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APPROPRIATE USE OF TELEMETRY IN THE HOSPITAL

LESSONS AND OPPORTUNITIES

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- Nothing to disclose

REFERENCES TO OFF-LABEL USAGE(S) OF PHARMACEUTICALS OR INSTRUMENTS

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LEARNING OBJECTIVES

- Describe the utility of cardiac telemetry in the hospital.
- Review the most recent cardiac telemetry practice standards.
- Recognize limitations and potential harms of cardiac telemetry.
- Identify ways to optimize use of cardiac telemetry at the individual and institutional levels.

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TERMINOLOGY



tele-
= distant

-metry
= measurement

telemetry
= remote monitoring

- Continuous electrocardiographic monitoring = cardiac telemetry = telemetry

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AUDIENCE POLL #1

I feel confident deciding which of my hospitalized patients will benefit from cardiac telemetry.

1. Yes
2. No

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AUDIENCE POLL #2

I worry about or have witnessed adverse patient events related to use of cardiac telemetry.

1. Yes
2. No

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AUDIENCE POLL #3

My institution has a clearly-defined protocol that governs continuation/discontinuation of cardiac telemetry in non-ICU settings.

1. Yes
2. No

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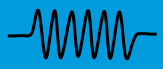
UTILITY OF TELEMETRY



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WHAT CAN TELEMETRY TELL YOU?

Arrythmia



Requiring intervention

ST segment changes



Myocardial ischemia

QT prolongation



Torsades de pointes

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BRIEF HISTORY OF CARDIAC TELEMETRY

1949
Norman J. Holter reports transmission of a radioelectrocardiograph via an 85-lb wearable backpack

1959
Edgar Haber describes a cardiac monitor equipped with an alarm that can record an ECG tracing at onset of arrhythmia

1960s
Telemetry is implemented in cardiac intensive care units and a reduction in mortality is observed post-MI

1980s
Studies are published regarding more selective use of cardiac telemetry

1991
American College of Cardiology publishes guidelines for in-hospital cardiac monitoring for detection of arrhythmias

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Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association[1]

Kristin E. Sandau, Marjorie Funk, Andrew Auerbach, Gregory W. Barsness, Kay Blum, Maria Cvach, Rachel Lampert, Jeanine L. May, George M. McDaniel, Marco V. Perez, Sue Sendelbach, Claire E. Sommargren, and Paul J. Wang and On behalf of the American Heart Association Council on Cardiovascular and Stroke Nursing; Council on Clinical Cardiology; and Council on Cardiovascular Disease in the Young

Circulation, 2017; 136: e273-e344

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Link to 2017 AHA scientific statement:

ABOUT THE AHA PRACTICE STANDARDS

INTRODUCTION

- Original practice standards published 2004
- Recommendations on usefulness and effectiveness of continuous electrocardiographic monitoring in the hospital
- Updated 2017 in response to new issues including:
  - Overuse of arrhythmia monitoring
  - Appropriate use of ischemia and QT-interval monitoring
  - Alarm management
  - Documentation in EHR

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

ABOUT THE AHA PRACTICE STANDARDS

LEVEL OF EVIDENCE

Estimate of Certainty (Precision) of Treatment Effect
Level A: Multiple populations evaluated Data from multiple RCTs or meta-analyses
Level B: Limited populations evaluated Data from a single RCT or nonrandomized studies
Level C: Very limited populations evaluated Only consensus opinion of experts, case studies, or standard of care

Size of Treatment Effect
Class I: Benefit >>> Risk Telemetry SHOULD be used
Class IIa: Benefit >> Risk IT IS REASONABLE to use telemetry
Class IIb: Benefit ≥ Risk Telemetry MAY BE CONSIDERED
Class III: No Benefit Telemetry not helpful
Class III: Harm Excess cost w/o benefit or harmful

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

ABOUT THE AHA PRACTICE STANDARDS

LEVEL OF EVIDENCE

- 97 recommendations on clinical use of cardiac telemetry
- Majority of recommendations are Level of Evidence C

