Addis Ababa University

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Department of Emergency and Critical Care Medicine

Competency in ECG Interpretations among Graduating Medical Students: Experience from two Ethiopian Medical Schools

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A thesis submitted to Addis Ababa University, College of Health Sciences, School of Medicine, Department of Emergency and Critical Care Medicine, in partial fulfillment of the requirements for the degree of specialty in Emergency and Critical Care Medicine

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LIST OF ABBREVIATIONS

AAU: Addis Ababa University

AV: Atrioventricular

ECG: Electrocardiography

ED: Emergency Department

FTP: Focused teaching program

GMS: Graduating Medical Students

GP: General Practitioners

HU: Haramaya University

PEA: Pulseless electrical activity

Vfib: Ventricular fibrillation

Vtac: Ventricular tachycardia

STEMI: ST segment Elevation Myocardial Infraction

ABSTRACT

Background: Electrocardiography (ECG) is the graphical display of electrical potential differences of an electric field originating in the heart. It is a commonly used procedure for the diagnosis of heart disease. Interpretation of ECG is a core clinical skill in emergency and critical care medicine. Only a few studies have been performed to evaluate the ECG interpretation skills of general practitioners worldwide. There is no study published until now in Ethiopia on the competence of ECG interpretation among graduating medical students.

Objective: To assess competency of ECG interpretation among 2018 graduating Class medical students in Addis Ababa University and Haramaya University.

Methodology: A cross-sectional study was conducted on graduating medical students at Addis Ababa University and Haramaya University. Data had collected from October 01, 2018, to October 30, 2018, by using structured questionnaires. Data were entered, cleaned, edited and analyzed by using SPSS version 25.0 statistical software. Descriptive statistics, cross-tabs, Chi-square, Mann-Whitney U test, and Binary logistic regression were utilized.

Results: 202 graduating medical students were involved on this study, out of this 61.3% (95% CI 56.3 – 66.3%) and 32.75% (95% CI 28.25-37.25) were able to correctly interpret the primary ECG parameters and the arrest rhythm of ECG abnormalities, respectively. The ability to detect from common emergency ECG abnormalities were Anterio septal ST segment elevation myocardial infraction, atrial fibrillation and first-degree atrioventricular block were 42.6%, 39.1% and 32.1% respectively.

Conclusion: This study showed graduating medical students had low competency in ECG interpretations.

Keywords: Competency, ECG abnormalities, ECG interpretation, Graduating medical students

1. INTRODUCTION

1.1. Background

Electrocardiography (ECG) is the graphical display of electrical potential differences of an electric field starting from the heart and, recorded at the body surface. It was introduced in 1902 by Einthoven. It is a unique laboratory procedure, which records the electrical activity of the heart, that provides information not readily obtained by another investigation modality (1). It is a frequently used investigation for the diagnosis of heart disease and electrolyte abnormalities. ECG abnormalities may be the first sign of myocardial infarction, electrolyte disturbance, or life-threatening dysrhythmias (2, 3). The advantages of the accurate interpretation of ECG have also shown in patients with cardiac arrest or acute myocardial infarction, in which ECG signs directly determine appropriate management (3). This investigation is simple and easily reproducible (1).

Accurate interpretation of ECG is an essential skill in emergency medicine (3). The 12-lead ECG is a common diagnostic test in the evaluation of patients with cardiac symptoms. In day to day clinical practice, it is important for physicians and graduating medical students to know the accuracy of their ECG interpretation skills to correctly rule out the presence of cardiac disease or manage their patients (4).

ECG interpretation is a core skill for the undergraduate medical students. There are specific ECG strips shows conduction and rhythm abnormalities that should be interpretable to be conceived competently (5). An increasing number of primary care health providers now have the facilities to perform the ECG. Most of the general practitioners have no extra training or course on ECG interpretation skill. These factors may impose some constraint on the value of this investigation and use of this investigation with-relative infrequency (6).

Studies from various countries have revealed deficiencies in ECG interpretation among medical students and physicians (3). Best teaching method for ECG interpretation remains unclear (7). Only a few studies have been performed to evaluate the ECG interpretation skills of General practitioners (4).

