Continuous ST-Segment Monitoring: Nurses' Attitudes, Practices, and Quality of Patient Care

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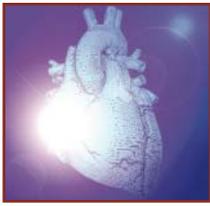NURSES

Continuous ST-Segment Monitoring: Nurses' Attitudes, Practices, and Quality of Patient Care

By Prasama Sangkachand, RN, MSN, CCRN, Brenda Sarosario, RN, BSN, and Marjorie Funk, RN, PhD

Background Continuous ischemia monitoring helps identify patients with acute, but often silent, myocardial ischemia. Evidence suggests nurses do not activate ischemia monitoring because they think it is difficult to use. ST-Map software incorporates graphic displays to make monitoring of ongoing ischemia easier.

Objectives To determine if nurses' use of and attitude toward ischemia monitoring and the quality of patient care improve with use of ST-Map.

Methods The study included 61 nurses and 202 patients with acute coronary syndrome in a cardiac intensive care unit. Baseline data on nurses' use of and attitude toward ischemia monitoring and quality of care were obtained. Education was then provided and ST-Map software was installed on all monitors. Follow-up data were obtained 4 months later.

Results The percentage of nurses who had ever used ischemia monitoring was 13% before ST Map and 90% afterward ($P < .001$). The most common reason for not using ischemia monitoring before ST Map was inadequate knowledge (62%). The most common reason for liking ischemia monitoring after ST Map was knowing when a patient has ischemia (80%). Time to acquisition of a 12-lead electrocardiogram in response to symptoms or ST-segment changes was 5 to 15 minutes before ST Map and always less than 5 minutes afterward ($P < .001$). Time to return to the catheterization laboratory did not differ before and after ST Map.

Conclusions ST Map was associated with more frequent use of ischemia monitoring, improved attitudes of nurses toward ischemia monitoring, and shorter time to obtaining 12-lead electrocardiograms. (*American Journal of Critical Care.* 2011; 12:226-238)

CE 1.0 Hour

Notice to CE enrollees:

A closed-book, multiple-choice examination following this article tests your understanding of the following objectives:

1. Identify patients who would benefit from continuous ST-segment monitoring.
2. Describe reasons nurses are hesitant to use continuous ST-segment monitoring.
3. Discuss the objectives and findings from the study using the ST-Map software for continuous ST-segment monitoring.

To read this article and take the CE test online, visit www.ajcconline.org and click "CE Articles in This Issue." No CE test fee for AACN members.

This article is followed by an *AJCC* Patient Care Page on page 239.

Acute coronary syndrome (ACS) is a condition in which patients have either acute myocardial infarction or unstable angina. In both acute myocardial infarction and unstable angina, the heart muscle receives insufficient blood supply and inadequate oxygen to meet its needs, precipitating ischemia. In 2006, an estimated 733 000 patients were discharged from hospitals in the United States with ACS as the primary diagnosis. When secondary discharge diagnoses were included, the number of hospital discharges was 1 365 000 unique hospitalizations for ACS, 810 000 for myocardial infarction, and 537 000 for unstable angina (in 18 000 hospitalizations, patients had both diagnoses).[1] Of the 31 982 patients in 25 countries with suspected ACS listed in the expanded Global Registry of Acute Coronary Events,[2] the diagnosis was ST-elevation myocardial infarction for 31%, non-ST-elevation myocardial infarction for 32%, and unstable angina for 26%.

Patients with ACS must be monitored for continuing or new myocardial ischemia. Although myocardial ischemia is often accompanied by symptoms, such as chest pain or shortness of breath, some patients, especially those with diabetes, do not experience typical ACS symptoms.[3] Ischemia is manifested on the electrocardiogram (ECG) by depression or elevation of the ST segment. ST-segment changes are noted on a 12-lead ECG; the ECG is typically recorded daily and whenever patients report symptoms suggestive of ACS. Although the 12-lead ECG is the standard for detecting myocardial ischemia, it provides a static snapshot rather than a continuous recording of the dynamic changes that can be seen by using continuous ischemia monitoring.[4] Because ischemia can be silent, episodes can be missed. Therefore, the American Heart Association/American Association of Critical-Care Nurses practice standards for ECG monitoring[5] recommend continuous ischemia monitoring for all patients at marked risk for myocardial ischemia that, if sustained, might result in acute myocardial infarction or extension of a myocardial infarction (Table 1).

Despite the recommendations of the practice standards,[5] ischemia monitoring has limitations, especially if not used correctly. Alarms can be activated

Table 1 Indications for ischemia monitoring	
Top priority patients	**Time frame of monitoring**
1. Present to emergency department with chest pain	1. 8-12 hours until biomarkers exclude myocardial infarction
2. Early phase of acute coronary syndrome (ST-elevation myocardial infarction, non-ST-elevation myocardial infarction, unstable angina, rule out myocardial infarction)	2. Minimum 24 hours and no ST events for 12-24 hours
3. After percutaneous coronary intervention with complications in catheterization laboratory (vessel dissection, no reflow, suboptimal angiographic results)	3. 24 hours; longer if ST events occur
4. Possible variant angina due to coronary vasospasm	4. If diagnosis confirmed: until definitive therapy (calcium channel blocker) and no ST events for 12-24 hours

Adapted from Drew and Funk,[6] with permission from Elsevier.

because of movement-related artifact, thus reducing specificity. If the appropriate leads are not monitored, ST-segment changes can be missed, thus decreasing sensitivity. However, research[7] has shown that ST-segment elevation as detected by continuous ST-segment monitoring is an independent predictor of mortality, even after adjustment for multiple clinical factors.

Although bedside ECG monitors can detect ST-segment changes indicative of ischemia, this feature is widely underused. Unlike arrhythmia monitoring, which is automatically performed, ST-segment ischemia monitoring generally must be activated and set up by a nurse. The results of a national random survey[8] of 192 nurse leaders in hospital cardiac units revealed that 46% did not use ST-segment monitoring

