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Unnecessary Arrhythmia Monitoring and Underutilization of Ischemia and QT Interval Monitoring in Current Clinical Practice: Baseline Results of the Practical Use of the Latest Standards for Electrocardiography (PULSE) Trial

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Abstract

Purpose—To examine the appropriate use of arrhythmia, ischemia, and QTc interval monitoring in the acute care setting.

Methods—We analyzed baseline data of the PULSE Trial, a multi-site randomized clinical trial evaluating the effect of implementing ECG monitoring practice standards. Research nurses reviewed medical records for indications for monitoring and observed if arrhythmia, ischemia, and QT interval monitoring were being done on 1,816 patients in 17 hospitals.

Results—Almost all (99%) patients with an indication for arrhythmia monitoring were being monitored, but 85% of patients with no indication were monitored. Of patients with an indication for ischemia monitoring, 35% were being monitored, but 26% with no indication were being monitored

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for ST-segment changes. Only 21% of patients with an indication for QT interval monitoring had a QTc documented, but 18% of patients with no indication had a QTc documented.

Conclusion—Our data show evidence of inappropriate monitoring: under-monitoring for ischemia and QTc prolongation and over-monitoring for all 3 types of monitoring, especially arrhythmia monitoring.

Although electrocardiographic (ECG) monitoring is the cornerstone of care in hospital cardiac units, few studies^{1–5} have evaluated how it is used. The American Heart Association (AHA) Practice Standards for ECG Monitoring in Hospital Settings⁶ specify indications and time frames for ECG monitoring. The purpose of this analysis of baseline data from the Practical Use of the Latest Standards for Electrocardiography (PULSE) Trial is to examine the appropriate use of arrhythmia, ST-segment (ischemia), and QT interval monitoring in current clinical practice.

Methods

The PULSE Trial is a 5-year (2008–2013) multi-site randomized clinical trial to evaluate the implementation of the AHA Practice Standards for ECG Monitoring⁶ on nurses' knowledge, quality of care including the appropriateness of monitoring, and patient outcomes. The intervention consists of an online ECG monitoring education program and strategies to implement and sustain change in practice, led by nurse champions on each unit. The study takes place in 17 hospitals: 15 in the United States, 1 in Ottawa, Canada, and 1 in Hong Kong, China (Table 1). All hospitals received institutional review board approval. Sites include both academic medical centers and community hospitals. Hospital units involved in the study are primarily for the treatment of cardiac surgical and medical patients. They include both intensive care units (ICUs) with “hard-wire” bedside cardiac monitoring and step-down units with “wireless” telemetry monitoring.

For the baseline quality of care data, our sample consisted of 2,744 observations on 1,816 patients on these adult cardiac units. One of three research nurses, who were experienced ICU nurses with expertise in ECG monitoring, visited each site for 5 days. If time permitted, they observed patients more than once during their 5-day visit. They collected data on the use and appropriateness of monitoring by reviewing the current medical records to determine if the patient had a Class I or II indication for arrhythmia, ischemia, or QT interval monitoring. The AHA Practice Standards⁶ used the following rating system for indications for ECG monitoring: Class I – indicated in most, if not all, patients; Class II – may be of benefit in some patients, but is not considered essential for all patients; and Class III – not indicated because a patient's risk of a serious event is so low that monitoring has no therapeutic benefit. The research nurses also observed if arrhythmia, ischemia, and QT interval monitoring were being done. Specifically, they determined whether nurses activated the ST-segment monitoring feature on the monitors or documented the QTc interval in the medical record. The classifications for appropriateness of monitoring are outlined in Table 2. If patients had a Class I indication for a particular type of monitoring, they should be monitored. If patients did not have either a Class I or II indication for a particular type of monitoring, they should not be monitored.

Tables 3–5 outline the Class I indications for arrhythmia, ischemia, and QT interval monitoring and recommendations for how long monitoring should be maintained.⁷ Patients who have top priority for arrhythmia monitoring are shown in Table 3. The research nurse determined if a patient had a Class I or II indication for arrhythmia monitoring and then observed if the patient was receiving continuous ECG monitoring when she was on the unit.

