann, J. H. M., & McGregor, A. H. (2011). Body-worn sensor design: What do patients and clinicians want. *Annals of Biomedical Engineering*, 39(9), 2299-2312.
- Bergmann, J. H., Chandaria, V., & McGregor, A. (2012). Wearable and implantable sensors: The patient's perspective. *Sensors*, 12(12), 16695-16709.
- Best, M., & Neuhauser, D. (2004). Avedis Donabedian: Father of quality assurance and poet. *BMJ Quality & Safety*, 13(6), 472-473.
- CDC, 2018. Division for heart disease and stroke prevention: Atrial fibrillation fact sheet. Retrieved on 7-4-18 from:
https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_atrial_fibrillation.htm
- Donabedian, A. (1966). Evaluating the quality of medical care. *The Milbank Memorial Fund Quarterly*, 44(3), 166-206.
- Ioannou, K., Ignaszewski, M., & Macdonald, I. (2014). Ambulatory electrocardiography: The contribution of Norman Jefferis Holter. *British Columbia Medical Journal*, 56(2).

- Katritsis, D. G., Siontis, G. C., & Camm, A. J. (2013). Prognostic significance of ambulatory ECG monitoring for ventricular arrhythmias. *Progress in Cardiovascular Diseases*, 56(2), 133-142.
- Kennedy, H. L. (2013). The evolution of ambulatory ECG monitoring. *Progress in Cardiovascular Diseases*, 56(2), 127-132.
- Manchanda, S., & Ehsanullah, M. (2001). Suspected cardiac syncope in elderly patients: Use of the 12-lead electrocardiogram to select patients for Holter monitoring. *Gerontology*, 47(4), 195-197.
- McCormick, K. M., McClement, S., & Naimark, B. J. (2005). A qualitative analysis of the experience of uncertainty while awaiting coronary artery bypass surgery. *Canadian Journal of Cardiovascular Nursing*, 15(1), 10-22.
- Mehta, L. S., Beckie, T. M., DeVon, H. A., Grines, C. L., Krumholz, H. M., Johnson, M. N., ... & Wenger, N. K. (2016). Acute myocardial infarction in women: A scientific statement from the American Heart Association. *Circulation*, 133(9), 916-947.
- National Institute of Health. (2018). Atrial fibrillation. Retrieved from <https://www.nhlbi.nih.gov/health-topics/atrial-fibrillation>
- Patel, P. R., & Quinn, J. V. (2015). Syncope: A review of emergency department management and disposition. *Clinical and experimental emergency medicine*, 2(2), 67.
- Polit, D. F., & Beck, C. T. (2010). *Essentials of nursing research: Appraising evidence for nursing practice*. Philadelphia, PA: Lippincott Williams & Wilkins.
- Reed, M. J., Grubb, N. R., Lang, C. C., Gray, A. J., Simpson, K., MacRaidl, A., & Weir, C. J. (2018). Diagnostic yield of an ambulatory patch monitor in patients with unexplained

- syncope after initial evaluation in the emergency department: The PATCH-ED study. *Emergency Medical Journal*, emermed-2018.
- Rosenberg, M. A., Samuel, M., Thosani, A., & Zimetbaum, P. J. (2013). Use of a noninvasive continuous monitoring device in the management of atrial fibrillation: A pilot study. *Pacing and Clinical Electrophysiology*, 36(3), 328-333.
- Rosero, S. Z., Kutyifa, V., Olshansky, B., & Zareba, W. (2013). Ambulatory ECG monitoring in atrial fibrillation management. *Progress in Cardiovascular Diseases*, 56(2), 143-152.
- Rho, R., Vossler, M., Blancher, S., & Poole, J. E. (2018). Comparison of two ambulatory patch ECG monitors: The benefit of the P-wave and signal clarity. *American Heart Journal*.
- Ruwald, M. H., & Zareba, W. (2013). ECG monitoring in syncope. *Progress in Cardiovascular Diseases*, 56(2), 203-210.
- Shrivastav, M., Padte, S., Arora, V., & Biffi, M. (2014). Pilot evaluation of an integrated monitor-adhesive patch for long-term cardiac arrhythmia detection in India. *Expert Review of Cardiovascular Therapy*, 12(1), 25-35.
- Smith, W. M., Riddell, F., Madon, M., & Gleva, M. J. (2017). Comparison of diagnostic value using a small, single channel, P-wave centric sternal ECG monitoring patch with a standard 3-lead Holter system over 24 hours. *American Heart Journal*, 185, 67-73.
- Solomon, M. D., Yang, J., Sung, S. H., Livingston, M. L., Sarlas, G., Lenane, J. C., & Go, A. S. (2016). Incidence and timing of potentially high-risk arrhythmias detected through long term continuous ambulatory electrocardiographic monitoring. *BMC Cardiovascular Disorders*, 16(1), 35.
- Steinberg, J. S., Varma, N., Cygankiewicz, I., Aziz, P., Balsam, P., Baranchuk, A., Cantillon, D.J., Dilaveris, P., Dubner, S.J., El-Shrif, N., & Krol, J. (2017). 2017 ISHNE-HRS expert

consensus statement on ambulatory ECG and external cardiac monitoring/telemetry.

Heart Rhythm, 14(7), e55-e96.

Tanno, K. (2017). Use of implantable and external loop recorders in syncope with unknown causes. *Journal of Arrhythmia*, 33(6), 579-582.

U.S Department of Health and Human Services. (2018). *Types of quality measures*. Retrieved from <https://www.ahrq.gov/professionals/quality-patient-safety/talkingquality/create/types.html>

Up to Date. (2018). *Ambulatory ECG monitoring*. Retrieved from https://www-upToDate-com.proxy.kumc.edu/contents/ambulatory-ecg-monitoring?source=history_widget

Zimetbaum, P., & Goldman, A. (2010). Ambulatory arrhythmia monitoring: Choosing the right device. *Circulation*, 122(16), 1629-1636