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Continuous ST-Segment Monitoring: Protocol for Practice

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In 1999, Drew et al[1] published consensus guidelines recommending use of continuous ST-segment monitoring for specific cardiac patients. However, these guidelines have not yet uniformly become the standard of practice.

To aid in implementing consensus guidelines, we describe a nurse-directed hospital-wide protocol with interdisciplinary agreement on continuous ST-segment monitoring. We begin with a review of current guidelines for continuous ST-segment monitoring among hospitalized patients. Results of a brief survey of hospital use of continuous ST-segment monitoring in our community are provided to facilitate discussion of the extent of implementation of the guidelines into practice. We also review research studies and discuss current limitations of continuous ST-segment monitoring. Finally, we present implications for further research to clarify best-practice use of continuous ST-segment monitoring.

PRIME POINTS

- The purpose of continuous ST-segment monitoring is to provide an alert for potential ischemia.
- A 12-lead ECG is still needed to provide definitive diagnosis in the context of a patient's clinical features.
- The level of critical thinking required in tailoring increasingly complex ECG-monitoring technology needs to be supported by ongoing education.

CE Continuing Education

This article has been designated for CE credit. A closed-book, multiple-choice examination follows this article, which tests your knowledge of the following objectives:

1. Understand that continuous ST-segment monitoring helps detect silent ischemia
2. Describe guidelines for implementing continuous ST-segment monitoring
3. Recognize that lead selection for continuous ST-segment monitoring should be based on each patient's priority monitoring needs

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Guidelines for In-Hospital Electrocardiographic Monitoring

Although the 12-lead electrocardiogram (ECG) is a standard for detecting ischemic coronary events, it provides a static snapshot rather than the continuous recording of dynamic changes that may be visualized by using continuous ST-segment monitoring.[2] Continuous ST-segment monitoring has been available since the mid-1980s,[3] but only about half of critical care units use this technology.[4]

In light of the newly published consensus guidelines for universal definition of myocardial infarction by experts from the American Heart Association (AHA), American College of Cardiology, and other relevant organizations,[5] more continuous and accurate ST-segment monitoring is needed. The consensus guidelines[5] describe ECG manifestations of acute myocardial ischemia (in absence of left ventricular hypertrophy and left bundle branch block) as new ST-segment elevation at the J-point in 2 contiguous leads, with the cutoff points of more than 2 mm in men or more than 1.5 mm in women in leads V_2 and V_3 and/or more than 1 mm in other leads. The J-point is located at the point where the QRS segment ends. Contiguous leads that provide information on surface areas of the heart are found in Table 1.[5-8] The guidelines also describe acute myocardial ischemia as ST-segment depression of greater than 0.5 mm in 2 contiguous leads and/or T-wave inversion greater than 1 mm in 2 contiguous leads with a prominent R wave.

Table 1 Best lead for ST-segment monitoring related to coronary artery suspected to be occluded[a]

Artery	Lead
Left anterior descending (anterior wall)	V_2 or V_3 preferred, then V_4 V_3 preferred for patients with acute coronary syndrome who do not have identified "ST fingerprint" (ST-segment changes during percutaneous coronary intervention or ST-segment elevation myocardial infarction) (V_1 and V_2 more specifically associated with the septal wall)
Right coronary (inferior wall) (right ventricular wall)[b]	III preferred, then aVF or II V_3R and V_4R
Circumflex (lateral wall)	I, aVL, V_5 preferred, or V_6 V_5 preferred for noncardiac patients undergoing surgery (V_5 and V_6 are more specifically low lateral; I and aVL, high lateral)
Posterior wall (inferobasal wall)[b]	Reciprocal changes (ST depression) in leads V_1 to V_3

[a] Sources: Drew et al,[1,3] Thygesen et al,[5] American Association of Critical-Care Nurses,[6] Field et al,[7] and Goldberger.[8]
[b] Recently published scientific statement[5] recommends the term *inferobasal* wall and use of right precordial leads in order to detect concomitant right ventricular infarction.

In 1999, a consensus statement[1] of practical clinical guidelines for optimal use of ST-segment monitoring was published by an international interdisciplinary work group consisting of physicians, nurses, and a cardiac monitoring engineering expert. The group recommended that continuous ST-segment monitoring be included in (but not limited to) monitoring for a minimum of 24 to 48 hours in patients who were experiencing acute myocardial infarction or acute coronary syndrome (ACS) and in patients after coronary artery intervention to detect patency after thrombolytic therapy or primary angioplasty. Recommendations were based largely on expert opinion and case reports because few randomized clinical trials of continuous ST-segment monitoring had been done.

In 2001, Patton and Funk[4] reported on the uniformity of continuous ST-segment monitoring as a standard of practice in the United States. A random sample (n = 192) of clinical nurse specialists and nurse managers were surveyed by US mail. Only 54.2% of respondents indicated that their departments used continuous ST-segment monitoring to detect ischemia in patients with ACS.

In 2004, a scientific statement of practice standards for ECG monitoring in the hospital was published by the AHA and endorsed by the American Association of Critical-Care Nurses (AACN) and the International Society of Computerized Electrocardiology.[3] The comprehensive best-practice standards were created to facilitate safe and effective monitoring for cardiac dysrhythmias, QT-segment monitoring, and ischemia monitoring and included guidelines for continuous ST-segment monitoring in certain patients.

Patients Who May Benefit From ST-Segment Monitoring

The task force writers of the scientific statement on practice standards

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Table 2 Recommended use of continuous ST-segment monitoring according to population of patients[a]

