AACN Practice Alert

Ensuring Accurate ST-Segment Monitoring

Scope and Impact of the Problem

ST-segment monitoring can enable the detection of silent ischemia and result in changes in clinical management.[1-6] Changes in the ST segment also add prognostic information that can potentially influence treatment decisions.[7-15] Although the evidence supports the treatment of detected myocardial ischemia, no randomized clinical trials have been done to test the effect of continuous ST-segment monitoring on clinical outcomes. Ischemia is present in hospitalized patients with acute coronary syndrome (ACS, unstable angina) and is also potentially present in noncardiac critically ill patients and in patients undergoing noncardiac surgery who have coronary disease or cardiac risk factors.[2,4,5,16-32]

A lack of awareness is apparent with respect to recommendations for ST-segment monitoring, and ST-segment monitoring is underused in clinical practice.[33,34] Accurate ST-segment monitoring requires nurses to have a high level of knowledge and skill for accuracy and for effective clinical decision-making. Deficits in nursing knowledge related to the assessment of injury and ischemia based on changes in ST segments and T waves have been documented.[35-38]

AACN Levels of Evidence

Level A Meta-analysis of quantitative studies or metasynthesis of qualitative studies with results that consistently support a specific action, intervention, or treatment (including systematic review of randomized controlled trials)

Level B Well-designed, controlled studies with results that consistently support a specific action, intervention, or treatment

Level C Qualitative studies, descriptive or correlational studies, integrative reviews, systematic reviews, or randomized controlled trials with inconsistent results

Level D Peer-reviewed professional and organizational standards with the support of clinical study recommendations

Level E Multiple case reports, theory-based evidence from expert opinions, or peer-reviewed professional organizational standards without clinical studies to support recommendations

Level M Manufacturer's recommendations only

Expected Nursing Practice

1. Ensure proper placement of electrodes to obtain accurate diagnosis of cardiac rhythm (Figure 1). Palpate patient to ensure proper intercostal spaces. Electrodes should be placed under the breast tissue in women. [level B]
2. Provide proper skin preparation for electrocardiography (ECG) electrodes; change ECG electrodes daily. [level B]
3. Once proper placement of the leads has been determined, skin can be marked with indelible ink to ensure that electrodes are returned to the same correct location if they are removed. Location should be marked only after the accuracy of the electrode placement is verified. [level D]
4. Perform ST-segment monitoring for patients with confirmed or suspected ACS for at least 48 hours. [level B]

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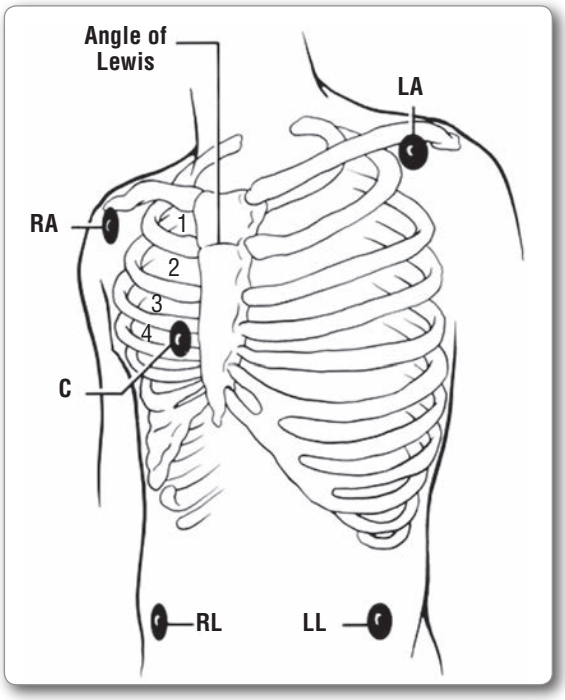

Figure 1 Placement of electrodes.

5. Consider ST-segment monitoring in patients after elective percutaneous coronary intervention and cardiac surgery. [level D]
6. Consider ST-segment monitoring useful in critically ill patients at risk for supply and demand ischemia, in patients undergoing noncardiac surgery who have coronary artery disease or risk factors for coronary artery disease, and in all patients undergoing vascular surgery. [level B]
7. Select monitoring leads according to the patient's needs and risk for ischemia and/or dysrhythmia, especially when only limited monitoring leads are available. [level B]
8. Use continuous ST-segment monitoring of all 12 leads or ST-segment mapping if available. [level B]
9. Use leads known to show recent injury or ischemia in patients with ACS and in patients who have had percutaneous coronary intervention. Known leads with ECG changes are referred to as the patient's "ST fingerprint." [level B]
10. Lead selection (see Table). [level B]
    a. Recognize that ST-segment depression in a particular lead being monitored can represent ischemia or it can represent ST-segment depression that is reciprocal to ST-segment elevation in another lead that is not being monitored.
    b. Use a recommended dysrhythmia monitoring lead (V_1) and a recommended ST-segment monitoring lead (see Table) in patients with ACS who are at risk for ventricular arrhythmias.
11. Evaluate the ST segment with the patient supine and the head of the bed elevated less than 45°. [level C]
12. Set the ST alarm parameter 1 mm or less above and below the patient's baseline ST segment in all leads except for leads V_2 and V_3, where the upper alarm limit can be set 1.5 mm from

