

# Impact of Cardiac Telemetry on Patient Safety and Cost

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**W**ith healthcare reform driving a heightened imperative for organizations to improve efficiency and reduce waste, it is timely and valuable to examine high-volume procedures and practices in order to identify overuse. At the same time, organizations must ensure that improved efficiency does not inadvertently reduce patient safety.

Cardiac disease or suspected cardiac disease is one of the most common reasons for which adults are admitted to the hospital.<sup>1,2</sup> Many of these patients are placed on telemetry monitoring based on local practice or commonly accepted recommendations.<sup>3,4</sup> Despite the well-defined indications for monitoring, developed by the American Heart Association in 2004,<sup>5</sup> telemetry is often applied outside of these guidelines.<sup>6,7</sup> A low incidence of clinically significant arrhythmias on nonindicated days has been documented by Curry and colleagues as well as by others.<sup>7</sup> There are also well-documented cases of patient harm, including death, associated with alarm fatigue from excessive monitoring and false alarms.<sup>8</sup> Telemetry is also expensive and labor intensive for hospitals. Equipment purchase, maintenance, and supplies, as well as nursing time, are responsible for this expense. Finally, patient admissions may be delayed because of limited telemetry bed availability in many hospitals. The appropriate utilization of telemetry may decrease costs, reduce delays in admissions, and improve patient safety.

We undertook a multicenter study of the use of cardiac telemetry at 4 Massachusetts teaching hospitals to determine the utilization patterns, the frequency of telemetry use unsupported by guideline indications, the incidence of arrhythmias on both indicated and nonindicated days, and the estimated financial cost of nonindicated telemetry.

## METHODS

This study originated as a quality assurance initiative. Subsequently, the data collected for the quality assurance study were de-identified and became the basis for this research study. The institutional review board at 1 site acknowledged that this study was exempt because it involved only an analysis of retrospective, completely de-identified data.

Four hospitals representing urban academic medical centers in Massachusetts participated in the study.

**Table 1** shows the proportion of non-intensive care unit medical and surgical beds with telemetry capacity at each institution.

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**Background:** With the impetus for healthcare reform and the imperative for healthcare organizations to improve efficiency and reduce waste, it is valuable to examine high-volume procedures and practices in order to identify potential overuse. At the same time, organizations must ensure that improved efficiency does not inadvertently reduce patient safety.

**Methods:** We undertook a multicenter analysis of the use of adult cardiac telemetry outside of the intensive care unit or step-down units at 4 teaching hospitals to determine the percentage of monitoring days that were not justified by an accepted indication and the monetary costs associated with these nonindicated days. We also assessed the safety of eliminating monitoring on days when it was not justified by looking at the incidence of arrhythmias.

**Results:** We found that in 35% of telemetry days, telemetry use was not supported by an accepted set of clinical indications. The incidence of arrhythmias on nonindicated days was low (3.1 per 100 days of monitoring per nonindicated day), and the arrhythmias detected were clinically insignificant. Eliminating monitoring on nonindicated days could save a minimum of \$53 per patient per day. The average 400-bed hospital with a conservative estimate of 5000 nonindicated patient days per year could save \$250,000 per year.

**Conclusion:** Reducing the use of telemetry on nonindicated days may provide an opportunity for institutions to safely reduce cost as well as staff time and effort, while maintaining and potentially increasing patient safety.

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**For author information and disclosures, see end of text.**

### Take-Away Points

We reviewed utilization patterns of inpatient cardiac telemetry at 4 academic medical centers.

Our study highlights the potential overuse of inpatient cardiac telemetry and suggests that reducing inappropriate telemetry may improve the cost of care while maintaining patient safety.

- More than one-third of all telemetry days did not meet accepted indications for telemetry.
- The incidence of significant arrhythmia on nonindicated telemetry days was extremely small.
- Reducing the use of cardiac telemetry to only accepted indications may safely reduce healthcare costs.