Monitoring of ischemia

Class I, indicated	Class II, has possible benefits	Class III, not indicated
Patients with acute coronary syndromes (ST-segment elevation or non–ST-segment elevation myocardial infarction [MI], unstable angina/rule out MI): minimum of 24 hours monitoring and until event-free for 12-24 hours Patients receiving thrombolytic therapy for MI: until event-free for 12-24 hours, to assess for effectiveness of therapy and assess patency of culprit artery after therapy[9] Patients with chest pain or angina-equivalent symptoms in the emergency or observational unit: 8-12 hours of monitoring in combination with assays of serum cardiac biomarkers to assess for new, transient, or resolving ischemia[10,11] Patients during percutaneous coronary revascularization: monitoring during procedure to identify "fingerprint" on waveform during ischemia upon balloon inflation[12,13] Patients after angioplasty without stent: 12-24 hours monitoring because of higher incidence of abrupt closure Patients after nonurgent percutaneous intervention with suboptimal angiographic results: monitoring immediately after procedure and continued 24 hours or longer if ST events occur Patients with potential for vasospasm (eg, Prinzmetal angina, cocaine): monitoring until therapy has been initiated and patient is event-free for 12-24 hours	Patients with ischemia after acute MI (patients with recurrent anginal symptoms or secondary increase in ischemia): 24-hour monitoring after final ischemic symptom to assess for resolution or extension Patients after successful angioplasty with stent: 4-8 hours monitoring to assess for abrupt or late reocclusion High-risk patients after cardiac or noncardiac surgery: intraoperatively and 24-48 hours postoperatively for those undergoing vascular surgery or prolonged surgical procedures, older adults, critically ill patients Patients with potential for ischemia associated with weaning from mechanical ventilation: monitoring may be warranted; particularly for patients who have hypoxia and cannot be weaned from mechanical ventilation[14,15]	Perioperatively in patients with no history of heart disease After anesthesia in patients with no history of heart disease (eg, for epidurals during cesarean section) Not likely to be helpful in patients with 100% ventricular paced rhythm[b] Left bundle branch block or intermittent right bundle branch block[b] Coarse atrial fibrillation or flutter Agitation, restlessness Confirmed pericarditis or myocardial contusion ST-segment "sagging" associated with administration of digoxin Ischemic heart disease (may have an intermittent accelerated ventricular rhythm that may interfere with ST-segment monitoring)

[a] Sources: Drew et al.[1,3]
[b] Some sources indicate continuous ST-segment monitoring may be helpful to detect ischemia in this situation, but advanced skill in interpretation is required.

for ECG monitoring[3] developed a rating system (Table 2)[9-15] based on research evidence and expert opinion to make recommendations about which patients should have continuous ST-segment monitoring.

In 2004, AACN published a practice alert[6] recommending that the standard of practice include continuous ST-segment monitoring of patients in the early phases of ACS who arrive in the emergency department with chest pain or anginal-equivalent syndromes, who have undergone a percutaneous coronary intervention with suboptimal results, or who may have a variant angina (eg, angina caused by vasospasm rather than by occlusion). The practice alert provides short, specific guidelines for monitoring based on the AHA/AACN consensus guidelines, including an audit tool for ST-segment monitoring.[16]

Community Survey of Use of Continuous ST-Segment Monitoring

In 2006, we conducted a brief community survey of 17 hospitals in and around the local St Paul/Minneapolis and Rochester, Minnesota, areas to determine use of continuous ST-segment monitoring in emergency department and inpatient areas. Of 17 hospitals surveyed, routine continuous ST-segment monitoring was used in 47% of progressive care units and 41% of intensive care units (ICUs). In hospitals in which patients were routinely monitored in an emergency department or observational unit to rule out acute myocardial infarction, only 29% of hospitals used continuous

ST-segment monitoring as part of their "rule out" protocol in these departments. One small regional hospital used continuous ST-segment monitoring as a standard of practice to help determine which patients qualified for immediate transfer to a level I facility for immediate intervention (with confirmation of ST-segment changes by 12-lead ECG). Overall, use of continuous ST-segment monitoring did not appear to be related to hospital size. Results of this Midwest survey may reflect a lack of improvement in use of this type of monitoring by hospitals since the national survey in 2001.[4] However, we used a convenience sample and surveyed only a single area of the United States; thus, the results may not be generalizable.

Why is continuous ST-segment monitoring not a consistent standard of practice across hospitals? Probable reasons include a lack of awareness of the consensus guidelines or a published protocol, lack of acceptance by physician and nurse leaders who may be awaiting the results of clinical trials to support a stronger level of evidence, and lack of education for nurses about what to do when findings on continuous ST-segment monitoring are abnormal.

Review of Studies

More clinical trials and awareness of existing trials are needed to strengthen the perceived level of evidence for continuous ST-segment monitoring. The level of evidence for use of this type of monitoring in hospitalized patients was initially based largely on expert opinion, case reports, and consensus guidelines. No controlled, randomized clinical trial has definitively indicated that patients who receive continuous ST-segment monitoring have better outcomes than do patients who do not have the monitoring. However, strong descriptive and comparative studies with prospective designs have been published.

Significance of Continuous ST-Segment Monitoring for Evaluation of Interventions

Jernberg et al[17] found that use of multilead ST-segment monitoring in patients with ACS allowed prospective identification of patients who had the best response to longer treatment with low-molecular-weight heparin, thus resulting in lower rates of mortality, myocardial infarction, and revascularization (35.3% vs 53.4%; relative risk reduction, 34%; $P = .01$). Researchers in a substudy[18] of the Global Utilization of Streptokinase and TPA for Occluded Coronary Arteries (GUSTO-I) trial concluded that recurrent ST-segment elevation as detected via continuous ST-segment monitoring was an independent predictor of mortality, even after consideration of multiple clinical risk factors in the GUSTO mortality model.

In a multisite, prospective, comparative study of 1777 patients, Maas et al[19] found that age, heart rate, and late ST-segment elevation were independent risk factors for adverse clinical outcomes. ST subgroupings resulted in significant stratification for both low- and high-risk patients for the composite end points (in-hospital death and combined death, reinfarction, or congestive heart failure). Maas et al concluded that continuous ST-segment monitoring is helpful in assessing response to therapy, especially in high-risk patients more than 70 years old.

In patients with ACS, transient myocardial ischemia is an independent predictor of worse outcomes. In a study[20] conducted at various sites in Canada, 681 patients admitted with non–ST-elevation ACS were randomly assigned to receive either enoxaparin or intravenous unfractionated heparin. At 30 months, patients with ST-segment shifts were more likely to die (17.7% vs 5.8%; $P < .001$) and to reach the composite end point for worse outcomes (24.6% vs 11.1%; $P < .001$) than were patients without such shifts. After adjustments for risk scores, the presence of ST-segment shifts on continuous ECGs was a stronger independent predictor of mortality than were the findings on admission 12-lead ECGs.[20] Several other investigators reported that using continuous ST-segment monitoring helped to predict patients' severity of disease at a variety of time points: during hospitalization,[19,21,22] after discharge,[23] and in long-term follow-up.[24]

In the first study involving a comprehensive evaluation of ST-segment changes before, during, and after percutaneous coronary intervention, Terkelsen et al[25] performed continuous ST-segment monitoring in 92 patients with ST-elevation myocardial infarction, from ambulance through the percutaneous procedure until 90 minutes after the procedure. The results indicated that a prespecified ST-monitoring classification was useful for stratifying patients at the time of percutaneous coronary intervention into groups at low, intermediate, and high risk. Terkelsen et al[25] recommended use of continuous ST-segment monitoring for an early indication of the degree of reperfusion after percutaneous intervention.

