Title

High-Value Care Education in the USA: Lessons from a National Value Curriculum for Resident and Fellow Physicians

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Eliminating Inappropriate Telemetry Monitoring
An Evidence-Based Implementation Guide

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In-hospital continuous electrocardiographic monitoring, commonly referred to as telemetry, has allowed for rapid recognition of life-threatening conditions, including complex arrhythmias and myocardial ischemia. However, inappropriate use can lead to unnecessary downstream testing from "false alarms," which in turn affects clinician efficiency and increases health care costs without benefiting patients. For these reasons, the Society of Hospital Medicine's Choosing Wisely campaign recommended use of a protocol-driven discontinuation of telemetry. The American Heart Association (AHA) developed a set of Practice Standards for the appropriate use of telemetry monitoring in 2004, which they updated in 2017. Unfortunately, the AHA Practice Standards have not been widely adopted—with as many as 43% of monitored patients lacking a recommended indication for monitoring. Thus, we created an overview discussing the safety and efficacy of incorporating the AHA Practice Standards and a review of studies highlighting their successful incorporation within patient care workflow. We conclude by outlining an "implementation blueprint" for health system professionals and administrators seeking to change their institution's culture of telemetry use. As the health care landscape continues to shift, enacting high-value initiatives that improve patient safety and efficiency of care will be critical.

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Over the past 50 years, in-hospital continuous electrocardiographic (ECG) monitoring has been increasingly incorporated into clinical care. In 2004, the American Heart Association (AHA) developed a comprehensive set of Practice Standards toward its use in admitted adult and pediatric populations.[1] These were based primarily on expert opinion without significant clinical trial evidence. Similarly, the 2017 update to the Practice Standards was developed using only limited trial data.[2] Despite the lack of trial data, this consensus opinion of a multidisciplinary, multi-institutional panel of experts is the best available evidence to guide clinical management. In addition, implementation of the Practice Standards in clinical practice has been demonstrated to be safe.[3-7]

The use of telemetry in the non–intensive care unit (ICU) setting has been controversial, with many clinicians opting to order telemetry as a proxy for perceived closer monitoring of vital signs. In addition, unfamiliarity with the AHA Practice Standards and general ease of ordering has led to inappropriate use, with as many as 43% of monitored patients continuing to receive telemetric monitoring despite lack of a recommended indication.[8,9] Individual hospital policies and practices may further drive inappropriate use by dictating patient placement in telemetry units for certain diagnoses. Studies have reported that continuous monitoring rarely led to changes in clinical decision-making, overall care or outcomes, or improved identification of patients at risk for clinical deterioration.[10-12] Despite this, inappropriate telemetry use remains high.[9,12,13]

The effects of inappropriate telemetry monitoring on resource use, workflow interruptions, and health care costs are significant and can result in potential patient harm. Overuse of telemetry can lead to excessive and unnecessary diagnostic workup—ranging from noninvasive surface echocardiography to invasive diagnostic catheterizations.[14,15] "Alarm fatigue" is a major concern, potentially leading to critical events going unnoticed.[16,17] In fact, the Joint Commission has made reduction of unnecessary monitors and alarms a National Patient Safety Goal since 2014.[18] Continuous monitoring also poses a significant financial burden, with the cost of daily monitoring estimated to be as high as $1400 per patient.[4,5,12,19]

Given the consequences of inappropriate use, the Society of Hospital Medicine has included on its Choosing Wisely[20] list a recommendation to not order continuous telemetry outside of the ICU unless there is a protocol that governs continuation. In the absence of new scientific findings suggesting that deviation from the AHA Practice Standards is systematically beneficial, it is important from care and cost-containment standpoints to limit the use of telemetry to those clinical situations in which it is truly indicated. Building on the High Value Practice Academic Alliance's (HVPAA) earlier work on implementation guides targeting low-value practices,[21-24] we seek to provide a set of best practices to achieve system-wide improvements in appropriate telemetry use.