We reviewed the American College of Cardiology and the American Hospital Association guidelines<sup>5,9</sup> for telemetry use and the local guidelines from the 4 participating institutions. We made minor modifications to the American College of Cardiology and American Hospital Association guidelines by classifying conditions into clear indications for telemetry monitoring and clear indications for discontinuing monitoring (Table 2). We used the modified guidelines to designate each day of monitoring as indicated (meeting 1 or more guideline criteria) or nonindicated (not meeting any indication), based on criteria for initiating and discontinuing monitoring. We then designed an audit tool to support structured data abstraction from medical records. Data to be collected included start and stop date for monitoring episodes, guideline indication(s) for initiation of monitoring (if any), other reasons for instituting monitoring, number of days in each episode that met guideline criteria (indicated days), number of nonindicated days, and the occurrence of any significant arrhythmias during a monitoring episode, based on notes in the medical record. An arrhythmia was considered significant if it met 1 or more of these criteria: ventricular tachycardia of at least 3 continuous beats, supraventricular tachycardia of at least 3 beats including atrial fibrillation, any atrioventricular nodal block, and bradycardia with a heart rate of less than 50 beats per minute for more than 30 seconds. When the significance of an arrhythmia was not clear to an auditor, the auditor presented the finding to one of the authors, who made a final decision on significance.

Study subjects were all patients who were receiving care on general medical-surgical wards from January 1 through January 7, 2008, at the 4 participating health centers and who had at least 1 day of cardiac telemetry monitoring. All monitoring days were included in the abstraction and analysis, including days that occurred before January 1 and after January 7 when monitoring episodes began before or ended after the period from January 1 to January 7. Data abstraction was completed during the summer and fall of 2008.

Estimates of the amount of nursing time required to manage cardiac monitors and costs of supplies (ie, monitor leads,

batteries, paper for monitor printers) were obtained from nurse managers at each institution, who were asked to make estimates based on their own organization and their observation of nurses' experience with the typical tasks related to the nurse management of cardiac monitoring equipment including placing, replacing, and repositioning monitoring leads; orienting patients to the monitor; responding to monitor alarms; running routine rhythm strips;

and charting on monitor output after each shift. The average hourly pay for registered nurses was obtained from the 2010 Massachusetts Hospital Association's *Healthcare Provider Compensation Survey*.<sup>10</sup> We added 20% to the estimated average base salary to cover the estimated average cost of benefits. To calculate nursing full-time equivalents (FTEs), we assumed an FTE nurse would be paid 40 hours per week for 52 weeks in a year (2080 hours per year).

To estimate the number of nonindicated days of monitoring in a typical year, we selected cases that began monitoring only during the study week (incident cases) and calculated the total number of nonindicated days during each related monitoring episode only in that week. We assumed that the number of incident cases and the duration of indicated and nonindicated monitoring in these cases were representative of all weeks in a typical year. We then multiplied the number of nonindicated days by 52 weeks to obtain an estimate of total annual nonindicated monitoring days. Adjusted cardiac arrhythmia event rates for indicated and nonindicated days and the significance of the difference in rates were obtained by fitting a generalized linear mixed model with a binomial distribution and logit link function, and using subjects and sites as random effects<sup>11-14</sup> (a form of logistic regression). The odds ratio estimate of relative risk was obtained by exponentiating the fitted model parameter for the variable identifying whether days were indicated or not.<sup>11,14</sup> A 95% confidence interval (CI) for the odds ratio was obtained by taking the fitted model parameter for indication and adding and subtracting 1.96 standard errors for the parameter, and then exponentiating these end points. Analysis was performed using the Proc GLIMIX procedure<sup>15</sup> with SAS statistical software, version 9.2 (SAS Institute Inc, Cary, North Carolina).

*P* values associated with an effect or difference that were less than or equal to .05 indicated statistical significance. To compare medians, we used the Mann-Whitney *U* test. To compare proportions across sites, we used a  $\chi^2$  test and adjusted multiple comparisons when indicated using a Bonferroni correction to the *P* value.

■ **Table 1.** Number of Medical/Surgical and Telemetry Beds Outside of ICUs and Average Occupancy by Site

Site	Medical/Surgical Beds (Non-ICU), n	Telemetry Beds (Non-ICU), n (%)	Average Bed Occupancy, n (%)
1	447	190 (42.5)	322 (72.0)
2	73	69 (94.5)	59 (80.8)
3	198	198 (100.0)	140 (70.7)
4	377	206 (54.6)	311 (82.5)
Total	1095	663 (60.5)	832 (76.0)

ICU indicates intensive care unit.

