Observer Variability in the Diagnosis of ST-Elevation Myocardial Infarction from Emergency Room Electrocardiograms of Patients Presenting with Chest Pain*

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ABSTRACT

BACKGROUND: The diagnosis of ST-elevation myocardial infarction on standard 12-lead electrocardiography is crucial to the timely institution of appropriate medical therapies and interventions. However, the electrocardiographic diagnosis may be prone to observer variability.

OBJECTIVES: We wanted to determine the 1) inter-observer variability among clinicians from a training hospital in the diagnosis of ST-elevation myocardial infarction (STEMI) from emergency room electrocardiograms (ECG) of patients presenting with chest pain, and 2) the accuracy of clinician readings compared to the final cardiac diagnosis in the official patient records.

METHODS: Forty electrocardiograms were independently interpreted by 40 clinicians which included 10 cardiologists (CC), 5 cardiology fellows (CF), 15 internal medicine (IM), and 10 internal medicine residents (MR), using uniform copies of the standard 12-lead electrocardiogram print-outs. All readers were blinded to the patient's clinical profile. The accuracy of clinician readings (% of tracings correctly identified as STEMI) were compared against a reference standard, which was the final cardiac diagnosis made based on historical, electrocardiographic, biochemical, and angiographic data.

RESULTS: The overall level of agreement among all readers (intergroup variability) was only fair with a kappa of 0.24. The level of agreement within the groups (intra-group variability) was likewise "fair" for the IM (0.35), MR (0.32), and CC (0.30 groups. Agreement was much less (0.18) among the cardiology fellows (0.18) among the cardiology fellows (CF). Accuracy of ECG diagnosis varied among the groups: IM (68%), MR (60%), CF (52%) and CC (50%).

CONCLUSIONS: There is substantial inter-group variability in the electrocardiographic diagnosis of STEMI by clinicians. The accurate diagnosis of STEMI, based on pure electrocardiographic information, varied among readers with different training backgrounds. These findings suggest that the electrocardiographic diagnosis of STEMI may be influenced by training background and experience, as well as presence or absence of supplemental medical information necessary to make a comprehensive and accurate cardiac diagnosis. More importantly, this underscores the need to harmonize electrocardiographic interpretations and recognize the value of reading ECGs in light of pertinent clinical data.

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INTRODUCTION

ST elevation myocardial infarction (STEMI) is usually caused by an acute total occlusion of a coronary artery following the rupture of a previously non-obstructing plaque that triggers platelet aggregation and thrombus formation of the site of rupture. On the other hand, non-STEMI (NSTEMI) most commonly results from severe but not total occlusion of a coronary artery due to plaque erosion or progressive arteriosclerosis.

It is generally accepted that patients with typical symptoms presenting with persistent ST elevation in at least two contiguous leads should be accorded prompt reperfusion therapy, either pharmacological or catheter-based. Fibrinolytic therapy is preferred over percutaneous coronary intervention, if it is anticipated that the latter could not be performed within two hours. Patients without ST segment elevations howerer, are not candidates for thrombolysis but should nevertheless receive anti -ischemic and anti-platelet agents. Thrombolytic therapy reduces mortality among patients with suspected acute myocardial infarction(AMI) and electrocardiogram (ECG) indicators of high risk including acute ST segment elevation of bundle branch block (1-3)

However, the standard electrocardiographic criteria used for triaging patients into STEMI or NSTEMI have not attained the level of specificity and sensitivity in which errors of omission or commission could be avoided upon implementing an intervention that is highly effective but not entirely risk-free. Errors in the identification of potentially eligible thrombolytic candidates occur and can be made in two directions [6-14].

According to the 2014 PHA guidelines on coronary artery disease, it is strongly recommended that a 12-lead ECG be taken within 10 minutes of arrival at the ER. The 12-lead ECG has a pivotal role in the initial evaluation and rapid diagnosis of STEMI patients to determine the patient's eligibility for reperfusion therapy.

Further, it is also recommended that if the initial ECG is not diagnostic and the patient remains asymptomatic, but there is high clinical suspicion for STEMI, serial ECG's at 5 to 10 minute intervals or continuous ST segment monitoring should be done.

