Comparing IM Residents with EM Resident for Their Skills of ECG Interpretation and Outlining Management Plan Accordingly

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Abstract

Background and Purpose: *Electrocardiogram (ECG) is one of the most commonly performed investigations in cardiac diseases and ECG abnormalities can reveal the early manifestations of cardiac ischemia, metabolic disorders, or life-threatening disrhythmias. Misinterpretation of ECG and its consequent mistreatment or performing inessential interventions may cause life-threatening cardiac events. Since EM residents and internal medicine (IM) residents are usually the first to visit at bedside and start treatments based on patient's ECG, we intended to evaluate the ability of EM residents to interpret ECGs and to compare it with that of IM residents using various ECG samples.*

Method: *63 participants including 33 IM residents and 30 EM residents from two education hospitals of Shahid Beheshti University of Medical Sciences were enrolled in our study. A diagnosis test consisting of 15 ECG samples associated with a questionnaire containing questions about gender, academic year and proficiency in ECG interpretation was taken from all participants. This study was conducted under the supervision of a cardiologist and an emergency specialist who supervised the ECG selection, answers and scoring of each ECG. The maximum score for each ECG was 6 which were given to a completely correct diagnosis and -0.25 negative point was given if the answer was wrong or any differential diagnosis was mentioned. After the test, the answer sheets were collected and were analyzed with SPSS program, by two of study authors who were kept blind to the real identities of participants.*

Results: *After classification of groups, the overall mean score was 45.5/100 (38-60). The mean score of IM and EM residents was 56.0/100 (44.9-72) and 38.9/100 (31.5-45.5), respectively ($p< 0.001$). No significant correlation was found between the diagnosis scores and participant's self-judgment on her/his ECG interpretation skills ($p=0.897$, $r=0.017$). Five ECGs were considered as the most important and analysis revealed the overall mean score (out of 6) of participants was 5 for MI, 4.4 for ventricular tachycardia, 1.18 for pericarditis, 5.91 for WPW, and 5.09 for pulmonary emboli.*

Conclusion: *our study revealed that the overall scores in ECG interpretation are low and the ECG interpretation skill in IM residents was better compared to EM residents. We demonstrated that there are several weaknesses in ECG interpretation which may have an important role in treatment of patients. Therefore there is a need for more and better ECG training programs especially in cardiac emergencies.*

Key Words: *ECG INTERPRETATION, EMERGENCY MEDICINE RESIDENTS, INTERNAL MEDICINE RESIDENTS*

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Introduction

Electrocardiogram (ECG) is one of the most commonly performed investigations in cardiac diseases (1) and ECG abnormalities can reveal the early manifestations of cardiac ischemia, metabolic disorders, or life-threatening disrhythmias(1). Common mistakes in ECG interpretation include inability to diagnose heart blocks, acute posterior myocardial infarction, supraventricular arrhythmias, and ventricular hypertrophy (2,3). On the other hand, misinterpretation of ECG and its consequent mistreatment or performing inessential interventions may cause life-threatening cardiac events (4). Despite the fact that electrocardiography is considered an important method in the diagnosis of cardiac diseases, previous studies have shown that misinterpretation of ECG may result in improper clinical decisions (5,6). Therefore, ECG training is considered an essential course in the medical education curriculum. Regarding the fact that a large number of ECGs are being taken every day in emergency rooms - which by itself cost high expenses, misinterpretation and consecutive mistreatment and inessential interventions will result in additional waste of resources.

Although the importance of ECG interpretation has been generally emphasized, little information exists on the methods of achieving it (7). Among reasons emphasizing the importance of ECG interpretation is the influence of multiple stresses when encountering it. The ability of senior house officers in the Accident and Emergency (A&E) Department to interpret electrocardiographs has been studied previously (8), nevertheless there are few studies aimed to compare the ability of emergency medicine (EM) residents in ECG interpretation with that of residents in other specialties (9). However, factors contributing to successful achievement of correct interpretation of ECG are mostly unknown. Since EM residents and internal medicine (IM) residents are usually the first to visit at bedside and start treatments based on patient's ECG, we intended to evaluate the ability of EM residents to interpret ECGs and to compare it with that of IM residents using various ECG samples.