Akkerhuis et al[26] performed a meta-analysis of 3 prospective clinical trials (n = 995) with retrospective blinded analysis of recordings of continuous monitoring done in a core laboratory. They found that the number of ischemic episodes in 24 hours was directly proportionate to the probability of cardiac events at 5 and 30 days. After known baseline predictors of worse outcomes were controlled for, each transient ischemic event was predictive of a 25% increase in the risk of death or myocardial infarction at 5 and 30 days. Akkerhuis et al[26] concluded that integration of continuous ST-segment monitoring via a 12-lead ECG system was warranted in the emergency and coronary care departments to enable early identification of patients who may benefit from early revascularization.

Finally, in an ongoing study, Drew et al[27] are investigating whether prehospital ST-segment monitoring with telephone transmission of ST events to the target hospital can improve hospital time-to-treatment in patients with ACS. Results from this study will add to the body of literature and may provide support for the use of continuous ST-segment monitoring in a prehospital environment.

Significance of Continuous ST-Segment Monitoring for Patients Vulnerable to Silent Ischemia

Patients with silent or unrecognized ischemia may benefit from continuous ST-segment monitoring. Reported rates of silent ischemia among hospitalized patients vary, from 21% to 77%, depending on the type of patient, hours of monitoring, and method of continuous ST-segment monitoring.[17,28-30] Gunnarsson et al[31] reported that continuous, real-time multilead ST-segment monitoring was as accurate as or more accurate than standard 12-lead ECG monitoring.

Kress et al[15] used continuous 3-lead Holter monitors with blinded ST-segment analysis by a cardiologist to detect myocardial ischemia in ICU patients receiving mechanical ventilation who had risk factors for coronary artery disease. Ischemia was defined as ST-segment elevation or depression of more than 0.1 mV from baseline. Myocardial ischemia was detected among 24% of patients, who subsequently had a longer ICU stay (mean, 17.4 days; SD, 17.5 vs mean, 9.6 days; SD, 6.7; $P = .04$) than did patients without ischemia. The study involved patients receiving continuous ST-segment monitoring to detect ischemia while being awakened from sedation. Continuous ST-segment monitoring was a more helpful end point than troponin T level for detecting myocardial ischemia because many patients had preexisting troponin leaks that could not be "undone" and because continuous ST-segment monitoring provided real-time data (rather than a static troponin marker).

Certain populations of patients with coronary ischemia, such as women and patients with diabetes mellitus, may have atypical anginal symptoms. In a large study[20] of patients with myocardial infarction, 33% did not have chest pain on arrival at the hospital. Patients without chest pain, compared with patients with chest pain, were significantly more likely to be women, have diabetes, or have prior heart failure. Additionally, patients with myocardial infarction without chest pain had a longer delay before going to a hospital (mean, 7.9 vs 5.3 hours); were less likely to have a diagnosis of confirmed myocardial infarction at the time of admission (22.2% vs 50.3%); and were less likely to receive thrombolysis or primary angioplasty (25.3% vs 74.0%), aspirin (60.4% vs 84.5%), β-blockers (28.0% vs 48.0%), or heparin (53.4% vs 83.2%).

In another study,[32] patients with myocardial infarction without chest pain had a 23.3% in-hospital mortality rate compared with a rate of 9.3% among patients with chest pain. Pope et al[33] also reported that failure to hospitalize patients who had acute myocardial infarction or unstable angina (missed diagnoses)

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was significantly related to the absence of typical features of cardiac ischemia.

Less well-recognized populations of patients vulnerable to silent ischemia may include patients with confusion and patients who cannot communicate effectively (eg, patients who are sedated and intubated, mentally impaired, or experiencing acute delirium). Continuous ST-segment monitoring may be helpful in detecting silent ischemia. Once ischemia is detected, interventions can be initiated that increase chances for maintaining viable myocardial tissue. In this era of widespread interventional capability, nurses caring for cardiac patients should examine available technology that alerts caregivers to changes in cardiac status.

A shift in thinking about ECG monitoring beyond heart rates and dysrhythmias is needed to match the current culture of aggressive intervention.

Practical Limitations of Continuous ST-Segment Monitoring

Nurse leaders and biomedical engineers must carefully consider continuous ST-segment monitoring preferences and alarm levels based on published recommendations. Number and volume of audible alarms should be designated to avoid "nuisance alarms."[34] Too many false-positive alarms may reduce the sensitivity of nurses and thus their response, as well as physicians' responses.

In addition to concerns about continuous ST-segment monitoring, general bedside ECG monitoring has concerns related to quality assurance that must be addressed. Drew et al[35] identified several weaknesses of ECG monitoring, including lack of skin preparation before ECG patches are applied and inaccurate placement of ECG leads. If the lead that overlies the current of injury is not the one selected for continuous ST-segment monitoring, a sense of false assurance may result, with potential for missed ischemia.

Even when ECG patches are correctly placed and maintained by knowledgeable nurses, certain limitations exist in current bedside ST-segment monitoring. Most current in-hospital monitors do not detect T-wave inversion, which may be the only objective sign of reversible ischemia in some patients. Also, physically restless or combative patients may create artifacts that trigger false alarms, requiring that ST monitoring be turned off so that staff do not become accustomed to ignoring ST alarms and to prevent patients from being burdened with meaningless alarms.

Education for Continuous ST-Segment Monitoring

Education of nurses responsible for ECG monitoring needs to be ongoing and evidence based. Results of a study[36] in which nurses' ability to differentiate ischemic from nonischemic ECG patterns was evaluated were disappointing; only 19% of nurses were able to correctly identify the presence or absence of ischemia in all 6 scenarios. However, Johanson et al[37] found that after the majority of critical care nurses in their sample attended a 2-day symposium on vectorcardiographic interpretation and analysis, bedside nurses' evaluations of ST trend curves were equal to evaluations done in a core laboratory.