In the rural setting, the ECG could be the only available tool in most institutions in the diagnosis of patients suffering from acute myocardial infarction. Oftentimes, it comprises the only basis for treatment of such patients even if the sensitivity and specificity of the ECG in the diagnosis of STEMI is approximately 39% and 69% respectively with inter and intra -observer variability.

This study aims to document the presence and the magnitude of inter-observer variability in the appraisal of ST segement elevations from the ECG of patients with chest pains recorded at the emergency room. The findings of significant inter- observer variability may play an integral role on enhancing the specificity and sensitivity in our flight to help our rural physicians establish a more accurate diagnosis of STEMI thru the 12-lead ECG. state focusing on acne-related QOL in adolescent students.

METHODOLOGY

Trial Design

Forty ECG tracings were selected among patient population presenting as STEMi in the emergency room of the Angeles University Foundation Medical Center. The respondents were made to choose whether or not the ECG tracings presented to them to analyzed were indeed represent a diagnosis of STEMI and for which the respondent is made to choose 'Yes'. On the other hand, if the respondent deems that it is not STEMI, he/she has to check 'No'. The ST-elevation was then confirmed with either the patient's Troponin I, CK-MB, coronary angiography or the presence of subsequent ECG dynamic changes.

Study Setting and Time Frame

The study was conducted from January 2014 to December 2015.The study included 10 cardiologists, 5 cardiology fellows, 15 general internists and 10 medical residents from the Angeles University Foundation Medical Center (AUFMC), Angeles City.

Study Maneuver

Forty electrocardiograms were independently interpreted by 40 clinicians which included 10 cardiologists (CC), 5 cardiology fellows (CF), 15 internal medicine (IM), and 10 internal medicine residents (MR), using uniform copies of the standard 12-lead electrocardiogram print-outs. All readers were blinded to the patient's clinical profile. The accuracy of

clinician readings (% of tracings correctly identified as STEMI) were compared against a reference standard, which was the final cardiac diagnosis made based on historical, electrocardiographic, biochemical, and angiographic data.

Definition of Outcomes or variables measured

Intra-observer and interobserver reliability was then compared among the different subgroups of respondents.

Statistical Analysis

For the statistical analysis, Kappa statistics were used to assess the agreement in ECG interpretation between different physicians. The mean of the correct responses from each group were also computed.

RESULTS

Participants

Forty clinicians which included 10 cardiologists, 5 cardiology fellows, 15 internal medicine specialists and 10 medical residents interpreted 30 12-lead ECG tracings.

Table 1 shows the demographics of the four groups of readers. There were significant gradients in terms of both age since medical school graduation and ECG reading experience favouring CC over trainees.

Table 1. Study Participants

Physician Group	Years since graduation	Average number of ECGs interpreted per week			
		<5	5-9	10-20	>20
Medical Residents (MR)	>3.0	++	+		
Internal Medicine Specialists (IM)	>4.0		++	+	
Cardiology Fellows (CF)	>5.0		+	++	
Cardiology Consultants (CC)	>10.0				+++

Observer variability

The overall level of agreement among all raters was only "fair" with a kappa of 0.24. Similarly, level of agreement within the cardiologist, IM specialist, and IM resident groups were "fair" with kappa = 0.30, 0.35 and 0.32, respectively. Only slight agreement (kappa = 0.18) was noted among cardiology fellows. Moreover, comparison of the overall number of patients correctly diagnosed with STEMI based on ECG showed significant differences between groups, particularly, between IM specialists and cardiologists with means of 27 and 20 respectively. Mean number of patients correctly diagnosed with STEMI based on ECG by cardiology fellows and medical residents were 21 and 24 respectively.