## RESULTS

We identified 501 patients receiving care during the study period who had cardiac monitoring at any time during their admission at the 4 study sites: 42 at site 1, 131 at site 2, 145 at site 3, and 183 at site 4. Among these patients, there were 302 monitoring episodes (60.3%) that included only days on which there was always an acceptable indication for monitoring; 77 (15.4%) included only days on which there was no acceptable indication. The remaining 122 episodes (24.4%) typically started with 1 or more indicated days and ended with 1 or more nonindicated days. At site 1, there were no episodes consisting entirely of nonindicated days. Overall, the total number of patient days of monitoring was 1559, including 1011 (65%) indicated days and 548 (35%) nonindicated days. Of the 548 nonindicated days, 325 (59.3%) occurred during episodes with a mix of indicated and nonindicated days and 223.5 (40.6%) occurred during episodes comprising only nonindicated days.

The median duration of all episodes across all sites was 2 days (range, 0-18 days). There was modest but significant ( $P < .0001$ ) variation across sites, with median episode duration ranging from 1 day at site 4 to 4 days at site 1. A total of 430 (85.8%) episodes lasted 5 or fewer days, and only 17 (3.4%) were longer than 10 days.

Of the 501 monitoring episodes, 407 included 1 or more indicated days of monitoring. **Table 3** shows the frequencies of telemetry indications. The most common indications for monitoring were suspected myocardial infarction (48.9% of episodes); arrhythmia, including atrial fibrillation (22.4%); and postcardiac procedures (16.2%). A total of 297 (73.0%) of the episodes with an indication were associated with only 1 indication for all or part of their monitoring episode, and 110 (27.0%) had more than 1 indication. For 326 episodes with an indication, information was available on adherence to guidelines for discontinuing monitoring. Telemetry was discontinued according to guidelines in 223 of those episodes (68.4%).

**Table 4** shows the incidence rates of arrhythmias occurring on indicated and nonindicated days. Overall, the rate of

arrhythmia was 20.7 per 100 indicated patient days and 3.1 per 100 nonindicated patient days. The unadjusted rate ratio comparing arrhythmia incidence on indicated and nonindicated days was 5.8 (95% CI, 3.58-9.40). The model-based, adjusted odds ratio comparing the arrhythmia rate on indicated days with that on nonindicated days was 4.48 (95% CI, 2.57-8.17). No arrhythmias occurred during episodes comprising nonindicated days only. Most (80.2%) arrhythmias occurred during episodes comprising indicated days only. A total of 42 patients (8.4% of episodes) had more than 1 occurrence of arrhythmia, including 1 patient with 13 occurrences. Patients with more than 1 incident arrhythmia ( $n = 42$ ) accounted for 70.5% of all arrhythmias.

At site 4, the 13 episodes of arrhythmia detected among 11 patients on nonindicated days included 6 episodes of tachycardia (heart rate, 121-151 beats per minute) and 4 episodes of bradycardia (heart rate, 43-48 beats per minute). In addition, there was 1 prolonged run of ventricular tachycardia, and 1 short (5 beats) run of ventricular tachycardia. At site 2, the single episode of arrhythmia on a nonindicated day was atrial fibrillation. At site 3, the 2 arrhythmias on nonindicated days were sinus tachycardia; at site 1, the 1 case was a single episode of bradycardia (heart rate, 45 beats per minute).

The average nurse manager estimate of total nursing time per patient each shift to manage a monitored patient was 30 minutes and the minimum was 15 minutes. Thus, the estimated minimum total daily nursing time over 3 shifts would be 45 minutes and the average would be 90 minutes per day for each monitored patient. The average hourly wage plus costs of benefits for nurses was \$48.29 per hour. Therefore, the estimated minimum daily nursing cost was \$36.22 (0.75 hour  $\times$  \$48.29 per hour) and the estimated average cost was \$72.44 (1.5 hours  $\times$  \$48.29 per hour). The estimated minimum cost of monitoring supplies was \$5 per day, and the average was \$10 per day. Based on this information, we estimated the minimum total cost of 1 day of monitoring to be \$53.29 and the average cost to be \$82.44. To estimate total annual nonindicated hours of monitoring, we included only

■ **Table 2.** Indications for Initiating Cardiac Monitoring and Criteria for Discontinuing Monitoring