Patients who have top priority for ST-segment monitoring include those at significant risk of myocardial ischemia which, if sustained, may result in acute myocardial infarction (MI) or

extension of the MI (Table 4). It is not appropriate for all patients to be monitored for myocardial ischemia. For example, patients with intermittent ventricular pacing that results in secondary ST/T wave abnormalities and triggers frequent false ST-segment alarms are inappropriate for ST monitoring. In addition, patients with left bundle branch block and those with intermittent right bundle branch block should not be continuously monitored for ST-segment changes.⁶ Activation of ST monitoring adds another layer of potential false alarms. The research nurse determined if a patient had a Class I or II indication for ischemia monitoring and observed if the ST-segment monitoring feature was activated.

Patients who have top priority for QT interval monitoring are shown in Table 5. The research nurse determined if a patient had a Class I or Class II indication for QT interval monitoring, specifically, whether the patient was started on a QT-prolonging drug, had a primary admission diagnosis of drug overdose, had a heart rate slower than 40 beats per minute or a pause > 2 seconds, or had existing drug-induced long-QT syndrome. She then determined if the nurse had documented the QTc value in the patient's medical record within the last 24 hours.

Results

Sample Characteristics

The sample of 1,816 patients had a mean age of 65, were 57.4% male, and 79.5% white (Table 6). The most common primary diagnosis was a non-cardiac diagnosis (28.2%), followed by acute MI or rule out MI (16.4%) and arrhythmia or syncope (15.7%). Cardiac procedures were relatively uncommon: 14.8% had cardiac surgery and 10.4% had a percutaneous coronary intervention (PCI). Almost all patients (94.1%) were receiving continuous ECG monitoring.

Appropriateness of ECG Monitoring

Table 7 shows the results related to the appropriateness of monitoring. Almost all (98.9%) patients with an indication for arrhythmia monitoring were being monitored. However, 84.9% of patients without an indication for arrhythmia monitoring were also being monitored. Of the patients with an indication for ischemia monitoring, 34.5% were being continuously monitored for ST-segment changes, but 26.3% of patients without an indication for ischemia monitoring were also being monitored for ST-segment changes. Only 21.4% of the patients with an indication for monitoring for QT prolongation had a QTc value documented by nurses in the previous 24 hours. However, 18.1% of patients with no indication for QT monitoring also had a QTc value documented.

Discussion

Our data show evidence of inappropriate monitoring – both under-monitoring for ischemia and QT interval, as well as over-monitoring for all three types of monitoring. There are several possible reasons for evidence of such widespread inappropriate monitoring.

The observation that there is over-monitoring for arrhythmias could be related to leaving patients on the monitor longer than necessary. Physicians may order monitoring because the patient – who may have no risk for arrhythmias – will be watched more closely due primarily to the increased nurse-to-patient ratios on units with ECG monitoring. In addition, once a patient is admitted to an ICU bed, ECG monitoring is usually automatically initiated. It could be deemed inappropriate to have a patient in the ICU without the bedside ECG monitor on, regardless of the admitting diagnosis.

Others have also reported unnecessary monitoring,^{1,3,4} and guidelines have been implemented to attempt to focus monitoring on patients most likely to benefit.^{2,5,8} These studies have taken place in single hospitals using guidelines from 1991^{2,5} or hospital-specific protocols.⁸ The

PULSE Trial is being conducted at 17 hospitals using more recent standards⁶ that also incorporate recommendations for ischemia and QT interval monitoring.

Langer et al.⁹ showed that ST-segment elevation as detected by continuous ST-segment monitoring is an independent predictor of mortality, even after controlling for multiple clinical factors. Our previous research^{10,11} revealed that nurses do not monitor for ST-segment changes indicative of ischemia because of lack of physician support for it, numerous false alarms that can be annoying, lack of knowledge about how to use the technology and what to do in response to ST alarms, and because they perceive it to be difficult to use. There was also evidence of over-monitoring for ischemia. There may have been initiatives on units to monitor for ST-segment changes, but nurses may not have taken the time to consider whether a particular patient was truly at risk for ischemia and just activated the ST-segment monitoring feature for all patients. In addition, on some patient care units the ST-segment option may be defaulted to be operational at all times. The nurse would need to turn it off if it is not appropriate for a particular patient, and may not have bothered to turn this feature off.

