The American Association of Critical-Care Nurses (AACN) posted 2 practice alerts to address issues in cardiac monitoring in 2004 and updated them in April 2008.1,2 The alerts addressed 2 main reasons for use of cardiac bedside monitoring. The first reason is to detect and provide early intervention for episodes of myocardial ischemia and injury.3,4 Correct ECG lead selection is crucial for detection of these episodes.1,5-9

When the correct lead or leads are used, ST-segment monitoring provides important information for patient care, provided alarms are set appropriately.

Because aggressive early treatment improves outcomes in patients who have myocardial ischemia and injury, ST-segment monitoring should be used by all nurses who work in areas with cardiac monitoring.1,2,10,11 The second reason for cardiac bedside monitoring is to

PRIME POINTS

- ST-segment monitoring should be used by all nurses who work in areas with cardiac monitoring.

- Ideally, treatment of acute coronary syndrome is started as soon as changes in coronary blood flow are evident.

- Nurses can learn to properly monitor rhythm changes to minimize misinterpretation of rhythms.

You are a nurse working in an intensive care unit (ICU), and your patient, a 62-year-old man, has just arrived from the operating room after a cholecystectomy. He is sleepy but arousable and says he has some incisional pain. You start cardiac monitoring with lead II, as is the practice in your area. One hour later, the patient has ventricular fibrillation. After successful defibrillation, 12-lead electrocardiography (ECG) is done. The patient has ST-segment depression in lead III and 4 mm of ST-segment elevation in leads V2 and V4. You note that the patient’s history includes placement of a stent to the left anterior descending coronary artery 3 months before the cholecystectomy and that he had stopped taking clopidogrel 2 weeks before the current surgery. Knowing this information, would you have chosen a different way to monitor this patient? How would you decide what leads to monitor? Is it possible that the ECG changes would have been visible before the arrest, allowing intervention that might have prevented the arrest?
detect serious dysrhythmias that may require treatment. If patients are not monitored by using the recommended lead for dysrhythmia interpretation, nurses and physicians correctly diagnose a wide QRS tachycardia only 34% of the time, and erroneous interpretation can lead to inappropriate treatment.5

The AACN practice alerts1,2 identified expected practice for monitoring ST-segments and dysrhythmias. During practice discussions in committees and at the bedside, some nurses at Mayo Clinic, Rochester, Minnesota, remarked that they did not understand application of the concepts covered in the alerts. The ECG lead monitoring algorithm was developed to provide a tool to assist bedside nurses in combining the 2 concepts.

Monitoring to Detect Ischemia and Injury

Early detection of ischemia and/or acute myocardial injury improves both patient safety and patient outcomes.3,4,8 ST-segment changes reflect changes in blood flow to myocardial cells. ST-segment elevation indicates an acute injury, whereas ST-segment depression signifies ischemia. The occurrence of either elevation or depression is considered an indication of acute coronary syndrome (ACS). Ideally, treatment of ACS is started as soon as changes in coronary blood flow are evident.3,8 As much as 70% to 80% of in-hospital ischemia is silent, and early treatment decreases in-hospital mortality due to ACS.4,6,8,10,12 Nurses who depend solely on patients’ self-reported signs and symptoms to suggest the occurrence of ischemia or acute injury can miss important information. Unfortunately, surveys4,9,11 of nurse leaders in hospital cardiac units revealed that even in hospitals with capabilities for ST-segment monitoring, ischemia monitoring is vastly underused.

The recommended practice for accurate ST-segment monitoring is lead selection based on a patient’s need.1 Patients have a unique, reproducible pattern of ST-segment changes known as the ST fingerprint.5,8 The ST fingerprint refers to a unique pattern of ST-segment depression and elevation during ischemic episodes.4 Lead selection is determined on the basis of the patient’s ST fingerprint if known, by review of areas of ST-segment change on ECGs, or by following the practice alert1 to use lead III and the precordial lead V3.5

Traditionally, lead II was the most common lead for monitoring because of its tall R wave and accurate detection of heart rate. However, studies5-8 have provided evidence that lead III is more sensitive for detection of injury in the right coronary artery because the lead indicates ST-segment changes early. When nurses began using dual-lead monitoring, the precordial lead V1 was the other most commonly selected lead for dysrhythmia monitoring because of its reliability in distinguishing wide QRS beats as supraventricular or ventricular.4,5,9,13-15 However, research has shown that lead V1 is less sensitive for detection of ischemic changes and that V3 provides more consistent detection.5,8 At the Mayo Clinic, Rochester, lead V2 was a common lead choice; the rationale dated back to when this lead was good for detecting heart rate and minimizing the occurrence of nuisance alarms.