Initial education must be supported by ongoing assessment of competency. Lead selection and placement based on the priority monitoring needs of each patient are a core education component. This level of education may require more than a single introductory class to ECG monitoring. It may also require unit policies that match monitoring lead selection to the population of patients served. Additionally, accuracy of lead placement may require close supervision of unlicensed assistants or float nurses, who may be placing or repositioning telemetry patches. Periodic quality assurance audits are needed to verify the lead placement skills of staff.

The most frequently cited reason (27%) a sample of critical care nurses gave for not using ST monitoring was the lack of interest by physicians.[4] This finding clearly indicates that practice changes in cardiac monitoring need interdisciplinary attention. Possibly, cardiologists are not aware of the consensus guidelines for cardiac monitoring.

Thus, interdisciplinary discussion and agreement on ECG monitoring protocols is imperative.[38]

Finally, a shift in thinking about ECG monitoring beyond heart rates and dysrhythmias is needed to match the current culture of aggressive intervention. The emphasis in cardiac management has shifted from observing development of a pathological q wave (a sign of irreversible transmural myocardial damage) and supportive management to prevention and rapid intervention when ST-segment changes that may indicate reversible ischemia are detected. Early intervention, particularly of an occluded left anterior descending artery, may prevent death of the myocardium and thus prevent development of heart failure.[39] Nurses in rural hospitals without an in-house physician often base their decisions on ST segments noted on the initial 12-lead ECG. For example, ST-segment results influence whether or not a level I hospital is contacted for transfer of a patient with ACS. Early and accurate identification of ischemia requires that acute care nurses use critical thinking about a monitoring process they understand well.

Critical Thinking in Lead Selection

Unfortunately, the leads selected for monitoring a particular patient may be based on habit or a unit protocol rather than a nurse's critical thinking about the patient's priority for monitoring. For patients who have undergone cardiac surgery, lead V_6 is understandably often used to avoid placing a lead near the sternum. Like lead V_1, V_6 is helpful for identifying intraventricular conduction defect and distinguishing between ventricular ectopy and aberrancy. However, V_6 may not be the best lead for observing abrupt reocclusion, depending on the artery that was revascularized (see Table 1). For example, if a patient's revascularized vessels were the right coronary artery and the left anterior descending artery, the best leads would be III and V_2 or V_3.[40,41]

Many units have equipment capability to select only 1 precordial (chest) lead and 1 limb lead and therefore have routinely used V_1 or V_6 (as ideal arrhythmia leads) and II (as ideal limb lead) for monitoring all patients.[41] Although these leads may provide classic ECG waveforms, they may be problematic, depending on the nurse's primary aim. For example, if a nurse wants to monitor for frequency of a patient's premature ventricular contractions, use of a standard V_1 lead may be adequate. Similarly, if the nurse's intent is to monitor for recurrence of atrial fibrillation, then the commonly selected lead II may be appropriate. However, if the priority for monitoring involves a patient who has had recent revascularization of the left circumflex artery, the nurse may miss abrupt reocclusion if only leads V_1 and II are selected for monitoring. The nurse would more correctly select a lead that monitors the lateral surface of the heart (I, aVL, or V_5-V_6).

Many units have equipment capability to select only 1 precordial (chest) lead and 1 limb lead and therefore have routinely used V_1 or V_6 (as ideal arrhythmia leads) and II (as ideal limb lead) for monitoring all patients.

Ideally, nurses should base lead selection on the priority monitoring needs of each patient. Although this concept seems simple, it requires more than an introductory class in ECG monitoring. Nurses responsible for cardiac monitoring should receive the appropriate ongoing education to enhance critical thinking about tailoring lead selection to a patient's need.

Daleiden and Schell[42] attributed the underuse of continuous ST-segment monitoring to technical problems (false alarms, inadequate hardware or software for accurate ST analyses), lack of practice standards, and lack of consensus by physicians about the need for continuous ST-segment monitoring. The authors[42] provided clear, succinct instructions for nurse leaders considering implementation of ST-segment monitoring technology. A particular focus included clinical education of staff nurses, physicians, and monitor technicians, who should be able to place leads correctly (initial and ongoing), recognize changes in the ST segment (ongoing elevation vs resolution), recognize abrupt reocclusion after a coronary intervention, recognize false alarms, and incorporate patients' symptoms and hemodynamic status along with a rhythm in order to better interpret the clinical significance of changes in the ST segment.

Utilization Protocols

Guidelines for protocols for continuous ST-segment monitoring have been offered by Drew and Funk,[43] Leeper,[2,44] and Flanders.[38,45] A handful of nurses have published clinical papers describing how continuous ST-segment monitoring is used in their institution. One of the earliest reports came from nurses in Australia,[46] who described the ease of use of this noninvasive technology and who used 2 case studies to illustrate how continuous ST-segment monitoring via 12-lead ECG provided additional diagnostic information in a patient who underwent emergency percutaneous intervention during a myocardial infarction and a patient who received thrombolytic therapy for an anteroseptal myocardial infarction. In the latter patient, continuous ST-segment monitoring provided early detection of poor perfusion, so the patient was able to undergo subsequent successful percutaneous coronary reperfusion.

Crater et al[47] used case studies to illustrate how nurses in the coronary care unit at Duke University Medical Center, Durham, North Carolina, monitored ST segments via a real-time portable 12-lead system. The authors offered a risk stratification model of patients with ST-segment monitoring for house officers to use during triage for ACS. A specific nursing protocol was not given.

Our Protocol: Education and Protocol for Standard Practice

Because we found no publication of a nursing protocol that is in active use throughout a hospital, we provide our hospital's ST-monitoring protocol, along with approaches to address currently perceived limitations of continuous ST-segment monitoring.

