

Accuracy of Electro Cardiogram (ECG) Interpretation and need for ECG Audit in Emergency Department, A prospective observational study from a tertiary care teaching hospital

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ABSTRACT

Background:

In spite of much recent advancement, 12 lead electro cardiogram (ECG) is still the most relied upon tool for diagnosis of cardiac emergencies in the emergency departments, especially in resource poor settings. Studies on accuracy of ECG interpretations, their likely impact in the emergency departments are scarce from India.

Objective:To assess the accuracy of the ECG interpretation by CMO/resident doctors and emergency physicians, in emergency department of a tertiary care teaching hospital in south India. **Methodology:**The study was a prospective observational study conducted in the emergency medicine department of tertiary care teaching hospital. ECG interpretations of CMO/resident doctor and emergency physicians are compared against the blinded, gold standard interpretation by a cardiologist panel. **Results:**A total of 2857 ECGs of the patients presenting with chest pain were analyzed. The overall concordance as assessed by mean pair agreement index (MPAI) was higher for emergency physician (MPAI=83.75%, Kappa statistic =0.50), compared to CMO/resident doctor (MPAI=75.95%, Kappa statistic =0.48). The concordance rate for abnormal ECG, as assessed by sensitivity of was only 67.2% for CMO/resident doctor and was 78.3% for emergency physician. The concordance rate for normal ECGs, as assessed by specificity was 81.5% and 87.2% respectively for both the groups. **Conclusions:**ECG interpretation skills for both normal and abnormal ECGs are better in emergency physicians, compared to CMO/resident doctors and are better for normal ECGs, compared to abnormal ECGs. Many life threatening emergencies, which need immediate intervention, are being missed.

Keywords: Accuracy, ECG, Emergency Department, Cardiac Emergencies

Introduction

There have been much advancement in the diagnosis of acute myocardial infarction and other cardiac emergencies in the recent past, in patients presenting with chest pain. But the 12 lead electro cardiogram (ECG) is still the most relied upon tool in the emergency departments, especially in resource poor

settings. Many western guidelines like American Heart Association/American College of Cardiology and Canadian Cardiovascular Society have been advocating the use of prehospital ECG interpretation in the evaluation of patients with chest pain. [1-3] But in Indian scenario, these systems have not evolved so far and many a times CMO or resident doctor is the first contact point, where the diagnosis of these cardiac emergencies is made and decision is taken about referral to cardiac care unit. But currently, many emergency departments are being manned by a separate cadre of qualified emergency physicians. So it is imperative to devise appropriate systems of care, to

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ensure accurate interpretation of the ECG and optimal communication between emergency department and cardiac reperfusion facilities. [4] This can have significant positive impact on the mortality and morbidity in patients with cardiac emergencies. Many studies in the past have demonstrated a significant discordance in the interpretation of ECGs between emergency medicine residents and cardiologists and have suggested that failure to interpret the ECG accurately was a important factor in patient management errors. [5,6] Despite the importance of the issue, not many studies were conducted in India on accuracy of ECG interpretations, their likely impact and the need to evolve appropriate mechanisms in the emergency departments to address the issue.

Methodology

Study setting: Emergency department of NRI medical college and hospital, which is a tertiary care teaching hospital in south India.

Study design: The study was prospective observational study of ECGs taken from patients presenting with symptoms of anterior chest pain

Study period: The data collection was done between 1st July 2013 to 31st June 2014, i.e. for the duration of one year

Sample size and sampling: All the ECGs of patients presenting with symptoms of anterior chest pain to the study setup were included, hence no sampling was done

Study procedure: All the ECGs were initially interpreted by the casualty medical officer (CMO) or the resident doctors in

the emergency department. In the second step, emergency physician has interpreted the ECGs. Both were asked to label the ECGs as normal or abnormal in the first step. In the second step they were asked to mention the diagnosis of abnormal ECGs. All these ECGs were analyzed by Independent panel of cardiologists. All the three groups of interpreters were blinded to each other's interpretation. The Cardiologist panel's diagnosis was taken as the gold standard and the remaining interpretations were compared against this gold standard.

Ethical approval: Ethical approval of Human Ethics committee, NRI medical college and hospital was obtained. No informed consent was sought from the subjects, as there was no additional data collection or intervention was done on patients.

Statistical procedures: Comparative descriptive analysis was done in the first step by cross tabulating normal and abnormal ECGs by all the interpreters. The number and proportion of concordant and discordant pairs were presented. The sensitivity, specificity, positive and negative predictive values were computed for CMO/resident doctor and emergency physician's interpretations of ECG. Mean pair agreement index and kappa statistic were calculated to assess the reliability. Microsoft excel and SPSS ver. 21 was used for statistical analysis.

Results: A total of 2857 ECGs of the patients presenting to the emergency department, with chest pain during the study period were included in the final analysis. Out of the total 2857 ECGs, 1103(38.6%) of the ECGs were abnormal, as diagnosed by cardiologist. CMO/resident doctor was able to diagnose only 67.2% abnormal ECGs and emergency physician could diagnose 78.3% of the abnormal ECGs (table1).