Monitoring to Detect Dysrhythmias

The other AACN practice alert2 addressed recommended leads for interpretation of dysrhythmias. Dysrhythmias occur in a variety of illnesses. Patients at marked risk for dysrhythmia should be monitored continuously.1,9 Many nurses select leads on the basis of the nurses’ practice routine, which may not be appropriate for dysrhythmia monitoring, and lead placement is not always accurate.5,7 Some rhythms, such as atrial fibrillation or atrial flutter, can be analyzed by using a variety of leads; however, accurate interpretation of wide QRS tachycardia depends primarily on precordial lead V1.5,13,15 Wide QRS tachycardia and the need for interpretation of this dysrhythmia are common among critically ill patients, and the treatments vary, depending on the origin of the wide QRS rhythm.5

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Accurate interpretation of wide QRS tachycardia requires using leads known to meet criteria that support interpretation of the ECG findings. Nurses can learn to properly monitor rhythm changes to minimize misinterpretation of rhythms. Drew supports the practice of using precordial lead V1 for rhythm monitoring for the following reasons. First, visible P waves allow visualization of atrioventricular dissociation (a criterion used to differentiate the origin of wide QRS tachycardia). Second, V1 provides visualization of the QRS width, and QRS morphology, when analyzed, is useful in differentiating the origin of wide QRS rhythms.

An important finding in a study of lead placement by Drew was that QRS morphology in MCL1 is not always identical to the QRS morphology in V1 and can lead to inaccurate diagnosis of rhythm. Other investigators have also indicated differences between MCL1 and lead V1. MCL1 was a configuration of lead placement to provide a modified precordial lead with the 3-lead bipolar system before the availability of the 5-lead system. The 3-lead system is not as accurate as the 5-lead system for the differential diagnosis of aberrancy versus ectopy. For a 5-lead system, the recommendation is to use the precordial V1 lead and place the electrodes accurately. If a 3-lead system is the only system available, the MCL1 lead configuration should be used. For MCL1 in a 3-lead bipolar system, the positive electrode is placed in the V1 position and the negative electrode in the left infraclavicular fossa; the ground lead can be placed anywhere.

### AACN Practice Alerts

Monitoring the routines of critical care nurses has indicated that nurses do not select leads according to diagnosis (or history of coronary disease). In an AACN survey of 769 ICU nurses published in 2002, 53% of the nurses stated that routine leads (standard lead choice) were used to monitor patients regardless of the diagnosis. Despite numerous publications since the introduction of monitoring in 1960, monitoring practices related to lead selection have not changed significantly. This lack of change was observed at Mayo Clinic, Rochester, and led to practice discussions about monitoring.

In order to incorporate the AACN practice alerts into evidence-based care at the clinic, the ECG lead monitoring algorithm was developed to help nursing staff understand and apply the recommendations. Tables 1 and 2 give the expected practices (as recommended in the AACN alerts).

### An Algorithm for Success

The ECG lead monitoring algorithm was developed in collaboration with the nursing clinical practice committee of the medical ICU, a clinical nurse specialist, and a nursing education specialist. Staff members’ questions and comments were incorporated into each version of the tool until nursing staff indicated the tool was simple and easy to use and accurately reflected the content from the practice alerts. The algorithm has been endorsed by the critical and progressive care nursing practice committees at Mayo Clinic, Rochester.

The algorithm (Figure 1) is a decision pathway that requires examination of a patient’s medical history for risk factors for ACS and any current signs and symptoms of myocardial infarction. If the patient is at cardiac risk, the nurse follows the pathway indicating ECG leads used to monitor specific coronary arteries or known area of ischemic involvement. If the patient

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### Table 1 ST-segment monitoring

1. Select the best lead to identify the ST fingerprint, or choose leads III and V3 for overall visualization of primary coronary artery anatomical areas
2. Apply the ST-monitoring feature when appropriate
3. Mark lead placement with indelible ink for consistency of information
4. Prepare skin properly for electrode application

### Table 2 Dysrhythmia monitoring

1. Measure QTc interval for patients at risk for torsades de pointe
2. Prepare skin properly for electrode application
3. Place V lead electrode accurately
4. Mark lead placement with indelible ink for consistency
5. Select V1 for wide QRS tachycardias
has a history of cardiac disease with no specific known area of ischemia, leads V₃ and III should be selected.¹

If the patient does not have a history of risk factors for ACS or has a history of dysrhythmia, the dysrhythmia pathway is followed, which indicates that the patient should be monitored by using lead V₁ and lead II or III.² Lead III commonly shows change in the ST segments earlier than lead II does.³,⁴ For patients with signs and symptoms of ACS and rhythm changes, the tool provides the following guide: “When patients have history of both ACS and dysrhythmias, monitor for ischemia; if wide QRS tachycardia occurs, switch to V₁ to determine rhythm” (Figure 2).