About the Authors
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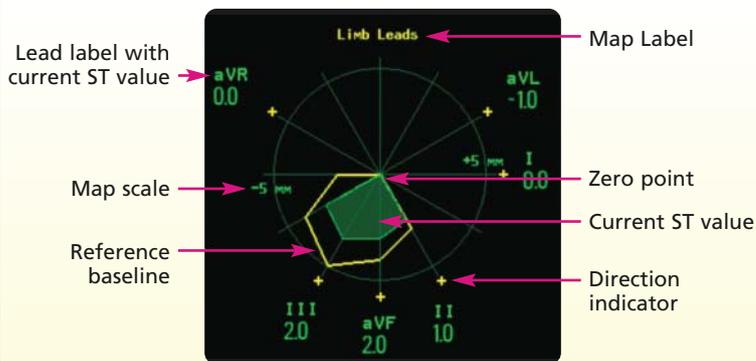**Figure 1** Bedside monitor ST-Map display.
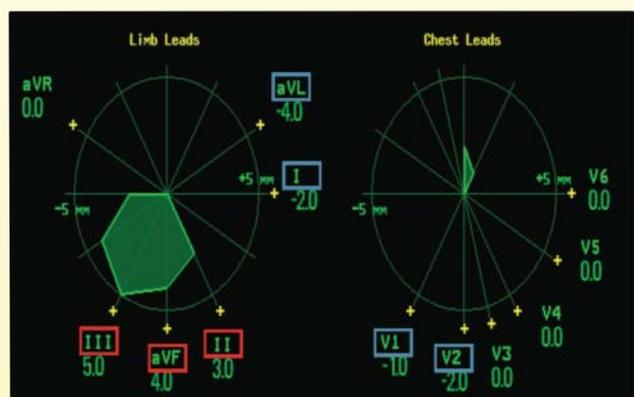
ST Elevation
ST Depression

Figure 2 Features of an ST-Map display. **Map label** indicates that this is the ST Map of the limb leads. **Zero point** indicates the isoelectric line. **Current ST value (green shaded area)** indicates the amount and location of the ischemia. **Direction indicator** shows the positive pole of the various leads. If a patient has ST-segment elevation, the ST Map moves toward the positive pole. **The reference baseline** (the yellow border) shows the maximum deviation from the 0 point or isoelectric line. This feature is useful for tracking ST-segment changes over time. **Map scale** can be set from ±1 to 15 mm so even the smallest ST-segment changes can be displayed. Here it is set at ±5 mm. It can be customized to the individual patient. **Lead label with the current ST value** shows no ST-segment change in aVR.

for the detection of myocardial ischemia in patients with ACS. The primary reasons given for not using ST-segment monitoring were lack of physicians' support, the high number of false ST alarms, and lack of education about how to use the technology and what to do in response to ST alarms. A national survey[9] of 200 cardiologists about continuous ST-segment monitoring revealed that they routinely ordered it for patients with ACS (67%) and after percutaneous coronary interventions (60%). Although 55% of the cardiologists were unaware of the published practice standards,[5] 80.5% thought that patients in intensive care units (ICUs) should have continuous ST-segment monitoring. The cardiologists were more likely to order continuous ST-segment monitoring if their hospitals had written interdisciplinary protocols for using it.

Recently, a manufacturer of bedside monitors (Philips Healthcare, Andover, Massachusetts) developed ST-Map software to make the monitoring of ischemia easier. The ST Map is a multiaxis portrait (map) derived from the ST analysis to help nurses detect changes in ST values. The traditional display of ST-segment changes on the bedside monitor is a list of the 12 leads with the corresponding numbers indicating the amount of ST-segment elevation or depression. The display does not show the location of the ST-segment changes, and it does not give any indication of the evolution of the changes over time.

With ST Map, the 12 ECG leads are shown in a graphic display that helps nurses recognize ST changes more easily. The ST Map displays 2 views obtained from a multilead ECG in a multiaxis diagram in which each axis represents a lead. The position of the axes within the diagram corresponds to the placement of the ECG leads (both limb and chest). By joining adjacent ST values, the monitor obtains the ST Map. The contour line and the shading are color coded to reflect the corresponding leads. Nurses should be able to glance at a bedside monitor and determine the location and extent of myocardial ischemia from the ST Map.

Figure 1 shows the bedside monitor screen with the ST Map that is continuously displayed and an enlarged image of the ST-Map section. The green-shaded sections indicate the areas of the heart that are ischemic. Figure 2 shows the features of the ST Map. With continuous ischemia monitoring on the bedside monitor, all leads can be monitored simultaneously. To display ST information on the chest leads, all 6 chest electrodes (V_1 through V_6) must be properly placed on the patient's chest.

Because the ST-Map software is a recent addition to bedside ECG monitors, whether or not it really

simplifies continuous monitoring of ischemia is not known. The purpose of our intervention study was to determine if the use of ST-Map software improves nurses' use of and attitude toward ischemia monitoring and the quality of patient care. The research questions were as follows:

• Will nurses' use of and attitude toward ischemia monitoring improve with the availability of ST-Map software?

• Will the quality of patient care related to ECG monitoring improve with the availability of ST-Map software? (Quality of care was defined as electrode placement and lead selection, time to acquisition of a 12-lead ECG in response to symptoms and/or ST-segment changes, and time to return to the cardiac catheterization laboratory if necessary.)

Methods

Design

In this pilot study, we used a preintervention-postintervention design to explore the effect of the availability of ST-Map software on nurses' use of and attitude toward ischemia monitoring and the quality of patient care related to ECG monitoring.

Setting and Sample

The study took place in the cardiac ICU at Yale–New Haven Hospital, New Haven, Connecticut. There were 2 samples: nurses and patients.

For the nurse sample, we based our calculation of the necessary sample size on the data on the proportion of nurses who had ever used ST-segment monitoring as reported by Patton and Funk.[8] We believed that the percentage of nurses in that study[8] (54%) who said that they used ST-segment monitoring was falsely high. Therefore, we estimated that 40% of nurses used ST-segment monitoring before the intervention and that 75% would use it after the intervention. A sample size of 28 nurses with data before and after the intervention would be required to detect a statistically significant difference in proportions at $\alpha = .05$ with 80% power. Figure 3 shows the sample of 61 nurses that resulted in 32 nurses who participated in the study both before and after the intervention.

For the patient sample, we based our sample size calculation on the practice we observed in our unit and the improvement we anticipated with use of ST Map. Before instituting ST Map, we estimated that nurses were able to obtain a 12-lead ECG in response to symptoms in 5 minutes or less only 5% of the time. We anticipated that after ST Map was available, nurses would be able to obtain a 12-lead ECG in 5 minutes or less 50% of the time. A sample size of 15 per group was required to detect a statistically

Figure 3 Nurse sample (N = 61).
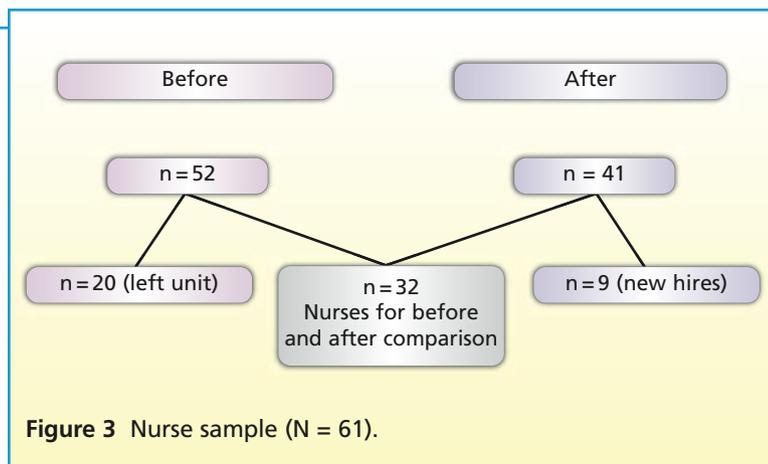
significant difference in proportions at $\alpha = .05$ with 80% power. Before instituting ST Map, we observed that nurses were able to facilitate the return of patients to the cardiac catheterization laboratory in 30 minutes or less only 5% of the time. We anticipated that after instituting ST Map, nurses would be able to get a patient back to the catheterization laboratory in 30 minutes or less 25% of the time. A sample size of 76 per group was required to detect a statistically significant difference in proportions at $\alpha = .05$ with 80% power.