Overview of Practice Standards Regarding Non-ICU Telemetry

Undergirding the original AHA Practice Standards were the knowledge that telemetry was intentionally very sensitive and the presumption that detection of subtle electrocardiographic signs would have clinically meaningful benefit in at least 3 domains: (1) early detection of arrhythmia or ST-segment changes in suspected acute coronary syndromes, (2) identification of treatment failures or device malfunctions by way of arrhythmia detection, and (3) recognition of prolonged QT-intervals given the increased use of QT-prolonging medications in the inpatient setting.[1]

Recommendations were categorized based on the risks and benefits of monitoring. Patients with class I indications are those who benefit from continuous monitoring and transport by clinicians trained in cardiopulmonary resuscitation due to the significant risk of developing ischemia or an immediate, life-threatening arrhythmia. Patients with class II indications may benefit from telemetry monitoring, but telemetry is not expected to be life-saving. Finally, patients with class III indications are those with a low to very low risk of a serious event and for whom the risks of telemetry outweigh the benefits. The updated 2017 Practice Standards (**Tables 1**, **2**, and **3**) further delineated appropriate telemetry use and outlined methods for alarm management, staff education, and documentation.[2]

Interventions for Reduction of Inappropriate Telemetry Use

A comprehensive literature search in reference databases (PubMed, Embase) was conducted to identify studies that (1) involved hospitalized patients, (2) evaluated telemetry use, and (3) reported results of intervention(s) to improve telemetry appropriateness (**Table 4**). Only full-text articles describing interventions aimed at improving telemetry use or appropriateness were included. Literature that referenced pediatric (age <18 years), surgical, or ICU patient populations were excluded. In addition, those studies that were devoid of an intervention or implementation strategy were excluded. Index search was performed on May 9, 2017, with an updated inquiry performed on December 22, 2017.

Understanding how telemetry is used in practice helps inform the drivers of unnecessary use, which can be characterized as either inappropriate initiation or continuation after the appropriately indicated duration has passed. Review of the literature revealed that drivers of such use included ease of initiating, continuing, and renewing orders; infrequent reassessment of need; misconception of closer monitoring; and general lack of awareness of the AHA Practice Standards. Interventions implemented to address these causes included indication-based ordering, automatic discontinuation, routine review of use and appropriateness, and education. Various combinations of interventions were used among the reviewed studies and are briefly described in the following section.

Study by Dressler et al

Dressler et al[5] performed a prospective study in which an indication-based order set was implemented within the electronic health record (EHR), requiring clinicians to justify each patient's need for telemetry based on the 2004 AHA Practice Standards. Nursing staff were also provided with assessment guidelines to help facilitate safe and timely discontinuation of telemetry orders of predetermined duration. Implementation resulted in an immediate and sustained decrease in mean (SD) weekly telemetry orders by 43% (1032.3 [32.1] to 593.2 [21.3]), duration of telemetry by 47% (57.8 [2.4] hours to 30.9 [0.9] hours), and number of patients monitored by 70% (357.5 [20.6] to 109.1 [4.3]). The mean daily cost for non-ICU telemetry monitoring also decreased from $18 971 to $5772, equating to about $4.8 million in cost savings a year, which was mostly driven by a decrease in nursing time related to telemetry tasks. In a follow-up study[30] evaluating the safety of this intervention, it was found that life-threatening arrhythmias were rare (occurring in 1 out of 2645 patients) and that reducing inappropriate telemetry is not likely to miss potential life-threatening arrhythmias.

Study by Ramkumar et al

In another prospective study performed in Australia by Ramkumar et al,[25] daily assessments of hospital telemetry use were performed to determine need for continued monitoring and appropriate discontinuation. Patients requiring telemetry were admitted using a form based on the 2004 AHA Practice Standards. Intervention resulted in a reduction in the use of telemetry for class III indications from 38% to 11% ($P < .001$); however, there was notably a significant increase in the proportion of class II admissions, from 49% to 71% ($P = .008$). Intervention was also associated with reduction in median telemetry duration from 2.4 (interquartile ratio [IQR], 2.5) to 1.8 (IQR, 1.8) days ($P = .047$), with median length of stay (LOS) remaining the same at 5.0 (IQR, 5.0) vs 5.0 (IQR, 6.0) days ($P = .76$).