	Class I	Class II	Class III	
Level A	-	-	-	
Level B	10.3%	6.2%	2.1%	**= 18.6%**
Level C	33.0%	23.7%	24.7%	**= 81.4%**

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

ABOUT THE AHA PRACTICE STANDARDS
ORGANIZATION

- Organized by patient population and indication
  - Duration of monitoring
- Majority of indications are for primary cardiac conditions

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

ABOUT THE AHA PRACTICE STANDARDS
PATIENT POPULATIONS

- Chest pain/ coronary artery disease
- Major cardiac interventions
- Arrythmias
- Syncope of suspected cardiac origin
- After electrophysiology procedures/ ablation
- After pacemaker or ICD implantation procedures
- Preexisting rhythm devices
- Other cardiac conditions
- Noncardiac conditions
- Medical conditions
- DNR/DNI

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS

CARDIAC CONDITIONS

New or recurrent atrial fibrillation	• Monitor until treatment strategy determined • *Class I; Level of Evidence C*
Hemodynamically unstable or symptomatic AF	• *Class I; Level of Evidence C*
Chronic AF	• If admitted for reason other than arrhythmia or rate and patient hemodynamically stable • *Class III: No Benefit; Level of Evidence C*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS

CARDIAC CONDITIONS

Acute decompensated heart failure	• Until precipitating event (e.g., volume overload; ischemia; anemia; progressive ventricular, respiratory, or renal failure; hypertension; exacerbation of comorbidities; new-onset AF; or infection) is successfully treated • *Class I; Level of Evidence B*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS

CARDIAC CONDITIONS

Syncope of suspected cardiac origin and meeting admission criteria for syncope

- Monitor for arrhythmia ≥ 24 h; until cause and treatment identified; then follow indications and durations per criteria in the practice standard
- *Class I; Level of Evidence B*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS

MEDICAL CONDITIONS

Stroke

- Monitor 24-48 h for arrhythmia
- *Class I; Level of Evidence B*

Moderate to severe imbalance of K or Mg

- Monitor for arrhythmia until normalization of electrolytes
  - *Class I; Level of Evidence B*
- QTc monitoring recommended until normalization of electrolytes and no evidence of QT-related arrhythmias
  - *Class I; Level of Evidence C*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS
MEDICAL CONDITIONS

Drug overdose

- Monitor for arrhythmia until free of the influence of the drug(s) and clinically stable
  - *Class I; Level of Evidence B*
- QTc monitoring until QT-prolonging drug levels have decreased, unknown drug has been identified as non-QT-prolonging, QTc interval is in normal range, and no evidence of QT-related arrhythmias
  - *Class I; Level of Evidence C*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS
MEDICAL CONDITIONS

Hemodialysis

- Arrhythmia monitoring efficacy is not well established for most patients receiving chronic hemodialysis unless they have another indication
- *Class IIb; Level of Evidence B*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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Link to 2017 AHA scientific statement:

SPECIFIC AHA RECOMMENDATIONS

DNR/DNI

When data gained would trigger interventions consistent with patient wishes

- Follow practice standards for related conditions

When data will not be acted on and comfort-focused care is the goal

- *Class III: Harm; Level of Evidence C*

Source: Sandau, K.E., et al., *Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association. Circulation, 2017.* ***136(19): p. e273-e344.***

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LIMITATIONS OF TELEMETRY



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WHAT IS TELEMETRY NOT?

- Substitute for closer monitoring or clinician assessment



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WHAT IS TELEMETRY NOT?

- Detector of clinical decompensation

	Continuous electrocardiography	NEWS	MEWS
Temperature		✓	✓
Systolic blood pressure		✓	✓
Heart rate	✓	✓	✓
Respiratory rate		✓	✓
Oxygen saturation		✓	
Use of supplemental oxygen		✓	
CNS response		✓	✓
Urine output			✓

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WHAT IS TELEMETRY NOT?