It is well-known that a prolonged QT interval is an important precursor to the lethal arrhythmia torsades de pointes.¹² There was evidence in our study of both under- and over-monitoring for QT-interval prolongation. Possible reasons for not monitoring for QT prolongation include that the physician does not order it or a lack of knowledge on the part of nurses regarding factors placing patients at risk for torsades de pointes or how to use the formula to correct for heart rate. In addition, nurses may perceive that using a correction formula may be too difficult and time-consuming. These nurses may not know about or be resistant to using electronic calipers, if it is option on the ECG monitor. We also observed over-monitoring for QT-interval prolongation. A nurse at one of the sites observed that it was easier to obtain QTc measurements on all patients rather than thinking about whether each individual patient had an indication.

The underutilization of ischemia and QT interval monitoring may be a reflection of a lack of knowledge on the part of nurses. Since its inception in the first coronary care units almost 50 years ago,^{13,14} continuous ECG monitoring has been primarily focused on the detection of arrhythmias, and arrhythmia interpretation has been the focus of ECG monitoring courses for nurses. Evaluation of ST-segment deviation and measurement of QT interval duration has traditionally been done only as part of an assessment of a 12-lead ECG. It is relatively recently that standards for continuous monitoring of ischemia¹⁵ and QT interval prolongation¹² have been published. Perhaps with the addition of content on ischemia and QT interval monitoring into academic curriculum and continuing education for nurses, the appropriate use of these types of monitoring will improve.

Some might argue that over-monitoring is preferable to under-monitoring and that we should monitor all patients on cardiac units for arrhythmias, ST-segment changes, and QT interval prolongation. In doing so, we may uncover clinically-relevant abnormalities in patients not considered to be at risk, while not having to search for information needed to decide if a particular patient should have a particular type of monitoring. Conversely, monitoring for ST segment deviations potentially requires additional nursing time in activating this option and responding to false alarms. In the absence of newly available continuous QT interval monitoring, nurses might consider measuring the QT interval and calculating the QTc to take too much time. Lastly, some patients on cardiac units do not have a primary cardiac diagnosis (28.2% of patients in our sample had a non-cardiac primary diagnosis) and may not be appropriate for all three types of monitoring. Studies are needed to determine if there are outcome differences in patients who are over-monitored. Currently, the AHA Practice Standards for ECG Monitoring⁶ specify Class I, II, and III indications for each type of monitoring. Until research demonstrates otherwise and updated Practice Standards are

published, physicians and nurses should be guided by these Practice Standards to decide which patients should have which types of monitoring.

Limitations and Strengths

This research has both limitations and strengths. The research nurse was at each hospital for only 5 days, so observed only a snapshot of ECG monitoring practice. There is also the possibility that nurses paid more attention to the quality of their practice because they knew they were being observed (Hawthorne effect). Practice could be worse than we observed. Because of time constraints, the research nurse was often not able to return to check if patients had an indication for monitoring on subsequent days. We defined doing QT interval monitoring as the nurse documenting the QTc in the patient's medical record. Nurses may not have had a chance to record this value before the research nurse left the unit for the day.

Strengths of this study include the relatively large sample of patients, the inclusion of all cardiac units in 17 hospitals across the United States and internationally, and the prospective design. Expert nurses observed clinical practice in every patient on the unit over consecutive days.

Conclusions

Our data show evidence of inappropriate monitoring: underutilization of ischemia monitoring and failure to monitor for QTc prolongation when indicated, as well as over-monitoring for all 3 types of monitoring, especially arrhythmia monitoring. The next phase of the PULSE Trial is testing whether an online ECG monitoring education program based on the AHA Practice Standards⁶ and strategies to implement and sustain change in practice will enhance the appropriateness of ECG monitoring.