Study by Leighton et al

Leighton et al[6] performed a prospective cohort study evaluating telemetry bed use after the implementation of an ordering system within the EHR geared toward enforcing appropriate telemetry use. The ordering system required clinicians to select from a list of indications for continuous monitoring. Telemetry orders automatically expired after 48 hours and had to be reordered if further monitoring was warranted and desired. Prior to implementation, 65% of telemetry orders were concordant with the 2004 AHA Practice Standards. After implementation, compliance significantly improved to 81% ($P < .001$). However, adherence to recommendations 48 hours after initial order was noted to drop from 31% to 13% ($P < .001$) after implementation, suggesting inappropriate renewal of telemetry orders. Furthermore, it was noted that there were no clinically

Key Points

Question What are the most effective interventions to reduce inappropriate telemetry use?

Findings Interventions that successfully reduced inappropriate telemetry use incorporated stakeholder education and workflow adjustments to promote routine multidisciplinary reassessment of indication and benefit of continued monitoring.

Meaning Successful implementation of these interventions can mitigate "false alarms," reduce unnecessary downstream testing, and improve value without sacrificing patient safety outcomes.

Table 1. 2017 American Heart Association Practice Standards, Class I Recommendations[a]

Indication	Duration of Monitoring (if Specified)
High-risk chest pain/coronary artery disease	
Early-phase ACS (<24 h)	24-48 h or until ruled out with biomarkers
After MI, with or without revascularization	12-24 h if revascularization of all lesions; 24-48 h if residual lesions
Newly diagnosed left main coronary lesion	Until revascularized
Targeted temperature management (ie, therapeutic hypothermia)	Clinical judgment
Vasospastic angina (ie, Prinzmetal)	Until symptom resolution
Apical ballooning syndrome (ie, Takotsubo cardiomyopathy)	Until symptom resolution
Periprocedure monitoring	
After open heart surgery, complicated or uncomplicated	48-72 h; until discharge from acute care if high risk for AF[b]
After implantation of mechanical circulatory support or if hemodynamic deterioration in patient with preexisting support device	Until discharge
Clinically significant cardiovascular or hemodynamic deterioration in patient with mechanical circulatory support	Until discharge
TAVR/TAVI	72 h
Other transcatheter procedures (ie, VSD, ASD, valvuloplasty)	Duration varies based on procedure and patient factors
Serious comorbidities (ie, heart failure) undergoing any ablation	12-24 h
Complex ablations (ie, pulmonary vein isolation)	12-24 h
After atrioventricular nodal ablation	12-24 h
Temporary pacemaker (transcutaneous or transvenous)	Until device removed or replaced with permanent device
After pacemaker or ICD placement in pacemaker-dependent patient	12-24 h
Arrhythmias	
Postresuscitation or hemodynamically unstable VT	Until ICD implantation, arrhythmia suppression, or resolution of reversible cause
Atrial tachyarrhythmias (new, recurrent, ongoing rate management, initiation of new antiarrhythmic; regardless of hemodynamic stability)	During active treatment planning or therapy management
Symptomatic sinus bradycardia	Until definitive therapy rendered
Symptomatic or asymptomatic second or third-degree atrioventricular block (except asymptomatic Wenckebach [no indication])	Clinical judgment
Hemodynamically unstable or symptomatic congenital or genetic arrhythmic syndromes (ie, WPW, Brugada, LQTS)	Until stabilization of rhythm, appropriate therapy, or resolution of reversible cause
Event requiring ICD shocks, requiring admission	Duration of hospitalization
Syncope of suspected cardiac origin	
Syncope suspected to be of cardiac origin	>24 h, until cause and treatment initiated
Other conditions	
Acute decompensation of congestive heart failure	Until event precipitating presentation treated
Cerebrovascular accident	24-48 h
Moderate to severe imbalance of potassium or magnesium	Until normalization
Drug overdose	Until free of influence of drug and clinically stable

Abbreviations: ACLS, advanced cardiac life support; ACS, acute coronary syndrome; AF, atrial fibrillation; ASD, atrial septal defect; ICD, implantable cardioverter-defibrillator; LQTS, long QT syndrome; MI, myocardial infarction; TAVR/TAVI transcatheter aortic valve replacement/implantation; VSD, ventricular septal defect; VT, ventricular tachycardia; WPW, Wolff-Parkinson-White.

[a] See Sandau et al.[2] Class I indications are those for which telemetry is safe and effective and in which telemetry should be used. Benefits are substantially greater than associated risks. Class I patients should be monitored for arrhythmias on a portable monitor with defibrillator/pacemaker functionality and transported by ACLS-trained personnel when away from their home unit. The need for continuous telemetry should be reevaluated at least every 24 to 48 hours.