Indication for Initiating Monitoring	Criteria for Discontinuing Monitoring
<b>After cardiac procedure<sup>a</sup></b>	
Pacemaker insertion Intracardiac defibrillator insertion Cardiac catheterization <sup>b</sup> Percutaneous transluminal coronary angioplasty Coronary artery stenting Ablation Electrophysiologic study	No arrhythmia for 24 h and successful procedure      Successful medical management of arrhythmias
<b>Rule out myocardial infarction</b>	
Low risk High risk <sup>c</sup>	No rise in creatine kinase in 2 measurements No electrocardiogram changes
<b>Congestive heart failure<sup>d</sup></b>	
With angina New diagnosis Evidence of arrhythmia Acute Excessive diuresis Serum potassium level <3.5 mEq/L	No myocardial infarction No ischemia No arrhythmia for 24 h Stable potassium level
<b>Arrhythmia<sup>e</sup></b>	
Atrial fibrillation (new onset or rapid rate) Ventricular tachycardia Other arrhythmia management <sup>f</sup>	Rate controlled or 24 h after successful cardioversion After 3 days, clinical judgment After 3 days of normal sinus rhythm and no arrhythmia in last 48 h
<b>Electrolyte imbalance</b>	
Potassium level either >5.5 mEq/L or <3.2 mEq/L Potassium infusion Hemodialysis	Correction of electrolyte imbalance
<b>After surgery</b>	
After noncardiac surgery if potentially unstable <sup>g</sup> After coronary artery bypass graft	Clinical judgment Day 3 and no epicardial wires or arrhythmias
<b>Other</b>	
Syncope  QT interval >0.49 s  After cardiac arrest After chest trauma Critical valve disease	Day 3 if arrhythmia ruled out or negative electrophysiologic study   After 3 days of normal sinus rhythm and no arrhythmia in last 48 h  Clinical judgment No arrhythmia for 24 h Day 3, clinical judgment
<sup>a</sup> Not indicated if patient has “do not resuscitate” order or has a negative electrophysiologic study. <sup>b</sup> Not indicated for routine, uncomplicated coronary artery catheterization. <sup>c</sup> Not indicated if ventricular tachycardia or ventricular fibrillation <48 hours of myocardial infarction. <sup>d</sup> Not indicated for stable congestive heart failure. <sup>e</sup> Not indicated for chronic atrial fibrillation, atrial fibrillation with controlled rate, or asymptomatic atrial fibrillation. <sup>f</sup> Not indicated for stable premature ventricular contractions. <sup>g</sup> Not indicated for low-risk postoperative patients.	

patients who had monitoring during the study week (January 1-7). For these cases, we then determined the number of nonindicated monitoring hours for each entire episode of monitoring. The number of these cases and related nonindicated days, respectively, were 14 and 6 (site 1), 76 and 25 (site 2), 68 and 33 (site 3), and 130 and 150 (site 4). We multiplied the number of nonindicated days in the study

week by 52 to estimate total annual number of nonindicated days. The estimated annual number of nonindicated patient days per year varied for each site (312 for site 1, 1300 for site 2, 1716 for site 3, and 7800 for site 4). If each site eliminated nonindicated days and only had monitoring that met guidelines, the minimum amount saved per site (\$16,626 for site 1; \$69,277 for site 2; \$91,446 for site 3; \$415,662 for site 4)

**Table 3.** Frequency of Indications for Cardiac Monitoring for Episodes With 1 or More Indications

Indication	No. <sup>a</sup>	% of Episodes (N = 407)
Possible myocardial infarction (low risk)	100	24.6
Possible myocardial infarction (high risk)	99	24.3
After cardiac procedure <sup>b</sup>	66	16.2
Arrhythmia management	59	14.5
Syncope	40	9.8
Congestive heart failure (other) <sup>c</sup>	39	9.6
After noncardiac procedure and high risk	36	8.9
Acute congestive heart failure	35	8.6
Atrial fibrillation (new onset or rapid rate)	32	7.9
After acute myocardial infarction	19	4.7
Electrolyte imbalance	15	3.7
Other indication <sup>d</sup>	11	2.7
Total	551	

<sup>a</sup>Patients may have more than 1 indication.

