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Emergency Department Nurses' Ability to Identify ST-Elevation

Myocardial Infarction in 12-Lead Electrocardiograms:

A Quality Improvement Project

A Major Paper Presented

by

Bruce L. Gillard, Jr.

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Emergency Department Nurses' Ability to Identify ST-Elevation
Myocardial Infarction in 12-Lead Electrocardiograms:
A Quality Improvement Project

by

Bruce L. Gillard, Jr.

A Major Paper Submitted in Partial Fulfillment

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Abstract

Cardiovascular disease (CVD) is the number one cause of death globally. World Health Organization (WHO) data shows more people die annually from CVD than from any other cause and it accounted for an estimated 17.9 million deaths in 2016. This represented 31% of all global deaths (WHO, 2017). When individuals experience a life-threatening cardiac event, early intervention is critical. Triage nurses are key players in the prioritization of patients in the emergency department (ED) setting. Obtaining an electrocardiogram (ECG) at triage is the standard of care and a vital part of initiating cardiac care. Research demonstrates there is limited data regarding ECG-specific nurse protocols. The purpose of this quality improvement project was to assess emergency department nurses' ability to identify ST-elevation myocardial infarction (STEMI) in 12-lead electrocardiograms. The design was pretest, educational intervention, and posttest that took place in the ED of a large, tertiary, academic medical center. Triage nurses were recruited to participate in the study. The educational sessions proved to have mixed results overall for participating nurses. The post-test resulted demonstrated a 2.1% overall improvement in scores. A marginal increase in STEMI recognition was demonstrated with results ranging from a ten percent decrease to a fifteen percent increase. There was a 4.5% mean decrease in STEMI recognition. A brief, targeted educational intervention may not be effective in broadly increasing nurses' ability to identify STEMI in 12-lead ECGs despite improvement in some participant scores.

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Table of Contents

Background/Statement of the Problem	1
Literature Review.....	5
Theoretical Framework	32
Methods	39
Results	44
Summary and Conclusions	49
Recommendations and Implications for Advanced Nursing Practice	53
References	56
Appendices	63

Emergency Department Nurses' Ability to Identify ST-Elevation Myocardial Infarction in 12-Lead Electrocardiograms: A Quality Improvement Project

Background/Statement of the Problem

Cardiovascular disease (CVD) is the number one cause of death globally. World Health Organization (WHO) data shows more people die annually from CVD than from any other cause and it accounted for an estimated 17.9 million deaths in 2016. This represented 31% of all global deaths (WHO, 2017). CVD and stroke account for more total health expenditures than any other major diagnostic group. Taking into account hospital, medication, physician, nursing home and home health care costs, the total direct medical costs of CVD are projected to increase from \$396 billion to \$918 billion from 2012 to 2030 (Benjamin, et al, 2017). Among cardiovascular diseases, acute myocardial infarction is the most common event (Goncalves, et al., 2018).

For individuals experiencing a life-threatening cardiac event, early intervention is critical. Every minute that passes starves heart muscle of the oxygen needed to function. This can lead to damage or death of that heart muscle and the patient. Eighty-five percent of EDs utilize a formal, structured triage protocol to screen patients for an early electrocardiogram (ECG) to diagnose ST-segment elevation myocardial infarction (STEMI). However, the AHA goal of ten minutes from arrival at the emergency department (ED) to an ECG can be difficult to meet. A study by Yiadom et al. b, (2017) noted that the first ten minutes typically consists of registration and intake of patients. There are also many variations in practice regarding criteria for obtaining ECGs and communicating with providers who interpret ECGs. Any delay in recognizing a

potentially life-threatening cardiac event, delays cardiologist evaluation and treatment (Yiadom et al. b, 2017).

Triage protocols, also known as advanced triage protocols, improve prioritization for evaluation and treatment of patients by severity. These standardized pathways are developed for many diseases or chief complaints. Triage protocols authorize non-providers, triage area staff or primary nurses to assess patients on arrival at the ED and to initiate diagnostic, therapeutic and management regimens based on chief complaints. (Wiler, et al., 2010).

Reading a 12-lead ECG is within the scope of practice of a registered nurse and recognizing a STEMI is a valuable but acquired skill when working in a triage area. Patients suffering a STEMI are experiencing a time-sensitive event. Every minute of delay in the restoration of cardiac circulation causes more heart muscle cells to die and this increases morbidity and mortality. Rapid identification of an abnormal ECG and activation of the cardiac team members and cardiologist consultation is the goal. Decreasing the time to STEMI identification may positively impact patient outcomes. Registered nurse evaluation of an ECG for STEMI in a patient with a possible cardiac etiology may decrease the time to cardiologist consultation and treatment.

STEMI is defined as ST-segment elevation of one millimeter or greater in two contiguous limb lead leads or two millimeters in precordial leads and/or presumably new-onset left bundle branch block (O’Gara, et al., 2013). In 2006, the American College of Cardiology (ACC) launched the Door-to-Balloon Alliance with a goal of providing treatment within ninety minutes after arrival for at least seventy-five percent of patients with STEMI who present directly to a PCI-capable hospital (Bates & Jacobs, 2013).

Timely diagnosis of STEMI in the emergency department (ED) is made solely by ECG. Obtaining this test within ten minutes of ED arrival is critical to achieving the best outcomes. The American Heart Association has recommended a goal of ten minutes from arrival to ECG time (Yiadom, et al. b, 2017).

Nurses order 12-lead ECGs per established Rhode Island Hospital Emergency Department protocol. They may be obtained for many reasons including, but not limited to chest pain, shortness of breath, syncope, dizziness, weakness or other symptoms concerning for a cardiac etiology. Patient care technicians (PCT) typically obtain the tracings under the nurse's direction. Once completed the PCT will seek out a provider, which must be an attending or senior resident. The nurses do not typically review the tracing first. This sometimes involves many minutes and potentially involves interrupting the provider from other patient-related tasks. The providers will examine the ECG and typically write the time, their name and "STEMI" or "no STEMI". If an ECG is recognized as a STEMI by the provider a "cardiac team" is called, which is paged overhead in the ED. This alerts the critical care providers and nurses a potential case for the cardiac catheterization suite has presented. The patient is then moved to the critical care area where the providers make the decision to alert the interventional cardiology team for emergent percutaneous coronary intervention (PCI). The ECG tracings are eventually given to a secretary for scanning into the patient's electronic health record (EHR). Rhode Island Hospital currently uses EPIC for all records, orders and medication administration documentation.

The current state requiring providers with specific training (attending, fourth-year, senior residents) to evaluate all ECGs presents several issues. First is the time taken to

find them. The second is the potential interruptions, which may have other negative effects. Third is the time staff is taking to find a provider is time away from their assigned area, which is detrimental in high volume periods. This quality improvement project aims to decrease time to STEMI identification and lessen provider interruptions to some degree. The purpose of this quality improvement project was to assess emergency department nurses' ability to identify ST-elevation myocardial infarction in 12-lead electrocardiograms. Next, a review of the relevant literature will be discussed.

Literature Review

A literature review was conducted using the following databases and websites:

Nursing Reference Center Plus; CINAHL; PUBMED; Medline; and Google Scholar.

Keywords included nurse, nurs*, EKG, ECG, electrocardiogram, competency, attitudes, STEMI, ST-elevation myocardial infarction, interpret*, recogni*, triage, nurse initiated, chest pain protocol and door to balloon time.

Heart disease in the United States

Cardiovascular disease, as the underlying cause of death, accounts for nearly 836,546 deaths, about one of every three deaths in the United States. About 2,300 Americans die from cardiovascular diseases each day, an average of one death every thirty-eight seconds. Cardiovascular diseases claim more lives each year than all forms of cancer and respiratory disease combined. About 92.1 million American adults are living with some form of cardiovascular disease or the after-effects of stroke. Direct and indirect costs of total cardiovascular diseases and stroke are estimated to total more than \$329.7 billion; that includes both health expenditures and lost productivity (Benjamin, et al., 2018).

The Centers for Disease Control (CDC) reports coronary artery disease is the most common type of heart disease and kills more than 370,000 people annually in the United States. Coronary artery disease (CAD) is described as “blockage” in the coronary arteries causing decreased blood flow and cardiac muscle tissue perfusion. Non-modifiable risk factors include age, sex, ethnicity and family history. Modifiable risk factors to prevent CAD include smoking, hypertension, elevated low-density lipoprotein, low high-density lipoprotein cholesterol, age, obesity and sedentary lifestyle. Individuals with diabetes are

at particularly increased risk for the development of cardiovascular disease (CVD) and have significant morbidity from the disease (Grossman, 2014).

The CDC heart disease statistics are broken down by sex, ethnicity, state and socioeconomic status. Every year about 735,000 Americans have a heart attack and 525,000 of these are first heart attacks and 210,000 are individuals who have had at least one heart attack previously. In 2014, coronary artery disease (CAD) death rates per one hundred thousand were 137.5 for white males, 150.6 for black males, and 98.4 for Hispanic males; for white females, the rate was 72.1; for black females, it was 89.4; and for Hispanic females, it was 57.2. The death rate attributable to CAD in 2014 was 98.8 per 100,000, a reduction of 23.5% from 2007 (CDC, 2018).

The annual direct and indirect cost of CVD and stroke in the United States between 2012-2013 was an estimated \$316.1 billion. Including nursing home care costs, the total direct medical costs of CVD are projected to increase from \$396 billion in 2012 to \$918 billion by 2030 (Benjamin, et al, 2017). Although the incidence of acute myocardial infarction has been decreasing in the US according to the American Heart Association, heart disease is still the leading cause of mortality in adults (Ambrose & Singh, 2015).

The 12-Lead Electrocardiogram

There were several milestones in the development of the 12-lead ECG for clinical diagnostics. In 1887 Augustus Waller recorded the first electrical tracing of a human heart. In 1893 Dr. Wilhelm Einthoven coined the term “EKG”. In 1934 the eight precordial lead system was developed. Then, in 1954 the American Heart Association standardized the 12-lead ECG as we know it today (AlGhatrif & Lindsay, 2012).