[b] Risk factors for AF include age greater than 65 years, left atrial enlargement, mitral valve disease, heart failure, hypertension, or history of AF.

significant events in patients who did not meet the 2004 AHA Practice Standards for continuous monitoring.

Study by Boggan et al

The study by Boggan et al[26] was performed to evaluate the effectiveness of reducing telemetry order duration, from 72 to 48 hours, on overall telemetry use. This intervention demonstrated that simply decreasing the duration of already time-limited telemetry orders did not change overall telemetry use, since clinicians would instead reorder telemetry. The order duration decreased by a mean (SD) of 33% (66.6 [8.3] hours to 44.5 [2.3] hours; $P < .01$), although the overall number of telemetry orders increased, making the total duration of telemetry during the hospitalization unchanged. Unlike the study by Dressler et al,[5] there was no clear collaboration between nurses and physicians to remove telemetry when the recommended duration of monitoring had passed.

Study by Wray et al

Wray et al[27] performed a prospective study aimed at reducing overall telemetry and urinary catheter use through use of a "silent" EHR indicator that allowed clinicians to perform rapid assessment of need. The silent EHR indicator was a column integrated in the patient list,

Table 2. 2017 American Heart Association Practice Standards, Class II Recommendations[a]

Indication	Duration of Monitoring (if Specified)
Class IIa[b]	
Chest pain/coronary artery disease	
After nonurgent PCI, with complications	>24 h or until complication resolved
Periprocedure monitoring	
Mechanical circulatory support patient admitted with noncardiac problems	Clinical judgment
Noncardiac major thoracic surgery in patient without AF risk factors	48-72 h
Noncardiac major thoracic surgery in patient with AF risk factors	Until discharge from acute care
TAVR/TAVI (>72 h postprocedure)	Clinical judgment
Arrhythmia	
Chronic AF with recurrence of RVR	Clinical judgment
Asymptomatic bradycardia with negative chronotropes initiated	Clinical judgment
Semipermanent transvenous pacing	24 h
Other conditions	
Infective endocarditis	Until clinical stability
Class IIb[c]	
Periprocedure monitoring	
Uncomplicated SVT ablation without transient AV block	Only in immediate postprocedure area
Semipermanent transvenous pacing (>24-h postprocedure)	Clinical judgment
After pacemaker or ICD placement in patient not dependent on pacemaker	Clinical judgment
Generator change	Only in immediate postprocedure area
After conscious sedation	Until patient is awake, alert, and stable
Arrhythmia	
Nonsustained ventricular tachycardia	Clinical judgment
Other conditions	
Hemodialysis	Clinical judgment

Abbreviations: AF, atrial fibrillation; AV, atrioventricular; ICD, implantable cardioverter-defibrillator; PCI, percutaneous coronary intervention; RVR, rapid ventricular rate; SVT, supraventricular tachycardia; TAVR/TAVI, transcatheter aortic valve replacement/implantation.

[a] See Sandau et al.[2] Class II patients are not generally recommended to be monitored for arrhythmias with portable monitors when transported away from their home unit. The need for continuous telemetry should be reevaluated at least every 24 to 48 hours.

[b] Class IIa indications are those for which telemetry use is reasonable.

[c] Class IIb indications are those for which telemetry use may be considered.

Table 3. 2017 American Heart Association Practice Standards, Class III Recommendations[a]

Indication	Duration of Monitoring (if Specified)
Class III: No Benefit[b]	
Chest pain/coronary artery disease	
After PCI, without complications	No further benefit beyond immediate postprocedure
After routine diagnostic coronary angiography	No further benefit beyond immediate postprocedure
Low risk (ie, HEART Score) and noncardiac chest pain	No further benefit if normal ECG and normal biomarkers
Periprocedure monitoring	
Mechanical circulatory support patient admitted to rehabilitation facility	NA
ICD or pacemaker admitted for unrelated indication	NA
Stable with wearable defibrillator admitted for unrelated indication	NA
Noncardiac surgery	NA
Arrhythmia	
Chronic AF admitted for noncardiac reason and hemodynamically stable	NA
Asymptomatic hemodynamically stable sinus bradycardia	NA
Asymptomatic Wenckebach or transient AV block of vagal origin	NA
Class III: Harm[c]	
Other conditions	NA
DNR/DNI patient whose care is comfort-focused	NA

Abbreviations: AF, atrial fibrillation; AV, atrioventricular; DNR/DNI, do not resuscitate/intubate; ECG, 12-lead electrocardiogram; HEART, history, ECG, age, risk factors, and troponin; ICD, implantable cardioverter-defibrillator; NA, not applicable; PCI, percutaneous coronary intervention.