In Nasseff Heart Center of the 572-bed United Hospital, continuous ST-segment monitoring was implemented in the early 1990s. Currently a 5-electrode ECG lead is used. Each staff nurse on the ICU or progressive care unit is required to pass a basic cardiac rhythms test. Nurses new to cardiac monitoring receive a 24-hour basic course, divided into 3 days over a period of up to 2 weeks, followed by verification of competency on the clinical unit. Both intermediate and advanced ECG classes (8 hours each) are encouraged but are not mandatory. Because only introductory content on ST-segment monitoring is provided in the basic cardiac rhythm course, all new nurses receive further individualized instruction from the assistant nurse manager on their units on the protocol for use of continuous ST-segment monitoring. This personalized instruction includes how to assess for patients who do not benefit from continuous ST-segment monitoring. New nurses are taught how to turn off the default alarm and how to answer and adjust alarm settings and are reminded of the parameters of as-needed 12-lead ECG.

Interdisciplinary agreement was sought so that the standard practice for using continuous ST-segment monitoring would be accepted by cardiologists, hospitalists, cardiac rehabilitation professionals, and nurses. A key decision by the interdisciplinary group was policy wording that stipulated that the ST alarm default must be the "on" setting for all patients. Thus, nurses must manually turn ST alarms to "off" for patients who meet exclusion criteria (Table 3). Before notifying a physician about an ST alarm, the nurse first verifies that the patient's patches are correctly placed and that the alarm is not due to an artifact, particularly an artifact caused by movement of the patient.[48]

Next, for any 2-mm change in the ST segment sustained for 15 minutes (with or without signs or symptoms), the nurse obtains an as-needed 12-lead ECG to confirm that ST changes are present. The house officer is paged to confirm findings on the 12-lead ECG suggestive of ischemia before the attending physician is called. By following this protocol, we are able to reduce the number of unnecessary telephone calls for false alarms.

The as-needed ECG is rarely required because nurses turn off continuous ST-segment monitoring alarms when appropriate. For example, a patient admitted to rule out ACS for whom tests for cardiac markers are normal and diffuse ST changes are apparent will have continuous ST-segment monitoring discontinued after a physician confirms a diagnosis of pericarditis. Similarly, for a patient who has declined further intervention but continues to have alarms on ST-segment monitoring,

Table 3 United Hospital's Nasseff Heart Center practice standard and protocol for continuous ST-segment cardiac monitoring

Practice standard	Protocol
For all patients receiving cardiac monitoring, the default for continuous ST-segment monitoring is "on" with alarm set for 2-mm change (depression or elevation) from baseline. Nurse turns "off" for patients with the following: • Intraventricular conduction defect (either left or right bundle branch block) • Pacemakers (where pacing is the dominant rhythm) • Confirmed pericarditis or myocardial contusion • ST-segment "sagging" due to digoxin	Assessment by nurse after ST alarms will include first verifying: • Patient is supine (<45° backrest elevation) • Leads are correctly placed on clean, dry skin If the patient has a 2-mm ST change sustained for 15 minutes (with or without symptoms): • Nurse will obtain a 12-lead electrocardiogram to confirm the ST-segment changes (standing order) and call a physician.

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the nurse can request an order from a physician to increase alarm limits to prevent continual alarms.

Minor modifications to the original protocol were made after case studies of actual patients were reviewed. Case studies provided learning opportunities to enhance patients' outcomes, nurses' education, and interdisciplinary discussions. Case studies may also provide a forum for discussion among institutions for how to incorporate consensus guidelines into actual practice. An article will be published later in *Critical Care Nurse* in which case studies are used to illustrate practical application of a protocol and related education for continuous ST-segment monitoring.

Implications for Research

Investigators evaluating use of chest pain observation units for ACS patients should clearly indicate whether continuous ST-segment monitoring is used and should consider randomization of units to receive or not receive continuous ST-segment monitoring so that the value of this monitoring can be further delineated. Suggested outcome variables to be tested upon implementation of continuous ST-segment monitoring in patients being observed because of chest pain may include evaluation of whether continuous ST-segment monitoring can be used along with cardiac markers to successfully detect perfusion defects. Other study outcome variables could include a possible change in the number of inpatient admissions, a reduction in the number of missed diagnoses of myocardial infarctions, and documentation of change in treatment based on the results of continuous ST-segment monitoring. Evaluation of an institution's outcomes before and after implementation of continuous ST-segment monitoring could include whether continuous ST-segment monitoring provided earlier detection of ischemia, and therefore decreased the time to cardiac catheterization, particularly in patients at risk for silent ischemia. Measurement and publication of outcome variables are acutely needed to verify appropriate interventions when alarms occur during continuous ST-segment monitoring.

Additional research is needed to better clarify which populations of patients will benefit from continuous ST-segment monitoring, as well as the length of time monitoring should be applied. For example, analysis of coarse atrial fibrillation based on changes in the ST segment is currently difficult. Further study is needed on normal variations in the ST segment after cardiac surgery. Finally, identifying the most efficient bedside monitoring equipment that minimizes interference with the healing of sternal incisions, is user friendly, and is cost-effective may improve use of this technology.

Implications for Practice

Nurse educators and administrators should thoughtfully consider whether staff nurses in the ICUs and progressive care units have sufficient education in ECG monitoring. A discussion of appropriate education is mandatory for implementing protocols for continuous ST-segment monitoring. The level of critical thinking required in tailoring increasingly complex ECG-monitoring technology needs to be supported by ongoing education.

Hospitalists and cardiologists need to partner with staff nurses in applying the protocols of continuous ECG monitoring used in hospitals where the physicians admit patients. If continuous ST-segment monitoring is initiated as a new policy in a hospital, nurse leaders in education and practice should consider measuring outcomes before and after the implementation. Nurses need to learn from each other, especially about policies for increasing alarm limits and when to request an ECG.

Conclusion

Consensus guidelines exist for appropriate use of continuous ST-segment monitoring. Many hospitals have not implemented guidelines for this type of monitoring, and practice has been limited by lack of published policies on how to apply the guidelines clinically. Implementation of the guidelines requires thoughtful interdisciplinary discussion among nurse leaders, cardiologists, hospitalists, and biomedical engineers for selecting alarm limits before monitoring begins and standards of practice for responding to alarms.

In our hospital, we implemented the use of continuous ST-segment monitoring with a well-defined protocol developed by a cardiovascular clinical nurse specialist and approved by an interdisciplinary team. The protocol included strategies to verify accuracy of continuous ST-segment monitoring alarms and to obtain a 12-lead ECG before calling a physician, thus avoiding unnecessary telephone calls for potentially false-positive alarms. Translation of consensus guidelines into actual practice policies helped us successfully use continuous ST-segment monitoring to enhance cardiac care. CCN

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To learn more about ST-Segment Monitoring, read "ST-Segment Changes in Right Ventricular Paced Rhythms" by Michele M. Pelter and Mary G. Carey in the *American Journal of Critical Care,* 2006;15:231-232. Available at **www.ajcconline.org**.