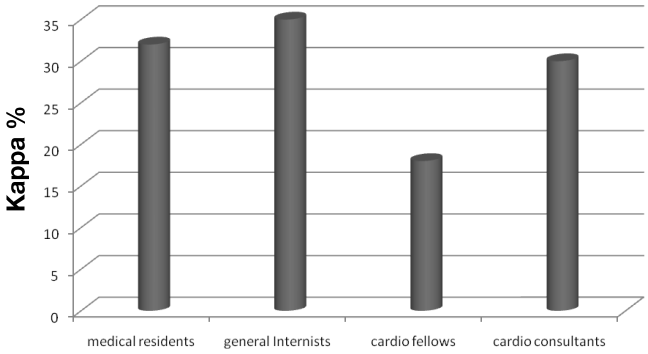

Fig 1. Inter-observer variability among physician groups. Shown are the inter-observer kappa values

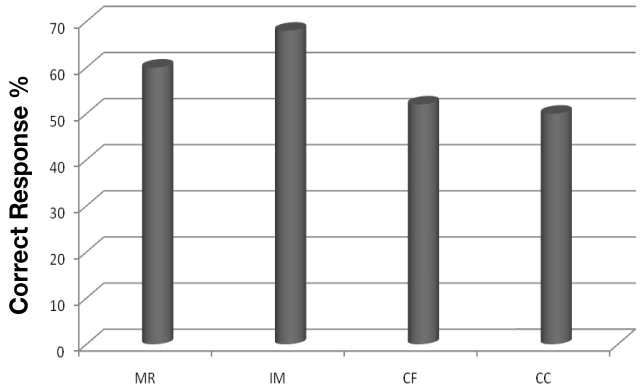

Fig. 2. Accuracy of ECG diagnosis among the physician groups MR- Medical residents; IM - Internal Medicine; CF - Cardiology Fellows

DISCUSSION

Our study has several findings. First, there was significant intergroup variability in the ECG interpretation. The accurate diagnosis of STEMI, based on pure electrocardiographic information varied among readers with different training backgrounds. These findings suggest that the electrocardiographic diagnosis of STEMI may be influenced by training background and experience, as well as the presence

or absence of supplemental medical information necessary to make a comprehensive and accurate cardiac diagnosis.

Unlike other studies, we found out that experience and educational attainment of readers may not be congruent with the accuracy of ECG readings. General internists and medical residents have greater percentages of correct responses identified as to whether a patient has STEMI and thus needs thrombolysis as a revascularization procedure. The correct response is based on cardiac enzymes, result of the coronary angiogram and the 2D echocardiography result.

This study has limited scope and involves only physicians who are active staff of the Angeles University Foundation Medical Centre. Individual patient's setting or clinical background is also not given to the interpreter which is a critical in decision making regarding thrombolysis.

Implications of the Study

Findings in this study would establish that the ECG continues to be an insensitive tool for the diagnosis of AMI and thus the authors would recommend a scoring system that improves the diagnostic sensitivity and specificity of the 12-lead ECG leading to a more determined decision to thrombolyse patients even in the absence of clinical data.

Consequences of variability in electrocardiogram interpretation

This highlights the fact that in the management of our patients, we should not take the diagnostic work-ups done as a standalone basis for our diagnosis. In fact, it is again stressed that the history and physical examination forms the cornerstone for the diagnosis of most if not all of human diseases.

Yet time and again, physicians, especially in the rural areas, may be pushed against the wall in terms of diagnosis of ST-elevation myocardial infarction.

We present in this paper, that 12-leads ECG that may present as STEMI are not actually what they appear to be or those that seems to be rather benign or not classified as STEMI are actually one. This has a big burden on the rural physician since additional diagnostic data are oftentimes not available as a adjunct for the diagnosis of such time-dependent disease which require one to act within a golden period. As again stressed, "time is myocardium".

Understanding the plight of these physicians, and with the results of this study, we deemed it necessary to improve the sensitivity and specificity of the 12-lead ECG in order that more lives be saved from this silent epidemic. A scoring system could be proposed to be used specially that of ongoing dynamic ECG changes.

In this study, we also emphasized that our training did not made us interpret ST-elevation MI as a definite diagnosis once the ECG is done. But as with all other diagnostics, there is an inter and intra-observer variability which makes it all the more complex for such situations.