Materials and Methods

Fifteen ECGs were selected by our cardiologist from the ECG SAR III program of the American College of Cardiology (ACC). The selection of ECGs was in a way that, each ECG was representative of what EM residents and IM residents are supposed to be able to diagnose. Especially, 5 of these were ECGs of emergent situations: myocardial infarction (Figure 1), ventricular tachycardia (Figure 2), pericarditis (Figure 3), Wolff-Parkinson-White syndrome (WPW) (Figure 4), and pulmonary emboli (Figure 5). With each ECG came a brief history of the patient. Participants were required to write down the definite diagnosis of each ECG without mentioning any differential diagnosis. Selected ECGs had defined diagnoses and the grading system is shown in table 1.

Since ECGs 6, 9, 10, 11, 12, 13, 14, and 15 had only one correct answer, -0.25 negative point was given if the answer was wrong or any differential diagnosis was mentioned.

In both studied education hospitals, IM residents attended weekly ECG training and other cardiology sessions held by attendees and cardiologists. They also participated in continual discussions about cardiac cases and ECG abnormalities through morning reports. Moreover, cardiology ward rotation was an educational course in internal medicine residency program and 50 ECGs on average per month were assessed by these residents.

On the other hand, EM residents averagely interpreted 8 ECGs during a 12 hour shift under the supervision of their attendees which equals 150 ECGs monthly. None of the EM residents had participated in cardiology rotation previously.

All participants were IM and EM residents at the end of their first or second year of residency.

A questionnaire containing questions about gender, academic year and proficiency in ECG interpretation was taken from all participants.

Participants were asked to report their ability of

ECG interpretation as excellent, good, moderate, or weak (excellent=4, good=3, moderate=2, weak=1). Consultation during the study was not possible for participants. In order to take theexamination, each participant was given 15 selected ECGs (each on an A4 paper) considering the standard principles of an examination. Duration of the exam was 45 minutes (3 minutes on average for each ECG). The maximum score for each ECG was 6 which was given to a completely correct diagnosis, thus the total score for 15 ECGs was 90.

After the test, the answer sheets were collected and were analyzed with SPSS program, by two of study authors who were kept blind to the real identities of participants.

The scoring system is shown in table 1. All participants were briefed before the commencement of study that 0.25 point is deducted from the total for each wrong answer and that they should not write any differential diagnosis for samples 6,9,10, 11,12,13,14, and 15, but only point out the definite answer. For instance, if MI and

Figure 1. A 48 year old CCU admitted male

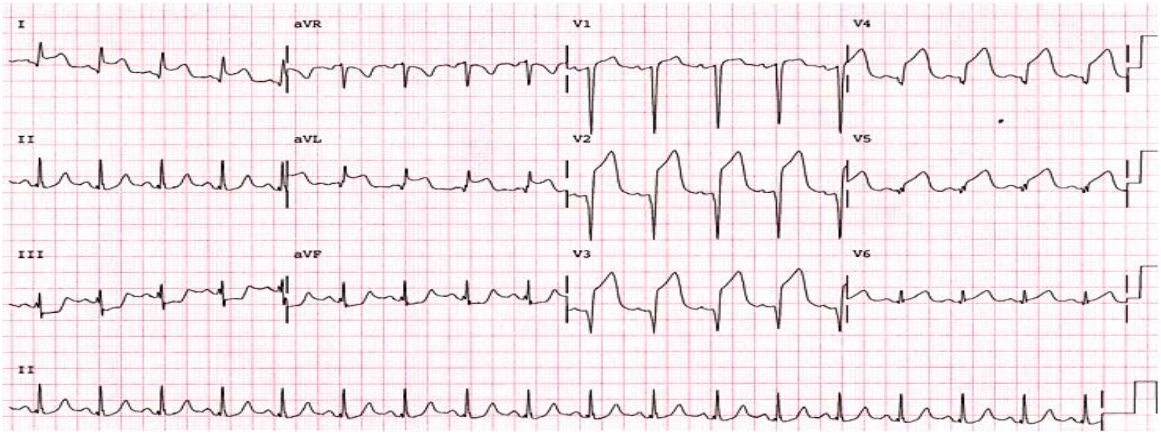

Figure 2. A 56 year old male with the history of cardiac disease who is brought to emergency unit with syncope