- Schull et al (2000)[2]
  - 0.02% of non-ICU telemetry ward patients were monitor-signaled survivors of cardiac arrest
  - 2 of 4 unmonitored patients who had cardiac arrest survived
- Snipelisky et al (2018)[3]
  - Of 242 patients who experienced cardiopulmonary arrest:
    - 110 had telemetry changes immediately prior to arrest
    - 66 of those had nonmalignant telemetry changes
  - Patients who had telemetry changes prior to arrest had no improvement in time to resuscitation or survival

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LIMITED USE IN NON-ICU HOSPITAL SETTINGS

- Estrada et al (1995)[4]
  - 0.8% of non-ICU telemetry ward patients transferred to the ICU because of arrhythmia identified by telemetry
  - 7% of telemetry findings resulted in management changes
- Sivaram et al (1998)[5]
  - Non-ICU patients on telemetry
  - 297 total telemetry events on 379 telemetry days
  - 4% of telemetry events resulted in management changes

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LIMITED USE IN NON-ICU HOSPITAL SETTINGS

- Dawson et al (2017)[6]
  - Non-ICU patients hospitalized with respiratory illness who did not meet AHA criteria for telemetry use
  - Between patients on telemetry vs. not on telemetry:
    - No difference in mortality at 30 and 90 days
    - No difference in 30-day readmission rates
    - Longer length of stay

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POTENTIAL HARMS OF TELEMETRY
FALSE ALARMS

- Staff must be adequately educated in correct interpretation of waveforms
- Knight et al (1999)[7]
  - Case series of 12 patients with misdiagnosis of artifact as VT
  - Underwent unnecessary interventions including:
    - Diagnostic cardiac catheterization
    - Intravenous lidocaine
    - “Successful” cardioversion
    - Permanent pacemaker or ICD placement

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POTENTIAL HARMS OF TELEMETRY
NONACTIONABLE ALARMS AND ALARM FATIGUE

- Alarm fatigue = significant patient safety issue
  - Alarm desensitization → inappropriate response delay or disabling alarms
- Joint Commission National Patient Safety Goals®
  - Reduce patient harm associated with clinical alarm systems
- Contributions to increase in nonactionable alarms include:
  - Default alarm limits too narrow, not customized to the patient
  - Issues obtaining proper readings (e.g., poor electrode adherence)
  - Overutilization of telemetry

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POTENTIAL HARMS OF TELEMETRY
PATIENT EXPERIENCE

- Excess noise from nonactionable alarms
- Restraint by wires
- Delirium



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POTENTIAL HARMS OF TELEMETRY
FINANCIAL BURDEN

- Benjamin et al (2013)[8]
  - Retrospective study at 4 teaching hospitals
  - 65% of telemetry days deemed indicated
  - Estimated excess cost of $250,000 per year for a 400-bed hospital
- Chong-Yik et al (2018)[9]
  - Review of 250 patients admitted to telemetry-capable beds
  - 24% of telemetry days deemed indicated
  - Estimated excess cost of $37,007 in those 250 patients
- Downstream effect of further testing that may not have patient benefit

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POTENTIAL HARMS OF TELEMETRY
HOSPITAL FLOW

- Limited resource at most hospitals
- Hospital throughput can be negatively affected

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OPTIMIZATION OF TELEMETRY USE



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OPTIMIZING INDIVIDUAL USE OF TELEMETRY

COMMON SENSE QUESTIONS

What is my primary concern? Is it likely to occur?

- Telemetry = cardiac test that can monitor for arrhythmia requiring intervention, myocardial ischemia, torsades de pointes

What test or intervention will be able to address this concern?

- Alternatives to telemetry = more frequent vital signs, oximetry, closer nurse/clinician monitoring at bedside, critical care consult/support

Will this test or intervention have more benefit than harm?