An ECG is a noninvasive, painless test with immediate results. During an ECG, sensors (electrodes) that can detect the electrical activity of the heart are attached to the chest and limbs. Each beat of the heart is initiated by an electrical impulse normally generated from special cells in the upper right chamber of the heart (pacemaker cells). An ECG records the timing and strength of these signals as they travel through the heart. An electrocardiogram, also called a 12-lead ECG, gathers information from different perspectives relative to the placement of the electrodes. These views of the electrical activity of the heart muscle are transmitted by electrodes, typically ten, placed on the skin of the chest and limbs. The electrical activity is recorded as waves on a graph, with different patterns corresponding to each electrical phase of the heartbeat (Mayo Clinic, 2019).

An ECG may be performed for a number of diagnostic purposes. The first is to detect irregularities in the heart's rhythm (arrhythmias). However, a standard ECG can record an abnormal heart rhythm only if it happens during the test. Other diagnostic reasons for an ECG include complaint of chest pain, shortness of breath, rapid heartbeat, dizziness, weakness, which may be related to CAD/CHD. ECGs may also be indicated to assess structural problems of the heart or the function of a cardiac (Mayo Clinic, 2019).

The diagnosis of STEMI in the emergency department (ED) is made solely by ECG. Obtaining this test within ten minutes of ED arrival is critical to achieving the best patient outcomes. The ten-minute time frame is defined as time from arrival in the ED to provider evaluation of the tracing. The American Heart Association has recommended the ten-minute ECG goal for anyone with symptoms concerning for

cardiac etiology in order to more rapidly identify STEMI and initiate treatment (Yiadom, et al. b, (2017).

The ACCF/AHA Guidelines for the Management of STEMI describe the STEMI ECG as:

“new ST elevation at the J point in at least 2 contiguous leads of ≥ 2 mm (0.2 mV) in men or ≥ 1.5 mm (0.15 mV) in women in leads V_2 – V_3 and/or of ≥ 1 mm (0.1 mV) in other contiguous chest leads or the limb leads. New or presumably new LBBB has been considered a STEMI equivalent. New or presumably new LBBB at presentation occurs infrequently, may interfere with ST-elevation analysis, and should not be considered diagnostic of acute myocardial infarction (MI) in isolation. In addition, ST depression in ≥ 2 precordial leads (V_1 – V_4) may indicate transmural posterior injury; multilead ST depression with coexistent ST elevation in lead aVR has been described in patients with left main or proximal left anterior descending artery occlusion. Reciprocal ST depressions found in other leads helps confirm the diagnosis of STEMI” (O’Gara, et al., 2013, p. 6).

Acute Coronary Syndrome (ACS) is the term used to describe the signs and symptoms of a group of diseases caused by blockages in coronary vessels. STEMI is one type of ACS. Grossman & Porth (2014) define STEMI as:

“the ischemic death of myocardial tissue associated with atherosclerotic disease of the coronary arteries...the area affected is determined by its distribution of blood flow and the extent of the infarct depends upon the location and extent of the

occlusion, metabolic needs of the affected tissue, extent of collateral circulation and other factors such as heart rate, blood pressure, and cardiac rhythm” (p.805).

There are several benign and serious conditions that can mimic STEMI in ECGs. A STEMI mimic is defined as “an activation of the STEMI pathway with ST segment elevation on a 12-lead ECG without evidence of occlusive coronary artery disease during angiography, or an acute MI being ruled out on clinical or biochemical grounds” (Hughes, et al, 2018). Some are benign and others are potentially very serious but are not caused by the same pathology as ACS. These include ventricular-paced rhythms, left ventricular hypertrophy, pericarditis, myocarditis, early repolarization pattern (J-point elevation), stress-induced cardiomyopathy, left ventricular aneurysm, and pulmonary embolism (Gu, et al, 2008).

Hughes, et al. (2018) conducted a retrospective review of all consecutive CODE STEMI activation’s over a two-year period. There were 586 activations of the code STEMI pathway. Seventy-seven percent of patients (451) patients had a final diagnosis of a STEMI. Of the remaining 135 there were 21 acute coronary syndrome patients, 2 aborted STEMI’s and 29 NSTEMI’s. There were 83 STEMI mimics cases representing 10.5% of all activations. The most common diagnosis was of non-cardiac pain (53%), followed by pericarditis (24%), arrhythmia (10%), myocarditis (7%) and takotsubo cardiomyopathy (6%). This is important because many of these mimics are potentially very serious even though not necessarily cardiac in nature. Evaluation of an ECG must take into consideration the clinical presentation as well as the tracing being reviewed. Staff working in triage should obtain an ECG as soon as possible as many presenting complaints may be potentially serious, time sensitive problems.

Pathophysiology, Signs and Symptoms of STEMI

Causes.

The underlying pathophysiologic mechanism for acute coronary syndrome (ACS) begins with the process of atherosclerosis. Atherosclerosis can also be described as a low-grade inflammatory state of the inner lining (intima) of medium-sized arteries that is accelerated by risk factors such as high blood pressure, high cholesterol, smoking, diabetes, and genetics. In the case of coronary atherosclerosis, this slow progression leads to the gradual thickening of the inner layer of the coronary arteries, which may narrow the lumen of the artery to various degrees over time. This is commonly called a blockage (Ambrose & Singh, 2015). A coronary artery may become blocked to the point where blood flow, and therefore oxygen, will not get to the heart muscle (myocardium). This may cause heart cell or tissue injury or death. These blockages are caused by a build-up of fat and cholesterol on the linings of the walls of arteries (referred to as plaque) which develop and progress for decades prior to an acute event. The arteries can become injured or damaged due to increased strain for reasons such as increased exertion or high blood pressure. Any injury or damage to these atherosclerotic plaques or the wall of a coronary artery results in exposure of the circulating blood to the cholesterol-rich material within the plaque. This stimulates the blood to form a clot which is known as a thrombosis. These thromboses may either block where they occur or travel to other arteries in the heart and partially or completely obstruct blood flow in the affected coronary artery and the heart muscle it supplies. The newly formed thrombus is soft, friable and only loosely adherent to the vessel wall (National, C. G. C. U., 2013).

In the case of an acute coronary thrombosis, there is an acute drop in blood flow, leading to heart muscle cell death in the area supplied by the coronary artery affected. Slow onset of atherosclerosis may be accelerated by one or more cycles of rapid progression. These are caused when there is a plaque disruption or hemorrhage involving the plaque itself with formation of a clot that may fully or partially block the vessel. The size or extent of the injury to heart muscle determines the type or degree of symptoms a patient may experience (Ambrose & Singh, 2015).

Symptoms.

When decreased blood and oxygen supply (ischemia) to a coronary artery or myocardial infarction (MI) is prolonged individuals may experience severe and sustained chest pain. The pain is often described as constricting, suffocating or like “something sitting on my chest”. It is usually substernal, radiating to the left arm, neck or jaw. Pain associated with a myocardial infarction STEMI is persistent and often not relieved by rest or nitroglycerin, which is given to relax a spasm in a coronary artery. Chest pain is the most common symptom for both males and females. Men may also experience shoulder or back pain, rapid or irregular heart rate, indigestion, shortness of breath, dizziness or sweating (Grossman, p. 806, 2013). In one article from the American Heart Association female participants described a wide variety of early symptoms that varied in both duration of onset and clinical presentation. Although they reported a range of symptoms, from discomfort or pain (eg, chest, neck, and jaw) to more general symptoms (eg, sweating, anxiety, fatigue, and dizziness), the vast majority reported chest pain (Lichtman, et al., 2015). Adults over 65 years old may present with shortness of breath

or other associated symptoms include nausea, vomiting and sweating, back or neck pain, indigestion, heartburn, fatigue, or dizziness (Grossman, p. 806, 2013).

Laboratory testing.

Myocardial (heart muscle) ischemia which causes myocardial necrosis (infarction) will result in an elevated biomarker, troponin, a protein specifically released by damaged heart cells. The American College of Cardiology/American Heart Association (ACC/AHA) and the European Society of Cardiology (ESC) guidelines recommend that cardiac biomarkers be measured at presentation in patients with suspected MI. Troponin is currently the only biomarker that is recommended to be used for diagnosis of acute MI due to its superior sensitivity and accuracy (Amsterdam, et al., 2014).

History of interventional cardiology

Percutaneous coronary intervention (PCI) with balloon dilation or implantation of a stent is the current standard treatment for STEMI. Door to balloon time (D2B) is the time from arrival in hospital to the time the first device (ie. balloon or stent) crosses the blockage in the PCI procedure. The American College of Cardiology/AHA guidelines for management of acute MI established a D2B time goal of less than 90 minutes for at least 75% of non-transferred patients with STEMI (O’Gara, et al, 2013).

The first investigation of interventional cardiology-like techniques was demonstrated by Stephen Hales in 1727. He performed the first cardiac catheterization on a horse using brass pipes to reach the ventricles. However, the term catheterization was not used until 1844, when the first record of intracardiac pressure via a catheter was

made by French physiologist Claude Bernard. Around fifty years later, in the mid-1890s, German scientist Wilhelm Röntgen discovered x-rays, a discovery that resulted in a major change in interventional cardiology practice (Mueller & Sanborn, 1995).

Throughout the 1900s, many advances were made in the field of interventional cardiology, including the first human percutaneous transluminal coronary angioplasty (PTCA) procedure by angiologist Andreas Grüntzig in 1977. Building on the work performed by Charles Dotter in the 1960's, Grüntzig worked on coronary artery cannulation techniques and development of balloon angioplasty catheters. His developments have resulted in the successful treatment of thousands of patients (Barton, et al., 2014).

Jones, et al, 1982 published data over a one-year period on 339 patients who underwent PTCA and compared them with 338 patients having isolated coronary artery bypass surgery. Patients undergoing PTCA had pre-procedure shorter duration of angina, a lower number of prior myocardial infarctions, and better left ventricular function ($p < 0.01$). PTCA was considered initially successful in 87% (295/339) of patients. Repeat angioplasty was performed in 10% of patients (34/339), with a successful outcome in all but one. The most common finding in those with failed angioplasty and urgent or emergency revascularization surgery was dissection of an atheromatous plaque. There were 28 early failures (requiring surgery within 24 hours) and twenty-four late failures (surgery required at more than 24 hours). Early and late failure rates reported were 8.3% and 7.1%, respectively.

