Utilizing early symptom recognition and electrocardiograph findings of acute ST-segment elevation myocardial infarction (STEMI) to decrease mortality and morbidity in women experiencing acute coronary syndromes (ACS)

Stone J. Johnson

Winona State University

November 26, 2024

Abstract

In this critical review of current diagnostic and treatment modalities regarding acute ST-segment elevation myocardial infarction (STEMI) in women and females, several strategies that can be utilized to decrease the time from symptom onset to diagnosis and definitive treatment will be introduced. The primary focus of this monograph is to present a systematic methodology for the diagnosis of STEMI in the presence of atypical symptoms of acute coronary syndrome (ACS). There are both social and biological factors impacting the current lack of timely diagnosis and treatment in women and females who experience acute STEMI. As a result, it is the purpose of this paper to introduce three critical implementations for improving mortality and morbidity in women and females experiencing a STEMI. First, recognition of atypical ACS symptoms and timely acquisition of a 12-lead electrocardiograph (ECG) is crucial. Secondly, recognition of patterns indicating a STEMI or STEMI "equivalent" on the 12-lead ECG is required. Lastly, immediate treatment of the STEMI through percutaneous coronary intervention or fibrinolytic therapy, is pivotal in improving patient outcomes.

Utilizing early symptom recognition and electrocardiograph findings of acute ST-segment elevation myocardial infarction (STEMI) to decrease mortality and morbidity in women experiencing acute coronary syndromes (ACS)

It is no secret that the "typical" heart attack symptoms are generally known to include excruciating chest pain, and are generally thought to be mainly in older males. However, this is not an accurate depiction of how myocardial infarctions (MI), or "heart attacks," manifest in all individuals. As such, individuals who experience acute coronary syndromes (ACS) without the classic crushing, excruciating chest pain, are thus at a disadvantage of receiving a time-sensitive diagnosis of what could potentially be a life-threatening MI. Among the individuals who often experience ACS symptoms differently than what is thought of as the "typical" symptoms are females. In addition to the fact that females often experience symptoms of MI differently than males, it should be noted that there is a great lack of knowledge of electrocardiographic findings consistent with a life-threatening type of MI known as a ST-segment elevation myocardial infarction (STEMI) among emergency medicine clinicians. In patients who are experiencing a STEMI, time is of the utmost importance, and those patients need to receive treatment as fast as possible in order to have the best mortality and morbidity outcomes. In this analysis of the diagnosis and treatment outcomes for women and females with acute STEMI, it will become evident that introducing a few crucial changes in the way healthcare professionals diagnose a STEMI can significantly improve the mortality and morbidity for all people experiencing a STEMI, but especially in women, given the current lack of timely and accurate recognition of STEMI and ACS symptoms in women.

In an effort to better understand the topic of this research paper, let's consider the different terminology surrounding myocardial infarctions. The term acute coronary syndromes

(ACS) is a blanket term for when the heart muscle, or myocardium, is not receiving an adequate amount of oxygen, as a result of a blockage or narrowing of the coronary arteries. There are three types of acute coronary syndromes: unstable angina, NSTEMI, and STEMI. Unstable angina is essentially impaired blood flow leading to ischemia of the heart muscle, accompanied by chest pain; however, this is not a myocardial infarction in that there is only ischemia of the tissue, not tissue death. Both NSTEMI and STEMI are types of myocardial infarctions (MI), in which the impaired oxygenation to the myocardium causes death to the tissue. An NSTEMI is a condition in which the myocardium is only partially damaged. Comparatively, a STEMI is a condition in which the tissue death is completely through all the layers of the myocardium. Out of the three types of ACS, a STEMI is significantly more severe than the other two, and a STEMI is a life-threatening medical emergency. The gold standard for the recognition of a STEMI is a 12-lead electrocardiograph (ECG/EKG), which is a test that measures the electrical conduction as it passes through the heart, and it can detect critical myocardial ischemia and infarction, as well as abnormal heart rhythms.