- Consider patient comorbidities and define patient care goals that may conflict with purpose of telemetry

When is it safe to deescalate the intervention?

- Reassess need for telemetry on a regular basis

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APPLICATION OF AHA PRACTICE STANDARDS
EXPERIENCES IN NON-ICU SETTINGS

- How does this apply to my patients?
- Limited recommendations in noncardiac medical conditions

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APPLICATION OF AHA PRACTICE STANDARDS
EXPERIENCES IN NON-ICU SETTINGS

Application of 2004 AHA Practice Standards for Continuous Electrocardiographic Monitoring

	Significant findings	Safety
Leighton et al (2013)[10]	Absolute 16% improvement in telemetry admissions meeting guideline indication	No clinically significant arrhythmias in patients without indications for monitoring
Dressler et al (2014)[11]	Mean daily number of telemetry patients decreased by 70%	Stable code blue, rapid response team activation, and mortality
Cantillon et al (2016)[12]	15.5% telemetry census reduction	No increase in cardiopulmonary arrests
Alsaad et al (2017)[13]	10% reduction in telemetry use	No significant increase in mortality
Ramkumar et al (2017)[14]	Absolute 27% reduction of class III telemetry admissions	No significant rise in all major tachy/bradyarrhythmias
Edholm et al (2018)[15]	69% telemetry utilization reduction	No significant increase in mortality, code event rates, or care escalation
Najafi et al (2019)[16]	Significant reduction of telemetry duration (8.7 h reduction per hospitalization)	No change in rapid-response calls or medical emergency events

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APPLICATION OF AHA PRACTICE STANDARDS
INSTITUTIONAL INTERVENTION

- Journal of Hospital Medicine, Choosing Wisely in Adult Hospital Medicine: Five Opportunities for Improved Healthcare Value[17]
  - Do not order continuous telemetry monitoring outside of the ICU without using a protocol that governs continuation.

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APPLICATION OF AHA PRACTICE STANDARDS
EXAMPLES OF INSTITUTIONAL INTERVENTIONS

- Clearly-defined institutional indications for telemetry made readily available and visible
- Removal of telemetry order from admission order sets when not indicated
- Electronic telemetry ordering system requiring selection of approved indication or with just-in-time education
- Auto-expiring telemetry orders with reminder to reorder if indicated
- Electronic reminder to reassess ongoing need for telemetry or notify clinicians when recommended duration has been exceeded
- Rounding checklist including discussion of ongoing need for telemetry (RN- or clinician-driven)