Table 1 shows the criteria for selecting patients for ischemia monitoring.[6] It lists the 4 types of patients who have top priority for ischemia monitoring, with recommendations about how long monitoring should be maintained, according to the practice standards for ECG monitoring.[5] These patients include those at marked risk for myocardial ischemia that, if sustained, might result in acute myocardial infarction or extension of the myocardial infarction. All patients with these indications for ischemia monitoring were included in the study. Agitated patients, whose ECG tracings have constant noise, are inappropriate for ST-segment monitoring and were excluded from the study. The sample of 202 patients included 99 patients who were in the cardiac ICU when data were collected before the intervention and 103 patients who were in the unit when data were obtained after the intervention.

> With ST Map, the 12 ECG leads, shown in a graphic display, help nurses recognize changes in the ST segment more easily.

Procedure

The study was approved by the appropriate institutional review board to ensure that the rights of human subjects were protected.

Traditionally, patients in the cardiac ICU have been monitored by using 5 ECG electrodes. Before the study began, we provided education on proper
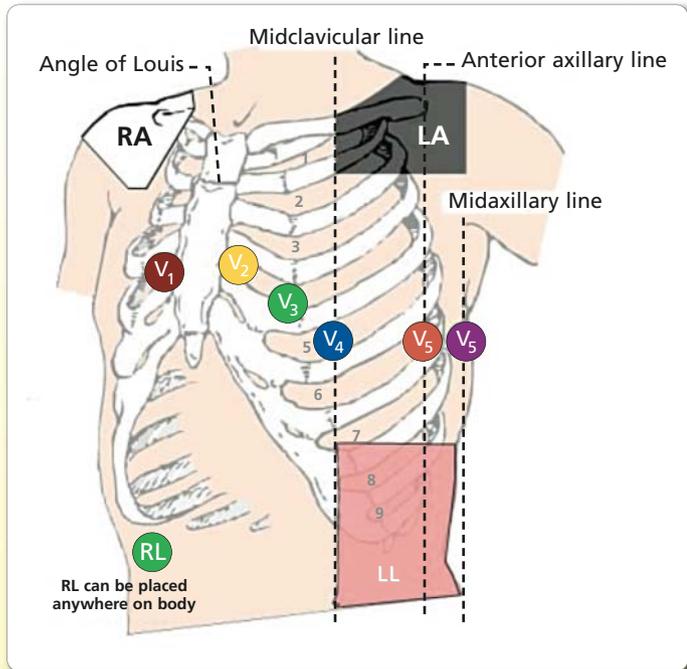
Figure 4 Proper electrode placement. LA, left arm; LL, left leg; RA, right arm; RL, right leg.

electrode placement and preparation of the skin before the electrodes are applied.

At the beginning of the study, we used a written survey to obtain baseline data on nurses' use of and attitude toward ischemia monitoring. We developed a 6-item survey based on the questionnaire used by Patton and Funk.[8] Two experts validated the items. Items addressed whether or not nurses had ever used ST-segment monitoring. If they had, additional items elicited the frequency of use and reasons the nurses liked or disliked using ST-segment monitoring. Nurses who had never used ST-segment monitoring were asked why they did not use it. Possible responses were provided for each of these items, as well as an "other" category. The final item provided an opportunity for nurses to write comments.

> Nurses in the unit had the opportunity to use the new ST-Map software on appropriate patients for 4 months.

In order to determine the quality of patient care related to ischemia monitoring, direct observation and review of medical records were used to collect baseline data on patients in the unit who had ACS. The data included demographic and clinical information, ECG electrode placement and lead selection, time to acquisition of a 12-lead ECG in response to symptoms and/or ST-segment changes, and time to return to the cardiac catheterization laboratory if necessary.

After baseline data from nurses and patients were obtained, all nurses in the unit received mandatory education on ischemia monitoring and the ST-Map software. The unit-based educator (P.S.) and a representative from the monitoring company conducted these on-site education sessions. Topics included patient selection, skin preparation, electrode placement, screen selection on the bedside monitor, characteristics of the ST-Map bedside display, troubleshooting, and obtaining a 12-lead ECG from the bedside monitor and transmitting it to the central monitor to be viewed and printed. The ST-Map software was then activated on all bedside monitors in the unit. A lead system that enables monitoring of all 12 leads had been previously purchased for each monitor. At each patient's bedside, we posted diagrams of proper electrode placement (Figure 4), criteria for study inclusion (Table 1), and instructions for obtaining and transmitting a 12-lead ECG from the bedside monitor to the central monitor. Nurses knew to begin ST-Map ischemia monitoring on patients who met the inclusion criteria. Nurses in the unit then had the opportunity to use the new ST-Map software on appropriate patients for 4 months.

After 4 months, we collected follow-up data on the same outcomes examined at baseline. For nurses' use of and attitude toward ischemia monitoring, we surveyed the same nurses by using the same questionnaire used at baseline. For the quality of patient care related to ischemia monitoring, we obtained data on different patients: those in the unit before the intervention and those in the unit after the intervention.

Data Analysis

Data were entered into an Excel spreadsheet and uploaded to SAS, version 9.1 (SAS Institute, Inc, Cary, North Carolina) for data analysis. In order to determine changes that occurred with the availability of ST-Map software, we used the McNemar test for the nurse data (the nurse sample was primarily the same before and after the intervention) and χ^2 analysis for the patient data (the patient sample had different patients before and after the intervention). Statistical significance was set at $\alpha = .05$.

Results
Nurses' Use of and Attitude Toward Ischemia Monitoring

The 61 nurses in the sample had a mean age of almost 42 years, were predominantly female, and most had a bachelor of science in nursing degree (Table 2). They had worked in the cardiac ICU a mean of 12.3 years; 1 nurse had worked there 32 years.