Table Lead selection

Lead	Clinical application
III (or aVF) and V_3 (or V_2)	In patients with suspected acute coronary syndrome who have not yet shown electrocardiographic changes or changes in coronary anatomy
III (or aVF)	In patients with known involvement of inferior wall or right coronary artery
V_3 (or V_2)	In patients with known involvement of anterior wall or left anterior descending artery
V_6	In patients in whom involvement of left circumflex artery is suspected
V_5 or V_4	In patients at risk for supply-and-demand ischemia (high-risk patient undergoing noncardiac surgery and patient with critical medical illness)
V_4R	In patients with acute ST-segment elevation myocardial infarction in the inferior wall to assess for coexisting right ventricular myocardial infarction because right ventricular infarct has special treatment considerations
II	Not recommended for ST-segment monitoring

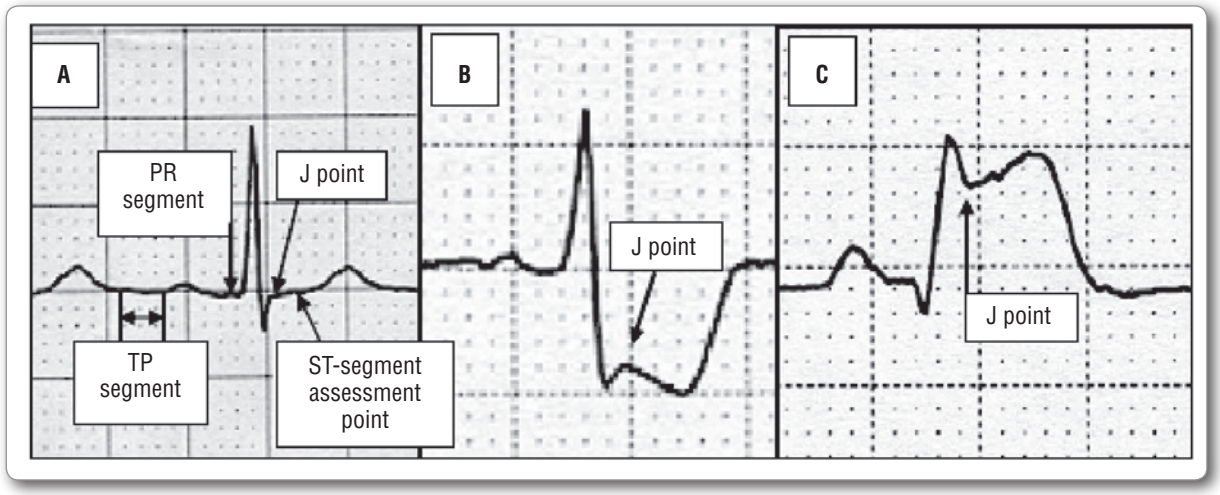

Figure 2 A, Normal electrocardiographic (ECG) complex shows TP segment and PR segment, which may be used as reference points for the isoelectric line. The ST segment is measured at 0.06 seconds after the J point. This ST segment is isoelectric. B, ECG complex shows ST-segment depression of almost 5 mm. C, ST-segment elevation of approximately 4 mm is depicted.

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baseline in women and 2.0 mm from baseline in men. [level C]

13. Set the isoelectric point and the ST-segment measurement point (60 milliseconds beyond the J point) before the start of ST-segment monitoring. [level E]
14. Do not adjust alarm limits for changes in the ST segment if a patient is being monitored to "rule out" ischemia or for potential ischemia. Alarm limits should remain set on the basis of the patient's admission baseline. The goal is to capture changes that trigger the alarms on the basis of the original baseline ST segment. [level D]
15. Reset alarm limits only in response to a good alarm. A good alarm is when ST-segment deviation evolves or resolves in a patient with known ACS. [level D]
16. Perform further assessment in response to a valid ST-segment alarm where the ST-segment deviation lasts more than a full minute. Further assessment of patients includes (a) analysis of the graphic recording (Figure 2), (b) ensuring supine positioning of patients and proper electrode placement, (c) assessment of patients' symptoms, and (d) 12-lead ECG. [level D]
17. Report the finding of a new left bundle branch as the potential equivalent of an ST-segment myocardial infarction. [level B]