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QUESTIONS & DISCUSSION



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REFERENCES

1. Sandau, K. E., M. Funk, A. Auerbach, G. W. Barsness, K. Blum, M. Cvach, R. Lampert, J. L. May, G. M. McDaniel, M. V. Perez, S. Sendelbach, C. E. Sommargren and P. J. Wang (2017). "Update to Practice Standards for Electrocardiographic Monitoring in Hospital Settings: A Scientific Statement From the American Heart Association." Circulation 136(19): e273-e344.
2. Schull, M. J. and D. A. Redelmeier (2000). "Continuous electrocardiographic monitoring and cardiac arrest outcomes in 8,932 telemetry ward patients." Acad Emerg Med 7(6): 647-652.
3. Snipelisky, D., J. Ray, G. Matcha, A. Roy, D. Harris, V. Bosworth, A. Dumitrascu, B. Clark, T. Vadeboncoeur, F. Kusumoto, C. Bowman and M. C. Burton (2018). "Mayo Registry for Telemetry Efficacy in Arrest Study: An Assessment of the Utility of Telemetry in Predicting Clinical Decompensation." J Intensive Care Med 33(3): 166-175.
4. Estrada, C. A., H. S. Rosman, N. K. Prasad, G. Battilana, M. Alexander, A. C. Held and M. J. Young (1995). "Role of telemetry monitoring in the non-intensive care unit." The American Journal of Cardiology 76(12): 960-965.
5. Sivaram, C. A., J. H. Summers and N. Ahmed (1998). "Telemetry outside critical care units: patterns of utilization and influence on management decisions." Clin Cardiol 21(7): 503-505.
6. Dawson, N., M. C. Burton, B. Hull, G. Beliles, I. Pritchard, C. Trautman, L. Ferry, A. Doyon, R. Colby, A. Chuu, S. T. Kung, T. Khang, D. Durocher, M. Buras, H. Kosiorek, N. Agrwal, A. Sen, D. Goss and H. Geyer (2017). "Relation of Telemetry Use and Mortality Risk, Hospital Length of Stay, and Readmission Rates in Patients With Respiratory Illness." Am J Cardiol 120(8): 1416-1420.
7. Knight, B. P., F. Pelosi, G. F. Michaud, S. A. Strickberger and F. Morady (1999). "Clinical Consequences of Electrocardiographic Artifact Mimicking Ventricular Tachycardia." New England Journal of Medicine 341(17): 1270-1274.
8. Benjamin, E. M., R. A. Klugman, R. Luckmann, D. G. Fairchild and S. A. Abookire (2013). "Impact of cardiac telemetry on patient safety and cost." Am J Manag Care 19(6): e225-232.
9. Chong-Yik, R., A. L. Bennett, R. V. Milani and D. P. Morin (2018). "Cost-Saving Opportunities with Appropriate Utilization of Cardiac Telemetry." Am J Cardiol 122(9): 1570-1573.

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REFERENCES

10. Leighton, H., H. Kianfar, S. Serynek and T. Kerwin (2013). "Effect of an electronic ordering system on adherence to the American College of Cardiology/American Heart Association guidelines for cardiac monitoring." Crit Pathw Cardiol 12(1): 6-8.
11. Dressler, R., M. M. Dryer, C. Coletti, D. Mahoney and A. J. Doorey (2014). "Altering Overuse of Cardiac Telemetry in Non–Intensive Care Unit Settings by Hardwiring the Use of American Heart Association Guidelines." JAMA Internal Medicine 174(11): 1852-1854.
12. Cantillon, D. J., M. Loy, A. Burkle, S. Pengel, D. Brosovich, A. Hamilton, U. N. Khot and B. D. Lindsay (2016). "Association Between Off-site Central Monitoring Using Standardized Cardiac Telemetry and Clinical Outcomes Among Non-Critically Ill Patients." Jama 316(5): 519-524.
13. Alsaad, A. A., C. R. Alman, K. M. Thompson, S. H. Park, R. E. Monteau and M. J. Maniaci (2017). "A multidisciplinary approach to reducing alarm fatigue and cost through appropriate use of cardiac telemetry." Postgrad Med J 93(1101): 430-435.
14. Ramkumar, S., E. H. Tsoi, A. Raghunath, F. F. Dias, C. Li Wai Suen, A. H. Tsoi and D. R. Mansfield (2017). "Guideline-based intervention to reduce telemetry rates in a large tertiary centre." Internal Medicine Journal 47(7): 754-760.
15. Edholm, K., P. Kukhareva, C. Ciarkowski, J. Carr, D. Gill, A. Rupp, J. Morshedzadeh, N. Wanner and K. Kawamoto (2018). "Decrease in Inpatient Telemetry Utilization Through a System-Wide Electronic Health Record Change and a Multifaceted Hospitalist Intervention." J Hosp Med 13(8): 531-536.
16. Najafi, N., R. Cucina, B. Pierre and R. Khanna (2019). "Assessment of a Targeted Electronic Health Record Intervention to Reduce Telemetry Duration: A Cluster-Randomized Clinical Trial." JAMA Intern Med 179(1): 11-15.
17. Bulger, J., W. Nickel, J. Messler, J. Goldstein, J. O'Callaghan, M. Auron and M. Gulati (2013). "Choosing wisely in adult hospital medicine: five opportunities for improved healthcare value." J Hosp Med 8(9): 486-492.

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