Before ST Map was instituted, 13% of the nurses had ever used ischemia monitoring; after ST Map, 90% had. This difference was significant ($P<.001$).

Before ST Map was available, the most common reason nurses (62%) gave for not using ischemia monitoring was a perception that they had inadequate knowledge to use it correctly. Other reasons were that the physicians did not ask for ischemia monitoring (25%), the nurses had not heard of it (17%), and the nurses had heard that it was associated with many false alarms, a situation that would be annoying (12%).

After ST Map was implemented, the most common reason nurses (81%) gave for liking ischemia monitoring was that they thought that it was important to know when their patients were having ischemia. Other reasons for liking it were that it was helpful in patient care (56%) and that it was easy to use (46%).

Quality of Patient Care Related to ECG Monitoring

The sample of 202 patients had a mean age of 61.6 years and 72.8% were men (Table 3). The most common diagnosis was ST-elevation myocardial infarction.

As an indicator of the quality of patient care, we evaluated the accuracy of electrode placement (Table 4). Before the use of ST Map, we monitored all patients with 5 electrodes (4 limb electrodes and 1 chest electrode). After ST Map, we used 10 electrodes (4 limb and all 6 chest electrodes) on all patients who had an indication for ischemia monitoring. Both before and after ST Map, all 4 limb electrodes were always observed to be in the correct location. Before ST Map, 82.8% of the chest electrodes were in the V_1 position, 1.0% in the V_2 position, and the remaining 16.2% in an incorrect position (13.1% on the abdomen and 3.0% on the sternum). After we implemented ST Map and were using 6 chest electrodes, the V_1 through V_6 electrodes were in the correct location 97.1% to 99.0% of the time. In a total of 385 observations of lead selection on the monitor before and after implementation of ST Map, lead II and a V lead were displayed 99.2% of the time. The percentages before and after implementation of ST Map did not differ.

We also examined the time it takes for nurses to obtain an urgent 12-lead ECG (17 patients; 7 before and 10 after ST Map) and to get a patient back to the cardiac catheterization laboratory because of evidence of possible vessel reocclusion such as chest pain or ST-segment changes (4 patients; 2 before and 2 after ST Map). The time required to obtain a 12-lead ECG in response to symptoms or ST-segment changes

Table 2
Characteristics of nurse sample (N = 61)

Characteristic	No.	%
Sex		
Female	57	93
Male	4	7
Education		
Bachelor of science in nursing	40	66
Associate degree	13	21
Diploma	5	8
Master of science in nursing	3	5
	Mean (SD)	**Range**
Age, y	41.9 (10.4)	24 - 64
Years worked in cardiac intensive care unit	12.3 (9.1)	0.25 - 32

Table 3
Characteristics of patient sample (N = 202)

Characteristic	No.	%[a]
Sex		
Male	147	72.8
Female	55	27.2
Diagnosis		
ST-elevation myocardial infarction	110	54.5
Non-ST-elevation myocardial infarction	46	22.8
Unstable angina	25	12.4
Other	21	10.4
Medical history		
Diabetes	60	29.7
Prior acute coronary syndrome (n = 200)	60	30.0
Need for additional diagnostic evaluation		
12-lead electrocardiography in response to symptoms or ST-segment changes	17	8.4
Return to cardiac catheterization laboratory for possible vessel occlusion	4	2.0
	Mean (SD)	**Range**
Age, y	61.6 (13.5)	29 - 90

[a] Because of rounding, percentages may not total 100.

was more than 5 minutes 100% of the time before ST Map was instituted and never more than 5 minutes after ST Map was available ($P<.001$). The time required to return to the catheterization laboratory did not differ from before to after implementation of ST Map; it was always more than 30 minutes.

Discussion

In our study, the new ST Map ischemia monitoring software was associated with more frequent use of ischemia monitoring, improved attitudes of nurses toward ischemia monitoring, and shorter time to the acquisition of a 12-lead ECG in response to symptoms or ST-segment changes.

Table 4
Accuracy of electrode placement before and after implementation of ST Map

Electrode	No. (%) of patients	
	Before ST Map (n = 99)[a]	After ST Map (n = 103)[b]
Right arm	99 (100)	103 (100)
Left arm	99 (100)	103 (100)
Right leg	99 (100)	103 (100)
Left leg	99 (100)	103 (100)
Chest		
V_1	82 (83)[c]	100 (97)
V_2	1 (1)[c]	102 (99)
V_3	—	101 (98)
V_4	—	102 (99)
V_5	—	102 (99)
V_6	—	102 (99)

[a] In 72 of the 99 patients, we observed electrode placement on a second day: it was correct for the V electrode 97% of the time. In 16 of the 99 patients, we observed electrode placement on a third day: placement was correct 100% of the time for the V electrode. Placement of the limb electrodes continued to be correct 100% of the time.

[b] In 79 of the 103 patients, we observed electrode placement on a second day: it was correct for V_1 97% of the time, for V_2 and V_3 99% of the time, and for V_4 through V_6 100% of the time. In 9 of the 103 patients, we observed electrode placement on a third day: placement was correct 100% of the time for all 6 chest electrodes. Placement of the limb electrodes continued to be correct 100% of the time.

[c] In the remaining 16 patients, the chest electrode was on the abdomen (n = 13; 13%) or on the sternum (n = 3; 3%).

ECG monitoring is exclusively within the domain of nursing practice. It is the independent responsibility of nurses to do the following:

• Place electrodes in the proper position on the chest.

• Determine goals of monitoring for each patient (arrhythmia only, ischemia, QT prolongation?)

• Select the leads to be displayed

• Select arrhythmia alarm parameters

• Choose whether to invoke ST-segment monitoring and determine alarm parameters

• Decide whether to monitor the QT interval

Early detection of ischemia via continuous monitoring can lead to life-saving interventions for patients at risk for myocardial ischemia that, if sustained, might result in acute myocardial infarction or extension of a myocardial infarction. Despite the recommendations,[5,10] ischemia monitoring is rarely incorporated into practice. Increasing recognition of the failure to implement standards and guidelines into practice has led to greater awareness of the importance of using active dissemination and implementation strategies.[11] In our study, the education on ischemia monitoring and the ST-Map software and the installation of the ST-Map software on all the bedside monitors began the dissemination of the practice standards on ischemia monitoring.

The use of and the attitude toward ischemia monitoring of the nurses in our sample before the institution of ST-Map software supported the findings of previously published research.[8] Before ST Map was implemented, only 13% of the nurses had ever used ischemia monitoring. The results of a national random survey[8] of 192 nurse leaders in hospital cardiac units revealed that 46% of the units did not use ischemia monitoring for the detection of myocardial ischemia in patients with ACS. Of note, this proportion of 46% may be falsely high and not directly comparable with our results. Patton and Funk[8] surveyed 1 nurse leader per unit. The leader would respond positively if any nurse on the unit ever used ischemia monitoring. Respondents to a national survey also might report compliance with a standard of practice when that compliance is rare, and ischemia monitoring is inconsistently, if ever, used.