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References

1. Drew BJ, Krucoff MW; ST-Segment Monitoring Practice Guidelines International Working Group. Multilead ST-segment monitoring in patients with acute coronary syndromes: a consensus statement for healthcare professionals. ST-segment Monitoring Practice International Guidelines Working Group. *Am J Crit Care.* 1999;8:372-388.
2. Leeper P. Continuous ST-segment monitoring. *AACN Clin Issues.* 2003;14:145-154.
3. Drew BJ, Califf RM, Funk M, et al; American Heart Association; Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young: endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses [published correction appears in *Circulation.* 2005; 111(3):378]. *Circulation.* 2004;110(17):2721-2746.
4. Patton JA, Funk M. Survey of use of ST-segment monitoring in patients with acute coronary syndromes. *Am J Crit Care.* 2001;10:23-34.
5. Thygesen K, Alpert JS, White HD; Joint ESC/ACCF/AHA/WHF Task Force for the Redefinition of Myocardial Infarction. Universal definition of myocardial infarction. *Circulation.* 2007;116(22):2634-2653.
6. American Association of Critical-Care Nurses. AACN practice alert: ST segment monitoring. American Association of Critical-Care Nurses Web site. http://www.aacn.org/WD/Practice/Docs/ST_Segment_Monitoring_04-2008.pdf. Issued April 2008. Accessed May 12, 2009.
7. Field JM, Hazinski MF, Gilmore D, eds. *Handbook of Emergency Cardiovascular Care for Healthcare Providers.* Dallas, TX: American Heart Association; 2006.
8. Goldberger AL, ed. *Clinical Electrocardiography: A Simplified Approach.* 7th ed. Philadelphia, PA: Mosby Elsevier; 2006.
9. Langer A, Singh N, Freeman MR, Tibshirani R, Armstrong P. Detection of silent ischemia adds to the prognostic value of coronary anatomy and left ventricular function in predicting outcome in unstable angina patients. *Can J Cardiol.* 1995;11:117-122.
10. Gomez MA, Anderson JL, Karagounis LA, Muhlestein JB, Mooers FB. An emergency department-based protocol for rapidly ruling out myocardial ischemia reduces hospital time and expense: results of a randomized study. *J Am Coll Cardiol.* 1996;28:25-33.
11. Gibler WB, Runyon JP, Levy RC, et al. A rapid diagnostic and treatment center for patients with chest pain in the emergency department. *Ann Emerg Med.* 1995;25:1-8.
12. Krucoff MW, Parente AR, Bottner RK, et al. Stability of multilead ST-segment "fingerprints" over time after percutaneous transluminal coronary angioplasty and its usefulness in detecting reocclusion. *Am J Cardiol.* 1988;61:1232-1237.
13. Bush HS, Ferguson JF, Angelini P, Willerson JT. Twelve-lead electrocardiographic evaluation of ischemia during percutaneous transluminal coronary angioplasty and its correlation with acute reocclusion. *Am Heart J.* 1991;121:1591-1599.
14. Srivastava S, Chatila W, Amoateng-Adjepong Y, et al. Myocardial ischemia and weaning failure in patients with coronary artery disease: an update. *Crit Care Med.* 1995;27:2109-2112.
15. Kress JP, Vinayak AG, Levitt J, et al. Daily sedative interruption in mechanically ventilated patients at risk for coronary artery disease. *Crit Care Med.* 2007;35:365-371.
16. American Association of Critical-Care Nurses. AACN Practice alert: audit of ST segment monitoring. http://www.aacn.org/WD/Practice/Docs/Audit_of_ST_Segment_Monitoring_04-2008.pdf. Issued April 2008. Accessed May 12, 2009.
17. Jernberg T, Abrahamsson P, Lindahl B, Johanson P, Wallentin I, Dellborg M. Continuous multilead ST-monitoring identifies patients with unstable coronary artery disease who benefit from extended antithrombotic treatment. *Eur Heart J.* 2002;23(14):1093-1101.
18. Langer A, Krucoff MW, Klootwijk P, et al. Prognostic significance of ST segment shift early after resolution of ST elevation in patients with myocardial infarction treated with thrombolytic therapy: the GUSTO-I ST segment monitoring substudy. *J Am Coll Cardiol.* 1998;31(4):783-789.
19. Maas ACP, Wyatt CM, Green CL, et al. Combining baseline clinical descriptors and real-time response to therapy: the incremental prognostic value of continuous ST-segment monitoring in acute myocardial infarction. *Am Heart J.* 2004;147:698-704.
20. Yan AT, Yan RT, Tan MT, et al; INTERACT Investigators. Long-term prognostic value and therapeutic implications of continuous ST-segment monitoring in acute coronary syndrome. *Am Heart J.* 2007;153(4):500-506.
21. Nørgaard BL, Andersen K, Delborg M, Abrahamsson P, Ravkilde J, Thygesen K. Admission risk assessment by cardiac troponin T in unstable coronary artery disease: additional prognostic information from continuous ST segment monitoring. TRIM study group. Thrombin Inhibition in Myocardial Ischemia. *J Am Coll Cardiol.* 1999;33(6):1519-1527.