Comparison with other studies

Storey and Rowley found considerable variability in the decision to administer thrombolysis based on a typical case history and 30 ECGs, of which 19 were performed on patients in the acute phase of myocardial infarction (17). Thrombolytic therapy was recommended in 75% -100% of cases when the ECG showed unequivocal or strong evidence of acute injury. House officers were more hesitant in deciding to do thrombolysis. On the other hand thrombolysis was advocated in 11-31% of scenarios when the ECG was abnormal but not diagnostic of acute injury. Holmvang and colleagues reported a κstatistics on both intra- and inter-observer variability on ECGs in patients participating in an acute coronary syndrome trial(16).

Intraobserver variability on ST segment elevation was good with a $\kappa$of 62%. Agreement between the core laboratory and the local investigators for ST elevation, however, was poor with a κ of only 5%. The latter seems disproportionately poor and may reflect the complexities of including patients in randomized trials. Jayes and colleagues compared ECG interpretations of emergency physicians to expert readers(9). Emergency physicians misinterpreted 7% of ST segments as being abnormal when no abnormalities were seen and 20% of the ST segments as normal when they were not. Moreover, misinterpretation lead to a higher likelihood of inappropriate patient triage. Another study done by Massel D. rating the level of observer variability in ECG interpretation for thrombolysis eligibility with basis of experience and context, shows the overall level of agreement among

all ratters was substantial with a kappa (kappa) of 70.4%. Intra-observer ECG reading reliability was stronger among cardiologists (CC) as compared with cardiology fellows (CF) and medical residents (MR). The reliability of ECG interpretation for deciding to administer thrombolysis was substantial; there was a gradient from lowest to highest commensurate with training and experience. Errors in thrombolysis eligibility are influenced by clinical history and the presence of a computerized ECG interpretation among less experienced clinicians(18).

Palmer and colleagues showed that delays in thrombolysis administration were due to a combination of patient and hospital factors; three are germane to this study: amount of ST segment elevation, an atypical versus typical presenting history, and the grade of doctor who initially assessed the patient in the emergency department (15). The median delays for thrombolysis were 148 and 160 minutes for interns and residents as compared with 65 and 38 minutes for registrars and senior doctors ($p<0.0001$). In their multivariate analysis the junior grade of doctor remained an important predictor in treatment delay; based on our study this may reflect the inability to identify more subtle ECG changes of acute AMI. It is also interesting to note that senior doctors were more likely to see patients with marked ST abnormalities and urgent triage priorities. This suggests that a visually alarming ECG may well expedite triage and treatment decisions (13).

Limitations of the study

Only ECGs from Angeles University Foundation Medical Center (AUFMC) were included in the study. Adult cardiology consultants, cardiology fellows, internists and medical residents from the same institution were included in the study. Other specialties such as general physicians, ER physicians, family medicine physicians were not included as respondents. The clinical profile of the patients were not given to the reader.

Our study was performed in a tertiary care teaching center and as a result may not be representative of all clinicians who interpret ECGs when assessing patients with chest pain in the emergency department. Moreover, ECG interpretations by emergency department physicians, who provide the initial assessment and triage of patients with acute chest pain, were not included in the study. Notwithstanding, the observation that less experienced readers may perform less well is an important one as the decision to administer thrombolysis in the vast majority of emergency departments does not hinge on the ECG interpretation of an experienced cardiologist. It does suggest however, that there may be value in seeking an experienced interpretation, possibly by facsime or other electronic methods, when the decision does not seem to be obvious.

Whether readers would make different interpretations on the same ECGs in 'real life' is speculative. Clinical history was not incorporated during the reading of the ECGs. Readers were also not timed for the whole ECG interpretation. They were allowed to proceed at their own pace. This eliminates the time pressure clinicians feel when using the ECG as one of the clinical tools to help with the decision to administer thrombolysis in a timely fashion.

CONCLUSIONS

There is substantial inter-group variability in the electrocardiographic diagnosis of STEMI by clinicians. The accurate diagnosis of STEMI, based on pure electrocardiographic information, varied among readers with different training backgrounds. These findings suggest that the electrocardiographic diagnosis of STEMI may be influenced by training background and experience, as well as presence or absence of supplemental medical information necessary to make a comprehensive and accurate cardiac diagnosis. More importantly, this underscores the need to harmonize electrocardiographic interpretations and recognize the value of reading ECGs in light of pertinent clinical data.

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