At baseline, the most common reason nurses in our study gave for not using ischemia monitoring was that they perceived that they had inadequate knowledge to use it correctly. Other reasons given were that the physicians did not ask for it, the nurses had not heard of it, and the nurses had heard that ischemia monitoring is associated with many false alarms, a situation that would be annoying. Patton and Funk[8] reported similar findings. In their investigation,[8] the primary reasons given for nonuse was lack of physician support, the high number of false ST alarms, and lack of education about how to use the technology and what to do in response to ST alarms.

We found that limb electrodes were always accurately placed both before and after institution of ST Map, whereas chest electrodes were accurately placed 83.8% of the time before ST Map and 97.1% to 99.0% of the time after ST Map. Electrode placement was better than that reported in previous studies.[12-14] Nurses in our sample almost always monitored lead II and a V lead. They did not customize leads to be displayed on the basis of the location of a patient's myocardial infarction or which coronary arteries had angioplasty and/or stents placed, as recommended by the practice standards.[5]

The time to the acquisition of a 12-lead ECG in response to symptoms or ST-segment changes was significantly reduced after the implementation of ST Map. This reduction could be due to the ease of obtaining a 12-lead ECG with ST Map vs the traditional method. With ST Map, patients already had all 6 chest electrodes in place. Patients had the limb electrodes on the torso for continuous monitoring but also had electrodes placed on the extremities. To obtain a 12-lead ECG, the nurses simply moved the lead wires from the 4 electrodes on a patient's torso to the correct electrodes on the lower arms and legs. Patient information was already entered

into the monitor, so the nurses simply had to press a button to obtain a 12-lead ECG. Nurses did not have to find a cart-mounted ECG machine, apply electrodes in the correct locations, attach the appropriate lead wires, enter patient information, and record the ECG. If a clinical improvement is easy to use, the likelihood is greater that nurses will adopt it.

The time required before implementation of ST Map to get a patient back to the cardiac catheterization laboratory when he or she had evidence of possible vessel reocclusion did not differ from the time required after ST Map. This lack of an improvement in time after ST Map could be due to the inexact measurement of time. We noted only whether the time required was more or less than 30 minutes, rather than the exact time. In our study, only 4 patients needed to return to the catheterization laboratory. With more patients returning to the catheterization laboratory and more exact measurement of time, we might have observed a significant reduction in the time after the institution of ST Map.

Limitations

Our study has several limitations. First, the preintervention-postintervention design is not as strong as a design in which implementation of the ST Map software would be randomly assigned. Random assignment was not feasible in this single-site pilot study. A multisite randomized clinical trial is indicated. Second, we did not record exact times from the onset of symptoms or ST-segment changes to the acquisition of a 12-lead ECG and return to the catheterization laboratory. Third, our sample size was relatively small and only a few patients required a 12-lead ECG in response to symptoms or ST-segment changes or needed to return to the catheterization laboratory. Fourth, we did not evaluate patient outcomes. With continuous ischemia monitoring, we should be able to detect ischemia earlier, a situation that should lead to earlier treatment, which could then result in improved patient outcomes by preventing a myocardial infarction or at least limiting the size of the infarct. To date, no published randomized clinical trials have addressed outcomes when continuous ischemia monitoring is used. Future large randomized clinical trials could include an estimation of infarct size as determined by echocardiography and/or measurement of biomarkers, but attribution of improved outcomes to the use of continuous ischemia monitoring may still be uncertain.

Implications for Practice

With ST Map, ischemia monitoring is now our standard of care for patients admitted because they

had ACS; patients who come to the emergency department because of chest pain, anginal equivalent, or variant angina; and patients who have a complication related to percutaneous coronary intervention. In these patients, we look at the monitor for extension of the ST Map and listen for alarms. ST Map is especially useful for patients who do not perceive or cannot communicate symptoms of ischemia. However, monitoring all patients for myocardial ischemia is not appropriate. For example, agitated patients, whose ECG tracings have constant noise, are inappropriate for ischemia monitoring. Activation of ischemia monitoring adds another layer of potentially false alarms. Hence, ischemia monitoring should not be used unless necessary and should not be extended beyond the time frames indicated in the practice standards (Table 1).

> Use of ST Map was associated with more frequent ischemia monitoring.

Case Studies

Case studies can provide examples of translating guidelines and research into clinical practice. Sandau and Smith[15] discuss 3 cases that illustrate the potential benefits of continuous ST-segment monitoring in progressive care units. The 3 cases illustrate the importance of activating audible alarms, selecting appropriate leads to monitor, and ensuring that patients at risk for silent ischemia are screened for use of continuous ST-segment monitoring. In the first case, silent ischemia was missed because an audible alarm was not activated. The ischemia was not detected until the cardiologist reviewed the alarms from the previous 24 hours. Ischemia was confirmed by an elevation in cardiac biomarkers and ischemic changes on a 12-lead ECG. Henceforth, an audible alarm was activated, and an ECG strip was produced when any 2-mm deviation in the ST-segment occurred.

> To obtain a 12-lead ECG, the lead wires from 4 torso electrodes were simply moved to the lower arms and legs.

The second case focused on lead selection. When not all 10 leads are being monitored for ischemia, nurses must rely on the static 12-lead ECG or know the coronary artery location of angioplasty or stent placement to determine which lead to monitor for further ischemia. Incorrect lead selection can result in missed ischemia, so nurses need education about the proper leads to monitor.