[a] See Sandau et al.[2] Class III patients should not be monitored for arrhythmias using a portable monitor when transported away from their home unit. The need for continuous telemetry should be reevaluated at least every 24 to 48 hours.

[b] Class III: No benefit (not recommended).

[c] Class III: Harm (potentially harmful).

which signaled the presence of an active telemetry or urinary catheter order. The indicator allowed for direct management of the order and immediate discontinuation, if indicated. Practice Standards and recommendations were bundled with the silent indicator and were provided to house staff through both email and presentations. With specific regard to telemetry ordering, there was no significant difference in the percentage of patients who received telemetry orders. However, patients receiving telemetry were monitored for significantly less time (42.5 vs 34.9 hours; $P < .01$), which equated to about a 25% reduction in total patient days on telemetry.

Study by Svec et al

In the prospective cohort study by Svec et al,[28] bundled interventions aimed at reducing telemetry use included (1) daily review of telemetry bed use, (2) education module for trainees, (3) quarterly feedback on use, and (4) financial incentive. Telemetry use before and after intervention was measured between hospitalist and nonhospitalist (general house staff teams not staffed by hospitalists) groups. Further analysis was performed during an "extension period," which spanned 7 months and occurred 1 year after intervention. Overall, mean LOS for patients on telemetry decreased from 2.75 days to 2.13 days ($P = .005$) in the hospitalist group, along with a nonstatistically significant decrease in the nonhospitalist group (2.75 days to 2.46 days; $P = .33$). Decrease within the hospitalist group was sustained during the extension period. Change in LOS translated to a 22.55% decrease in total telemetry cost in the hospitalist group and a 10.55% decrease in the nonhospitalist group. An increase in trainee awareness and ability to identify the most (20.3% vs 51.1%; $P = .002$) and least (23.7% vs 60.0%; $P = .003$) cost-saving intervention was noted.