22. Pelter MM, Adams MG, Drew BJ. Transient myocardial ischemia is an independent predictor of adverse in-hospital outcomes in patients with acute coronary syndromes treated in the telemetry unit. *Heart Lung.* 2003;32:71-78.
23. Nørgaard BL, Andersen K, Thygesen K, et al. Long term risk stratification of patients with acute coronary syndromes: characteristics of troponin T testing and continuous ST segment monitoring. *Heart.* 2004;90(7):739-744.
24. Jernberg T, Lindahl B, Wallentin L. ST-segment monitoring with continuous 12-lead ECG improves early risk stratification in patients with chest pain and ECG nondiagnostic of acute myocardial infarction. *J Am Coll Cardiol.* 1999;34:1413-1419.
25. Terkelsen CJ, Nørgaard BL, Lassen JF, et al. Potential significance of spontaneous and interventional ST-changes in patients transferred for primary percutaneous coronary intervention: observations from the ST-MONitoring in Acute Myocardial Infarction study (the MONAMI study). *Eur Heart J.* 2006;27(3):267-275.
26. Akkerhuis KM, Klootwijk P, Lindeboom W, et al. Recurrent ischaemia during continuous multilead ST-segment monitoring identifies patients with acute coronary syndromes at high risk of adverse cardiac events. *Eur Heart J.* 2001;22:1997-2006.
27. Drew BJ, Dempsey ED, Joo TH, et al. Pre-hospital synthesized 12-lead ECG ischemia monitoring with trans-telephonic transmission with acute coronary syndromes: pilot study results of the ST SMART trial. *J Electrocardiol.* 2004;37(suppl):214-221.
28. Klootwijk P, Meij S, Müller EJ, et al. Comparison of usefulness of computer assisted continuous 48-h 3-lead with 12-lead ECG ischaemia monitoring for detection and quantitation of ischaemia in patients with unstable angina. *Eur Heart J.* 1997;18:931-940.
29. Zairis MN, Ambrose JA, Papadaki OA, et al. C-reactive protein and ST-segment monitoring by continuous 12-lead electrocardiogram in patients with primary unstable angina pectoris. *Am J Cardiol.* 2003;91:600-603.
30. Landesberg G, Vesselov Y, Einav S, Goodman S, Sprung CL, Weissman C. Myocardial ischemia, cardiac troponin, and long-term survival of high-cardiac risk critically ill intensive care unit patients. *Crit Care Med.* 2005;33:1281-1287.
31. Gunnarsson G, Eriksson P, Dellborg M. Continuous ST-segment monitoring of patients with left bundle branch block and suspicion of acute myocardial infarction. *J Intern Med.* 2004;255:571-578.
32. Canto JG, Shlipak MG, Rogers WJ, et al. Prevalence, clinical characteristics, and mortality among patients with myocardial infarction presenting without chest pain. *JAMA.* 2000;283:3223-3229.
33. Pope JH, Aufderheide TP, Ruthazer R, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med.* 2000;342:1163-1170.
34. Critical alarms and patient safety: ECRI's guide to developing effective alarm strategies and responding to JCAHO's alarm-safety goal. *Health Devices.* 2002;31(11):397-417.
35. Drew BJ, Ide B, Sparacino P. Accuracy of bedside ECG monitoring: a report on the current practices of critical care nurses. *Heart Lung.* 1991;20:597-607.
36 Stephens KE, Anderson H, Carey MG, Pelter MM. Interpreting 12-lead electrocardiograms for acute ST-elevation myocardial infarction: what nurses know. *J Cardiovasc Nurs.* 2007;22:186-193.
37. Johanson P, Rossberg J, Dellborg M. Continuous ST monitoring: a bedside instrument? A report from the Assessment of the Safety of a New Thrombolytic (ASSENT 2) ST monitoring substudy. *Am Heart J.* 2001;142(1):58-62.
38. Flanders SA. Continuous ST-segment monitoring: raising the bar. *Crit Care Nurs Clin North Am.* 2006;18:169-177.
39. Antman EM, Anbe DT, Armstrong PW, et al; ACC/AHA Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines on the Management of Patients with Acute Myocardial Infarction). ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction—executive summary: a report of the ACC/AHA Task Force on Practice Guidelines (Committee to Revise the 1999 Guidelines on the Management of Patients with Acute Myocardial Infarction) [published correction appears in *Circulation.* 2005;111(15):2013]. *Circulation.* 2004;110(5):588-636.
40. Aldrich HR, Hindman NB, Hinohara T, et al. Identification of the optimal electrocardiographic leads for detecting acute epicardial injury in acute myocardial infarction. *Am J Cardiol.* 1987;59:20-23.
41. Drew BJ, Tisdale LA. ST segment monitoring for coronary artery reocclusion following thrombolytic therapy and coronary angioplasty: identification of optimal bedside monitoring leads. *Am J Crit Care.* 1993;2(4):280-292.
42. Daleiden AM, Schell H. Setting a new gold standard: ST-segment monitoring provides early detection of myocardial ischemia. *Am J Nurs.* 2001;101(May suppl):4-8.
43. Drew BJ, Funk M. Practice standards for ECG monitoring in hospital settings: executive summary and guide for implementation. *Crit Care Nurs Clin North Am.* 2006;18:157-168.
44. Leeper B. Saving lives with continuous ST-segment monitoring. *Am Nurse Today.* 2007;2(2):21-14.
45. Flanders SA. ST-segment monitoring: putting standards into practice. *AACN Adv Crit Care.* 2007;18:275-284.
46. Kucia AM, Stewart S. The role of ST-segment monitoring in assessment of acute myocardial infarction. *Dimens Crit Care Nurs.* 1999;18:12-18.
47. Crater SW, Taylor CA, Maas AC, et al. Realtime application of continuous 12-lead ST-segment monitoring: 3 case studies [published correction appears in *Crit Care Nurse.* 2000;20(3):26]. *Crit Care Nurse.* 2000;20(2):93-99.
48. Aberg N, Sharkey S, Hadfield P. ST segment shift induced by body position changes during continuous 12 lead electrocardiographic ischemia monitoring in the CCU [abstract]. *Circulation.* 1991;84:II-472.

CCN Fast Facts

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Continuous ST-Segment Monitoring: Protocol for Practice

Detecting Silent Ischemia

Silent ischemia occurs in 21% to 77% of hospitalized patients. Continuous ST-segment monitoring may be helpful in detecting silent ischemia, reducing delays to intervention, and increasing chances for maintaining viable myocardial tissue.

Implementing Guidelines

Implementation of guidelines for continuous ST-segment monitoring involves thoughtful interdisciplinary discussion among nurse leaders, cardiologists, hospitalists, and biomedical engineers for presetting selection of alarms and standards of practice for responding to alarms.

Educating Health Care Professionals

Education of physicians about the purpose of this technology is needed before cardiologists and hospitalistsmay accept potential benefits.

Nurses should be educated about the significance of ST-segment changes and should base lead selection for a patient on the priority monitoring needs of that patient. This education may require more than an introductory class to ECG monitoring.

