Recognition of Acute Coronary Syndrome in the Clinical Setting

The recognition of acute coronary syndrome (ACS), and of stable and unstable angina in any care setting, requires a thorough knowledge of not only the obvious, but also and especially of the not so obvious electrocardiographic (ECG) patterns suggestive of ischemic heart disease. This article explores the reasons for missing the diagnosis of ACS, and of stable and unstable angina, and makes recommendations for improving ECG recognition skills and overall diagnostic abilities.

A literature search for explanations why missing the diagnosis of ischemic heart disease is distressingly common revealed that being female, under age 55 years and of a non-white race placed one at a greater risk of being sent home with an unrecognized, impending coronary event. One can easily understand why women are at risk when they present with symptoms that are not considered typical of coronary disease. It has been well documented over the past decade that women often have a different clinical presentation from men. What isn’t as well understood is why non-whites are documented to be at risk of being sent home with coronary disease. One would hope that these two groups are not being missed because of social or economic reasons.

An investigation of the clinical presentations and ECG patterns presented by each of these high risk groups needs further study to determine if they could be gender or race specific. Other factors influencing our ability to accurately diagnose ACS, and stable and unstable angina may very well be a lack of knowledge of the five patterns suggestive of myocardial injury, ten suggestive of myocardial ischemia, and the seventeen or more myocardial infarction mimics. A search of reference books and articles addressing the spectrum of ECG patterns that represent ischemic heart disease yielded little. Most references will mention the
horizontal ST-T wave depression, the inverted T wave, and the down sloping ST to an inverted T wave. The current ACC/AHA guidelines for patient bedside monitoring and 12-lead recordings do not mention, let alone stress the importance of accurate lead placement which is critical to an accurate diagnosis. When physicians were interviewed, they all admitted the problem but didn’t quite know how to correct it, nor did they have the time it would take to initiate an effective educational program for technicians and nurses. To complicate matters, today’s interpreting ECG machines are at least 50% in error in their diagnostic abilities, which can prove fatal if the interpretations of bedside ECG monitors or 12-lead ECG machines are trusted.

There are at least 11 different varieties of myocardial injury, three of which require the use of a 15-lead and two the use of an 18-lead ECG to accurate diagnosis. Once the 12-lead has been recorded it is easy to collect the 15 or 18 lead ECG and takes about one minute.

Table 1: Identified Problems with Differential Diagnosis of Heart Disease

1. Not enough attention paid to female ECG presentations
2. Not enough attention paid to the indigent population and non-white races
3. Not enough written in the literature about the various patterns suggestive of coronary ischemia and injury
4. Leadership organizations not taking a stand on 12-lead recording and bedside monitoring practice
5. Physician awareness without taking initiative to change the poor recordings being made on a wide scale by nurses, technicians, and even physicians.
6. ECG machines diagnostic are 50% or more in error.
7. The majority collect only the 12-lead ECG when 5 variations of infarctions require the use of a 15-18 lead ECG recording.

8. Lack of knowledge of the various myocardial infarction mimics and obscure ischemia patterns

Table 2: Eleven Varieties of Myocardial Infarction

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<tr>
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<th>1) Anterior</th>
<th>2) Antero-septal</th>
<th>3) Antero-lateral</th>
<th>4) Septal</th>
<th>5) Inferior</th>
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<td></td>
<td>6) Infero-lateral</td>
<td>7) Infero-posterior (18 lead)</td>
<td>8) Infero-right ventricular (15 lead)</td>
<td>9) Posterior (15 lead)</td>
<td>10) Right ventricular (15 lead)</td>
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<td></td>
<td>11) Infero-posterior-right ventricular (18 lead)</td>
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A careful study of the bedside ECG monitoring practice in one of America’s top 10 rated Heart Hospitals revealed that only one out of 133 patients had ECG chest leads correctly placed. This misplacement caused aberrations of the ECG that often indicated a serious problem might be present needing further investigation. Patients were selected for inclusion in the study if their ECG telemetry strips indicated a possible abnormality the investigator wanted to record. The patients studied literally had ECG electrodes in all positions but the correct ones, and it became apparent that the staff nurses and ECG monitor technicians did not know how to properly record their patients.

After the ECG rhythm strips were recorded from these patients, the lead placement was corrected, and the strips run again. The differences were substantial and most either revealed that there was a more serious problem than had appeared with the poor placement, or that there was no problem, just misplaced electrodes. The most important finding of the study was that even an inch of misplacement of the electrodes matters to the recording of an accurate
ECG. We simply cannot accurately interpret ECG’s that are not collected properly.