A ninety-minute door-to-balloon (D2B) time goal was established in 2006 based on recommendations by the American College of Cardiology (ACC) after a large observational study of patients with STEMI (n=29,222) found evidence of increased mortality with increased door-to-balloon times. Mortality rates of 3.0%, 4.2%, 5.7% and 7.4% were seen for door-to-balloon times of ≤ 90 minutes, 91 to 120 minutes, 121 to 150 minutes and >150 minutes respectively; ($p < 0.01$) (McNamara, et al., 2006). The goal applied to patients with STEMI who presented directly to percutaneous coronary intervention (PCI)-capable hospitals (Bates & Jacobs, 2013). In a single-center, a retrospective study by Alayhya, et al (2016) reviewed the effects of the introduction of a “code-STEMI” program on the reduction of D2B times to streamline the process for patients eligible for PCI. The cohort was divided into two groups, the first group consisted of 50 patients who were treated before establishing the code STEMI protocol, whereas the second group were 50 patients who were treated according to the protocol. The mean age in both groups was 54 ± 12 years and 86% (43) and 94% (47) of the patients in the two groups were males, respectively. Ninety percent (90) of patients in both groups had one or more comorbidities. The code STEMI group had a significantly lower D2B time with 70% of patients treated within the recommended 90 minutes (median = 76.5 min, IQR (inner quartile range): 63–90 min) compared to only 26% of pre code STEMI patients (median = 107 min, IQR: 74–149 min). In-hospital complications were lower in the code STEMI group; however, the only statistically significant reduction was in non-fatal re-infarction, (8% vs. 0%, $p = 0.043$). In addition, the number of patients with more than one in-hospital complications was also reduced by 20%. The

median D2B time decreased from 107 minutes to 76.5 minutes. A noted limitation to the study was high percentage of male patients at 70% and 86% respectively.

A 2014 systematic review and meta-analysis by Sorita et al., included 48 studies and enrolled 1,896,859 patients. Thirty-six studies reported mortality outcomes for 1,892,424 patients with acute myocardial infarction, and 30 studies reported door to balloon times for 70,534 patients with ST elevation myocardial infarction (STEMI). Off-hour presentation for patients with acute myocardial infarction was associated with higher short-term mortality (odds ratio 1.06, 95% confidence interval 1.04 to 1.09). Patients with STEMI presenting during off-hours were less likely to receive percutaneous coronary intervention within 90 minutes (odds ratio 0.40, 0.35 to 0.45) and had longer door to balloon time by 14.8 (95% confidence interval 10.7 to 19.0) minutes. Patients who presented during off-hours had higher mortality than those who presented during regular hours due to increased D2B times. The researchers found a nearly 30-minute delay in door to balloon time was associated with a twenty to thirty percent relative increase in in-hospital mortality for STEMI patients. The higher mortality during off-hours was seen for both in-hospital and thirty-day mortality. The researchers observed that a 15-minute increase in door to balloon time observed during off-hours could increase mortality by as much as 10-15% (Sorita, et al, 2014). Limitations include a poor definition of “off-hours” and lack of randomization or consideration of individual patient acuity on arrival.

The Health and Human Services National Inpatient Sample (NIS) is the largest publicly available all-payer inpatient care database in the United States and contains data on more than seven million annual hospital stays. Data on Medicare beneficiaries

undergoing a coronary revascularization procedure demonstrates that efforts to decrease time to appropriate care has improved patient outcomes. Between 2005 and 2011, in-hospital mortality declined from 5.3% to 4.7%, and 30-day mortality declined from 14.4% to 12.9%. Each decrease of 10 minutes in D2B time was associated with an overall reduction for in-hospital mortality of 0.92 (95% CI, 0.91–0.93) and an overall reduction for six-month mortality of 0.94 (95% CI, 0.93–0.95) (Benjamin, et al, 2017).

A systematic review and meta-analysis by Giacoppo, et al., (2017) examined a total of four randomized clinical trials. A total of 4394 patients were included in the analysis. Of these, 3371 (76.7%) were men. The pooled mean age was 65.4 years. PCI and coronary artery bypass grafting (CABG) were associated with a comparable risk of all-cause death, myocardial infarction, or stroke both by fixed-effect (hazard ratio (HR), 1.06; 95% CI, 0.90-1.24; P = 0.48) and random-effects (HR, 1.06; 95% CI, 0.85-1.32; P = 0.60) analysis. Data did not show significant variations over time between the techniques, with a five-year incidence of all-cause death, myocardial infarction, or stroke of 18.3% (319 events) in patients treated with PCI and 16.9% (292 events) in patients treated with CABG. However, repeat revascularization after PCI was increased (HR, 1.70; 95% CI, 1.42-2.05; P < .001).

Triage

History.

The French word “trier” is the origin of the word “triage”. It was originally applied to the process of sorting, probably around 1792, by Baron Dominique Jean Larrey, Surgeon in Chief to Napoleon's Imperial Guard. The original concepts of triage

were primarily focused on mass casualty situations. Many of the original concepts of triage, the sorting into immediate, urgent, and non-urgent with the use of the holding category, remain in use today (Robertson-Steel, 2006).

Emergency department visits increased from 90.5 million to 136.3 million (50.5%) between 1994 and 2014. The number of EDs decreased from 4,960 to 4,408 (11.7%) in the same period. In 2011 the American Nurses Association (ANA) formally recognized emergency nursing as a specialty practice. It has been stated that the triage area of the ED is “one of the most dangerous places in healthcare and demands the highest level of clinical expertise” (Jefferies, 2019).

Triage systems.

Various systems are used internationally to determine initial treatment priorities. These range from unstructured classification according to one’s own experience (“best guess”) to systems such as a three-level “traffic light” sorting (red: emergency; amber: urgent; green: non-urgent). More sophisticated programs use four and five-level scales. Comparison of methods has shown that three-level triage systems have insufficient reliability. Five-level triage instruments are significantly correlated with improved resource utilization, rates of admission for inpatient treatment, duration of emergency treatment, and frequency of transfer to intensive care or mortality. The inter-rater reliability between triage personnel and experts using three and four level systems is low ($\kappa = 0.19$ to 0.38). The inter-rater reliability in five-level systems are significantly higher ($\kappa = 0.68$) and are considered the gold standard in emergency medicine worldwide (Christ, et al, 2010).

In a systematic review and meta-analysis by Zachariasse, et al. (2019) 66 eligible studies evaluated 33 different triage systems. Comparisons were restricted to the three triage systems that had at least multiple evaluations using the same reference standard (Canadian triage and acuity scale, emergency severity index and Manchester triage system). The researchers reported the overall validity of each triage system to identify high and low-urgency patients was moderate to good, but performance was highly variable. Specificity of the triage systems to accurately classify patients discharged home as “low urgent” ranged from 0.64 (95% CI 0.62 to 0.66) to 0.98 (95% CI 0.95 to 0.99) in adults and 0.69 (95% CI 0.66 to 0.72) to 0.96 (95% CI 0.94 to 0.98) in children. Sensitivity for ICU admission was moderate to good, ranging from 0.58 (95% CI 0.48 to 0.68) to 0.88 (95% CI 0.70 to 0.96) in adults and 0.71 (95% CI 0.66 to 0.77) to 0.93 (95% CI 0.89 to 0.95) in children. A clear difference in performance between the triage systems was not seen. They concluded that established triage systems show a reasonable validity for the triage of patients at the ED, but performance varied considerably.

Triage protocols.

Triage-based protocols, also known as triage protocols, have offered a way to improve the intake process and facilitate the earlier treatment of patients who are waiting to see a provider. They can also decrease the total time spent by patients in the ED. These standardized pathways are developed for disease-specific conditions or complaints and allow the initiation of diagnostic, therapeutic and management regimens based on patients' chief complaints or triage staff/primary nurse assessment (Wiler, et al., 2010). Examples include chest pain, shortness of breath, abdominal pain, fever and extremity injury.

An integrative review by Robinson, et al. (2013) sought to determine if the use of triage protocols would correlate with a reduced total ED length of stay (TLOS) and length of stay after provider assessment (LOS-PPA) for low and middle-acuity adult patients. Inclusion criteria included studies that correlated ED LOS with use of nursing protocols. Emergency Severity Index (ESI) is a triage tool which uses an algorithm to help sort patients by acuity and the number of resources that will be needed to care for them. Patients are scored from 1-5 with 1 being the most urgent, and requiring the most resources, and 5 being the least. The researchers found that the greatest time-savings was seen inpatient with an ESI acuity level of three. This distinction was noteworthy because patients with higher acuity generally do not wait to be seen and those with lower acuity may wait for long periods. Investigators found that TLOS was decreased in all eight studies reviewed despite the presence of several variables, such as procedural interventions (i.e. casting/splinting) and ranged from 2.45 to 24 minutes. LOS-PPA mean time-savings for protocols initiated in triage ranged from 8.5 to 89 minutes with orthopedic injury variability being a main contributor. The authors noted that there was limited research found in this area even though the use of protocol orders in triage areas is a widely accepted practice.

Eighty-five percent of EDs utilize a formal, structured triage protocol to screen patients for an early ECG to diagnose STEMI and only seventeen percent of those use chest pain as a sole criterion (Yiadom, et al. a, 2017). Timely diagnosis of ST-segment elevation myocardial infarction (STEMI) in the ED is made solely by ECG. The American Heart Association has recommended a goal of ten minutes from arrival to ECG time. A study from the Journal of the American Heart Association examined STEMI

screening performance in seven EDs across the United States. This unadjusted analysis with a prospective historical design involved 472,166 adult patients who were primarily screened at triage for an early ECG to diagnose STEMI. There were a total of 407 patients diagnosed with STEMI with a total study prevalence for primarily screened ED STEMI of 0.09% (95% CI 0.08–0.10%). The investigators reviewed the missed case rate (MCR) of nurse-screened ED patients diagnosed with STEMI who did not receive an ECG within fifteen minutes of ED arrival. Physicians were not involved in STEMI screening at any of the sites and STEMI designation was determined by the hospital discharge diagnosis. The overall MCR for all seven EDs was 12.8%. The lowest and highest MCRs were 3.4% and 32.6%, respectively. The mean difference in door-to-ECG times for captured and missed patients was 31 minutes, with a range of 14 to 80 minutes of additional myocardial ischemia time for missed cases. Study-site STEMI prevalence ranged from 0.03% to 0.18%. The difference in the median door-to-ECG time between captured and missed primarily screened STEMI patients was 31 minutes (95% CI 9.7–52.3; $P=0.018$). The authors noted sensitivity and specificity of STEMI screening ranged from 65% to 97% and 81% to 97%, respectively. The positive predictive value ranged from 0.29% to 5.06%, and the negative predictive value was nearly 1 with a range of 99.97% to 99.99%. EDs with a triage registered nurse as the first point of contact for emergency medical service (EMS) arrival patients had lower MCRs compared with EDs with other first points of contact ($P=0.034$). Limitations included low prevalence of STEMI for the study population (Yiadom, et al. b, 2017). More investigation in this area is warranted.