Table Recommended use of continuous ST-segment monitoring according to population of patients[a]

Monitoring of ischemia

Class I, indicated	Class II, has possible benefits	Class III, not indicated
Patients with acute coronary syndromes (ST-segment elevation or non–ST-segment elevation myocardial infarction [MI], unstable angina/rule out MI): minimum of 24 hours monitoring and until event-free for 12-24 hours Patients receiving thrombolytic therapy for MI: until event-free for 12-24 hours, to assess for effectiveness of therapy and assess patency of culprit artery after therapy Patients with chest pain or angina-equivalent symptoms in the emergency or observational unit: 8-12 hours of monitoring in combination with assays of serum cardiac biomarkers to assess for new, transient, or resolving ischemia Patients during percutaneous coronary revascularization: monitoring during procedure to identify "fingerprint" on waveform during ischemia upon balloon inflation Patients after angioplasty without stent: 12-24 hours monitoring because of higher incidence of abrupt closure Patients after nonurgent percutaneous intervention with suboptimal angiographic results: monitoring immediately after procedure and continued 24 hours or longer if ST events occur Patients with potential for vasospasm (eg, Prinzmetal angina, cocaine): monitoring until therapy has been initiated and patient is event-free for 12-24 hours	Patients with ischemia after acute MI (patients with recurrent anginal symptoms or secondary increase in ischemia): 24-hour monitoring after final ischemic symptom to assess for resolution or extension Patients after successful angioplasty with stent: 4-8 hours monitoring to assess for abrupt or late reocclusion High-risk patients after cardiac or noncardiac surgery: intraoperatively and 24-48 hours postoperatively for those undergoing vascular surgery or prolonged surgical procedures, older adults, critically ill patients Patients with potential for ischemia associated with weaning from mechanical ventilation: monitoring may be warranted; particularly for patients who have hypoxia and cannot be weaned from mechanical ventilation	Perioperatively in patients with no history of heart disease After anesthesia in patients with no history of heart disease (eg, for epidurals during cesarean section) Not likely to be helpful in patients with 100% ventricular paced rhythm[b] Left bundle branch block or intermittent right bundle branch block[b] Coarse atrial fibrillation or flutter Agitation, restlessness Confirmed pericarditis or myocardial contusion ST-segment "sagging" associated with administration of digoxin Ischemic heart disease (may have an intermittent accelerated ventricular rhythm that may interfere with ST-segment monitoring)

[a] Sources: Drew BJ, Krucoff MW; ST-Segment Monitoring Practice Guidelines International Working Group. Multilead ST-segment monitoring in patients with acute coronary syndromes: a consensus statement for healthcare professionals. ST-segment Monitoring Practice International Guidelines Working Group. *Am J Crit Care.* 1999;8:372-388 and Drew BJ, Califf RM, Funk M, et al; American Heart Association; Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young. Practice standards for electrocardiographic monitoring in hospital settings: an American Heart Association scientific statement from the Councils on Cardiovascular Nursing, Clinical Cardiology, and Cardiovascular Disease in the Young: endorsed by the International Society of Computerized Electrocardiology and the American Association of Critical-Care Nurses [published correction appears in *Circulation.* 2005;111(3):378]. *Circulation.* 2004;110(17):2721-2746.

[b] Some sources indicate continuous ST-segment monitoring may be helpful to detect ischemia in this situation, but advanced skill in interpretation is required.

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CE Test Test ID C0943: Continuous ST-Segment Monitoring: Protocol for Practice

Learning objectives: 1. Understand that continuous ST-segment monitoring helps detect silent ischemia 2. Describe guidelines for implementing continuous ST-segment monitoring 3. Recognize that lead selection for continuous ST-segment monitoring should be based on each patient's priority monitoring needs

1. What is the purpose of continuous ST-segment monitoring?
a. To provide an alert for potential ischemia
b. To detect life-threatening dysrhythmias
c. To replace serial serum cardiac biomarkers
d. To provide a definitive acute coronary syndrome diagnosis

2. Electrocardiographic manifestations of acute myocardial ischemia include new ST-segment elevation in 2 contiguous leads with what cut-off point in leads V_2 and V_3 for women?
a. More than 0.5 mm
b. More than 1 mm
c. More than 1.5 mm
d. More than 2 mm

3. What did a study of patients with myocardial ischemia demonstrate about patients without chest pain compared to patients with chest pain?
a. Patients without chest pain had a shorter delay before going to a hospital.
b. Patients without chest pain had an increased in-hospital mortality rate.
c. Patients without chest pain were more likely to receive aspirin.
d. Patients without chest pain were more likely to receive thrombolytic therapy.

4. What was the most frequently cited reason given by a sample of critical care nurses for not using ST monitoring?
a. Lack of physician interest
b. False alarms
c. Lack of practice standards
d. Inadequate software

5. On what should nurses base ST-segment monitoring lead selection for each patient?
a. Habit
b. Unit protocol
c. Patient comfort
d. Individual priority monitoring needs

6. What should the nurse's first action be after an ST alarm?
a. Obtain a 12-lead ECG.
b. Call the attending physician.
c. Ensure correct lead placement.
d. Place the patient in high Fowler's position.

7. What is the preferred lead for ST-segment monitoring for noncardiac patients undergoing surgery?
a. I
b. aVL
c. V_5
d. V_6

8. What is the preferred lead for ST-segment monitoring related to occlusion of the right coronary artery?
a. II
b. III
c. aVF
d. V_2

9. Continuous ST-segment monitoring is a class I recommendation for which patients?
a. Patients with ischemia after acute myocardial infarction
b. Patients after successful coronary angioplasty with stent placement
c. High-risk patients after cardiac surgery
d. Patients receiving thrombolytic therapy for myocardial infarction

10. Continuous ST-segment monitoring is a class II recommendation for which patients?
a. High-risk patients after noncardiac surgery
b. Patients with confirmed pericarditis
c. Patients with atrial fibrillation
d. Patients with 100% paced rhythm

11. Which of the following patients meet the United Hospital's Nasseff Heart Center's exclusion criteria for ST-segment cardiac monitoring?
a. Patients with acute coronary syndrome and no ST "fingerprint"
b. Patients with first-degree atrioventricular block
c. Patients with sinus bradycardia
d. Patients with left bundle branch block

Test answers: Mark only one box for your answer to each question. You may photocopy this form.

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❑c	❑c	❑c	❑c	❑c	❑c	❑c	❑c	❑c	❑c	❑c
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