Point of view is everything and critical to the physician or nurse who must interpret the ECG.

Patterns Suggestive of Injury

Most interpreters would not fail to identify patterns a, b, d, or e, but many will miss pattern c which could be an early infarction pattern, or unstable angina, or related to hypertension with or without left ventricular hypertrophy, or secondary to cocaine induced coronary spasm.

Pattern c should be ruled out in the cath lab, as it may represent a proximal left anterior descending lesion that can become unstable at any time. A good rule of thumb is that the T waves in V1 are gently inverted in most normal hearts. Therefore any upright T wave in V1 should be investigated with a 12-lead ECG to look for further ST-T abnormalities in other V leads. The gross abnormality seen in pattern c is that of a “swinging” T wave (one that is initially upright and then inverts below the baseline). This is the pattern identified by Wellens in the cath lab as indicating a severe proximal left anterior descending lesion needing urgent attention.
The ten patterns of ischemia are even less well known. Patterns a, b, and c in diagram 2 seem to be well known and published, but the remainder need our attention as each has been documented representing myocardial ischemia. Patients may have one or a combination of these patterns. Pattern d is also seen in the injury chart, because it may represent ischemia or early infarction: an ST segment up sloping to a positive T wave in V1.

The J point may not be elevated which tends to throw one off the track, but if we obtain cardiac enzymes and wait for the second ECG to be recorded, we may find the truth. It represents a
possible unstable vessel and should not be overlooked. Pattern e represents a long horizontal ST-T segment of greater than 0.12 sec. (0.08-0.12 sec being the range in normal sinus rhythms). An acute abdomen caused from pancreatitis may also produce this same lengthening of the ST segment as the patient loses calcium during the attack. Pattern f represents a sharp angulation of the ST-T junction and a more symmetrical T wave than normal. The ST segments are normal on the baseline and therefore considered by most to be normal. It has been seen in numerous female patients but needs further correlation in a larger study. Pattern g represents the inverted U wave which is often best seen in the mid precordial leads V3-V4 and invariably indicates ischemia. Pattern h represents low voltage T waves in the presence of normal sized QRS complexes. If one notices low voltage T waves in any particular zone of the myocardium e.g., leads, 2, 3, and aVF, one should think of a right coronary artery occlusion. Patients with low voltage T waves should be considered at risk of a coronary event and further investigated. A healthy T wave should be about one third the size of the QRS. If the T waves become abnormally tall without ST elevation, this may also represent an ischemic episode and requires further investigation. Pattern i represents the swinging T wave in V1, V2 or V3 and indicates a possible left anterior descending lesion. This same pattern is seen in hypertensive patients with and without ventricular hypertrophy with normal coronary arteries. It has also been seen in the patient with cocaine induced coronary artery spasms. Pattern i when presented with chest discomfort or other signs of ischemic disease, warrants a trip to the cardiac cath lab for differentiation. This pattern was pointed out by Wellens as a possible unstable LAD lesion that could result in significant infarction if not addressed. Pattern j is where the T wave in V1 is upright and taller than the T wave in V6. Keep in mind that the T wave
in V1 should be normally gently inverted, not upright, and if it rivals the T wave in V6, think of ischemia. Marriott refers to patterns d through j as the “subtle signs of ischemia,” and has taught these patterns to physicians around the globe, and published them in his various textbooks, journal articles, but few have heeded the warning.

Diagram 2: Ten Patterns Suggestive of Unstable and/or Stable Angina
To complicate the problems of differential diagnosis, there are no less than 17 myocardial infarction mimics to consider, that all present with suggestive patterns. Many of these patients present with coronary like symptoms, making it difficult to differentiate the varying clinical presentations from real myocardial injury.