There is a significant relationship between sex and outcomes of STEMI in that females have a significantly higher mortality in the 30-days following a STEMI. It should also be noted that these differences are mainly prevalent in younger women who experience a STEMI, and that sex differences are not observed as much in individuals over 60 years old (Cenko et al., 2018). Sex differences in mortality appear to be precipitated by lack of recognition of acute coronary syndromes and their symptoms in the prehospital setting, thus increasing the time of onset to treatment for STEMI. In a large study that examined prehospital symptoms of STEMI, it was found that there is a statistically significant increase in the time of symptom onset to treatment in women who experience a STEMI when compared to men (Bugiardini et al., 2017).

While there are likely social aspects to the delayed care in women who experience a STEMI, there are also biological impacts of this. Delays in diagnosis and treatment of a STEMI affect females more significantly given that females tend to experience worse outcomes from the prolonged, untreated ischemia and myocardial tissue death from a STEMI (Bugiardini et al., 2017). This provides further justification for the argument that not only is it that women are less likely to receive time-sensitive care, but it is also that women are disproportionately affected by the delayed diagnosis and treatment of a STEMI. Given these differences in outcomes, it is unmistakingly evident that healthcare professionals, as well as the general public, need to be more aware about how ACS signs and symptoms may differ from the "typical" older man with crushing chest pain presentation.

There are a few important implementations that can be utilized in an effort to improve timely diagnosis and treatment of patients, and especially in women, experiencing a STEMI. The first, and arguably most crucial, is improving knowledge of "atypical" ACS symptoms to ensure timely arrival to the emergency department and a faster symptom onset to STEMI diagnosis timeline through obtaining a 12-lead ECG for all patients experiencing both typical *and* atypical ACS symptoms within ten minutes of arrival at the emergency department, or within ten minutes of arrival at the scene for EMS. Following obtaining a 12-lead ECG, the next important implementation is effectively recognizing ECG characteristics consistent with a STEMI; while this is oftentimes an uncomplicated diagnosis, the 12-lead ECG can sometimes show more subtle and difficult to determine changes consistent with a STEMI. The final important implementation is the implementation of early percutaneous coronary intervention (PCI), or fibrinolytic therapy if PCI is unavailable, following timely diagnosis of a STEMI. PCI is a procedure in which an interventional cardiologist inserts a catheter into the occluded coronary artery in order to open up

the blockage. Comparatively, fibrinolytic therapy is done by providing intravenous medications in an effort to lyse or "break up" the clot. The implementation of (1) recognition of ACS symptoms and timely 12-lead ECG acquisition, (2) recognition of STEMI characteristics on the 12-lead ECG, and (3) PCI and/or fibrinolytic therapy without delay, are paramount in improving mortality and morbidity in patients experiencing a STEMI. Please see figure 1 regarding the proposed STEMI diagnosis and treatment flowchart.