In another study by Yiadom, et al. a (2017) the authors examined sixty-two facility members of the Emergency Department Operations Study Group (EDOSG) involving a total of 3,323,071 ED visits for utilization of formal, structured triage protocols for acute coronary syndrome arrivals. Eighty-five percent of EDs screened patients for an early ECG to diagnose STEMI. They noted 17% used chest pain as a sole criterion for inclusion but also noted twenty to thirty percent of patients with STEMI never report “chest pain” but report atypical symptoms like shortness of breath and dizziness. The authors also noted an association was found between the number of criteria used for patient screening and the proportion of STEMI patients with a delayed time to ECG (Yiadom, et al. b, 2017).

Interruptions and Distractions

One benefit of RN evaluation of ECG for STEMI at triage would be decreased provider interruption or distraction. Interruptions have been shown to occur in the ED as frequently as every six to nine minutes. Medical errors are likely to increase as the number of distractions or interruptions increase. A study by Dull, et al. (2010) defined an interruption as any event that diverted the physician’s attention from the task at hand. During a five-month prospective observational study a total of 570 oral case presentations (OCPs) were observed involving 53 emergency medicine (EM) faculty, 52 house staff and eleven medical students. The mean duration of presentation was 3.4 ± 2.2 minutes (range 0.5 to 14 minutes). There were a total of 1739 interruptions during case presentations; mean 3.0 ± 2.4 interruptions per presentation or 0.94 ± 0.70 interruptions per minute. At least one interruption occurred in 94% of OCPs, with a maximum of 16. The interruptions were categorized as follows: interruptions by faculty

(88%), phone calls (4%), questions by nursing staff (7%), ECG interpretation (1%), and orders on other patients (1%). Most faculty interruptions (55%) involved questions about history or exam findings or injection of teaching points. In 37% of OCPs, attending physicians interrupted to give an assessment and/or a treatment plan before the learner had done so. The number of interruptions (per OCP) and duration of OCP varied by learner level and training ($p < 0.01$), with more experienced learners giving shorter presentations and being interrupted less often. Neither frequency nor number (per OCP) of interruptions was statistically different by time of day.

An observational, two-phase study by Eng et al., (2019), examined perceived versus actual distractions and interruptions in an emergency department. For the purposes of this paper only the actual distraction and interruption data was examined. The study took place in an urban, academic center with an annual volume of 90,000 patients. The first phase focused on distractions while phase two focused on interruptions. During the first five weeks (phase one) results showed that 2438 overhead pages were recorded, and these occurred, on average, 23.2 times per shift (averaging 2.9 per hour). During the three-week phase two 333 individual interruptions occurred, on average, 4.26 times per shift and requests to read an ECG are cited as a top reason for interruption. ED attendings were the most interrupted for that reason (Eng, et al, 2019).

Nurse Initiated Interventions

EDs across the United States are experiencing overcrowding and excessive wait times. One study noted in one six-year period that the mean wait time to see a provider increased 25% from 46.5 minutes to 58.1 minutes. The mean wait time increased as the

volume of annual ED visits increased from 33.8 for EDs with less than 20,000 visits to 69.8 minutes for those with 50,000 or more annual visits. Seventy-eight percent of visits occurred in EDs that reported boarding admitted patients in hallways and in other spaces while waiting for an inpatient bed to become available. These problems are more acute in large urban centers (Hing & Bhuiya, 2012).

Nursing protocol orders offer one solution to increased wait times in the ED. Protocols are developed by multidisciplinary teams and are approved by physician and nursing leadership. The goal is to make patients more comfortable, decrease the total time in the ED and move patients through the department. The orders may include laboratory testing, x-rays, medications, intravenous access or intravenous infusions.

A 27-month retrospective cross-sectional observational study conducted by Barksdale, et al., (2016) examined the initiation of nurse-initiated pain protocols in triage and its effects on time to analgesia. The study took place in an emergency department with an annual patient volume of 67,000 visits. They compared pre and post-implementation differences in time to analgesia for patient with six specific chief complaints: back pain, dental pain, extremity trauma, sore throat, ear pain and pain from an abscess. During the study period they saw 23,409 patients and the protocol was used for 1,002 patients. The authors found mean time to analgesia administration decreased from 238 minutes to 168 minutes ($P<.0001$). Limitations include the retrospective nature of the study which occurred at a single site. The authors also noted they did not control for variations in ED patient volume. Also, the authors left decision to administer the initial medications to the discretion of the triage nurses, although the pain level for follow-up dosing was set at five out of ten (on a 1-10 scale).

Hendrickson, et al (2018) examined the use of a triage-based, nurse-initiated protocol for earlier administration of ondansetron and oral rehydration therapy (ORT) could safely improve care in patients aged six-month to five years with symptoms of gastroenteritis. Patients with chronic disease were excluded (i.e. oncology, metabolic diseases). The preintervention and post intervention analysis reviewed the use of a clinical pathway of triage. The study was conducted in a single pediatric ED with an annual census of 11,000 patients. One hundred twenty-eight patients were analyzed (eighty-one pre-intervention and forty-seven post -intervention). The mean age was 2.1 years. Ondansetron use increased from 36% to 76% ($P<0.001$). Time to ondansetron decreased from sixty to thirty minutes ($P=0.004$). Documented ORT increased from fifty-one percent to one hundred percent ($P<0.001$). Blood testing decreased from thirty-seven percent to twenty-one percent ($P=0.007$). Used of intravenous fluids was decreased from twenty-three percent to nine percent ($P=0.03$). There were no significant changes in LOS, admissions or unscheduled return for care. Use of retrospective data collection was a limitation of this study. Also, this was a single center design with a small sample size. Generalizability may be limited.

Considine, et al (2019), using a prospective exploratory design, examined the effects of a team-based learning (TBL) program and a decision support checklist on the appropriateness of nurse-initiated x-rays (NIXR) in patients with extremity injuries in a single emergency department. During the six-month study period there were 276 NIXRs by 40 RNs with and without postgraduate education. Analysis of all RNs showed those without postgraduate education had higher incidence of appropriate x-ray requests (91.0% vs 74.1, $p = 0.001$). However, when controlled for the NIXR education program,

statistical significance was lost (83.6% vs 67.5%, $p = 0.017$). RNs who undertook the NIXR education program had higher incidence of appropriate x-ray requests than RNs who did not undertake the NIXR education program (80.4% vs 65.2%, $p = 0.042$). They concluded that RNs without postgraduate education can safely and appropriately order NIXR after completing a structured education using TBL and a decision support checklist. Limitations included a single site study with a limited sample size.

Hayden et al., (2016) conducted a retrospective, quasi-experimental study of adult ED patients admitted with suspected sepsis, severe sepsis, or septic shock. The study took place in a single center, which is an urban, academic medical center with a patient volume of 48,000 annual visits. The goal was to determine if implementation of a sepsis work-up and treatment protocol (SWAT) improved time to intravenous fluids and antibiotics post-implementation. The protocol included a practice alert in the electronic health record, direct communication, mobilization of resources and standardized order sets. There were 108 patients in the pre-SWAT group and 130 patients in the post-SWAT group. The mean time to bolus was 31 minutes less in the post-implementation group, 51 vs 82 minutes (95% confidence interval, 15-46; P value < .01). The mean time to antibiotics was 59 minutes less in the postimplementation group, 81 vs 139 minutes (95% confidence interval, 44-74; P value < .01). Segmented regression modeling did not identify trends in these outcomes. There was no significant difference in mortality rates. Limitations included use of a retrospective design at a single site and the use of different methods used to identify the pre and post intervention groups and they were not matched for illness severity. Despite these limitations the data indicates the interventions had a marked reduction in time to fluid and antibiotics.

Yatim, et al (2016) investigated the effectiveness of a nurse-driven urinary catheter decision support tool for optimizing appropriate catheter usage as well as a removal process in reducing the duration of urinary catheter usage on a general medical ward. A pre- and post-study design was chosen for this quality improvement project. The pre-implementation data included urinary catheter utilization ratios and catheter-associated urinary tract infection (CAUTI) rates. Utilization of the protocol by staff was eighty-nine percent. Over a 6-month period the catheter utilization ratio increased from 0.12 to 0.18. During the same period CAUTI rates decreased from four to zero infections per 1000 catheter-days. This revealed a marginally significant difference between the pre- and post-implementation period ($p=0.06$).

Nurse-Driven ECG Protocols

In a study by Phelan, et al. (2009) the authors sought to improve door to ECG times for patients with suspected ACS. Nurses and paramedics working in triage were taught via small group education to recognize signs and symptoms of heart attack such as chest pain as well as other symptoms. Patients who were high-risk for a delayed ECG were identified as patients who were older than 50 years of age, without chest pain, but with symptoms consistent with ACS. These patients were prioritized to ensure an ECG was obtained as early as possible without delays such as registration. The paramedics were assigned at the entrance to the ED triage rather than non-medical staff to help with earlier identification of ACS patients. In order to minimize delays, nurses made obtaining ECGs the priority function for appropriate patients before performing other functions. All case failures were reviewed at monthly meetings. Staff were provided continuous feedback for cases that fell outside the 10-minute goal.