The last case involved monitoring patients at risk for silent ischemia. Although not a top priority for continuous ST-segment monitoring, patients
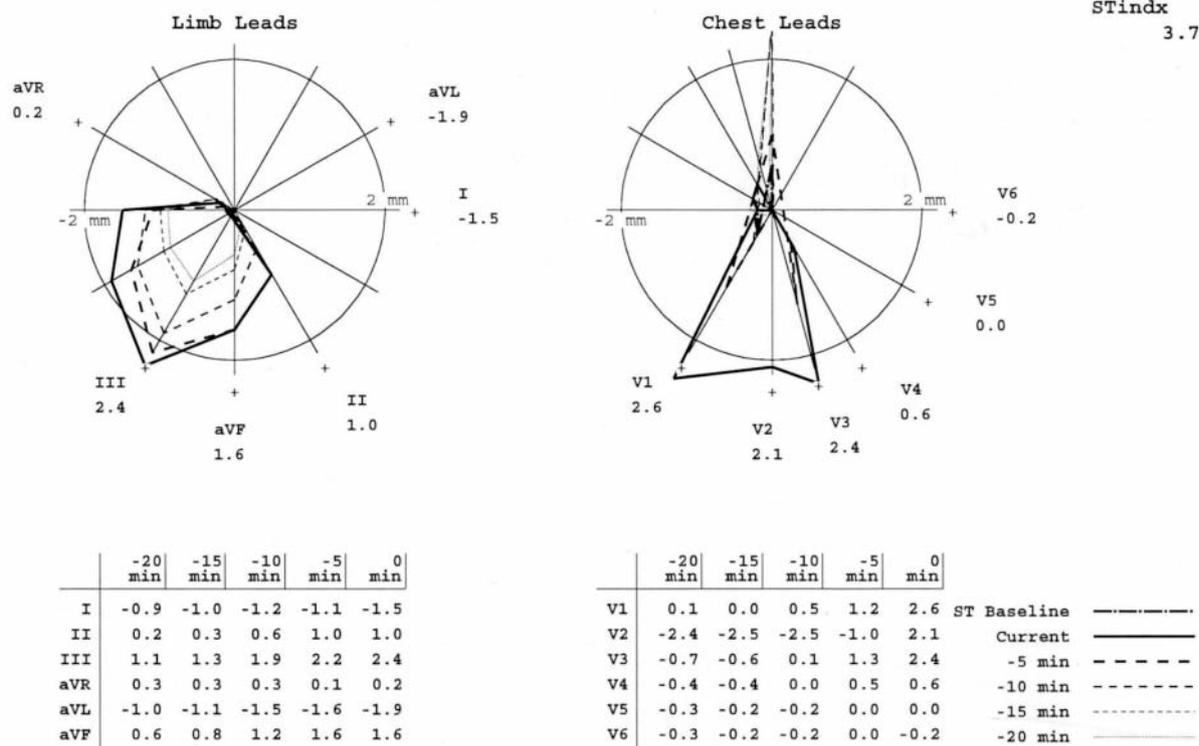
Figure 5 Printout of ST-Map display for patient 1. The solid border, which shows the current ST value, extended beyond the 2-mm ST Map scale in both the limb and chest leads, thus setting off the alarm. The ST-segment trend had been progressing, as shown by the dashed and dotted borders, indicating that the patient's ischemia was worsening.

who have comorbid conditions (eg, diabetes) that put them at risk for silent ischemia and patients with other cardiac risk factors should be considered for ST-segment monitoring. Patients at risk for myocardial ischemia who may be unable to communicate symptoms because of the effects of anesthesia or altered mental status should also be considered for ST-segment monitoring. Continuous ST-segment monitoring could be helpful in the early detection of ischemia even for patients without overt cardiac disease.

The following 2 cases from our cardiac ICU illustrate other uses of continuous ischemia monitoring. Our protocol incorporates the use of continuous 12-lead ischemia monitoring with ST Map. Because all 6 chest electrodes are in place, we are able to monitor all limb and chest leads simultaneously and do not have to select particular leads to monitor.

Case 1

An 88-year-old woman with multiple medical problems was admitted to a community hospital

with chest pain; the diagnosis was ST-elevation myocardial infarction. While she was waiting to be transferred to our hospital for cardiac catheterization and possible percutaneous coronary intervention, she experienced cardiac arrest due to ventricular fibrillation and was successfully resuscitated. She arrived at our hospital intubated, in atrial fibrillation, and was being treated with dopamine and amiodarone. Cardiac catheterization showed 80% occlusion of the left anterior descending coronary artery and 50% stenosis of the right coronary artery. An intra-aortic balloon pump was placed because of cardiogenic shock.

When the patient arrived in the cardiac ICU, her blood pressure was widely fluctuating, requiring ongoing titration of dopamine. The rapid atrial fibrillation did not respond to intravenous amiodarone, and her condition continued to deteriorate, requiring multiple additional interventions. Then the ST alarm sounded. Her nurse noted that the ST Map border had extended beyond the 2-mm limits, indicating that the ischemia was worsening (Figure 5). The patient became pulseless and had a cardiac arrest.
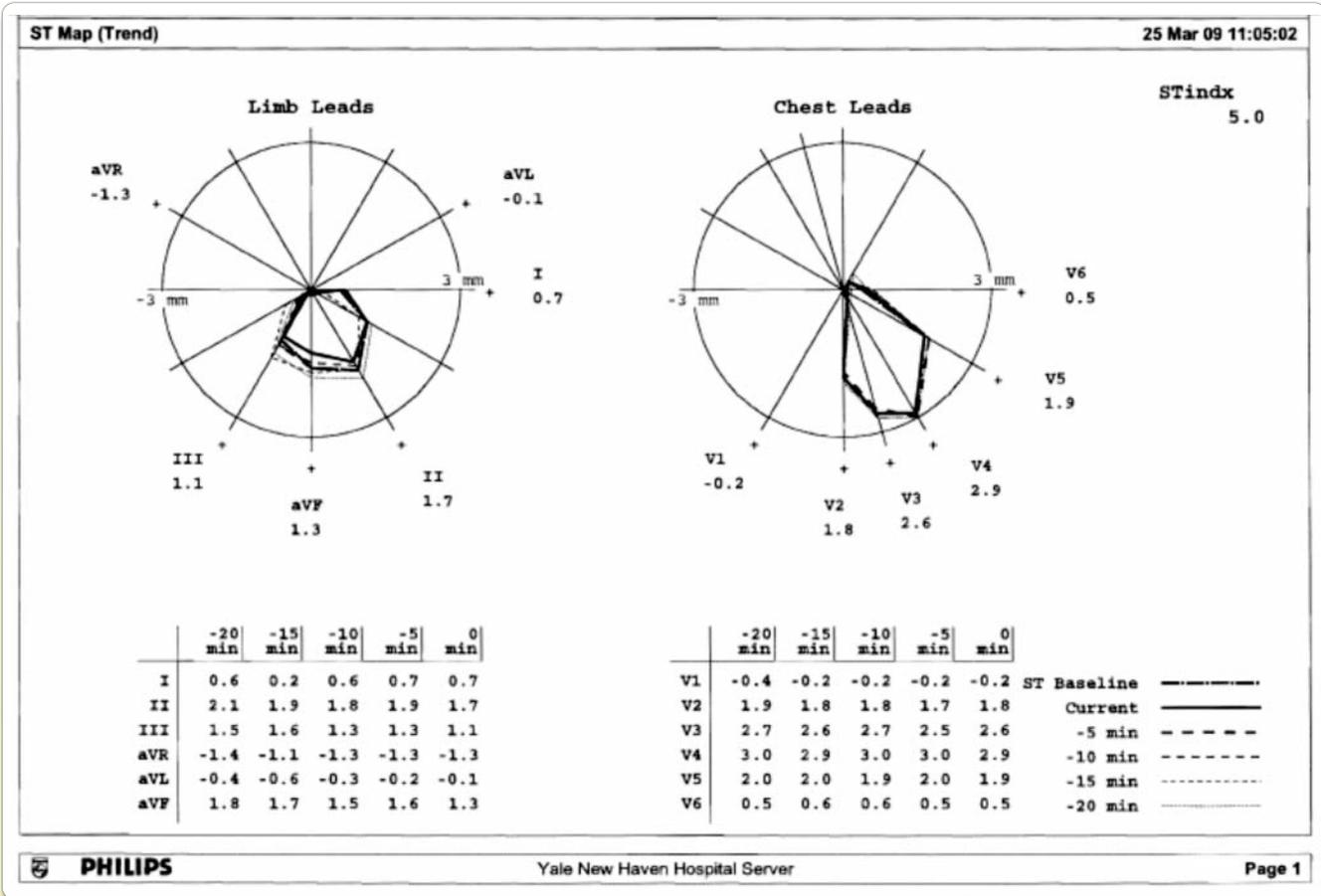
Limb Leads