Table 1: Comparison of ECG interpretation by CMOs/resident doctors and cardiologist (N=2857)

Emergency department	Cardiologist panel (Gold standard)		
	Abnormal	Normal	Total
CMO/Resident doctor			
Abnormal	741(67.2%)	325(18.5%)	1066
Normal	362(32.8%)	1429(81.5%)	1791
Total	1103	1754	2857
Emergency physician			
Abnormal	864 (78.3%)	225(12.8%)	1089
Normal	239 (21.7%)	1529(87.2%)	1768
Total	1103	1754	2857

The sensitivity, specificity and predictive values of the CMO/resident doctor and emergency physician interpretation are compared with gold standard. The sensitivity of diagnosing an abnormal ECG was only 67.2% for CMO/ resident doctor and was 78.3% for emergency physician so they have missed 32.8% and 21.7% of the abnormal ECGs respectively. The False positive rate i. e labeling normal ECGs, as abnormal

was 18.5% and 12.8% for the CMO/ resident doctor and emergency physician respectively. The positive predictive value (PPV) and negative predictive value (NPV) of CMO/resident doctor was 69.5% and 79.7% respectively and the similar values for emergency physician were 79.3% and 86.4% respectively. (table2).

Table 2: Validity and predictive values of ECG interpretation by CMO/resident doctor and emergency physician

Parameter	CMO/Resident doctor	Emergency physician
Sensitivity	67.2%	78.3%
Specificity	81.5%	87.2%
False positive rate	18.5%	12.8%
False negative rate	32.8%	21.7%
Positive predictive value (PPV)	69.5%	79.3%
Negative predictive value (NPV)	79.7%	86.4%

Table 3: Reliability of ECG interpretation by CMO/resident doctor and emergency physician

Parameter	CMO/resident doctor	Emergency physician
Mean pair agreement index (MPAI)	75.95%	83.75%
Kappa statistic	0.48	0.50

The reliability as assessed by mean pair agreement and kappa statistic was higher for emergency physician (MPAI=83.75%, Kappa statistic =0.50), compared to CMO/resident doctor (MPAI=75.95%, Kappa statistic =0.48). The descriptive analysis shows that, both emergency physicians and CMO or

resident doctors were having difficulty in diagnosing pulmonary embolism, arrhythmia's and bundle branch blocks. The spectrum of coronary artery disease (CAD) was relatively better diagnosed by both these groups, compared to the above mentioned conditions. (table4)

Table 4: Descriptive analysis of false negative ECGs (missed diagnoses) by the study groups

Diagnosis by cardiologist panel	CMO/Resident doctor (N=362)	Emergency physician (N=239)
Angina	16 (6.7%)	45 (12.5%)
STEMI	11(4.8%)	31(8.7%)
Old Infarct	21(8.9%)	45(12.5%)
Bundle branch block	38(16.0%)	77(21.2%)
Arrhythmia	71(29.5%)	85(23.5%)
Ventricular hypertrophy	29(12.1%)	29(8.1%)
Pulmonary embolism	53(22.0%)	49(13.5%)

Discussion

The 12 lead electro cardiogram (ECG) is still the most relied upon tool for, in the emergency departments, especially in resource poor settings. In these settings, the decision on referral to specialist cardiac care is taken sometimes solely on the basis of ECG interpretation. So it is imperative to assume, ECG interpretation skills of health care personal in emergency department will have significant impact on morbidity and mortality of these patients. In Indian scenario, traditionally, CMO or resident doctor is the first contact point, where the diagnosis of these cardiac emergencies is made. But currently, many emergency departments are being manned by a separate cadre of qualified emergency physicians. Assessing the accuracy of ECG interpretation skills of these different cadres of health care providers in the emergency department is vital, in setting up appropriate systems of

care to deal with cardiac emergencies. In the current study, the overall concordance was higher for emergency physician (MPAI=83.75%, Kappa statistic =0.50), compared to CMO/resident doctor (MPAI=75.95%, Kappa statistic =0.48). The concordance rate for abnormal ECG, as assessed by sensitivity of was only 67.2% for CMO/ resident doctor and was 78.3% for emergency physician. The concordance rate for normal ECGs, as assessed by specificity was 81.5% and 87.2% respectively for both the groups. The current study also concludes that, emergency physicians and CMO or resident doctors were having difficulty in diagnosing pulmonary embolism, arrhythmia's and bundle branch blocks. The spectrum of coronary artery disease (CAD) was relatively better diagnosed by both these groups, compared to the above mentioned conditions. Bouida W