Table 4. Trial Interventions for Reducing Inappropriate Telemetry Use

Source	Population	Setting	Intervention(s)	Comparator/Control	Outcome
Dressler et al,[5] 2014	Adult non-ICU inpatients >18 y	Christiana Health Care System (DE), 1100-bed tertiary care hospital system; intervention in 2013	AHA Practice Standards (2004) incorporated into EHR order interface; bedside nursing assessments for automatic discontinuation; measured for 22 wks after initiation of efforts	11-wk Preimplementation in the same calendar year	43% Reduction in mean weekly telemetry orders placed; 47% reduction in mean duration of telemetry; 70% reduction in mean daily number of monitored patients; estimated organizational cost savings $4.8M per year
Ramkumar et al,[25] 2017	Adult non-ICU general medicine inpatients >18 y; patients stepped down from ICU to telemetry excluded	Monash University Hospital; 640-bed tertiary care hospital; intervention in 2015	AHA Practice Standards (2004) incorporated into telemetry request process; daily telemetry rounds by senior registrars (MD equivalent) briefed on recommendations; communication of results to primary team with shared decision-making process for telemetry continuation; measured for 3 mo after initiation of efforts	3-mo Preimplementation in the calendar year 2011 (phase 1 comparison)	71% Reduction in nonindicated telemetry orders placed; 25% reduction in average duration of telemetry order, from 2.4 d to 1.8 d; no difference in length of stay, events captured, or mortality
Leighton et al,[6] 2013	Adult non-ICU inpatients >18 y; 196 patients (preintervention) and 156 patients (postintervention)	New York Hospital Queens; 535-bed urban acute care teaching hospital; intervention in 2013	AHA Practice Standards (2004) incorporated into EHR order interface, user selects indication; order automatically discontinues at 48 h but may be reordered; measured for 4 wk after initiation of efforts	4-wk Preimplementation in same calendar year	25% Increase in patients with class I or II indication for telemetry; 58% reduction in compliance with recommendations at 48 h
Boggan et al,[26] 2014	Adult non-ICU inpatients >18 y; 557 patients (preintervention) and 684 patients (postintervention)	Durham Veterans Affairs Medical Center (NC); 151-bed tertiary care hospital; intervention in 2013	Reduced duration of telemetry order from 72 h to 48 h, with automatic discontinuation at 48 h unless renewed; measured 12 weeks postintervention	12-wk Preimplementation in the same calendar year	33% Decrease in duration of orders, although increase in number of orders, and same rate per hospitalization; overall same total amount of patient-days on telemetry
Wray et al,[27] 2017	Adult non-ICU patients >18 y with length of stay <14 d	University of Chicago (IL); 805-bed urban acute care teaching hospital; intervention in 2016	Email communication and presentation at start of rotation; silent indicator in EHR	Preintervention trends determined over 6-mo period of time in 2015	No difference in percentage of telemetry orders placed; 18% reduction in average duration of telemetry
Svec et al,[28] 2015	Adult non-ICU patients >18 y on inpatient general medicine services, stratified by house staff vs hospitalist services	Stanford Hospital (CA); 444-bed suburban acute care teaching hospital; intervention in 2013	Daily hospitalist review of telemetry use; AHA indication-based education effort for hospitalists; hospitalists received feedback on telemetry use; financial incentives	52-wk Preintervention in the calendar year 2012	22% Reduction in length of stay and cost savings for hospitalist services; sustained intervention for hospitalist services; no change in LOS or cost savings among nonhospitalist services
Kanwar et al,[8] 2008	Adult non-ICU inpatients >18 y	St John Hospital and Medical Center (MI); 608-bed urban acute care teaching hospital; intervention in 2006	Education interventions in 2 phases, first targeting ordering MDs in emergency department and general medicine wards and then NPs, PAs, and unit clerks	4-wk Preimplementation in same calendar year	12% Reduction in telemetry ordering rate. 24% Increase in patients with class I or II indication for telemetry
Edholm et al,[29] 2018	Adult patients >18 y with at least 1 non-ICU room charge. 16 912 Encounters in preintervention and 18 959 encounters in postintervention; stratified by hospitalist vs nonhospitalist (all admitting clinicians who are not hospitalists)	University of Utah; 537-bed academic medical center; intervention in 2015-2016	System-wide EHR intervention requiring indication and duration for telemetry monitoring; multifaceted hospitalist group intervention included education, removal of telemetry order from admission order set, recommendations for daily telemetry discussion on rounds, monthly feedback, and group financial incentive (no individual payments)	Compared telemetry use on hospitalist service vs nonhospitalist clinicians; 1-y preintervention, 6-mo "run-in" period, 1-y postintervention	Multifaceted intervention led to 69% reduction in telemetry use in the hospitalist group; EHR-intervention resulted in a 22% reduction in the nonhospitalist group; compared with nonhospitalists, hospitalists had a 60% greater reduction in telemetry use; no increase in mortality, code event rates, or care escalation

Abbreviations: AHA, American Hospital Association; CA, California; DE, Delaware; EHR, electronic health record; ICU, intensive care unit; IL, Illinois; LOS, length of stay; MI, Michigan; NC, North Carolina; NY, New York.

Study by Kanwar et al

The retrospective study by Kanwar et al[8] evaluated the effect of educational interventions on compliance to the 2004 AHA Practice Standards. Education on telemetry recommendations was provided to emergency medicine and internal medicine residents and faculty, nurse practitioners, physician assistants, and unit clerks. Unit clerks were encouraged to contact care teams to confirm telemetry indication, and residents were encouraged to discontinue telemetry once the indication had been addressed. In addition, admitting physicians were asked to identify indication for telemetry using a "telemetry order sheet" as part of the ordering process. Preintervention and postintervention analysis demonstrated a reduction in telemetry use from 43% to 37% ($P = .03$) and an increase in appropriate class I/II indication from 57% to 71% ($P < .001$). Notably, mean (SD) duration of telemetry trended down from 4.3 (4.0) days to 3.8 (3.0) days ($P = .18$).