Figure 3. A 30 year old male who presented with chest pain

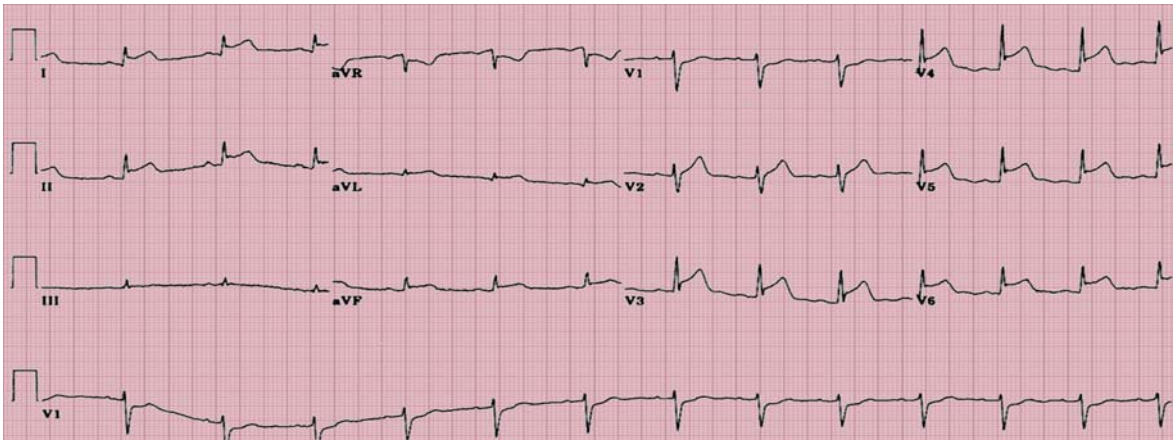

Figure 4. A 28 year old female who presented with vertigo

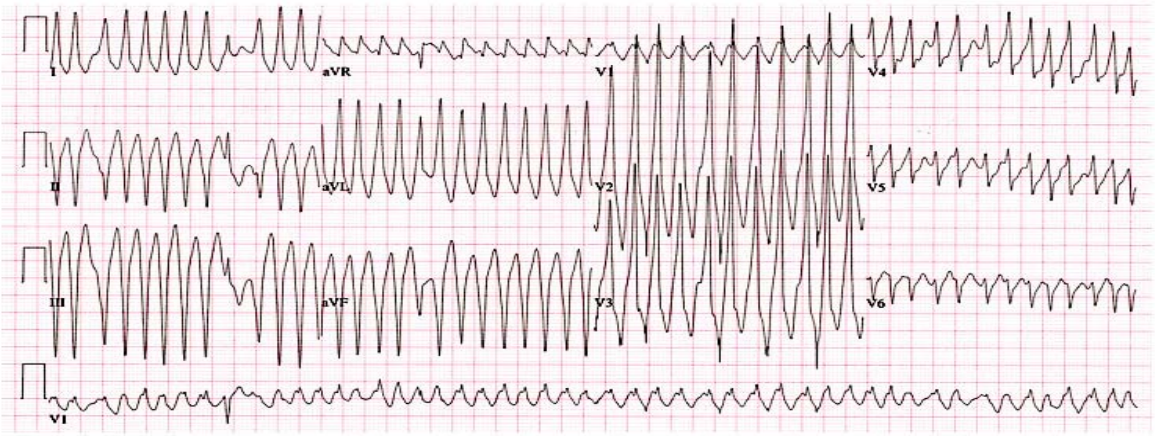

Figure 5. A 80 year old female who presented with chest pain

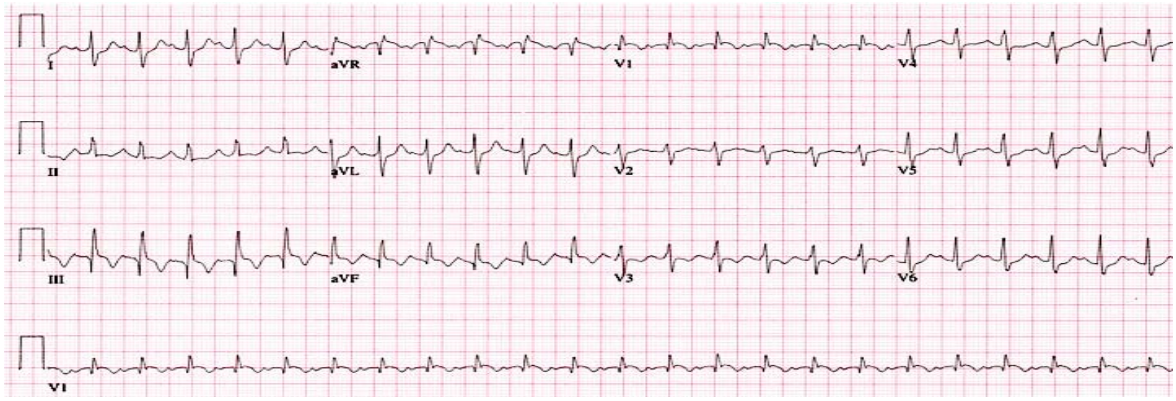

Table 1. The diagnoses of 15 selected ECGs and their scoring

No	Diagnosis	Score
1	Ectopic Atrial Tachycardia or Supra Ventricular Tachycardia Left Ventricular Hypertrophy	2 4
2	Sinus Bradycardia Ischemia Increased QT Interval	1 4 1
3	Sinus Rhythm Ventricular Scape Atrio Ventricular Block	1 2 3
4	Sinus Rhythm Premature Ventricular Complex Left Bundle Branch Block	1 2 3
5	Ischemia Myocardial Infarction : Anterior Septal Lateral	1 2 1.5 1.5
6	Ventricular Tachycardia	6
7	Sinus Rhythm Accelerated Idioventrular Rhythm Ventricular Tachycardia	1 2.5 2.5
8	Sinus Tachycardia Right Bandle Branch Block Anterior Hemiblock	1 2.5 2.5
9	Pericarditis	6
10	Early Repolarization	6
11	Wolf Parkinson White syndrome	6
12	Buargada Syndrome	6
13	Dextrocardia	6
14	Hypothermia	6
15	Pulmonary Emboli	6

pericarditis was written as the diagnoses of ECG number 9, for which was pericarditis, the participant would score a negative point value of 0.25.

Results

Thirty EM residents (16 at the end of their first year of residency, 14 at the end of their second year of residency) and thirty-three IM residents (16 at the end of their first year of residency, 17 at the end of their second tear of residency) from two education hospitals of Shahid Beheshti University of