aVR
-1.3

aVL
-0.1

I
0.7

III
1.1

II
1.7

aVF
1.3

Chest Leads

STindx
5.0

V6
0.5

V5
1.9

V1
-0.2

V4
2.9

V2
1.8

V3
2.6

	-20 min	-15 min	-10 min	-5 min	0 min
I	0.6	0.2	0.6	0.7	0.7
II	2.1	1.9	1.8	1.9	1.7
III	1.5	1.6	1.3	1.3	1.1
aVR	-1.4	-1.1	-1.3	-1.3	-1.3
aVL	-0.4	-0.6	-0.3	-0.2	-0.1
aVF	1.8	1.7	1.5	1.6	1.3

	-20 min	-15 min	-10 min	-5 min	0 min
V1	-0.4	-0.2	-0.2	-0.2	-0.2
V2	1.9	1.8	1.8	1.7	1.8
V3	2.7	2.6	2.7	2.5	2.6
V4	3.0	2.9	3.0	3.0	2.9
V5	2.0	2.0	1.9	2.0	1.9
V6	0.5	0.6	0.6	0.5	0.5

ST Baseline ——·——·——·
Current ————————
-5 min – – – – –
-10 min - - - - - - -
-15 min ·········
-20 min ——————

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Figure 6 Printout of morning ST-Map display for patient 2. In lead II, the solid border is not extending beyond the previous levels of ST-segment trends (dashed and dotted borders), indicating no new ischemia.

She was resuscitated, but her condition remained tenuous throughout the night, and she died later that morning.

In retrospect, we wondered if her ischemia could have been detected sooner. In an unresponsive intubated patient, ST-segment changes evident on a 12-lead ECG or on a bedside monitor are the most reliable clinical tools for detecting acute ischemia. Perhaps we would have noticed the ST-segment changes earlier, but because of the patient's tenuous clinical status and multiple interventions, we did not recognize the trend in the progression of the ST segments soon enough. In addition, perhaps if we had set the ST alarms at 1 mm instead of 2 mm, we would have responded to the audible alarm. Clearly, alarm settings must be customized for each patient. However, we question whether the ultimate outcome for this critically ill elderly woman would have been different.

Case 2

A 59-year-old man was admitted to a community hospital after he experienced chest pain and diaphoresis while at work. He had multiple cardiac risk factors and had had a myocardial infarction and stent placement 5 years before this admission. The initial 12-lead ECG showed evidence of a ST-elevation myocardial infarction. The patient was promptly transferred to our hospital for cardiac catheterization and possible percutaneous coronary intervention. He had stents placed in the left anterior descending coronary artery. An echocardiogram showed a left ventricular ejection fraction of 30%. While he was in the cardiac ICU, rapid atrial fibrillation developed, and he was given intravenous amiodarone. He also had evidence of heart failure and pneumonia.

While he was sleeping the next morning, his nurse noted ST-segment elevation in lead II on the bedside monitor. She also observed that no ST-segment changes were evident in lead V_1. At that time, the patient's ST Map showed no new ischemia (Figure 6), a finding that was confirmed with a 12-lead ECG. Later that afternoon, the ST-Map display indicated resolving ischemia (Figure 7).

In this case, ST-segment elevation was evident on the monitor, but the ST Map showed no new
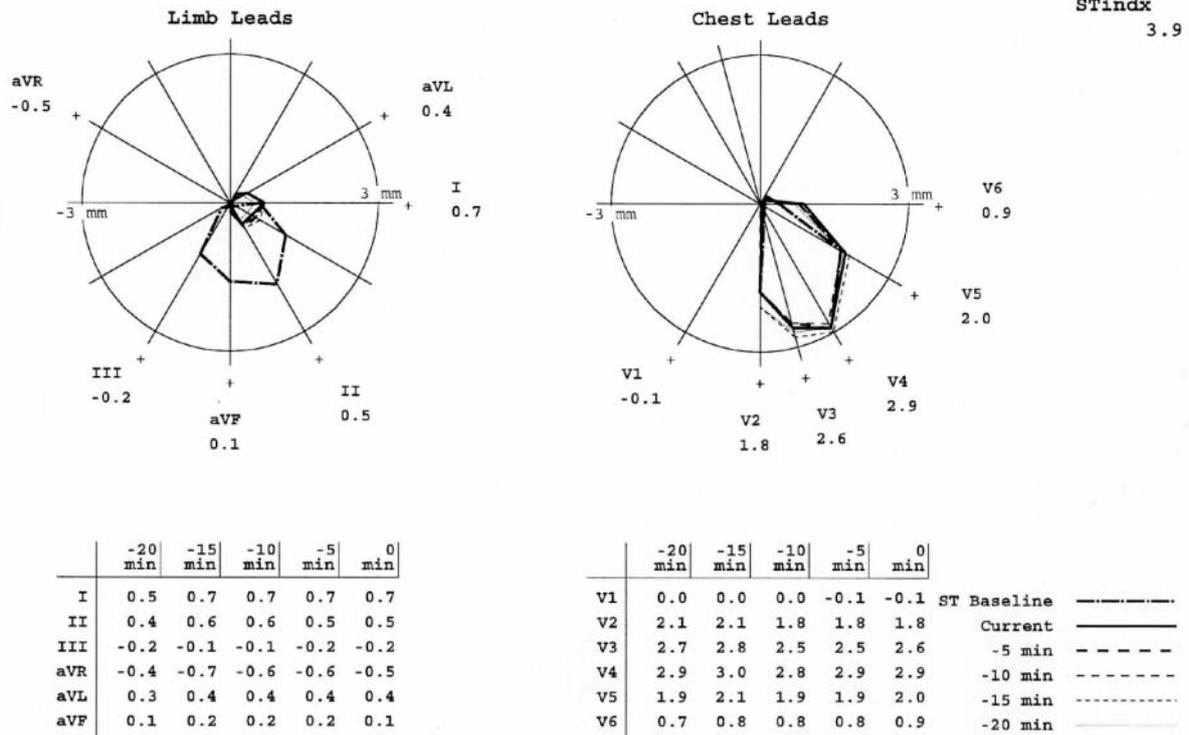
Figure 7 Printout of afternoon ST-Map display for patient 2. The solid borders in the limb leads are receding back toward the zero point, meaning that the ischemia is resolving.

changes. The nurse then could delay obtaining a 12-lead ECG for a few minutes while she addressed other patient care priorities. Also, if a nurse routinely monitors leads II and V_1 on the bedside monitor, he or she can still see ST-segment changes in other leads by using ST Map. In this case, the patient initially had ST elevation in leads V_2 through V_5. Ideally, we should have monitored another V lead. Still, ST Map allowed us to view ST changes in other leads simultaneously.