During the overall study period there were 72 patients diagnosed with STEMI, 29 before the intervention and 43 after, with a mean age of 59 ± 1.78 years; 71% were men, over 90% had a chief complaint of chest pain. The mean time to ECG before interventions were initiated was 21.28 ± 5.49 minutes. After implementation of the interventions described above, the mean time from arrival until performance of the ECG declined to 9.47 ± 2.48 minutes. This represented a 55% improvement. Limitations included this being a prospectively designed study at a single center with a small sample size (Phelan, et al., 2009).

In one study by Levis, et al (2010) the authors measured door to ECG time as part of a door-to balloon protocol aimed at increasing the percentage of patients meeting the goal of under 90 minutes. The authors evaluated data from patients with STEMI over a one-year period. The study took place in a 46-bed ED with approximately 60,000 annual patient visits. Patients who presented to the ED with chest pain or symptoms suggestive of angina had a 12-lead ECG obtained immediately. This was done before a detailed medical screening examination or registration occurred. The ECGs were immediately requested by either a charge nurse or unit assistant as the patient was being placed in a room and before seen by a provider. Excluding pre-hospital ECGs, the mean door-to-ECG time for the patients was 4.1 ± 8.7 minutes. Sixty-five of the 72 patients (90.3%) in this study survived to hospital discharge. The authors reported an all-cause in hospital mortality rate of 9.7% was higher than rates reported after implementation of two similar STEMI protocols (4.2% and 4.7%, respectively). This was a small single center study without pre-implementation data for comparison.

An interventional study by Coyne, et al., (2015) measured pre- and post-intervention performance in door-to ECG time at a large, urban, public teaching hospital, with 175,000 annual visits. Implementations included the creation of a “cardiac triage” designation that was assigned by the ED intake nurses upon arrival based on chief complaint. The cardiac triage designation prioritized the patients if they had either chest pain, shortness of breath, or if they were thought to have other anginal equivalents based on the triage provider’s interpretation. An ECG technician and machine were also moved to the patient arrival area to facilitate more rapid completion. Included patients either received an immediate ECG in triage or an initial medical screening exam and ECG simultaneously if an advanced provider professional was available.

Investigators examined all patients who walked into the ED with a confirmed STEMI diagnosis from April 2010 to June 2012. There were two outcome measures. The first was door-to-ECG time and the secondary was door-to-balloon time. The authors enrolled 91 walk-in STEMI patients prior to the intervention period and 141 patients post invention. Reported results indicated statistically significant reductions in door-to-ECG time (43 ± 93 to 30 ± 72 minutes, median 23 to 14 minutes ($p<0.01$), and door-to-balloon time (134 ± 146 to 84 ± 40 minutes, median 85-75 minutes ($p=0.03$). Limitations in this study included a single site and small sample size (Coyne, et al., 2015).

In a retrospective before-and-after study by Lee, et al. (2019) the authors examined the effects a set of interventions would have on door-to ECG and door-to balloon times in a teaching hospital in urban China with an annual census of approximately 80,000 ED visits. Primary outcome measures were the percentage of

patients with STEMI who received ECG within 10 min of arrival. Primary interventions included a nurse-driven ECG protocol (including chest pain, chest tightness, shortness of breath, upper abdominal discomfort (greater than 40 years old), syncope, and hemodynamic instability (systolic blood pressure less than 90 mmHg or heart rate less than 50/min) and moving an ECG station and technician to the ED triage area. The study group included 214 STEMI patients. One-hundred nine patients before the intervention and 105 patients after the interventions. One hundred and two patients (48%) arrived in the ED on their own and 112 patients (52%) arrived in the ED by ambulance.

The authors reported the intervention group had significantly higher rates of meeting the door-to-ECG target time of within 10 minutes than did the control group: 98 of the 105 patients (93.3%) in the intervention group and 87 of the 109 patients (79.8%) in the control group. No significant difference in door-to-ECG time was observed: 5 minutes (IQR = 3–6 minutes) in the intervention group and 4 minutes (IQR = 2–7) in the control group. The improvement in the rate of meeting the door-to-ECG target time was observed in the subgroup of non-transferred STEMI (91.2% vs. 71.1%, $p = 0.008$) and in the subgroup of walk-in patients with STEMI (91.2% vs. 73.3%, $p = 0.030$) (Lee, et al., 2019).

Results also showed a total of 202 patients received PCI for STEMI. Half (101) of the patients before and half (101) after interventions. The authors noted no significant difference in the median door-to-balloon time between the pre intervention group (median, 64 min; IQR, 51–83 min) and post- intervention group (median, 65 min; IQR, 50–78 min) was observed. It was noted the post intervention group had a higher rate of meeting the door-to-balloon target time than the control group (91.1% vs. 76.5%, $p =$

0.007). The improvement in the rate of meeting the door-to-balloon target time was observed in the subgroup of non-transferred STEMI (83.0% vs. 60.4%, $p = 0.017$) and in the subgroup of walk-in patients with STEMI (83% vs. 68.3%, $p < 0.001$). The authors noted limitations including this being a single center analysis and “the potential presence of unmeasured confounders that could not be adjusted in multivariate analysis” (Lee, et al., 2019).

In a study by O'Donnell, et al (2019) the use of a tablet-based application called the Acute Coronary Syndrome Application (AcSAP), was evaluated to determine if there was improved identification of patients who require an electrocardiogram within ten minutes of arrival in the ED. The AcSAP was prospectively tested over four months by experienced triage nurses ($n=18$). During the evaluation the AcSAP was activated 379 times. More patients were male (204; 54%) and aged 40–65 years (185; 49%). Chest pain was the main presenting symptom (172; 45%). Only 98 (26%) patients reported diabetes and/or previous CAD. A total of 201 (53%) received a cardiac diagnosis of which 67 (18%) were diagnosed with ACS. Six of these patients received a diagnosis of STEMI, 12 had non-STEMI (NSTEMI) and 49 had unstable angina. The remaining 134 (35%) had other cardiac illnesses.

The authors evaluated door to ECG time and triage to ECG times during use of the AcSAP. Results showed a median door to ECG time of 18 min with an interquartile range of 12–29 minutes. Results also indicated 15.8 % met the guideline of receiving an ECG in 10 min or less. The median triage to ECG time was 12 minutes with an interquartile range of 8–22 minutes. Patients with STEMI and NSTEMI were significantly more likely to return a categorization of immediate ECG (67% and 58%

respectively) or ECG within 10 min (33% and 42% respectively) ($p < 0.001$). There was a significant difference in triage to ECG times across categories. The “immediate ECG” categorization resulting in the shortest time ($p = 0.002$). Evaluations suggest that staff found the tool quick and easy to use and results seemed accurate. During these prospective study’s authors did not collect data on the number of patients on whom the AcSAP was not activated. Limitations included that only experienced nurses were evaluated at a single site (O’Donnell, et al., 2019). Next, the theoretical frameworks guiding this project will be discussed.

Theoretical Framework

This quality improvement project used two theoretical models, Malcom Knowles Adult Learning theory and the Kellogg Logic Model.

Knowles Adult Learning Theory

Malcom Knowles advanced andragogy is a “unified theory” of adult learning. This separated pedagogy and andragogy, the theories of child and adult learning, into two distinct theories recognizing their differences. It states the most important points in helping adults to learn is keeping them comfortable, maintaining an environment of trust and the acceptance of differences (Knowles, 2005). People who take the initiative in learning (pro-active learners) enter learning more purposefully and with greater motivation than those who passively wait to be taught by teachers (reactive learners). Self-directed learners learn more things and learn better than reactive learners. Knowles also postulated that self-directed learning is more in tune with our natural processes of psychological development. These learners also tend to retain and make better use of what they learn (Knowles, 1978).

Knowles’ theory makes six assumptions regarding adult education. The first assumption is adults need to know why they are learning something. This is divided into two parts. The first is the self-driven individual looking for information on their own. They see a gap in their own knowledge or have questions they want answered. For this reason, the recruitment phase of the project explained the rationale for testing the staff and implications of the results.

The second element is the teacher showing the student the value of the information or how it may improve the students work or life. Adult learners need to know why they are learning before they are willing to participate. If adults are aware why they are learning new skills, there will be a readiness to learn and they will be more willing to participate in discussions in the classroom or learning context (Knowles, 2005). The triage staff have often commented on frustrations with finding a provider to read a completed ECG. These comments have included time away from the triage area and difficulty finding someone who is permitted to review the ECG.

Knowles' second assumption is the idea of self-concept. He notes as people mature their self-concept moves from being dependent toward being self-directed. Children enter the world in a condition of complete dependency. Their needs must be taken care of by someone else. However, people eventually become aware they are responsible for their own lives. This occurs at varying ages. This self-concept is a "psychological need" to be seen and treated by others as someone able to make their own decisions. If the adult learner is treated like a child, they may mentally revert to a state of dependency. This can cause a lack of motivation (Knowles, 2005). This can happen even though the individual may be completely self-directing in all other aspects of their lives (Knowles, 1980). One benefit of assessing the skill level of the participant may be increased autonomy. When participants demonstrate they have the skills to evaluate ECGs at triage they can independently decide to review an ECG and identify a STEMI before a physician review which may save time.

Knowles' third assumption is that of past learning experience. Individuals accumulate many experiences that can serve as an important resource for learning. These

experiences may also cause individuals to be less open to new ideas or different perspectives. Educators and adult learners should acknowledge this possibility. If the teacher does not value or recognize the student's experiences the student may feel rejected. Adults learn better when their own experiences are incorporated into the learning process. Real-life problems or situations create a readiness to learn in the adult (Knowles, 2005). The educational component included real-life ECG examples and relied upon participant input. Participant experiences were incorporated and helped guide the conversation and enhanced learning.

The fourth assumption is readiness to learn. Real-life situations can create a readiness to learn. Adults are more open to new learning when they have a self-identified knowledge gap that affects them. Other factors influence readiness to learn such as relevance and timing (Knowles, 2005). The skills that were assessed and built upon in this project were and are actively used on a daily basis in the emergency department setting. This was another opportunity to use real ECGs, patient scenarios and participant input to drive the learning process during this project.