et al, have reported 76% ($\kappa = 0.41$) overall concordance between emergency physicians' and cardiologist ECG interpretations and concluded that the quality of ECG interpretation by ED physicians is satisfactory and the rare misinterpretations have minimal clinical impact.[7] Eken C et al, have reported 94.6% ($\kappa = 0.85$) consistency in the interpretation of ECG between the emergency physicians and cardiologists for ST segment elevation, 78.6% ($\kappa = 0.57$) for ischemic ECG findings and 79.3% ($\kappa = 0.36$) for dynamic ECG changes. [8] Wathen JE et al We conclude that, overall, a high rate of concordance exists between the pediatric emergency physician's and the cardiologist's ECG interpretation. The majority of discordant ECGs are not clinically significant. However, among the clinically significant ECGs, there is a higher rate of discordance. These data suggest that review of pediatric ECGs by pediatric cardiologists may significantly reduce underdetection of clinically important ECG findings in children.[9] Salerno SM et al in their review have summarized all the published evidence on accuracy of ECG interpretation. According to the review the Proportion of ECG diagnoses correctly identified by noncardiologist physicians ranged from 36% to 96% in various studies. [10] False-positive ECG diagnosis could lead to unnecessary treatment and resulting unnecessary expenditure and sometimes likelihood of adverse effects of treatment. In the current study, the false positive rate i.e. labeling normal ECGs, as abnormal was 18.5% and 12.8% for the CMO/ resident doctor and emergency physician respectively. Many studies in the past have evaluated the magnitude and impact of false positive ECG interpretations. They have reported a false positivity ranging from zero to 27% for non cardiologists. These studies also concluded that, the specificity of noncardiologists is closer to that of cardiologists in simpler interpretations, such as differentiating normal from abnormal ECGs. [11-14] Many studies in the past have evaluated various strategies in the emergency department to address the issue. Various strategies evaluated were capacity building, taking computer assistance, ECG audit by cardiologist. Snyder CS et al, analyzed and compared the accuracy of ECG interpretation by ED physicians and a computer-generated interpretation. The authors felt that distributing the computer-generated interpretation to the ED physicians and formal review of all ED ECGs by a skilled interpreter may decrease the number of missed diagnoses. (15) Srikanthan VS et al have evaluated the impact of using a fax machine and review by cardiologist in increasing the accuracy of ECG interpretation. They concluded that use of fax machine can provide vital assistance assists in decision making

to junior doctors with regard to critical treatment decisions in cardiac emergencies, especially coronary artery disease (CAD). [16] In their study of 1,000 ECGs, Todd KH et al have evaluated the impact of ECG review process as mandated by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). They have concluded that, the review process will likely have minimal influence on patient outcomes and recommended evaluation of the effectiveness of this review process to avoid wastage of scarce resources for this purpose.[17] In their study, White T et al have evaluated the role of capacity building by single seminar and guidelines on interpretation of ECGs in increasing the accuracy of ECG interpretation by senior house officers in the Accident and Emergency (A&E) Department. They have concluded that, the formal training in ECG interpretation can reduce serious errors in ECG interpretation. [18] Schull, M. J., et al, in their study have concluded that, "lower-volume EDs have up to 2-fold higher odds of missed acute myocardial infarctions compared with highest volume ones after controlling for patient factors. Many current technologies designed to increase diagnostic sensitivity are feasible only in higher-volume centers. Efforts to reduce overall rates of missed acute myocardial infarctions should instead focus on simpler solutions appropriate for lower-volume EDs, such as telemedicine to improve access to consultant expertise". [19] In an extensive review of all the published literature on the subject, Salerno SM et al have made few vital conclusions regarding the accuracy of ECG interpretations by non cardiologist health care providers, especially in emergency setting. They have concluded that "physicians of all specialties and levels of training, as well as computer software for interpreting ECGs, frequently made errors in interpreting ECGs when compared to expert electro cardiographers". Adverse patient outcomes occurred infrequently as a result of inaccurate ECG interpretations. The authors also have concluded that, there is no evidence-based minimum number of ECG interpretations that is ideal for attaining or maintaining competency in ECG interpretation skills. Further research is needed to clarify the optimal way to build and maintain ECG interpretation skills based on patient outcomes. [10]

Limitations

The study could not analyze the impact of many confounding variables, which can influence the accuracy of ECG interpretation.

Conclusions and recommendations

The study clearly concludes that, the ECG interpretation skills for both normal and abnormal ECGs are better in emergency physicians, compared to CMO/resident doctors. The Interpretation skills in both the groups are better for normal ECGs, compared to abnormal ECGs. Many life threatening emergencies, which needs immediate interventions are being missed by CMO/resident doctors and less so by emergency physicians.

Recommendations

A large volume of research is required in this area to understand various factors influencing the ECG interpretations, their likely impact on the mortality and morbidity of the patients. There is a need to conduct regular capacity building programmes these cadres of health care providers, to reduce the inaccuracies in ECG interpretations. There is a need to evolve appropriate standard operating procedures like ECG audit in emergency departments. These capacity building and administrative interventions also needs to be constantly evaluated for their impact, by further research.

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