Supporting Evidence

Nurse Awareness, Education, and Competency

1. In addition to the lack of awareness and underuse of ST-segment monitoring, gaps in knowledge and skill related to ST-segment monitoring are apparent.[33-41] [level C]
2. Successful implementation of ST-segment monitoring requires nurse education (knowledge and skill building), process implementation, competency assessment, and ongoing quality improvement monitoring.[1,37,38,42-49] [level B]

Electrode Placement

1. Continuous 12-lead monitoring and ST mapping systems may use altered electrode placement to obtain a derived ECG. Electrode placement for derived ECGs is according to the manufacturer's recommendation and differs from that used in the standard 12-lead ECG. The ST map collects ST values and trends derived from both limb leads and horizontal leads and creates an integrated display.[36,50-53] [level C]

2. Changing electrode placement can result in a change in the ST-segment measurement and may produce a false alarm.[54] [level C]
3. Failure to prepare the skin properly before placing the electrodes may cause the monitoring alarms to sound erroneously. Preparation may include carefully clipping hair in areas where electrodes are to be placed and/or cleaning the skin with alcohol to remove skin oils.[50,54-56] [level C]
4. Expert consensus recommends marking the locations of the electrodes with indelible ink to ensure that electrodes can be replaced in their original locations if they are removed for any reason. ECG information obtained from electrodes located close to the heart (precordial leads) is especially prone to waveform changes when the electrodes are relocated as little as 1 cm away from the original locations. It is imperative that marking accurate electrode placement with indelible ink be done only by clinicians who are trained and competent in accurate placement of electrodes.[40,54,57] [level C]

Use of ST-Segment Monitoring

1. ST-segment monitoring can be used to assess for successful reperfusion or reocclusion in an ST-segment elevation myocardial infarction.[51,58-64] [level B]
2. ST-segment monitoring is useful for detecting ischemia in potential or actual ACS, including silent ischemia. In most ST-segment monitoring studies, monitoring was done for 24 to 48 hours. ST-segment monitoring is more sensitive than patients' self-reporting of symptoms because most episodes of myocardial ischemia detected with ECG are clinically silent.[2-5,7-10,16,17,50,52,58,65-67] [level B]

Selection of Patients for ST-Segment Monitoring

1. Ischemia detected during ST-segment monitoring in patients with ACS is associated with increased risk. Assessment of increased risk by ST-segment monitoring may affect clinical decision-making and should be performed for 48 hours after presentation.[4,6,11-15,18,68-77] [level B]
2. A new left bundle branch may represent the presence of an ST-segment elevation myocardial infarction and should be reported. Although ST-segment monitoring has not been recommended in patients with an existing left bundle branch, it can be useful in differentiating those with and without myocardial infarction in patients in whom infarction is suspected. The presence of a right bundle branch is not a contraindication to ST-segment monitoring.[64,78] [level C]
3. Several studies have demonstrated silent myocardial ischemia in patients who are critically ill, including ischemia during weaning from mechanical ventilation. Additionally, several studies have identified perioperative ischemia during vascular surgery or during other noncardiac surgeries in patients with coronary artery disease. It is useful in these populations of patients to use ST-segment monitoring as a noninvasive tool to detect ischemia as part of the patient's assessment and determination of risk.[19-32] [level B]
4. The goal of monitoring must be considered for each patient. For instance, in patients with ST-segment elevation myocardial infarction, the goal of ST-segment monitoring is to observe rapid ST-segment recovery (back to isoelectric) within the 1 hour of treatment and to observe the appropriate evolutionary changes of the ST segment and T wave in the subsequent 48 hours or more. Conversely, in patients with non-ST elevation ACS, the goal is to detect transient or recurrent changes in the ST segment.[9] Additionally, patients with ACS are also at high risk for ventricular arrhythmias and will require diligent dysrhythmia monitoring.[54,64,76] [level E]

Lead Selection

1. Research demonstrates that monitoring for ST-segment changes in multiple leads, preferably 12 leads, substantially improves the chance of identifying ischemic events. ST-segment mapping may also increase nurses' use of ST-segment monitoring. It is important to know that if only 2 channels are available for viewing, the monitor may be capable of assessing the ST segment in

all other available leads. Although the recordings of these additional leads are not viewed, there can be a digital display of the ST-segment measurement. For example, in a 5-lead system with ST-segment monitoring capabilities, the monitor can assess 1 chest lead and all 6 limb leads simultaneously.[36,50-53] [level B]