Study by Edholm et al

More recently, the retrospective, observational preintervention to postintervention study by Edholm et al[29] compared the effect of 2 interventions aimed at reducing unnecessary telemetry monitoring. The hospitalist group received a multifaceted intervention that included education, process change, routine feedback, and a financial incentive, while all other clinicians were exposed only to a system-wide change in the EHR ordering process that required selection of clinical indication and duration for monitoring. This resulted in a 69% (95% CI, −72% to −64%; $P < .001$) reduction in telemetry use on the hospitalist service, and a 22% (95% CI, −27% to −16%; $P < .001$) reduction among other clinicians.

Implementation Blueprint

Research has shown that implementing a telemetry program based on the original 2004 AHA Practice Standards decreases inappropriate resource use and promotes cost savings without increase in adverse clinical outcomes. Herein, the HVPAA provides a blueprint to help ensure that appropriate patients are monitored on telemetry and that monitoring is discontinued when the indicated duration has passed. Building on these principles, health systems will have a foundation for improving telemetry use within their institution. We fully recognize that institutions may have limitations as to which interventions they can use, and we encourage each institution to focus on interventions that garner maximum support, from both clinical and administrative standpoints.

Step 1: Formulate a Quality Improvement Team and Recruit Relevant Stakeholders

Early buy-in and recruitment of relevant stakeholders are essential to successful improvement efforts. Involvement of services that most often use telemetry, such as general medicine, cardiology, and cardiothoracic surgery, along with nursing and ancillary staff, is crucial for performing root cause analyses and providing a foothold for education efforts in subsequent Plan-Do-Study-Act (PDSA) cycles.[31] Emergency medical professionals should also be included because they often determine initial level of care. Furthermore, information technology support and bed manager input are both integral to facilitate EHR-specific interventions and coordinate bed assignments, respectively. We recommend broad representation involving unit administration, nursing, and physicians, including house staff representatives and chief medical residents, within academic medical centers.

Step 2: Incorporate Indication-Based Ordering and Leverage the EHR

Inappropriate telemetry monitoring frequently stems from ease of ordering and lack of awareness of the AHA Practice Standards. As such, institutions should incorporate indication-based ordering within the EHR adherent to the class of recommendations outlined by the AHA. Although most of the recommendations are based on expert opinion, their implementation in clinical practice has been found to be safe.[3-7] Studies that required clinicians to perform indication-based ordering demonstrated significant improvement in adherence and notable decreases in inappropriate monitoring[5,6,8,25,29]—making it a strong intervention capable of significant change.

Organizations should also limit the duration of monitoring and the ability to renew orders. Studies that predetermined duration and automatically discontinued orders yielded varying results.[5,6,26] However, appropriateness was significantly improved when paired with multidisciplinary collaboration, as demonstrated in the study by Dressler et al.[5] Therefore, limiting duration and renewing ability can be a strong intervention when properly coupled with stakeholder partnerships. Finally, orders for telemetry monitoring should be removed from admission order sets for services and conditions for which telemetry monitoring is not usually indicated (ie, general medicine, general surgery, orthopedic surgery, class III indications) because exclusion has also been shown to decrease inappropriate initiation of telemetry.[5,29]

Step 3: Implement Routine Review of Telemetry Appropriateness and Use

Institutions should consider implementing a workflow to review ongoing indications for telemetry monitoring based on the AHA Practice Standards. In 3 studies,[25,28,29] the need for telemetry was reviewed daily, leading to significant improvements with stewardship. It should be noted that while routine review does facilitate reassessment of need, it relies on clinician action to discontinue monitoring. As opposed to the forced function of automated discontinuation, clinician review of use lends itself to interclinician variability and increased potential for unnecessary continuation—making it a weaker intervention compared with hardwired, indication-based interventions as in step 2. Nonetheless, empowering both clinicians and nursing to discontinue monitoring when it is no longer indicated is both safe and effective.

Step 4: Implement Education and Training on AHA Practice Standards and Safety

Misconception of closer monitoring and unfamiliarity with the AHA Practice Standards have also contributed to inappropriate telemetry use.[9] In an effort to address this, education and training should be geared toward increasing familiarity with the AHA recommendations and highlighting the potential harms that inappropriate monitoring can lead to. Such initiatives should include all members of the health care team because multidisciplinary collaboration can increase the success rate of intervention(s).[5,8,25,28,29] It is important to note that education, without active or automated action toward

discontinuation, did not yield significant reduction in telemetry use or improve appropriateness[27]—and as such is a weak intervention when performed alone. Education should therefore be coupled with other interventions to improve sustained change and adherence to consensus recommendations.