The fifth assumption is orientation to learning. This refers to the focus of the subject matter presented in classes. For children, it is generally subject based. Adults are "life-centered" learners which revolve around tasks or problem-centered issues. They want to learn tasks or subjects that will help them accomplish real-world tasks. Rather than teaching a pre-determined set of subjects an instructor should assess the student's abilities then tailor the instruction toward real-world application. Case studies and simulations are examples (Knowles, 2005). Combining the real-life ECG examples and

participant-driven methods with a process flow helped describe how the new knowledge applies to the current work environment.

Knowles' sixth assumption is motivation to learn. Adults are both internally and externally motivated to learn. Internal motivators are matters such as the drive to self-improve, change to a more satisfying career or have a better life. External factors may be a better paying job or a promotion. Adults are also problem-oriented learners. They seek out information to help them solve a specific problem. They are motivated to solve immediate and practical problems and that motivation to learn is stimulated by internal stimuli rather than external sources. Programs or content that go against any of the noted principles of adult learning risk loss of student motivation (Knowles, 2005). This project sought volunteers and sought to improve a specific set of barriers. The voluntary nature of the process likely drew nurses with internal motivation.

By adhering to the principles identified in Knowles' learning theory this project sought out and enrolled motivated individuals. The project materials incorporated a real-world themed, participant driven methodology to engage and enhance the experience of the adult learners.

The Logic Model

The logic model is a method of documenting a planned strategy using a graphic representation of all aspects of a project. There are many other names for this such as a project blueprint or road map. They help demonstrate and describe why the planned strategy has been chosen. They show the relationships between the specific elements and the goals of a program. They also show what the measurements of success will be. The

level of detail will depend upon the goals, those involved or the audience. For example, the details may vary for two different groups such as a hospital administrator or the students in a class. However, there may some overlap and there should include enough detail to determine what types and resources will be needed and the level of data to collect. The model is a fluid document and must have the flexibility for modifications should any barriers present themselves. The model shows the connections between the resources, activities and expected results. The results should be described in ways that are specific, measurable, realistic and have a reasonable timeframe. The timeframe includes the outcomes which should be divided into short, medium and long-term goals. All of which are the result of the resources and activities used. The purpose of a logic model is to provide specific step-by-step details in a logical sequence, hence the name (WK Kellogg Foundation, p. 3). Figure 1 below is a diagram of a basic logic model from the Kellogg Foundation.

Figure 1:

The Logic Model

The logic model map organizes the different parts of a project and connects each of them in an input/output relationship. Resources are used to accomplish activities which will deliver a specific result. Those results will have some type of benefit which

will then hopefully cause a change or impact on the organization (system). These results are the short, medium and long-term goals.

The first two steps involve the planned work. The first step identifies resources that will be used in the project. These can be people, money or any other assets that will produce work completed in a program. These, for example, may include the department heads, volunteers or funding. The second step in the sequence is activities. Activities include the tools, events, technology and actions that are part of the program implementation to bring about the intended goal. Examples are the educational program itself, administering the surveys and administration of the pre and post-test (WK Kellogg Foundation, 2004).

The last three steps in the sequence are the intended results. Outputs are what comes from a program, or the product. Examples are the test and survey results and the related analysis. Outcomes are the changes acquired or expected or the benefits intended during and after the program activities. These are broken down into short, medium, and long-term impact outcomes. Examples are meeting the goal number of participants in a program, increased scores in a post-test after and educational program or practice change. The final step in the sequence is impact on the future state in benefits to an organization, community or system. This could include an elevation in nursing practice or practice change at the unit or institutional level (WK Kellogg Foundation, 2004).

The purpose of this quality improvement project was to measure emergency department nurses' ability to identify ST-elevation myocardial infarction in 12-lead electrocardiograms. The systematic approach of the Logic Model helped guide the

process and showed the plan, activities and expected outcomes. The Knowles Learning Theory was used to ensure the needs of the participants were considered and met during this quality improvement project. Next, the methodology for this quality improvement project will be presented.

Methods

Purpose

The purpose of this quality improvement project was to assess emergency department nurses' ability to identify ST-elevation myocardial infarction in 12-Lead electrocardiograms.

Design

The design of this quality improvement project was a pretest, educational intervention, and posttest.

Participants/Sample and Site

A convenience sample of Advanced Cardiac Life Support (ACLS) certified registered nurses (N=74) who had completed training and preceptorship and were credentialed to work in triage areas of the Emergency Department at Rhode Island Hospital, a 719-bed tertiary, academic medical center, were recruited to participate in the study. Non-nurses and Registered Nurses who were not RIH ED triage-credentialed were excluded from the project.

Procedures

The procedures used for this project were based upon the principles of the Logic Model. The first two were resources, or inputs, and activities. The Chief Nursing Officer and ED Director from the Rhode Island Hospital approved the project before beginning any unit activities. Lifespan IRB and Rhode Island College IRB reviews were obtained prior to recruitment.

Recruitment of participants was performed by departmental e-mail, an informational brochure (Appendix A) and face-to-face group invitations at departmental team huddles and occurred two weeks prior to implementation of any testing or education. The ED clinical nurse specialist, education coordinator and this writer participated in recruitment activities. Potential participants were asked to voluntarily participate in this project. All activities of this project took place in the ED.

The pretest assessed the triage RN participants ability to recognize 12-lead STEMI ECGs. Participants were provided a pretest packet which contained a manila envelope, an answer sheet, a blank envelope containing three cards with a preassigned four-digit personal identification number and total of twenty ECGs (Appendix B). Ten of which were known STEMI tracings validated by a cardiologist. Ten others were non-STEMI tracing with several containing other non-STEMI normal and abnormal rhythms. Examples of non-STEMI ECGs included normal sinus rhythm, right bundle branch block, sinus tachycardia, second degree AV-block, ventricular paced, atrial fibrillation, supra-ventricular tachycardia and left ventricular hypertrophy. Each ECG was numbered 1-20. Participants were asked to record an answer for each ECG on the answer sheet (Appendix C) with a choice of “STEMI” or “Not a STEMI” for each. Upon completion of the pretest participants placed all the ECGs, the answer sheet and one of the pre-printed PIN cards inside the manila envelope which were sealed. They left the exterior of the manila envelopes unmarked and place them a provided, locked drop box. They placed the remaining PIN cards in a blank envelop which was saved and keep anonymous for use with the posttest.

An educational program was provided to all participants after all volunteers had completed the pretest. Content included information on rationale and criteria for determining STEMI, J-point location and measuring ST-elevation or depressions. Information regarding STEMI mimics was also included. Educational sessions occurred during the two weeks anteceding the pretest included 10-15-minute educational sessions which were offered on the unit at varying times. A PowerPoint presentation (Appendix D) was used to as a visual teaching aid for each session.

The posttests were administered at conclusion of the educational sessions provided to each participant. The posttest reassessed the participants ability to recognize 12-lead STEMI ECGs and was the same as the pre-test. Participants were each provided a posttest packet which contained a manila envelope, an answer sheet and 20 ECGs. Upon completion of the posttest participants placed all the ECGs, the answer sheet and one of the remaining pre-printed PIN cards inside the manila envelope which were sealed. The exterior of each manila envelope was marked "Post-test" only.

Participants were surveyed (Appendix E) during the pretest phase to gain information regarding experience as a registered nurse, experience as an ED nurse and a self-rating regarding skill recognizing a STEMI on ECG. Ranges for experience questions were zero to five years, six to ten years and greater than ten years. A Likert scale for self-rating of ability to recognize STEMI on ECG with a zero to ten scale was used. Zero equated to no skill and ten was expert. Participants placed completed surveys in a lock box along with the posttests. All completed test materials and surveys were stored in a locked cabinet on-site until testing was closed and analysis started.

One packet was chosen at random from the participant test packets. The PIN number was used to award a gift card valued at \$50. Letters thanking participants along with a summary of the project results were provided. The exterior of each envelope had the PINs printed for each participant. The gift card was placed in the envelope with the randomly chosen PIN.

Ethical and human subject considerations were identified related to administering this quality improvement project. The first was whether having members of the departmental leadership team involved in this project exerts pressure on any staff members to become participants. Potential participants were informed of the strictly voluntary nature of participation and that they could decline participation at any time for any reason without prejudice. Second, were concerns for maintaining participant confidentiality and anonymity regarding administration of the pre and post-tests and when awarding any prize during a raffle for participation. The use of confidential numbering of participants tests and locked storage of the completed tests prevented participants from being identified individually for the project and their identities were obscured by data only being reported as a group. The collected aggregate data was anonymized and no link between participants and the data was created. All participants were given a thank you letter for participation. One randomly chosen participant had the gift card placed in with the letter. Neither the administrators nor the participants knew the identity of the recipient. Lastly, a modest amount was chosen as compensation (ie. prize) offered for participation.

There were some potential barriers to completion of this project. These include time constraints within the ED schedule and activities taking place during the COVID-19

pandemic period. Freeing up nurses for educational time during work periods was logistically challenging. Space was also an issue. The ED had limited some areas for use due to COVID-19 restrictions. The timeline was aggressive, but with available resources and cooperation from the ED leadership and educational teams it was completed within the anticipated timeline.

Measurement

Development of the pretest and posttest was based on the evaluation of ECGs reviewed by an interventional cardiologist who served as the content expert. The 20-ECG tests were used to measure nurses' improvement in their ability to recognize STEMI based on the current ACC/AHA definitions.

Data analysis:

A descriptive statistical analysis was used to measure the effectiveness of this quality improvement project. All answers on the pre-test were analyzed and compared to the answers on the post-test. Next, the results will be presented.

Results

A total of twenty-three nurses attended ten educational sessions. Four nurses who met inclusion criteria took the pre-test and attended an educational session but did not submit a posttest. Their pre-test data was excluded from the comparison. Nineteen of a possible 74 nurses completed the pre-test, educational session, and post-test ($n=19$; 25.7%). The pre-test and post-test consisted of twenty questions. The twenty questions allowed for one of two choices, “STEMI” or “NOT A STEMI”. Each question had a single correct response. There were no questions that were left unanswered or had multiple responses selected. The post-test scores showed a 4.8% increase in overall correct answers from pre-test (73.1%) to posttest scores (77.9%). The ECGs used in the pre-test and post-test may be found in Appendix E. Comparison of test scores from the pre-test and posttest are illustrated in Table 1.