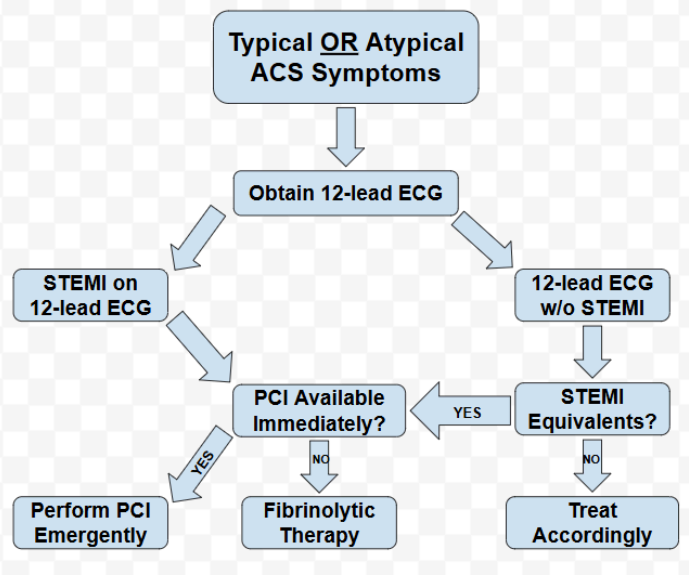


Figure 1 - Proposed STEMI Flowchart

While chest pain/discomfort is generally regarded as the hallmark symptom of ACS, it is wildly inappropriate to characterize all ACS patients as having chest pain/discomfort since this neglects patients who exhibit atypical ACS symptoms. Atypical ACS symptoms can include shortness of breath, a feeling of indigestion, epigastric pain, left arm or shoulder pain, jaw pain, dizziness, syncope, fatigue, unexplained sweating, nausea, and vomiting–this is not a comprehensive list (Canto et al., 2007). Given this lengthy list of symptoms that could be indicative of ACS, it is clear that mistakes could be easy to be made in determining if these patients are at a risk of ACS. However, it is the proposal of these implementations to treat patients with any of these symptoms as potentially having ACS; thus, it is important to obtain a

12-lead ECG in all of these patients, especially women since they often present with atypical ACS symptoms, as a precaution. Additionally, in a study that examined EMS/prehospital diagnosis of STEMI in Los Angeles, it found that approximately 20% of STEMI patients exhibited atypical ACS symptoms. However, it should be considered that this was a limited study in Los Angeles county, and the vast majority of the patients were males (Taylor et al., 2021). In another, likely more generalizable study, it identified 37% of women and 27% of men who experienced a STEMI as exhibiting atypical ACS symptoms (Canto, 2007). With the 12-lead ECG being the gold standard for patients with suspected ACS, it is evident that recognizing these atypical ACS symptoms will decrease the time from symptom onset to recognition of STEMI. As such, it is the recommendation to provide additional education to emergency medicine and prehospital providers regarding obtaining a 12-lead ECG on any patients who exhibit atypical ACS symptoms. It is also the recommendation to have the American Heart Association, and other cardiovascular associations, to continue and expand the effort to educate the public on atypical ACS symptoms to improve the time from symptom onset to receiving care.

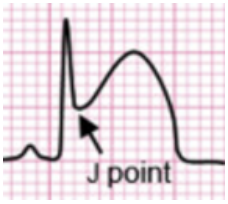
With the first strategy working to acquire a 12-lead ECG as quickly as possible and utilizing more education of atypical ACS symptoms, the second strategy of recognizing 12-lead ECG findings consistent with a STEMI can now be effectively put in place. This step involves providing further education to both emergency medicine providers and prehospital providers on recognizing STEMI and STEMI equivalents on the 12-lead ECG. Recognizing a typical STEMI on a 12-lead ECG is generally relatively simple, given that it manifests as typical ST elevation. However, patients can have STEMI “equivalents” that can be demonstrated on a 12-lead ECG, which should be recognized so that those patients can receive PCI without delay. A major missed

ECG finding of patients with STEMI "equivalents" is the ECG finding of Wellens' syndrome, which indicates acute left anterior descending coronary artery occlusion and is demonstrated on the 12-lead ECG with biphasic T waves in leads V2 and V3 *or* deeply inverted and symmetrical T waves (Oo et al., 2016). The T wave on the ECG is the deflection that occurs following the large positive or negative complex. There are also many other STEMI "equivalent" findings consistent with the need for emergent PCI, such as De Winter Syndrome and Hyperacute T Waves, which both also concern an abnormal T wave on the 12-lead ECG (Asatryan et al., 2019). Further education geared toward emergency medicine and prehospital providers on these topics surrounding STEMI "equivalents" on the 12-lead ECG is of utmost importance, as time to PCI is incredibly important in these patients in order to improve both mortality and morbidity. Please see figures 2-4 regarding a normal ECG ST segment, an elevated ST segment consistent with a STEMI, and a biphasic T wave associated with Wellens' syndrome, respectively. For the purposes of clarity, only one ECG lead is visualized here, as opposed to the full 12-lead ECG.