Medical Sciences were selected and enrolled in our study; 5 IM residents were on cardiology rotation; 16 (25.4%) were females. The mean ability of ECG interpretation according to the participants' self judgment was 2.13 out of 4; 2.06 for IM residents and 2.2 for EM residents (p=0.599(.

After classification of groups, the overall mean score was 45.5/100 (38-60). The mean score of

IM and EM residents was 56.0/100 (44.9-72) and 38.9/100 (31.5-45.5), respectively (p< 0.001). No statistically significant correlation was found between the diagnosis scores and participant's self-judgment on her/his ECG interpretation skills (p=0.897, r=0.017).

Five ECGs with the diagnoses of MI (number 5), ventricular tachycardia (number 6), pericarditis (number 9), WPW (number 11), and pulmonary edema (number 15) were considered as the most important and are demonstrated in figures 1-5.

Overall diagnosis accuracy of participants was 1.6 for MI, 2.6 for ventricular tachycardia, 2.9 for pericarditis, 2.8 for WPW, and 2.2 for pulmonary edema. Scores of the IM residents versus EM residents are as follows: 2.8 vs. 0.1 (p 0.001) for ECG 9 (pericarditis), 3.1 vs. 0.1 (p< 0.001) for ECG 11 (WPW) and 2.6 vs. 1.6 (p=0.003) for ECG 15 (pulmonary edema); there was no significant difference between the IM residents and EM residents in the diagnosis scores of ECG 5 (MI) or ECG 6 (ventricular tachycardia) which were 0.9 vs. 2.0 (p=0.232) and 2.0 vs. 2.9 (p=0.199) respectively. In general, the skill of ECG interpretation was higher in second year residents (table 3).