ECG interpretation skills vary among medical students, general practitioners (GP) and specialists. Accurate diagnosis of ECG abnormalities by a physician in any specialty contributes to appropriate clinical decision-making. Correct ECG interpretation assumes technical standards adhere to during the acquisition and recording of tracings. Many technical and patient-related factors may alter the quality of recorded ECG strips. These ECG strip artifacts in clinical practice must be recognized by the physician (1).

1.2. Statement of the Problem

Most of the patients who visit the emergency department (ED) had ECG abnormalities. A study performed in Ontario, Canada, showed up to 29% patient with acute myocardial infarction was missed in ED. It causes higher mortality and morbidity of the patient. In Portugal, where undergraduate programs are firmly established, the overall accuracy of GP for detecting ECG abnormalities were 81.0% (8). The overall missed case rate for all seven ED were 12.8% (9). The study performed at Albert Einstein College of Medicine, Beth Israel Medical Center, New York, NY, USA on first-year internal medicine resident revealed merely 50% of ECG reading were correct (10).

Interpretation of the ECG is a core clinical ability that ought to be developed in undergraduate medical education. In order to reduce mortality from cardiac and metabolic emergencies, graduating medical students (GMS) need to be assed for competency in ECG interpretations. Appropriate ECG interpretation will improve patient care at ED and early referral to tertiary health center. However, studies from various countries have revealed deficiencies in ECG interpretation among medical students and physicians [3]. Most of GMS do not feel competent in interpretation of ECG. In the extension this could negatively influence patient management decisions (1). Incorrect interpretation of ECG findings can result in inappropriate management decisions with the adverse and sometimes fatal patient outcome (4).

In Ethiopia, the Ministry of health standards for medical faculties specify that medical graduate should be able to perform and interpret standard resting 12 lead ECG. However, there have been no protocol in medical schools which guarantees competency in ECG interpretation. Therefore, this study aimed to assess the fundamental skills in the interpretation of

ECG among Ethiopian graduating medical students and analyzed whether the skills are developed during the process of medical education.

1.3. Significance of the Study

The ability to accurately interpret ECG abnormalities is a core competency for a medical school graduate. Incorrect interpretation of ECG findings can result in inappropriate diagnosis, management and fatal patient outcome.

This study will evaluate the effectiveness of the structured teaching program on knowledge and practice regarding interpretation of the electrocardiogram (ECG) among graduating medical students (GMS) in Addis Ababa University (AAU) and Haramaya University (HU), Ethiopia.

To our knowledge, there has been no study published evaluating the level of competency in ECG interpretation in medical students graduating from medical schools in Ethiopia. This study is expected to come up with better information on competency of GMS in basic ECG interpretation, picking common life threating arrhythmia and common ECG abnormalities. This study will also be used as base line for further studies on this area.

2. LITERATURE REVIEW

A Web-based survey done in all Polish undergraduate medical schools, which enrolled 536 medical students (most (72%), were in their clinical years), showed that only 164 (31%) participants assessed their ECG interpretation skills as good; these were more often students in their clinical rather than preclinical years. The competency in ECG interpretation was higher in students who reported ECG self-learning (69% vs. 62%; P < 0.0001) but no difference was found between students who attended or did not attend regular ECG classes (66% vs. 66%; p=0.99). Most students of clinical years (86%) were able to correctly interpret the primary ECG parameters such as heart rate, heart rhythm and electrical axis of the heart; 69% of them were able to recognize ECG emergencies and only 58% were able to recognize common ECG abnormalities such as ischemia, rhythm disorder, and cardiac chambers hypertrophy. The overall rate of correct responses was 66%. On multivariable analysis (P < 0.0001), being in clinical years (OR: 2.45 [1.35-4.46] and self-learning (OR: 2.44 [1.46–4.08]) determined competency in ECG interpretation (3).