Figure 2 - Normal ECG tracing

(Oo et al., 2016)

Figure 3 - Typical STEMI ECG tracing



(Asatryan et al., 2019)

Figure 4 - Wellens' Syndrome ECG tracing

(Asatryan et al., 2019)

The third and final strategy that should be implemented is receiving definitive treatment for the STEMI once it has been identified. This can be accomplished through ensuring immediate PCI is performed when a STEMI or STEMI "equivalent" is identified. If PCI is not available, as is the case at many rural community medical centers, fibrinolytic therapy should be

started. Primary PCI is the gold standard treatment for a STEMI, and is associated with significantly lower mortality rates than other treatments, such as fibrinolytic therapy, regardless of sex (Cenko et al., 2018). Ideally, PCI should be performed as fast as feasibly possible once STEMI or STEMI equivalent findings are identified on the 12-lead ECG; as time enduring a STEMI continues without treatment, more myocardial tissue death continues to occur, and thus increases both mortality and morbidity.

There are major disparities in timely recognition of symptoms and diagnosis of a STEMI in women, as compared to men. As a result, women who experience a STEMI are especially more prone to mortality and morbidity as a result from a STEMI. Thus, it is evident that a proposal for combating these changes in recognition and treatment of acute STEMI is needed. Therefore, it is the proposal based on these research findings that a system that incorporates early symptom recognition of atypical ACS symptoms is crucial, in an effort to ensure a 12-lead ECG is obtained within ten minutes of arrival at the emergency department; the 12-lead ECG results then need to be interpreted critically, looking for any potential STEMI or STEMI "equivalent" patterns, in which case the recommended course of treatment is to perform PCI immediately once available. Patients who do not receive PCI within a timely manner have higher mortality and morbidity, and females are especially predisposed to the prolonged ischemia and infarction. It is of utmost importance that physicians and emergency clinicians be able to recognize atypical ACS symptoms and perform diagnostics and treatments in an appropriate, timely fashion in order to restore the best outcomes possible for patients, and especially women, experiencing an acute STEMI.

References

Bugiardini, R., Ricci, B., Cenko, E., Vasiljevic, Z., Kedev, S., Davidovic, G., Zdravkovic, M., Milicic, D., Dilic, M., Manfrini, O., Koller, A., & Badimon, L. (2017). Delayed care and mortality among women and men with myocardial infarction. *Journal of the American Heart Association*, *6*(8). https://doi.org/10.1161/JAHA.117.005968

Oo, S. Z. M. W. H., Khalighi, K., Kodali, A., May, C., Aung, T. T., & Snyder, R. (2016). Ominous T-wave inversions: Wellens' syndrome revisited. *Journal of Community Hospital Internal Medicine Perspectives*, *6*(4). https://doi.org/10.3402/jchimp.v6.32011

Cenko E, Yoon J, Kedev S, et al. (2018). Sex differences in outcomes after STEMI: Effect modification by treatment strategy and age. *JAMA Intern Med.* https://doi.org/10.1001/jamainternmed.2018.0514

Asatryan, B, Vaisnora, L, Manavifar, N. (2019). Electrocardiographic diagnosis of life-threatening STEMI equivalents: When every minute counts. *JACC: Case Reports, Vol. 1, Issue 4 (666-668)*. https://doi.org/10.1016/j.jaccas.2019.10.030

Taylor, T. G., Stickney, R. E., French, W. J., Jollis, J. G., Kontos, M. C., Niemann, J.T., Sanko, S.G., Eckstein, M.K., & Bosson, N. (2021). Prehospital predictors of atypical STEMI symptoms. *Prehospital Emergency Care*, *26*(6), 756–763. https://doi.org/10.1080/10903127.2021.1987597

Canto, J.G., Goldberg, R.J., Hand, M.M., Bonow, R.O., Sopko, G., Pepine, C.J., & Long, T. (2007). Symptom presentation of women with acute coronary syndromes: Myth vs reality. *Arch Intern Med.* https://doi:10.1001/archinte.167.22.2405