The scores of IM residents got higher with the increase in their year of residency (r=0.764, p 0.001) but this correlation was not found in EM residents (r=0.158, p=0.403).There was no correlation between year of residency and total score for ECGs 5, 6, 9, 11 and 15 (table 4).

Five (15.2%) of 33 IM residents had had cardiology rotations; they scored a mean of 84.5 (80.5-84.9) whereas the mean score of other IM residents was 63.3 (59.3-72.1) (p=0.002).

Although second year IM residents who had passed cardiology rotation scores higher points comparing to other second year residents

Table 2. ECG interpretation scores in critical ECGs

Definite diagnosis	Myocardial Infarction	Ventricular Tachycardia	Pericarditis	W.P.W	Pulmonary Emboli
IM (n= 33)	18 (54.5%)	18 (54.5%)	13 (39.4%)	18 (54.5%)	24 (72.7%)
EM (n=30)	16 (53.3%)	15 (50.0%)	0 (0%)	6 (20.0%)	28 (93.3%)
Nearly *Correct					
IM (n= 33)	14 (42.2%)	11 (33.3%)	10 (30.0%)	0 (0%)	2 (5.1%)
EM (n=30)	7 (23.3%)	4 (13.3%)	0 (0%)	0(0%)	0 (0%)
Without answer					
IM (n= 33)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
EM (n=30)	6 (20.0%)	4 (13.3%)	7 (23.3%)	0 (0%)	1 (3.3%)
Wrong **answer					
IM (n= 33)	1 (3%)	4 (12.1%)	10 (30.0%)	15 (45.5%)	7 (21.2%)
EM (n=30)	1 (3.3%)	6 (23.3%)	23 (76.7%)	24 (80.0%)	1 (3.3%)

Table 3. ECG interpretation scores based on the year of residency

Overall	1st year of Residency	2nd year of Residency	P Value
	(n=32)	(n= 31	
Self-Judgment (1-4)	2.1	2.2	0.655
Score (0-90)	43.4	54.7	0.037
Internal medicine	(n= 16)	(n= 17)	
Self-Judgment (1-4)	2.0	2.1	0.853
Score (0-90)	46.1	69.5	<0.001
Emergency medicine	(n= 16)	(n= 14)	
Self-Judgment (1-4)	2.1	2.3	0.612
Score (0-90)	40.6	36.8	0.403

Table 4. ECG interpretation scores for 5 important ECGs according to the year of residency

Myocardial Infarction	1st year of residency Scores	2nd year of residency Scores	P Value
Overall (n= 63)	5.30	4.87	0.273
IM (n= 33)	5.38	5.71	0.678
EM (n=30)	4.36	4.80	0.342
Ventricular Tachycardia			
Overall (n= 63)	4.53	4.28	0.887
IM (n= 33)	5.08	5.07	0.512
EM (n=30)	3.98	3.32	0.929
Pericarditis			
Overall (n= 63)	1.28	2.72	0.030
IM (n= 33)	2.77	5.10	0.030
EM (n=30)	-0.20	-0.18	0.533
Wolff- Parkinson- White			
Overall (n= 63)	1.16	1.98	0.631
IM (n= 33)	2.48	3.79	0.234
EM (n=30)	-0.17	-0.23	0.105
Pulmonary Emboli			
Overall (n= 63)	4.80	5.39	0.143
IM (n= 33)	4.38	4.88	0.279
EM (n=30)	5.23	6.00	0.178

**All of the scores are out of 6*

who had not passed this course, there was no significant difference between the mean scores of second year residents of both specialties when this group was omitted from the analysis.

Discussion

Jeffrey S.Berger demonstrated the total score of 14.5 (60%) for 12 ECG samples with maximum score of 24 (9). Frequency of misinterpretations has been estimated in several studies and 4-33% of these misinterpretations were related to very important diagnoses (7). Despite this, assessment of treatments based upon them reveals 0-11% of mistreatments(5,6,12,13). Despite thorough search through literature, we could not find an acceptable mean score for ECG interpretation skill; this is an important issue which needs to be defined by researchers in the future studies.