Conclusion

We found that ST-Map software was associated with more frequent use of ischemia monitoring, improved attitudes of nurses toward ischemia monitoring, and shorter time to the acquisition of a 12-lead ECG in response to symptoms or ST-segment changes. We learned from our study and from subsequent use of ST-Map ischemia monitoring how being able to visualize a patient's ischemia can enhance our practice. The ST Map provides a visual aid for bedside nurses that is more easily interpreted

than the traditional numeric display on the monitor. The visual expansion of a patient's ST Map beyond his or her baseline will elicit an alarm to alert the nurse of ischemia. The ease of using ST Map to monitor ischemia enables nurses to recognize ischemia more readily and intervene quickly.

Additional research with larger samples is needed to examine the association of ST Map with patient outcomes. Evaluation of ST Map in other patient care settings and with broader populations of patients is also indicated. A multisite randomized clinical trial would reduce potential bias.

about ST Map, for answering all our questions quickly, and for enthusiastically supporting our work to improve ECG monitoring practice.

SEE ALSO

For more about continuous ST-segment monitoring, visit the *Critical Care Nurse* Web site, **www.ccnonline.org**, and read the article by Fox et al, "Continuous ST-Segment Monitoring in the Intensive Care Unit" (October 2010).

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eLetters

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CE Test

Test ID A1120033: Continuous ST-Segment Monitoring: Nurses' Attitudes, Practices, and Quality of Patient Care.

Learning objectives: 1. Identify patients who would benefit from continuous ST-segment monitoring. 2. Describe reasons nurses are hesitant to use continuous ST-segment monitoring. 3. Discuss the objectives and findings from the study using the ST-Map software for continuous ST-segment monitoring.

1. Continuous ST-segment monitoring is recommended for which of the following reasons?
a. It is the gold standard to diagnose myocardial ischemia.
b. Diabetics often complain of shortness of breath that can be due to ischemia.
c. A silent ischemic episode could be missed by a single 12-lead electrocardiogram (ECG).
d. Lead placement is not crucial in setting up ST monitoring.

2. ST-segment elevation as detected by continuous ST-segment monitoring is an independent predictor of which of the following outcomes?
a. Quality of life
b. Intensive care unit length of stay
c. Mortality
d. Hospital length of stay

3. Which of the following were identified by nurse leaders as primary reasons for the lack of use of continuous ST-segment monitoring?
a. Lack of physician support, high number of false alarms, uncertainty about how to respond to ST alarms, and lack of administrative support.
b. Lack of physician support, high number of false alarms, uncertainty about how to respond to ST alarms, and lack of education about how to use the technology.
c. Lack of administrative support, high number of false alarms, uncertainty about how to respond to ST alarms, and lack of education about how to use the technology.
d. Lack of administrative support, high number of false alarms, lack of physician support, and lack of education about how to use the technology.

4. Which of the following groups issued practice standards for the use of continuous ST-segment monitoring?
a. American Cancer Society and the American Association of Critical-Care Nurses
b. American Heart Association and the American Association of Critical-Care Nurses
c. American Medical Association and the American Association of Critical-Care Nurses
d. American Heart Association and the American Nurses Association

5. Which of the following are limitations of cardiac ischemia monitoring?
a. Artifact related alarm activation and inappropriate leads monitored
b. Artifact related alarm activation and lack of physician orders
c. Inappropriate leads monitored and lack of physician orders
d. Lack of understanding about the technology and artifact related alarm activation

6. Which of the following patients were excluded from the continuous ST-segment monitoring study?
a. Patients who were complaining of variant angina following coronary vasospasm
b. Patients who came to the emergency department with chest pain
c. Patients who were agitated and had persistent artifact on their ECG tracings
d. Patients who were admitted in the early stages of acute coronary syndrome

7. The top reason given by nurses for not using ST-segment monitoring prior to the study was:
a. Inadequate knowledge of how to use it correctly
b. Lack of physician interest
c. An increase in nuisance alarms
d. It made patient care more complicated

8. In regard to ECG monitoring, nurses have a responsibility to do which of the following?
a. Use preset arrhythmia alarm parameters
b. Use unit standards to select the leads to be displayed
c. Use unit standards to determine the need for monitoring the QT interval
d. Choose when to invoke ST-segment monitoring and determine alarm parameters

9. In this study, the use of ST-Map monitoring required that the patient have which of the following?
a. A standard 5-electrode configuration
b. A standard 3-electrode configuration
c. A standard 7-electrode configuration that included 2 V electrodes
d. A standard 10-electrode configuration that included all 6 V electrodes

10. Which of the following patients is least likely to benefit from continuous ST monitoring?
a. A patient with diabetes
b. A patient recovering from anesthesia
c. A patient with altered mental status
d. A patient who is agitated

11. Which of the following was not a finding after the implementation of the ST-Map monitoring system?
a. Improved accuracy of chest electrode placement
b. No change in the time to get a patient back to the cardiac catheterization lab when there was evidence of vessel reocclusion
c. Improved time to acquire a 12-lead ECG in response to symptoms or ST-segment changes
d. Improved accuracy of limb electrode placement

12. Which of the following patients would not benefit from continuous ST-segment monitoring?
a. Patients who cannot communicate symptoms of ischemia
b. Patients who come to the emergency department because of chest pain
c. Agitated patients with constant noise on their ECG tracings
d. Patients who have a complication related to percutaneous coronary intervention

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Test ID: A1120033 Contact hours: 1.0 Form expires: May 1, 2013. **Test Answers:** Mark only one box for your answer to each question. You may photocopy this form.

1. ☐a	2. ☐a	3. ☐a	4. ☐a	5. ☐a	6. ☐a	7. ☐a	8. ☐a	9. ☐a	10. ☐a	11. ☐a	12. ☐a
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