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**Figure 1** Algorithm for selection of electrocardiography (ECG) leads.
Used with permission of Mayo Foundation for Education and Research, Rochester, Minnesota.

**Figure 2** Common QRS morphology in wide QRS tachycardia: What to look for, use V₁ only. When patients have a history of both acute coronary syndrome and dysrhythmias, monitor for ischemia; if wide QRS tachycardia occurs, switch to V₁ to determine rhythm.
Abbreviations: SVT, supraventricular tachycardia; VT, ventricular tachycardia.
Used with permission of Mayo Foundation for Education and Research, Rochester, Minnesota.
Implementation of the Algorithm

Education was provided to staff nurses to improve their understanding of rationale for appropriate ECG lead placement. A variety of venues and teaching methods were used to present the algorithm and provide opportunities for case study practice and questions. In the progressive care and intensive care orientation programs, formal educational content on how to monitor patients has been included. ECG lead selection is also incorporated into simulation training for orientees during critical care orientation. Basic and advanced ECG classes are offered continually throughout the year, and the algorithm is included in these classes. For advanced training, an advanced arrhythmia class is offered twice a year, and the ECG lead selection algorithm and electrode placement are incorporated into this class. The algorithm is part of the procedural guideline on cardiac monitoring.

During all education sessions, nurses are given case studies to allow discussion and practice in use of the tool. Laminated copies of the algorithm were created and hung next to each ECG monitor as a visual tool to assist staff with appropriate ECG lead placement. Table 3 is a summary of the educational activities.

During simulation exercises, nurses now readily identify appropriate lead selection and correct anatomical placement of ECG patches. They bring case studies to the progressive care and critical care clinical nurse specialists and nursing education specialists for questions or case study use that support application of the information at the bedside. Ongoing practice discussions have revealed that many staff can articulate the need to individualize lead selection and which leads to choose. Lead placement by nurse orientees is verified by preceptors in one of the orientees’ skill demonstrations.

Use of the Algorithm

The front page of the ECG lead selection algorithm (Figure 1) is the main focus of the document and incorporates both AACN practice alerts. Nurses are taught to consider the main reason a patient is having cardiac monitoring: are the nurses most concerned with potential cardiac blood flow problems, which correspond to a history of ACS, or are they concerned about rhythm changes? The main decision point on the algorithm asks this question and directs the nurses to lead selection according to the answer.

If the answer is yes to blood flow problems, a table is included that provides lead selection based on coronary artery and corresponding cardiac anatomy. If current ECG findings (bedside monitor and 12-lead ECG) and a patient’s history do not indicate specific coronary artery or cardiac anatomy to monitor, leads V3 and III should be used. On the front page (Figure 1) is a drawing of a chest that shows correct placement of the precordial (V) lead. Each precordial lead also has a corresponding diagram of the normal QRS configuration for the lead. The purpose of the diagrams is to guide the decision on where to place the precordial (V) lead on the chest and provides a quick reference for how the placement normally should look.

For instances in which rhythm monitoring is a priority, illustrations are provided for quick reference on appropriate QRS configuration for

<table>
<thead>
<tr>
<th>Class or teaching venue</th>
<th>Concepts taught with lead monitoring algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic ECG class</td>
<td>Coronary anatomy and lead placement</td>
</tr>
<tr>
<td>Essentials of Progressive and Intensive Care (EPIC), ST/QT class</td>
<td>Lead selection</td>
</tr>
<tr>
<td>EPIC, bundle branch blocks</td>
<td>Lead selection</td>
</tr>
<tr>
<td>EPIC, cardiovascular complications</td>
<td>Lead selection</td>
</tr>
<tr>
<td>EPIC, simulation center laboratories</td>
<td>Lead placement and lead selection</td>
</tr>
<tr>
<td>Advanced ECG class</td>
<td>Lead selection, lead placement, normal QRS configuration, interpretation of wide QRS tachycardia</td>
</tr>
<tr>
<td>Team day in multiple individual intensive care units and progressive care units</td>
<td>Lead placement, lead selection, interpretation of wide QRS tachycardia</td>
</tr>
<tr>
<td>New Wings, cardiovascular progressive care class</td>
<td>Lead placement, lead selection, interpretation of wide QRS rhythms, hands-on lead inspection of patients</td>
</tr>
<tr>
<td>Cardiovascular surgery 6-week review sessions</td>
<td>Lead selection, interpretation of wide QRS tachycardia</td>
</tr>
<tr>
<td>Hearts All-a-Flutter Class (an advanced dysrhythmia class)</td>
<td>Lead selection</td>
</tr>
</tbody>
</table>
V6 was not helpful and made the tool specifically indicated that information on lead V1 is ischemia and injury changes, and they should monitor for rhythm along with ischemia or injury, which appears to be more common in this noncardiac group of patients. The evidence for this practice is level IV: limited clinical studies to support recommendations. Therefore, these changes were not included in the ECG lead monitoring algorithm. One source publication for using precordial lead V5 did not provide data for use of the lead, and the case study actually described changes in lead V3.