Table 1:

Test Score Comparison Pre-Test/Post-Test

Seven out of twenty questions showed improvement after educational intervention. Three questions had unchanged results. Nine questions had a decline in results. The greatest overall improvement was seen in questions five, thirteen and fifteen (17% improvement). The decreased scores were seen in questions fourteen, eighteen and twenty (11% and 16% decrease, respectively). Six out of nineteen individual participant test scores improved after the educational intervention. Comparison of test scores from the pre-test and posttest are illustrated in Table 2.

Table 2 illustrates the percent correct for each of the questions on the pre-test and post-test.

Table 2:

Percentage Breakdown of Test Score Comparison Pre/Post-Test

Question (ECG)	Pre-Test (N=19)	Post-Test (N=19)
1	80% (18/20)	95% (19/20)
2	65% (13/20)	75% (15/20)
3	90% (18/20)	90% (18/20)
4	90% (18/20)	85% (17/20)
5	55% (11/20)	70% (14/20)
6	80% (16/20)	75% (15/20)
7	95% (19/20)	90% (18/20)
8	35% (7/20)	50% (10/20)
9	60% (12/20)	65% (13/20)
10	95% (19/20)	85% (17/20)
11	95% (19/20)	95% (19/20)
12	85% (17/20)	75% (15/20)
13	50% (10/20)	70% (14/20)
14	40% (8/20)	30% (6/20)
15	75% (15/20)	90% (18/20)
16	60% (12/20)	75% (15/20)
17	65% (13/20)	80% (16/20)
18	65% (13/20)	55% (11/20)
19	80% (16/20)	75% (15/20)
20	70% (14/20)	60% (12/20)

Questions 1, 2, 4, 5, 7, 11, 13, 16, 17 and 20 involved non-STEMI ECGs. Questions 3, 6, 8, 9, 10, 12, 14, 15, 18 and 19 involved STEMI ECGs. Pre-tests ranged from 35% to 95% correct answers on individual questions. The post-test ranged from 30% to 95% correct answers on individual questions. Forty-five percent of the questions demonstrated an increase in correct answers from the pre-test to the post-test. Ten percent were unchanged. Forty-five percent had decreased scores. After the educational sessions, participants were able to increase scores in nine of the questions. Three questions (30%) involved STEMI ECGs, one of which was a left bundle branch block. The six other questions (60%) involved non-STEMI ECGs. Results for STEMI ECGs ranged from a 10% decrease to a 15% increase (4.5% mean decrease). Results for non-STEMI ECGs ranged from a 10% decrease to a twenty percent increase (7% mean increase).

Participant performance on the pre-tests ranged from 60-90% and averaged 75.7%. Performance on the post-tests ranged from 65 to 95% and averaged 78.1%. Six out of nineteen (31.6%) participants had increased score with a range of 10 to 30%. Three participants (15.8%) had scores that were unchanged. Ten participants (52.6%) had scores decrease by a range from 5% to 25%. The resultant performance on the post-test equated to a 2.4% overall improvement in test scores.

All participants were surveyed to voluntarily provide their years of nursing experience as well as their personal rating of their ability to identify STEMI in ECG. This was broken into the categories of zero to five years, six to ten years and greater than ten years. There were no participants in the 0-5 years' nursing experience group (n=0). The 6-10-year experience (n=7) began with a mean pre-test score of 73.3% and improved

to 81% after educational intervention, a 7.7% overall increase. The participants with >10-year experience (n=16) began with a mean pre-test score of 77.2% and decreased to 71.4% after educational intervention, a 5.8% overall decrease. The 6-10-year experience group had the most significant overall mean test score improvement.

Table 3 illustrates the percent correct for each of the participants on each ECG in the pre-test and post-test.

Table 3:

Participant Test Score Comparison Pre-Test/Post-Test

Participant	Pre-Test (N=23)	Post-Test (N=19)
1	70% (14/20)	90% (18/20)
2	85% (17/20)	85% (17/20)
3	80% (16/20)	80% (16/20)
4	90% (18/20)	90% (18/20)
5	60% (12/20)	90% (18/20)
6	85% (17/20)	80% (16/20)
7	80% (16/20)	70% (14/20)
8	70% (14/20)	80% (16/20)
9	60% (12/20)	80% (16/20)
10	65% (13/20)	95% (19/20)
11	65% (13/20)	80% (16/20)
12	75% (15/20)	65% (13/20)
13	80% (16/20)	75% (15/20)
14	75% (15/20)	65% (13/20)
15	90% (18/20)	65% (13/20)
16	85% (17/20)	80% (16/20)
17	70% (14/20)	70% (14/20)
18	80% (16/20)	70% (14/20)
19	80% (16/20)	75% (15/20)

Data for false positive and false negative results were also calculated. There were 190 possible chances for both the pre and post-tests (nineteen participants and ten ECGs of either STEMI or non-STEMI). There were forty-two false positive results (22.1%)

and forty-seven false negative results (24.7%) during the pre-test phase. There were thirty false positive results (15.8%) and fifty-one false negative results (26.8%) during the post-test phase. This represented a 6.3% decrease in false positive results and a 2.1% increase in false negative results. Next, the summary and conclusions will be discussed.

Summary and Conclusions

Cardiovascular disease accounts for nearly 836,546 deaths annually, about one of every three deaths in the United States. About 2,300 Americans die from cardiovascular diseases each day and this claims more lives each year than all forms of cancer and respiratory disease combined (Benjamin, et al., 2018). The annual direct and indirect cost of CVD and stroke in the United States between 2012-2013 was an estimated \$316.1 billion. Including nursing home care costs, the total direct medical costs of CVD are projected to increase from \$396 billion in 2012 to \$918 billion by 2030 (Benjamin, et al, 2017). Although the incidence of acute myocardial infarction has been decreasing in the US according to the American Heart Association, heart disease is still the leading cause of mortality in adults (Ambrose & Singh, 2015).

The AHA has recommended a goal of ten minutes from arrival at an ED with a possible heart attack to a diagnostic standard ECG. Research has shown that although a very high percentage of EDs utilize structured triage protocols, the AHA goal can be difficult to meet. The first ten minutes may consist of the registration and intake of patients. There are also many variations in practice regarding criteria for obtaining ECGs and communicating with providers who interpret ECGs. Triage nurses must consistently seek out an emergency department provider to review any ECG obtained at triage in order to assess for STEMI which is done not only to meet the AHA recommendation, but to improve patient outcomes. Any delay in recognizing a potentially life-threatening cardiac event, delays cardiologist evaluation and treatment (Yiadom et al. b, 2017). Providers are usually very busy with ever-present interruptions or distractions. Research

has shown that nurses are capable of acting within established protocols to improve outcomes.

A quality improvement project was developed using a pre-test, education intervention, post-test design to assess nurse's ability identify STEMI ECGs from non-STEMI ECGs and to assess the impact of a brief educational program on nurses' performance. The pre-tests were available to nursing staff over a two-week period to obtain the nurses' baseline knowledge. Following the pre-test period nurses were provided the educational sessions followed immediately by distribution of the post-test. The pre-tests were then compared to the post-tests to assess whether or not the education improved nurses' performance in STEMI recognition.

A total of twenty-three nurses out of a possible seventy-four completed the pre-test and attended the educational sessions. Nineteen nurses completed the post-test. There were several participants and individual test questions that showed improvement after the educational intervention. However, when evaluated in aggregate the results did not show any significant improvement. Participants were able to increase scores in nine of the questions (45%), three of which (30%) involved STEMI ECGs and one was a left bundle branch block. Six other questions (60%) involved non-STEMI ECGs. Results for all STEMI ECGs ranged from a 10% decrease to a 15% increase (4.5% mean decrease). Results for the non-STEMI ECGs ranged from a 10% decrease to a 20% increase (7% mean increase). Performance on the post-tests ranged from 65 to 95%. Six out of nineteen (31.6%) participants had increased score with a range of 10 to 30%. Three participants (15.8%) had scores that were unchanged. Ten participants (52.6%) had

decreased scores ranging from -5 to -25%. The resultant performance on the post-test equated to a 2.4% overall improvement in test scores.

There were thirty-seven false positive results (9.7%) and fifty-two false negative results (13.7%) during the pre-test phase. There were twenty-three false positive results (6.1%) and fifty-two false negative results (15.3%) during the post-test phase. This represented a 3.6% decrease in false positive results and a 1.6% increase in false negative results.

There were several limitations identified. The overall percentage of staff participation in this project was relatively low (25.7%). Although there were adequate invitational activities including informational flyers and unit leadership encouragement, the activities took place during a time period involving the COVID-19 pandemic. There was a major shift in departmental resources and many staff opted not to participate as a direct result. Remaining flexible and maintaining a consistent schedule of availability for staff was integral in gaining the final level of participation. However, four of the original 23 participants did not complete the post-test following the educational session. It is unclear if conducting this project during more normal operations would have yielded greater participation. The educational sessions proved to have mixed results overall for participating nurses. There was marginal increased knowledge of STEMI recognition demonstrated.

A longer lead time with a greater window for completion of the testing materials may have increased participation and completion of all parts of the project. Also, the educational sessions for staff might include longer periods for interaction and return

demonstration which were lacking in this project. The use of more examples and STEMI ECGs in a case study-based curriculum may have resulted in a better yield. Next, recommendations and implications for advanced nursing practice will be discussed.

Recommendations and Implications for Advanced Nursing Practice

Advanced Practice Registered Nurses (APRNs) who practice in the emergency department have the opportunity to identify issues with clinical practice and intervene and make changes that can affect patient outcomes. Relatively small changes in practice or protocol can have great effect on patient outcomes and staff performance or autonomy. An assessment of potential gaps in performance paired with sound evidence-based teaching strategies can positively impact unit operations. This APRN student identified potential opportunities for earlier identification of STEMI in patients who arrive with cardiac symptoms.