2. If all 12 leads are not available in the bedside monitor, use the patient's "ST fingerprint" to select the best ECG lead(s), which show maximal ST-segment deviation. An ST fingerprint is defined as the pattern of ST-segment elevation and/or depression unique to a particular patient depending on the anatomic site of coronary occlusion. A fingerprint can be obtained during known ischemia (ST-elevation myocardial infarction) or during percutaneous coronary intervention.[50,54,58-60,62,79] [level B]
3. If only 2 leads are available for ST-segment monitoring, and an ST fingerprint is not available, leads III (or aVF) and V_3 (or V_2) are recommended for patients with suspected ACS. Leads III and aVF are the preferred leads for concern with the inferior wall of the left ventricle or with the right coronary artery. Leads V_3 and V_2 are the preferred leads for concern with the anterior wall of the left ventricle or the left anterior descending artery. A combination of leads covers the distribution of 2 of the 3 major epicardial arteries. If there is concern for the low lateral wall or the left circumflex artery, lead V_6 is the preferred lead.[50,54,58,80-82] [level B]
4. Lead V_4R should be assessed in patients with acute inferior wall ST-segment elevation myocardial infarction to assess for coexisting right ventricular myocardial infarction because right ventricular infarcts have special treatment considerations.[83-87] [level C]
5. Lead V_5 or lead V_4 is valuable for identifying demand-related ischemia in patients undergoing vascular surgery or in patients with coronary disease or risk factors who are undergoing noncardiac surgical procedures, or in critically ill patients at risk for supply and demand ischemia.[19,29,30,88] [level C]

Positioning of Patients

1. Because a change in body position (lying on right or left side) can alter the ST segment, mimicking ischemia, when an ST alarm sounds and the patient is found in a side-lying position, the patient should be returned to the supine position. If the ST-segment deviation persists with the patient supine, it should be considered indicative of myocardial ischemia. If possible, obtain "positional 12-lead ECGs" with the patient assuming right- and left-side lying positions at the start of ST-segment monitoring. These positional ECGs can be used to identify false ST-segment changes.[10,50,54,58,89,90] [level C]

Setting Alarm Parameters and Measurement

1. Set the ST alarm parameter 1 mm or less above and below the patient's baseline ST segment in all leads except for leads V_2 and V_3, where the upper alarm limit can be 1.5 mm from baseline in women and 2.0 mm from baseline in men. Baseline ST-segment elevation of 1 to 2 mm is common in leads V_2 and V_3; however, ST segments in the limb leads are normally more isoelectric. For this reason, subtle ST-segment elevation in the limb leads can represent an early acute ST-segment elevation myocardial infarction. Transient ST-segment changes of more than 0.5 mm during symptoms at rest is strongly suggestive of ischemia and the presence of severe coronary artery disease. Marked symmetrical precordial T-wave inversion (>2 mm) suggests acute ischemia, particularly ischemia due to a critical stenosis of the left anterior descending coronary artery.[76,91-94] [level C]
2. Measure ST-segment changes 60 milliseconds beyond the J point of the ECG complex.[54] [level E]

Implementation/Organizational Support for Practice

When replacing current bedside monitoring equipment, **ensure** that units caring for patients who have indications for continuous ischemia monitoring have ST-segment monitoring capabilities.

Review organization policies and protocols related to cardiac monitoring to ensure the same standard of care across settings.

Provide appropriate initial and continuing education for staff, including but not limited to electrode placement, lead selection, ECG recognition of injury and ischemia, technical considerations for ST-segment monitoring, ACS, and clinical implications for ischemia. Include didactic content and "hands-on" practice with return demonstration of lead placement.

Develop competency standards for all staff involved in the monitoring process to ensure patient safety and effective ST-segment monitoring.

Conduct audits at regular intervals to ensure actual practice matches recommended practice for ST-segment monitoring of appropriate patients, appropriate lead selection, appropriate ST-alarm parameters, and appropriate response to alarms.

Need More Information or Help?

1. Go to www.aacn.org, click Clinical Resources, and scroll down to select AACN Practice Resource Network.
2. Review the standards. AHA Scientific Statement: Practice Standards for Electrocardiographic Monitoring in Hospital Settings. http://circ.ahajournals.org/content/110/17/2721.full.pdf+html. Accessed July 14, 2016.
3. AACN Practice Alert: Alarm Management. http://www.aacn.org/wd/practice/content/practicealerts/alarm-management-practice-alert.pcms?menu=practice.

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None reported.

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