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Table 1

Participating hospitals

Hospital & Location	Type of Hospital*	# of Beds in Hospital	# of Participating Units	# of Beds on Participating Units	# of Nurses on Participating Units
Aultman Hospital, Canton, OH	C	327	3	86	178
Baylor University Medical Center, Dallas, TX	A	700	4	104	153
Baystate Medical Center, Springfield, MA	A	539	3	93	157
Eastern Maine Medical Center, Bangor, ME	C	297	3	84	176
Eric County Medical Center, Buffalo, NY	A	550	3	38	52
Hong Kong Sanatorium & Hospital, Hong Kong, China	C	321	1	11	36
Hospital of the University of Pennsylvania, Philadelphia, PA	A	640	4	96	244
Long Beach Memorial Medical Center, Long Beach, CA	C	300	6	100	220
Maine Medical Center, Portland, ME	A	475	4	104	202
Meriter Heart Hospital, Madison, WI	A	237	3	79	145
Seton Medical Center, Austin, TX	C	389	3	124	302
Thomas Jefferson University Hospital, Philadelphia, PA	A	587	3	50	105
United Hospital – Nasseff Heart Center, St. Paul, MN	C	350	5	149	356
University of California, San Francisco Medical Center, San Francisco, CA	A	450	2	61	191
University of North Carolina Hospitals, Chapel Hill, NC	A	610	4	67	144
University of Ottawa Heart Institute, Ottawa, Canada	A	136	6	135	303
Yale-New Haven Hospital, New Haven, CT	A	770	5	111	221

* A, academic medical center; C, community hospital

Table 2

Classifications for appropriateness of monitoring

Indication	Monitored?	Appropriateness Classification
Class I	Yes	Appropriate
Class I	No	Under-monitoring
Class II	Yes	Appropriate
Class II	No	Appropriate
Class III	Yes	Over-monitoring
Class III	No	Appropriate

Table 3

Indications for arrhythmia monitoring

Top Priority for Arrhythmia Monitoring	Timeframe of Monitoring
1. Patients resuscitated from cardiac arrest	1. Until cardioverter-defibrillator device implanted or reversible cause corrected (eg, hyperkalemia)
2. Patients in early phase of acute coronary syndromes (ST-elevation/non-ST-elevation MI, unstable angina), "rule-out" MI	2. Minimum 24 hours for uncomplicated MI; until 24 hours after complications resolved (e.g., ongoing chest pain)
3. Patients with newly-diagnosed high-risk coronary lesions (eg, critical left main coronary artery stenosis)	3. Until intervention (e.g., revascularization)
4. Patients after cardiac surgery (record atrial electrogram from epicardial pacer wires with tachycardias of unknown origin)	4. Minimum 48–72 hours; until hospital discharge in patients at risk for postoperative atrial fibrillation (e.g., history of atrial fibrillation)
5. Patients after nonurgent percutaneous coronary intervention (angioplasty, stenting) with complications in catheterization laboratory (e.g., vessel dissection, no reflow, suboptimal angiographic result)	5. Minimum 24 hours; longer if arrhythmias or ischemia occur
6. Patients after implantation of automatic defibrillator or pacemaker lead who are pacemaker dependent (ie, unstable or absent rhythm without pacing)	6. 12–24 hours after implantation
7. Patients with temporary or transcatheter pacemaker	7. Until pacing no longer necessary and device removed or replaced with permanent device
8. Patients who have AV block: Wenkebach (unless stable long-term condition), Mobitz II, advanced (2:1 or higher), complete AV block, or new-onset bundle branch block in setting of acute MI	8. Until block resolves or definitive therapy (e.g., permanent pacemaker)
9. Patients who have arrhythmias complicating WPW syndrome with rapid conduction over an accessory pathway (e.g., atrial fibrillation with rate >150)	9. Until definitive therapy (usually catheter ablation)
10. Patients who have drug-induced long-QT syndrome	10. Until proarrhythmic drug discontinued and QTc returned to predrug state and no QT-related arrhythmias
11. Patients who have intra-aortic balloon counterpulsation	11. Until weaned from intra-aortic balloon pump
12. Patients who have acute heart failure, pulmonary edema	12. Until signs/symptoms of acute heart failure resolved and no hemodynamically significant arrhythmias for 24 hours
13. Patients who require intensive care (e.g., major trauma, acute respiratory failure, sepsis, shock, pulmonary embolus, major noncardiac surgery, drug overdose)	13. Until weaned from mechanical ventilation and hemodynamically stable
14. Patients who undergo procedures that require conscious sedation or anesthesia	14. Until awake, alert, hemodynamically stable

AV, atrioventricular; MI, myocardial infarction; WPW, Wolff-Parkinson-White.