This study revealed that the ECG interpretation skill in IM residents was better compared to EM residents; also there is no correlation between the self judgment of participants on their ability and their attained scores. Also there was a statistically significant direct relationship between ECG interpretation skill and higher year of residency in IM residents; nonetheless such relationship was not found in EM residents which could be due to fewer number of the EM residents (9) .

According to the results of the current study, scores of the IM residents were higher in diagnosing pericarditis and WPW syndrome whereas there was no significant difference in diagnosing MI and ventricular tachycardia. Although this result could be caused by confounding factors such as the bias in the selection of ECGs, it should be studied more in the future. A group of previous studies have shown that ECG interpretation skill gets better with training. Hatal et al. tested 34 medical students, 15 IM residents and 15 cardiology residents using 8 ECG cases and demonstrated that training improves their skill to interpret ECG (14).

Gillespie et al. tested 26 junior house officers and 31 senior house officers using 8 ECG cases and showed that the scores and skills of senior house officers were compatible with predefined standards(2). ECG cases were representatives of common vital emergency states in which the residents were supposed to start immediate treatment; they included ventricular tachycardia, complete heart block, pericarditis and prolongation of QT-interval.

In the current study, evaluation of the answers to 3 important ECG cases revealed total frequency of misdiagnosis as 61.9% in WPW syndrome [consisting 15 (45.5%) of IM residents; 24 (80%) of EM residents], 52.4% in pericarditis [consisting 10 (30%) of IM residents; 23 (76.7%) of EM residents] and 16.3% in ventricular tachycardia[consisting 4 (12.1%) of IM residents; 6 (23.3%) of EM residents] (table 2). These cases require immediate diagnosis and misdiagnosis leads to serious consequences.

There is little information on how to become skillful in ECG interpretation. In 2001, the American Heart Association and the American College of Cardiology recommended that it's necessary to interpret at least 500 ECG cases; some references even mention up to 800 ECGs. In one study, it's been reported that before commencing any study for comparison of ECG interpretation skills, they must have been trained with 100 ECG cases on average (15).

This study does not suggest a definite number of ECG cases in order to improve ECG interpretation skill but it's obvious that the current standard education of ECG is not adequate to meet the needs. There are various methods for improving the ECG interpretation skill; it's been proven that even one brief ECG training course improves this skill (10) but its efficiency in long-term is not clear.

Also some studies demonstrated that training via computers, improves this skill (16,17). Furthermore if the ECG case is associated with a patient history, could result in higher interpretation accuracy (14). The goal of our next study will be to determine if a high quality ECG training course, results in long-term improvement of ECG interpretation skill.

This study had several limitations. Firstly, few

participants could be a reason in finding no correlation between higher academic level and better ECG interpretation skill in EM residents. Secondly, the number and type of selected ECG samples was subjective and although we believed that the selected ECG cases were representative of actual situations, there was a possibility of getting different results in case of facing other ECG samples. Thirdly despite the fact that our scoring criteria were based on a standard test, other scoring methods exist (24). The important point of our study, according to previous notification to participants, was assigning negative point values to the answers which considered more than one diagnosis for the ECGs which were important differentials of each other with totally different treatment approaches; the reason for choosing this approach was to encourage residents to do their best effort to reach their best diagnostic guess. Another important issue is that there is no predefined schedule for classic ECG training in the curriculum for emergency residents and their education is mostly performed by attending on patients' bedside.

In previous studies, it's been demonstrated that mentioning the clinical situation of the patients besides their ECGs, results in increased ECG interpretation accuracy (18) and this is essential for proper assessment of ECG (14, 19).

Finally, this study has been conducted in two educational centers with similar ECG training methods; other results are possible in different centers with different training methods.

Overall we demonstrated that there are several weaknesses in ECG interpretation skills which could be very important for treatment of patients and there is a need to more training programs especially for cardiac emergencies. Our next studies will focus on the best methods of achieving ECG interpretation and diagnosis skill.

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