There are several barriers to rapid management of patients who present in the ED and are found to have a STEMI on ECG. A key point is how systems have inherent barriers which cause delays in notification of cardiac specialist for patients who require immediate intervention. The literature review demonstrated several points in this area. While there is much written regarding how improving the processes of obtaining an ECG earlier can positively impact patients, there was little past or current research specific to the triage nurse interpreting or evaluating ECGs at triage. Most information has focused on improving processes to get ECGs completed and to an ED provider earlier. The research indicates that ED providers are distracted during their work and requests to read an ECG are cited as a top reason for delay (Eng, et al, 2019). The APRN is in the perfect position to educate, monitor and improve processes wherein the triage nurse obtains and evaluates the ECG for a STEMI or any other concerning rhythm. This would allow for more rapid notification of an interventional cardiologist when necessary while limiting

delays and decreasing unnecessarily interruption of the ED providers performing other work.

Several authors described the positive impact of nurse-driven protocols. Triage nurses initiating protocols were able to significantly reduce the number of blood draws and intravenous fluid use as well as be able to safely and appropriately order x-rays (Hendrickson et al., 2018; Considine et al., 2019).

Advanced practice nurses are in an ideal position to lead and advocate for improved patient outcomes by providing consistent education. By collaborating with other leaders and APRNs in the emergency department, a more in-depth training program could be developed to raise the aggregate skill level of the nursing staff regarding abnormal ECG recognition. More specifically, a smaller cohort of nurses with interest and aptitude could receive individualized, comprehensive unit-level credentialing in not only STEMI recognition but other abnormal ECG tracings. This could create a group of subject matter experts who could champion the program to peers. APRNs could also use their leadership and knowledge of organizational and system nuances to oversee the program which could expand to elevate and maintain high-level nursing practice across departments.

The educational program evaluated was specific in focus but may be modified to become generalizable not only to other EDs, but other specialty units as well. APRNs could also act as liaison to interventional cardiology providers and nurses on the cardiac care unit team. Evidence-based protocols might be created for improved patient outcomes and satisfaction. This could also improve continuity of care and create sustainable

practice change care across the system. Additional research in the area of ECG-specific nursing protocols is needed to improve outcomes for patients experiencing cardiac events who present to the emergency department.

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Appendix A

Invitational Brochure

INVITATION TO PARTICIPATE **ECGs IN TRIAGE** A QUALITY IMPROVEMENT PROJECT

ORGANIZED BY BRUCE GILLARD, BSN, RN
RHODE ISLAND COLLEGE SCHOOL OF NURSING

RHODE ISLAND HOSPITAL EMERGENCY DEPARTMENT
PROVIDENCE, RHODE ISLAND

We are conducting a quality improvement project as part of a study to assess a triage nurse's ability to identify certain ECG abnormalities. Registered nurses who are currently credentialed to work in the triage areas are eligible to participate. Participants will be asked to take part in an educational program regarding ECGs and evaluate several ECGs for specific abnormalities before and after the program. Participation is completely voluntary. Nurses who complete the program will be entered in a raffle to win a \$50 gift card. Activities will take place during participants regular work hours and will occur in the ED breakroom or education office. Please contact Bruce Gillard or Linda Dysktra if you are willing to participate, and please do not hesitate to ask any questions you may have.

FOR MORE INFORMATION CONTACT: BGILLARD_4565@EMAIL.RIC.EDU(401)954-1145

Appendix B

Project ECGs

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Appendix C

Answer Sheet

Please review each ECG and circle only one answer. There are only two answer choices for each tracing. These will be "STEMI" or "NOT A STEMI".

1. STEMI or NOT A STEMI

2. STEMI or NOT A STEMI

3. STEMI or NOT A STEMI

4. STEMI or NOT A STEMI

5. STEMI or NOT A STEMI

6. STEMI or NOT A STEMI

7. STEMI or NOT A STEMI

8. STEMI or NOT A STEMI

9. STEMI or NOT A STEMI

10. STEMI or NOT A STEMI

11. STEMI or NOT A STEMI

12. STEMI or NOT A STEMI

13. STEMI or NOT A STEMI

14. STEMI or NOT A STEMI

15. STEMI or NOT A STEMI

16. STEMI or NOT A STEMI

17. STEMI or NOT A STEMI

18. STEMI or NOT A STEMI

19. STEMI or NOT A STEMI

20. STEMI or NOT A STEMI

Appendix D

PowerPoint Presentation

STEMI RECOGNITION IN 12-LEAD ECGs

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Goals of this Program

- Understand the ACC/AHA definition of STEMI
- Learn the location of the J-point in an ECG tracing
- Understand how to measure ST elevation and depression using the PR baseline and J-point
- Learn some common STEMI false positives/negative (mimics)

STEMI-Defined (ACC/AHA guidelines)

- New ST elevation at the J point in two contiguous leads of >0.1 mV in all leads other than leads V2-V3
- For leads V2-V3 the following cut points apply: ≥ 0.2 mV in men ≥ 40 years, ≥ 0.25 mV in men <40 years, or ≥ 0.15 mV in women
- New or presumed new LBBB (in patients with symptoms suspicious for cardiac origin)
- Reciprocal ST depression

J-Point

Perez, Friday & Froelicher, (2012).

ST ELEVATION EXAMPLES

ST Depression Measurement

ECG & Echocardiography Education. (2019).

ST DEPRESSIONS

False Positives and Negatives

- Ventricular pacing
- Left bundle branch block (LBBB)
- Left ventricular hypertrophy
- Early repolarization
- Pericarditis
- Metabolic disturbance
 - Hyperkalemia
 - Medications (tricyclics/phenothiazines)

False positives

- Early repolarization
- LBBB
- Pre-excitation
- J point elevation syndromes, e.g. Brugada syndrome
- Peri-/myocarditis
- Pulmonary embolism
- Subarachnoid haemorrhage
- Metabolic disturbances such as hyperkalaemia
- Cardiomyopathy
- Lead transposition
- Cholecystitis
- Persistent juvenile pattern
- Malposition of precordial ECG electrodes
- Tricyclic antidepressants or phenothiazines

False negatives

- Prior MI with Q-waves and/or persistent ST elevation
- Right ventricular pacing
- LBBB

PERICARDITIS

Hyperkalemia

Sims & Sperling, 2005

Left Ventricular Hypertrophy (ECG Learning Center, 2018)

LVH Algorithm

Ventricular Paced

Left Bundle Branch Block (LBBB)

REVIEW

- New ST elevation at the J point in two contiguous leads of >0.1 mV in all leads other than leads V2-V3
- For leads V2-V3 the following cut points apply: ≥ 0.2 mV in men ≥ 40 years, ≥ 0.25 mV in men < 40 years, or ≥ 0.15 mV in women
- New or presumed new LBBB (in patients with symptoms suspicious for cardiac origin)
- Reciprocal ST depression

REVIEW

- ACC/AHA definition of STEMI
- Location of the J-point in an ECG tracing
- Measuring ST elevation and depression using the PR baseline and J-point
- STEMI false positives/negative (mimics)

Review

Pericarditis

Diffuse ST elevations in all leads

Hyperkalemia

ST elevations mainly in V1 and V2 and peaked T-waves in all leads

LBBB

Rhythm must be of super-ventricular origin (EG: ventricular activation coming from atrial or AV nodal activation)

QRS Duration greater than 120ms

Lead V1 should have either a QS or a small r wave with large S wave

Lead V6 should have a notched R wave and no Q wave

LVH

Elevation in V1-V3 AND R/S wave ratio >25% AND 3 or more leads with elevation →STEMI

If elevations in V1-V3 AND R/S ratio >25% AND NOT 3 or more leads with elevations but V1-V3 with ST depression →STEMI

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ECG Power Point Notes

Slide 4:

J point: The point where the QRS ends and the ST segment begins.

J-point elevation: An elevation of the J point ≥ 1 mm above the isoelectric baseline.

(Patton, et al., 2016)

The American Heart Association

Junction (J) Point

The junction (J) point is where the QRS complex and ST segment meet. It marks the beginning of the ST segment. Any displacement of the ST segment above or below baseline is often measured at the J point. However, it is not always easy to discern the J point because of various ST-segment morphologies. For instance, diffuse J points can be seen with early repolarization, pericarditis, left ventricular hypertrophy (LVH) with strain, and acute myocardial infarctions (MI). Because it is often difficult to make out the J point and/or the beginning of the T wave, the ST segment is frequently an approximation or evaluated at ST, which is the ST segment at 60 ms after the J point. (Kashou, Basit, & Malik (2019))

Slide 8:

Measured in the same way as ST-elevations.

Slide 10:

False positive=falsely indicates a disease

False negative=falsely indicates a disease is not present when it is.

Also known as mimics or chameleons.

Phenothiazines=end in “zines” (thorazine, compazine)

Slide 11:

Pericarditis-note the diffuse ST elevations in all leads

Slide 12:

Note- ST elevations mainly in V1 and V2 and peaked T-waves in all leads

Slide 13:

$\geq$ QRS amplitude (voltage criteria; i.e., tall R-waves in LV leads, deep S-waves in RV leads)

Slide 14:

R/S ratio

Elevation in V1-V3 AND R/S wave ratio $>25\%$ AND 3 or more leads with elevation $\rightarrow$ STEMI

If elevations in V1-V3 AND R/S ratio $>25\%$ AND NOT 3 or more leads with elevations but V1-V3 with ST depression $\rightarrow$ STEMI

This algorithm reduces false positive by 35% (Armstrong, et al., 2012)

Slide 15:

Note pacer spikes preceding the wide QRS complexes.

Slide 16:

LBBB is often detected on ECG. Diagnostic criteria are defined by the American College of Cardiology (ACC) and American Heart Association (AHA) as follows:

Rhythm must be of super-ventricular origin (EG: ventricular activation coming from atrial or AV nodal activation)

QRS Duration greater than 120 ms

Lead V1 should have either a QS or a small r wave with large S wave

Lead V6 should have a notched R wave and no Q wave

Scherbak, D., & Hicks, G. J. (2018).

Appendix E

Survey Questions

1. How long have you been practicing as a registered nurse? (circle one)

0-5 years

5-10 years

Greater than 10 years

2. How many years of emergency department experience do you have as a registered nurse? (circle one)

0-5 years

5-10 years

Greater than 10 years

3. How would you rate your own ability to recognize STEMI in 12-lead ECGs on a 0-10 scale (with 0 being no skill and 10 being expert)? (circle one number)

0---1---2---3---4---5---6---7---8---9---10

PIN _____