Adapted from Drew & Funk, 2006⁷

Table 4

Indications for ST-segment ischemia monitoring

Top Priority for Ischemia Monitoring	Timeframe of Monitoring
1. Patients in early phase of acute coronary syndromes (ST-elevation/non-ST-elevation MI, unstable angina) or “rule-out” MI	1. Minimum 24 hours and no ST events for 12–24 hours
2. Patients who present to emergency department with chest pain/anginal equivalent	2. 8–12 hours until negative biomarkers exclude acute MI
3. Patients after nonurgent percutaneous coronary intervention (angioplasty, stenting) with complications in catheterization laboratory (e.g., vessel dissection, no reflow, or suboptimal angiographic result)	3. 24 hours; longer if ST events occur
4. Patients who have possible variant angina due to coronary vasospasm	4. If diagnosis confirmed: until definitive therapy (e.g., calcium-channel blocker) and no ST events for 12–24 hours

MI, myocardial infarction

Adapted from Drew & Funk, 2006⁷

Table 5

Indications for QT interval monitoring

Top Priority for QT Monitoring	Timeframe of Monitoring
1. Patients started on antiarrhythmic drug known to cause torsades de pointes (especially, disopyramide, dofetilide, ibutilide, procainamide, quinidine, sotalol)	1. Until drug is discontinued or dosage stable and no prolonged QTc (>0.48 seconds, women; >0.47 seconds, men) and no QT-related arrhythmias (polymorphic ventricular ectopy, couplets, nonsustained VT, torsades de pointes)
2. Patients who overdose from potentially proarrhythmic agent	2. Until drug levels decreased and no QT-related arrhythmias
3. Patients who have new-onset bradyarrhythmias (e.g., complete heart block, long sinus pauses)	3. Until bradyarrhythmia resolved or definitive therapy (e.g., permanent pacemaker)
4. Patients who have severe hypokalemia or hypomagnesemia	4. Until electrolyte disorder corrected and no QT-related arrhythmias

VT, ventricular tachycardia.

Adapted from Drew & Funk, 2006⁷

Table 6

Sample characteristics (N = 1,816 patients)

Characteristic	N	%
Gender		
Male	1043	57.4%
Female	773	42.6%
Race		
White	1444	79.5%
Black	216	11.9%
Asian	91	5.0%
Other or mixed	12	0.7%
Unknown	53	2.9%
Ethnicity		
Hispanic	89	5.0%
Primary diagnosis		
Non-cardiac diagnosis	513	28.2%
Acute MI or rule out MI	297	16.4%
Arrhythmia/syncope	286	15.7%
Heart failure	259	14.3%
Other cardiac diagnosis	196	10.8%
Known coronary artery disease, admitted for CABG surgery or PCI	119	6.6%
Unstable angina	78	4.3%
Rule out coronary artery disease, admitted for coronary angiography	59	3.2%
Drug overdose	7	0.4%
Other unknown	2	0.1%
Cardiac procedure		
Cardiac surgery	269	14.8%
PCI	188	10.4%
On monitor (hardwire or telemetry)		
Yes	1709	94.1%
No	107	5.9%
	Mean ± SD	Range
Age (years)	64.9 ± 15.3	18 – 98

MI, myocardial infarction; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention

Table 7

Appropriateness of continuous ECG monitoring (N = 2,744 observations on 1,816 patients)

Indications	N Monitored	% Monitored
Arrhythmia monitoring		
Yes (n = 1,961)	1,940	98.9%
No (n = 783)	665	84.9%
Ischemia monitoring		
Yes (n = 339)	117	34.5%
No (n = 2,348)	617	26.3%
QT interval monitoring		
Yes (n = 336)	72	21.4%
No (n = 2,294)	415	18.1%