According to the study done at George Washington University school of medicine to determine competency in ECG interpretation among GMS, which was done on 168 GMS (63 incoming house staff and 22 graduating internal medicine house staff), showed significantly associated with GMS rating of importance of ECG interpretation to their future work as interns (p < .001). Similarly, 77% of GMS rated accurate ECG interpretation as very important or extremely important to their future work as practicing physicians. On the 6 life-threatening ECGs, GMS scored lower than graduating residents (3.4 *SE* = 0.191 vs. 4.6 *SE* = 0.541; *p* < .0002). Mean score in the GMS' group was associated with increasing levels of reported confidence and degree of ECG experience (11).

In prospective cross-sectional study done in Netherland to assess the skills of final year medical students and resident medical officers in recognizing and interpreting important common or life-threatening abnormalities in the electrocardiogram (ECG) 102 participants at two study sites (52 of whom were final year medical students) attempted to determine the heart rate and rhythm and identify and interpret any abnormalities present in 15 ECGs in a 30-minute time period were involved. Of these, 50% had received no formal training in ECG interpretation, although 89% had tried to learn ECG interpretation from books. Only 9% were

felt confident in their interpretation of ECG tracings. Of the rhythm-strips, 100% were correctly identified VF, 96% recognized VT, and 67% identified complete heart block. Of the 12-lead ECG tracings, 61 % recognized the MI, 54% recognized AF, and only 46% successfully identified the normal ECG as such. The group was significantly worse at 12-lead ECG interpretation compared to rhythm-strips ($P < 0.01$). The members of the group who had received formal training in ECG interpretation were significantly better at interpreting both rhythm-strips and 12-lead ECG tracings ($P < 0.05$). Accurate determination of heart rate was poor, ranging from 0% to 89% correct across the 15 ECGs. Normal sinus rhythm in 8 ECGs was identified 81% to 95% of the time, and ventricular tachycardia was identified by 98% of participants. Atrial fibrillation (55%), second-degree heart block (19%) and ventricular pacing (9%) were not well identified. Four ECGs showed acute ischemic ST-segment changes, and these were correctly identified in 87% to 93% of cases, although interpretation of these abnormalities was less accurate. Nearly half of the participants have rated their ability to interpret ECGs as less than satisfactory while just over half rated the ECG teaching, they had received as less than satisfactory (7).

The similar study was done on final-year medical students who had successfully completed their written final examinations, to interpret three rhythm-strip tracings, and three 12-lead ECG tracings. Of these, 50% had received no formal training in ECG interpretation, although 89% had tried to learn ECG interpretation from books. Only 9% were felt confident in their interpretation of ECG tracings. Of the rhythm-strips, 100% correctly identified VF, 96% recognized VT, and 67% identified complete heart block. Of the 12-lead ECG tracings, 61 % recognized the MI, 54% recognized AF, and only 46% were successfully identified the normal ECG as such. The group was significantly worse at 12-lead ECG interpretation compared to rhythm-strips ($P < 0.01$). The members of the group who had received formal training in ECG interpretation were significantly better at interpreting both rhythm-strips and 12-lead ECG tracings ($P < 0.05$) (12).

A study was performed in the district of Ebeltoft, Denmark, from December 1991 to June 1992 on ECG interpretations in general practice showed Overall, the sensitivity of abnormal diagnoses made by the GPs (69.8%) was significantly lower (P 0.001) than that of diagnoses made by the interpretive ECG recorder (84.4%). The overall specificity of abnormal diagnoses

made by the GP (85.7%) was significantly higher (P 0.001) than that achieved by the interpretive ECG recorder (75.6%) (**4**).

A prospective comparative study was conducted to assess the effect of two various learning strategies (focused teaching program (FTP) and self-directed learning (SDL)) on confidence in ECG interpretation for undergraduate and postgraduate medical trainees. There were 26 post graduate first year doctors and 36 third year medical students based at Worcester Royal Hospital during the study period. The FTP group of undergraduates demonstrated a significant difference in successfully interpreting "ventricular tachycardia" (P = 0.046) and "narrow complex tachycardia" (P = 0.009) than the SDL group. Participant confidence increased in both learning strategies. FTP confidence demonstrated a greater improvement than SDL for both cohorts. The study concluded a dedicated teaching program can improve trainee confidence and competence in ECG interpretation. A larger benefit is observed in undergraduates and those undertaking an FTP (5).