<sup>b</sup>Includes ablation, pacemaker insertion, intracardiac defibrillator insertion, electrophysiologic study, cardiac catheterization, and percutaneous transluminal coronary angioplasty.

<sup>c</sup>Includes new diagnosis of congestive heart failure, congestive heart failure with arrhythmia, congestive heart failure with angina, and unstable congestive heart failure.

<sup>d</sup>Includes potassium abnormality or infusion, prolonged corrected QT (QTc) interval, and ventricular tachycardia.

and the estimated minimum nursing FTEs saved (0.12 for site 1; 0.70 for site 2; 0.93 for site 3; 4.22 for site 4) were significant. Estimates of the average costs saving rather than the minimums would yield higher savings. The number of nonindicated days per monitored bed varied widely across the 4 institutions.

## DISCUSSION

Cardiac telemetry has expanded in the past 30 years from its initial use for cardiac patients in the intensive care unit to include monitoring for lower-risk cardiac patients and even for noncardiac patients. Although there are well-established guidelines for telemetry use,<sup>5,9</sup> our study and others have shown that many practitioners do not adhere to these recommendations. As with many frequently used technologies, this variability has both positive and negative effects. The literature is replete with economic analyses demonstrating variations in healthcare costs across the country, as well as a lack of correlation between these expenses and improved quality.<sup>16-18</sup>

This retrospective study at 4 teaching hospitals revealed that cardiac telemetry was being utilized in many patients without a guideline-supported indication. We found that 35% of all cardiac telemetry days were considered nonindicated days, with a range from 20% to 40% of all days at across study sites. We identified 2 types of overuse: nonindicated

initiation of telemetry and continuation past the guideline-recommended stop date. The economic impact of use of telemetry without a guideline-based indication was significant. Based on data for nursing time and supplies alone, we estimated that the average annualized excess cost for a 400-bed hospital with 5000 nonindicated days per year based on a 35% rate of nonindicated cardiac telemetry was \$250,000 per year. In addition, for many hospitals, access to telemetry beds impacts the ability to admit patients from the emergency department, resulting in flow bottlenecks and backups. The opportunity cost resulting from improved patient flow would add to these savings.

Another major aspect of the overuse of technology relates to the question of improved safety versus reduced safety. Cardiac telemetry use represents such an issue. Our study demonstrated that there were a significant number of arrhythmic events in patients who met the criteria for telemetry and many fewer in patients who did not. This circumstance has been demonstrated in a number of prior publications. Kanwar and colleagues studied patients at a single hospital and determined that on a per patient level, more than 50% of patients received cardiac telemetry that was not indicated.<sup>18</sup> Comparing the rates of arrhythmic events on indicated and nonindicated telemetry days, Curry and colleagues determined that when the guidelines derived from the American College of Cardiology policy statement were followed for those patients with nonindicated days, the rate of arrhyth-

■ **Table 4.** Number of Days on Monitor and Number and Rate of Arrhythmias Detected by Site

Massachusetts Site	Indicated Days				Nonindicated Days			
	Days, n	Arrhythmias, n	Incidence Rate per 100 Days		Days, n	Arrhythmias, n	Incidence Rate per 100 Days	
			No.	95% CI			No.	95% CI
Baystate	190	48	25.3	20.7-32.9	48	1	2.1	0.5-7.7
Mt. Auburn	195	12	6.2	3.5-10.1	105	1	1.0	0.2-3.5
Tufts	278	53	19.1	14.6-24.5	159	2	1.26	0.4-3.5
University of Massachusetts	348	80	23.0	18.5-28.3	236	13	5.51	3.2-8.9
Total	1011	210	20.7	17.4-24.6	548	17	3.10	1.9-4.7

CI indicates confidence interval.

mias was very low at 2.6 per 100 monitored days, which is very close to our low rate of arrhythmias on nonindicated days.<sup>7</sup> Our study also documented the safety of closely adhering to agreed-on guidelines for cardiac telemetry. We determined that the rate of arrhythmia on nonindicated days was low—about one-sixth the rate on indicated days. While the rate of arrhythmias was not zero for nonindicated days, the severity of the arrhythmias on nonindicated days was quite low and more often asymptomatic.