Rhythm interpretation. Common QRS configurations in wide QRS tachycardia in ventricular tachycardia and in supraventricular tachycardia are presented in columns on the back of the algorithm as the configurations would appear in lead V1. The rationale for recommendation of V1 for monitoring of dysrhythmias is based on criteria that apply to V1 specifically to aid in distinguishing between ventricular and supraventricular rhythms.

Although criteria also exist for differentiation of wide QRS tachycardia that apply to the precordial lead V6, nurses stated that including these criteria in the tool was confusing. A survey of staff nurses indicated that information on lead V6 was not helpful and made the tool harder to use; thus, pictures of lead V6 are not included. During teaching sessions on arrhythmia detection, right bundle branch block and left bundle branch block are reviewed to improve nurses’ understanding and recognition of QRS morphology.

Nurses are taught that when a patient has ECG evidence of dysrhythmia along with ischemia or injury, they should monitor for ischemia and injury changes, switching to the precordial lead V1 for recording of strips when a wide QRS tachycardia is present. The nurses are instructed to place 2 electrodes on the chest, 1 in the V1 position and 1 in the V3 position, to simplify changing from one lead to another when the clinical events change. (Treatment for ongoing ischemia and/or injury requires continual assessment of response to interventions. When a rhythm change occurs, a nurse can switch leads to interpret the ECG findings and treat the patient.) A statement on the back page of the tool reminds nurses to change the leads monitored when a change is clinically indicated. The algorithm is printed front to back in a bright color and is placed on or near the monitors in monitored units. The tool is laminated to facilitate cleaning with disinfectant in between patient admissions.

Practice Alert Revisions 2008

The updated ST-segment monitoring practice alert from April 2008 includes an expected practice for patients who do not have definitive ACS but may have ACS or are having the syndrome ruled out. For these patients, leads III and V5 should be monitored. The practice alert does not include a statement of supporting evidence for this recommendation. The practice alert also includes an expected practice for noncardiac patients undergoing surgical procedure or admitted to the ICU. Lead V5 is valuable for identifying demand-related ischemia, which appears to be more common in this noncardiac group of patients. The evidence for this practice is level IV: limited clinical studies to support recommendations. Therefore, these changes were not included in the ECG lead monitoring algorithm. One source publication for using precordial lead V5 did not provide data for use of the lead, and the case study actually described changes in lead V3.

Recommendations for Practice

Use of the ECG lead monitoring algorithm or a similar tool at the bedside can help nurses select leads and individualize monitoring according to a patient’s needs. Strategic placement of the algorithm at the bedside will facilitate its use. Nurses will continue to need ongoing education and mentoring in correct application of ECG leads and principles of monitoring. Audits of nursing practice should include physical placement of electrodes and lead selection. The results from audits will highlight improvement in practice and/or ongoing educational needs. Involvement of staff nurses in the audit process is an excellent method of highlighting evidence-based practice at the bedside.

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Financial Disclosures

None reported.

References


Skilled Cardiac Monitoring at the Bedside: An Algorithm for Success

Facts

According to 2 practice alerts from the American Association of Critical-Care Nurses (AACN), there are 2 main reasons for use of cardiac bedside monitoring: (1) to detect and provide early intervention for episodes of myocardial ischemia and injury and (2) to detect serious dysrhythmias that may require treatment.

At Mayo Clinic, Rochester, Minnesota, we developed the ECG lead monitoring algorithm to provide a tool to assist bedside nurses in combining the 2 concepts of ST-segment monitoring and dysrhythmias (Figure).

The algorithm is a decision pathway that requires examination of a patient’s medical history for risk factors of acute coronary syndrome and any current signs and symptoms of myocardial infarction. Use of this algorithm or a similar tool at the bedside can help nurses select leads and individualize monitoring according to a patient’s needs. Strategic placement of the algorithm at the bedside will facilitate its use. Nurses will continue to need ongoing education and mentoring in correct application of ECG leads and principles of monitoring.

![Algorithm for selection of electrocardiography (ECG) leads.](http://ccn.aacnjournals.org/)

**Figure** Algorithm for selection of electrocardiography (ECG) leads.

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Skilled Cardiac Monitoring at the Bedside: An Algorithm for Success
Laura Evenson and Monica Farnsworth

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