A study was conducted with the purpose to the evaluate accuracy of ECG readings done by GPs by comparison with those done by a cardiologist as the gold standard. 195 ECGs were collected consecutively during the first semester of 2010 in an urban Health Centre of Portugal. Each ECG was read by each physician, and inter-observer agreement was evaluated. Results revealed inter-observer agreement between GP readings was "good" with an intraclass correlation coefficient of 0.727 (CI 95%: 0.670–0.779). When compared with gold standard, GP achieved a "good" agreement with an intraclass correlation coefficient of 0.712 (CI 95%: 0.659–0.762). The general accuracy of GP for detecting abnormalities was 81.0% (95%CI: 75.7–85.6%), with a sensitivity of 84.8% (95%CI: 77.3–90.6%) and a specificity of 77.5% (95%CI: 69.7–84.2%). For normal tests, accuracy was 79.9% (95%CI: 74.7–84.3). In the most prevalent classes of abnormalities, accuracy was more superior than 90%. Study concluded GP practiced good skills in reading ECGs in their practice of Primary Care. Better attention should be focused to ischemic abnormalities present on ECGs (8).

A survey was conducted to examine the interpretation of ECGs in primary and secondary care and a total of 262 primary care clinicians and 20 cardiology clinicians were surveyed via the questionnaire. In primary care, abnormal ECGs were interpreted as normal by 23% of responders. ST elevation and prolonged QT were incorrectly interpreted as normal by 1% and

22%, respectively. In cardiology, abnormal ECGs were interpreted as normal by 3%. The study concluded ECG provision and interpretation remains inconsistent in both primary and secondary care. Primary care practitioners are rarely experienced and less confident with ECG interpretation than cardiologists, and require support in this area (13).

3. OBJECTIVES

3.1. General Objective

- To assess competency in ECG interpretation among 2018 graduating class medical students in Addis Ababa university and Haramaya university.

3.2. Specific Objectives

- To assess ECG interpretation skills among 2018 graduating Class medical students in Addis Ababa University and Haramaya University;
- To compare ECG interpretations skill of Addis Ababa University graduating class medical students with Haramaya University graduating class medical students and
- To identify factors associated with competency of ECG interpretations among graduating medical students.

4. METHODS

4.1. Study Area

The study was conducted at AAU, College of health science and HU, college of health and medical science. AAU was formed with the establishment of the University College of Addis Ababa (UCAA) in 1950, and the School of Medicine was established in 1972. HU was established in 1950, which is located at about 510 km East of Addis Ababa, between Dire Dawa and Harar towns. The Haramaya University School of Medicine was established in 2007, which is located at the Harar Campus about 515 km east of the capital, Addis Ababa. AAU school of medicine had Emergency medicine rotation as curriculum while in 4th year. HU school of medicine did not have Emergency medicine rotation as curriculum. There was no Emergency medicine physician in HU.

4.2. Study Design and Period

A cross-sectional study was employed. The study was conducted from October 01, 2018, to October 30, 2018.

4.3. Source of Population

Source of population of this study were Medical students of HU and AAU.

4.4. Study Population

The study population was Addis Ababa University and Haramaya University 2018 graduating class medical students, who agreed for answering the questionnaire.

4.5. Inclusion and Exclusion Criteria

4.5.1. Inclusion criteria

All medical students graduating in 2018 from HU and AAU, who practiced for more than 9 months.

4.5.2. Exclusion Criteria

A. Who are not willing or unable to participate for different reasons was excluded.

B. On attachment rotation less than 9 months because of possible lack of enough experience and awareness on EM training.

4.6. Variables

4.6.1. Dependent Variables

- ✓ Competency of ECG interpretations

4.6.2. Independent Variables

- ✓ Undergraduate Emergency medicine rotation
- ✓ ECG class
- ✓ Previous training (other than undergraduate ECG class) on ECG interpretations
- ✓ Frequency of use of ECG machine per month
- ✓ Frequency of previous ECG interpretation
- ✓ ECG interpretations as part of exam
- ✓ Self Confidence for ECG interpretations
- ✓ Frequency of asking for help
- ✓ Self-learning methods

4.7. Operational Definition

Competency: is consistent with competency greater than or equal to 80% of correct answers; this is a commonly-used threshold for a good grade on exams (3).