One could argue that missing any opportunity to detect a serious cardiac arrhythmia is a concern. Although our study did not have a control arm to determine the incidence of significant arrhythmias in a “healthy” inpatient population, there is indirect evidence from the cardiology literature on Holter monitoring that demonstrates that arrhythmias can be identified with monitoring even in apparently healthy populations.<sup>16</sup> So it is possible that the rate of arrhythmias occurring on nonindicated days in monitored patients may be comparable to the rate in hospitalized patients who have not been monitored. A formal cost-effectiveness analysis is beyond the scope of this study, but given the cost of monitoring that we documented and the questionable clinical significance of the arrhythmias documented, it is likely that monitoring without an indication would not be cost-effective compared with other evidence-based hospital service.

From a safety perspective, the overuse of telemetry has significant implications. First, there is good evidence that alert fatigue and interruptions negatively impact quality.<sup>17</sup> The work generated by monitoring nonindicated patients creates both false alarms and interruptions for nurses. Second, this “noise” distracts staff from paying closer attention to the indicated patients, and there are cases in the literature and the press where adverse outcomes have resulted. Last, one could argue that the time required to attend to monitoring nonindicated patients

takes away from nurses’ availability for both other patient needs and face time, which also leads to better quality.

We found wide variation in the number of nonindicated days per monitored bed across sites and a modest amount of variation in the duration of episodes. The variation may be the result of local clinician practices, availability of monitored beds (which differs by organization), case mix, or other factors that we did not address in this study. Site 1 had fewer telemetry beds than the other sites and also had the lowest number of nonindicated days per bed. This suggests that it may be possible to improve adherence to guidelines by limiting the availability of telemetry, although the association between limited telemetry availability and guideline adherence is not definitive evidence that limiting telemetry would result in improved guideline adherence.

There are significant limitations to our study. We studied 4 urban hospitals for only 1 week retrospectively and reviewed a relatively small number of patients. This review may have underestimated or overestimated the true rate of indicated versus nonindicated use of cardiac telemetry, as well as the estimates of annual nonindicated days and related costs, especially if there was significant seasonal or month-to-month variation in telemetry use. In addition, even though we saw a statistically significant difference in the rate of arrhythmias on indicated versus nonindicated days, we did not determine the effect on actual outcomes (ie, mortality) of these patients. It is likely, however, that given the significantly higher rate and severity of arrhythmias in the indicated group, this observation would hold in a larger study. Although all 4 hospitals were urban hospitals in Massachusetts, the types of cases are overwhelmingly primary, not secondary or tertiary care. Among the cases we studied, 12% involved preprocedure or postprocedure patients and 88% involved general cardiac and medical patients. We studied patients during only 1 week of the year and then extrapolated the rates of nonindicated days

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across an entire year. As a result, we may have overestimated or underestimated the nonindicated days, yet the cases we included represented a broad array of common cardiac diagnoses that have little seasonal variation.

Our economic analysis was limited in scope. There are indirect economic impacts of the volume of telemetry on equipment, maintenance of equipment, and other costs that we did not include. In addition, we did not take into account the economic impact of impaired patient flow resulting from access to telemetry beds. Our cost-savings estimate assumed that nursing staffing could be adjusted to accommodate the reduced demand. That being said, even with our minimalist economic projections, the cost of monitoring nonindicated patients is substantial, both to an individual hospital and in aggregate for the nation.

A strength of the study is that data from 4 separate hospitals with different individual patterns of utilization yielded similar trends. We looked at all patients outside of the intensive care units at each institution, and so did not exclude any subjects. The literature contains evidence of the lack of value of monitoring patients who do not meet the American Hospital Association criteria, and our study supports that conclusion. In addition, and perhaps more importantly, our study shines a light on the financial and patient care implications of over-utilization of telemetry monitoring.

Others have studied the effectiveness of implementing quality improvement programs to reduce unnecessary cardiac telemetry successfully.<sup>19</sup> The initiation of quality improvement and more intensely managed telemetry programs have the potential to reduce the nonindicated utilization of telemetry monitoring. Computerized order entry with decision tools and clinician education could have a significant impact on the correct utilization of telemetry. More research to implement better systems to promote adherence to guidelines is necessary.

## CONCLUSION

Cardiac telemetry monitoring may be overused in US hospitals and can be safely reduced, resulting in cost savings to healthcare system. Efforts to reduce utilization need to be explored.

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