Conclusions

Interventions to reduce inappropriate telemetry use can help to prevent unnecessary monitoring and reduce overall health care expenditure. Existing literature demonstrates that using multimodal interventions that include indication-based ordering, automatic discontinuation, routine review of use and appropriateness, and education can lead to significant reduction in inappropriate telemetry use, and subsequently significant cost savings. Understanding the local drivers of telemetry use can help identify which interventions are likely to be beneficial and underscores the need for a multidisciplinary team to champion changes at an institutional level. The blueprint described herein should be considered by clinicians and health care administrators alike as a foundation for reducing inappropriate telemetry use and improving high-value care.

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Invited Commentary

LESS IS MORE

Continuing to Improve Appropriateness of Continuous Electrocardiographic Monitoring (Telemetry)

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Continuous electrocardiographic monitoring (telemetry) is widely used in hospitalized adult patients for many reasons. Clinicians presume that closely monitoring a patient's heart rate, rhythm, ST-segment, and QT-interval could lead to overall benefit through multiple possible mechanisms. Detecting arrhythmias that may reflect severe clinical deterioration, such as ventricular tachycardia or high-grade atrioventricular block, could lead to stabilizing interventions. Ischemia identified through ST-segment changes could help avert infarction. QT prolongation could be corrected before leading to life-threatening arrhythmias, such as torsades de pointes. More commonly, the absence of abnormalities on telemetry could guide treatment decisions by excluding possible arrhythmic causes of patient symptoms. Finally, the sense that patients are receiving close vital sign monitoring may drive the decision to use telemetry.

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Despite these hopes of garnering helpful information through telemetry, there is an absence of robust data to support its use. A 2017 Scientific Statement by the American Heart Association on Practice Standards for Electrocardiographic Monitoring in Hospital Settings provided multiple recommendations on indications for in-hospital telemetry and duration of its use.[1] The expert authors conducted a comprehensive literature review to inform their effort. But even with the exhaustive search, none of the Class I recommendations (those for which benefits far outweigh risks and telemetry should be performed) are based on data derived from multiple randomized clinical trials (RCTs) or meta-analyses (Level of Evidence A), which are generally accepted as the gold standard. In fact, the authors note that many of their recommendations were based on limited data,[1] which included both single RCTs or nonrandomized studies (Level of Evidence B) and consensus expert opinion, case studies, and standard of care (Level of Evidence C).

In addition to the evidence base for telemetry being generally weak, much current telemetry use still falls outside of current standards. When telemetry orders do follow the practice standards, they are left in place for longer durations than recommended and, in some cases, for the entirety of a patient's hospitalization. One example demonstrating overuse of telemetry is that a single health system's effort to increase appropriateness of telemetry orders led to a 70% decrease in use and nearly $5 million in annual savings without any adverse patient safety events.[2]

Telemetry for many indications is unlikely to benefit patients. More worrisome, inappropriate telemetry can also lead to patient harm. Such harm may be direct, such as incorrect diagnosis of ventricular tachycardia that has resulted in unnecessary interventions, including implantable cardioverter defibrillator placement.[1] Harm may also be indirect, such as leading patients to receive follow-up testing unrelated to their reason for hospitalization and diverting the attention of nursing staff toward possible false alarms and away from other care that may better help improve a hospitalized patient's health. Nurses are estimated to spend an average of 30 minutes per shift managing telemetry-related tasks.[3] Given these possible harms and the lack of high-quality evidence for benefit from telemetry, strategies to reduce inappropriate telemetry use are needed.

In this issue of *JAMA Internal Medicine*, members of the High Value Practice Academic Alliance led by Yeow and colleagues[4] review the literature of interventions to improve telemetry utilization or appropriateness in hospitalized adults. Informed by this thorough review, the authors offer an "implementation blueprint" that can help increase the likelihood that only patients who may gain clinical benefit are monitored on telemetry. Their suggestions also can support discontinuation after a patient's clinical condition has transitioned and the duration