ECG training: a course or demonstration on ECG given to medical students other than formal ECG class.

Knowledge: It refers to the understanding of all information regarding interpretation of ECG.

Interpretation of ECG: It refers to interpretation of ECG in order to differentiate certain aspects such as heart rate, rhythm, conduction analysis, and detecting of abnormal ECG strips.

4.8. Sample Size and Sampling Techniques

Sample size will be determined will be determined by using Eq. 1.

$$N = \frac{z^2 P(1-P)}{d^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 1}$$

$$N = \frac{(1.96^2)(0.5)(0.5)}{(0.05^2)}$$

$$= 384$$

Final correction formula for N < 10,000

$$N = \frac{n}{1 + \frac{n}{N}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{Eq. 2}$$

$$N = \frac{384}{1 + \frac{384}{420}}$$

$$= 200.5 \sim 200$$

Where n= sample size, N= source population, P= degree of variability= 0.5, d= margin of error. Five percent non-respondent rate added, and final sample size was 210 graduate medical students. Graduate medical students were selected randomly from HU and AAU.

4.9. Data Collection Instruments and Procedure

ECGs were selected from the ECG textbooks and ECG web blogs. After the ECG strips selection, the previous questionnaire was modified and included in the final questionnaire. Pretested and reviewed structured questionnaire were distributed to the study participants. The examination has consisted of basic information of GMS and ECGs, including a specific focus on basic, arrest ECG rhythms and common emergency ECG abnormalities strips. The ECG examination was administered to GMS. Performance on the ECG examination was correlated with self-reported confidence in ECG interpretation, student rating regarding the adequacy of ECG training, and the number of ECGs and use of ECG machine evaluated during the prior month.

4.10. Data Quality Control

Before starting the data collection, questionnaires were checked and pretest was performed on 5 % of study participants. After data collection, the questionnaires were checked by data collector for completeness.

4.11. Data Analysis

The collected data were coded and entered to SPSS 25. The proportions of correct answers to individual questions were calculated by dividing the number of correct answers to a question by the total number of answers to this question.

Categorical variables were described as counts and percentages. Continuous variables were described as means, standard deviations, and standard errors. Man-Whitney U test was used to compare the mean score of groups for their correct answers. Chi-square test was used to compare differences in ECG interpretation skills, with significance level was set at $P < 0.05$.

Binary logistic regression was implemented to assess which factors significantly influence competency in ECG interpretation. The outcome variable was the correct answer to at least 14 questions, which is consistent with competency greater than 80%; this is a commonly used threshold for a good grade on exams (3).

4.12. Ethical Consideration

An official formal letter was written from Addis Ababa University College of health sciences, Department of Emergency and Critical care medicine to get permission to conduct this study. Involvement of the participants in the study was on a voluntary basis. Confidentiality of information was maintained by removing the student's name.

5. RESULTS

5.1. Characteristics of Study Participant

In this study, 202 graduating medical students (Males: n=117, 57.9%; Females n=85, 42.1%), aged 23 to 28 (24.66 ± 1.04) years from both HU (102 GMS) and AAU (100 GMS) medical schools participated and completed the questionnaires. In this study, the nonresponse rate was 3.8 %. Characteristics of the study participants are displayed in table 1. Almost half of the medical interns (49.5 %) received ECG class which were from AAU in the 4th year (clinical year two) of study. Most of the medical students 78 (78%) feel ECG class was not enough. Only Seventy-two (35.6%) of GMS received ECG interpretation as part of the assessment.