### Table 3: Potential Myocardial Infarction Mimics

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<tbody>
<tr>
<td>1.</td>
<td>Bundle branch block</td>
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<td>2.</td>
<td>Early repolarization</td>
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<td>3.</td>
<td>Hemiblock</td>
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<td>4.</td>
<td>Hyperkalemia</td>
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<td>5.</td>
<td>Hypocalcemia</td>
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<td>6.</td>
<td>Intracranial hemorrhage</td>
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<td>7.</td>
<td>Myocardial metastases</td>
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<td>8.</td>
<td>Acute pancreatitis</td>
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<td>9.</td>
<td>Acute pericarditis</td>
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<td>10.</td>
<td>Prinzemetal's angina or variant form</td>
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<td>11.</td>
<td>Vasospasm from cocaine intoxication</td>
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<td>12.</td>
<td>Ventricular hypertrophy</td>
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<td>13.</td>
<td>Hypertension</td>
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<td>14.</td>
<td>WPW</td>
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<td>15.</td>
<td>Pacemaker rhyhtms</td>
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<td>16.</td>
<td>Supraventricular and ventricular tachycardias</td>
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<tr>
<td>17.</td>
<td>Pulmonary embolus</td>
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### How to Monitor the Patients with Documented Injury or Ischemia.

The patient with documented myocardial injury or ischemia needs careful attention to their bedside monitoring while admitted for observation or treatment. When making the lead selection per patient, one should always keep in mind that patients with myocardial ischemia and injury will more likely than not have lethal ventricular arrhythmias that present with wide-QRS complex patterns. Ventricular arrhythmias are the most frequently encountered arrhythmias that occur in the presence of an unstable myocardium. The “gold standard” leads
for arrhythmia monitoring are V1 and/or V6. For patients with anterior wall ischemia or injury patterns, we like to monitor these patients in one lead facing the anterior surface and V3 has become the most favored lead because it generally shows the greatest ST-T displacement, and simultaneously employ V6 for the wide-QRS arrhythmias. For patients with inferior wall ischemia or injury patterns, it is important to monitor them in standard lead 3 because it shows the earliest and most ST-T displacement, and simultaneously employ V1 for the wide-QRS arrhythmias.

It is also important to obtain an 18 lead ECG if the 12-lead shows inferior ischemia or infarction since there is about a 40% association of right ventricular infarction with inferior wall injury. To view the right ventricle, move V2 and V3 to the V3R and V4R positions, or move V1, V2, and V3 to the V3R, V4R, and V5R positions and record the 12-lead again.

We used to rely on V1 and V2 to make the diagnosis of posterior infarction, but it is much easier to see when we move V4, V5, and V6 to the V7, V8, and V9 positions. Anytime the ST-T segment is more elevated in V6 than V5, consider moving electrodes to the posterior wall to see if there isn’t elevation in these leads as well.
Diagram 3: Recording the 15-18 Lead ECG

Obtaining the 18-Lead ECG

A) Right Ventricular Leads
- Move V1 to V3R
- Move V2 to V4R
- Move V3 to V5R

B) Posterior Leads
- Move V4 to V7
- Move V5 to V8
- Move V6 to V9

Conclusion
Because there are still a significant percentage of patients being sent home with undiagnosed coronary disease, it is important for us to learn the varying patterns of injury, and ischemia, and to be familiar with the many myocardial infarction mimics. We also need to record 12-18 lead ECG’s with careful attention to precordial lead placement. If patients are diagnosed and sent to one of our varying units for further observation and monitoring, it is important for the staff to know which leads to monitor which patient in and to accurately place the electrodes for these selected leads. The nursing and technical staff’s role is to report any ECG changes to the attending physician and they cannot effectively tell what is
going on if the electrodes are misplaced. It is evident that we do not know enough about
women's and non-white patients ECG patterns and that further
investigation is warranted. We know that women sometimes present with what we call vague
symptoms of the disease and they may also prove to present with the more obscure or less
obvious ECG pattern suggestive of ischemia or injury. One shouldn't depend upon the
interpretation of the ECG machine. And finally, one should always be aware of the bedside
differential diagnosis needed to distinguish between the many myocardial infarction mimics
and actual infarction. It is hoped that, with a careful study of the multiple ECG patterns
suggestive of ischemia and injury, and an awareness of the many myocardial mimics, we can
avoid sending patients home without the correct diagnosis and therefore improve outcomes
and reduce mortality in the patients at risk. Finally, physicians need to take the initiative in proper
lead recordings and thereby help to improve the overall interpretive skills of those who have to
read the urgent ECG. Physicians should no longer ignore the prevailing inadequacies. The
ECG remains the most often ordered test in cardiology, the most often misinterpreted, and the
most often misunderstood. Furthermore, we spend millions on the data collection tools to
collect the ECG in all cardiovascular settings yet, we almost never apply the 12-leads or
bedside monitoring leads correctly. How then can we begin to identify coronary disease from
this valuable tool without missing all that is important?
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