Forty-eight percent of GMS did not used ECG machine at all. Forty-five percent of GMS were not interpreted ECG at all. Majority of HU GMS (59.8%) did not interpreted ECG per month. One hundred nineteen GMS 119 (58.9%) were always asked help for the interpretation of ECG and only 10 (5%) of GMS did not asking at all, as it is shown in table 1

Table 1: Characteristics of the study participant

		Place		Total
		AAU	HU	
Age (years) mean ± SD		24.1 (± 0.689)	25.21 (±1.037)	24.66 ± 1.04
Gender	Male	55 (55%)	62 (60.8%)	117 (57.9%)
	Female	45 (45%)	40 (39.2%)	85 (42.1%)
Received ECG class		100 (100 %)	-	100 (49.5%)
Fully attending ECG class	Yes	85 (85%)	-	
	No	15 (15%)	-	
Amount of ECG classes	Enough	22 (22%)	-	
	Not enough	78 (78%)	-	
ECG interpretation as part of the exam	Yes	72 (72%)	-	72(35.6%)
	No	28 (28%)	-	28 (13.9%)
Frequency of ECG machine use per month	<5	22 (22%)	22 (21.6%)	44 (21.8%)
	5-10	6 (6%)	6 (5.9%)	12 (5.9%)
	>10	30 (30%)	13 (12.7%)	43 (21.3%)
	Not at all	42 (42%)	61 (59.8%)	103 (51.0%)
Frequency of ECG Interpretations per month	<5	49 (49.0%)	38 (37.2%)	87 (43.1%)
	5-10	6 (6.0%)	2 (2.0%)	8 (4.0%)
	>10	15 (15.0%)	1(1.0%)	16 (7.9%)
	Not at all	30 (30.0%)	61 (59.8%)	91 (45.0%)
Asking help for ECG interpretations	Rarely	6 (6%)	3 (2.9%)	9 (4.5%)
	Sometimes	36 (36%)	28 (27.5%)	64 (31.7%)
	Always	52 (52%)	67 (65.7%)	119 (58.9%)
	Not at all	6 (6%)	4 (3.9%)	10 (5.0%)

Only eighty-two (40.6 %) of GMS from the participant had received ECG training from medical staff other than formal medical school teaching, and fifty-three (64.6%) of GMS of them were from HU. Most of GMS (50.5%) rated their level of confidence in ECG interpretation as not confident (figure 1). The confidence level of GMS in ECG interpretation was associated with performance on the 17 ECG examinations.

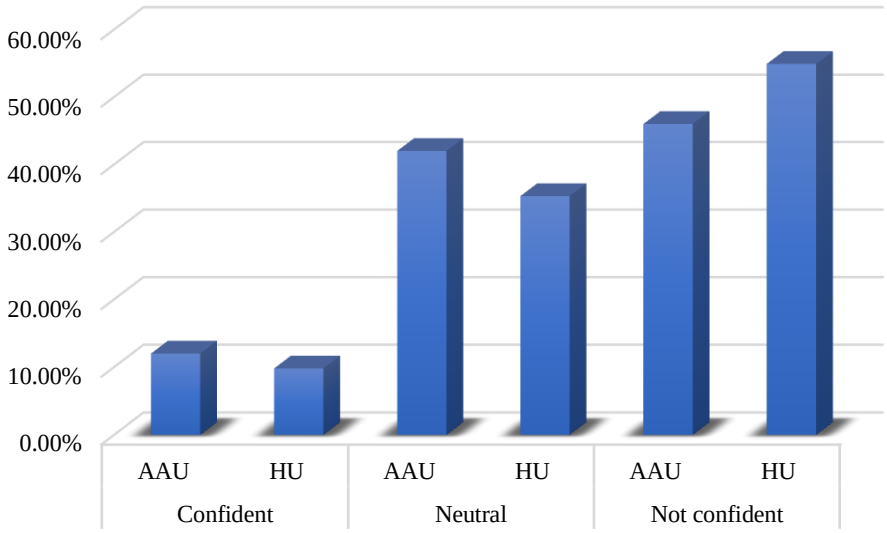

Figure 1: Confidence rating response for ECG interpretation

One hundred thirty-five (66.8%) of GMS got help from residents for ECG interpretation as it is shown in figure 2.

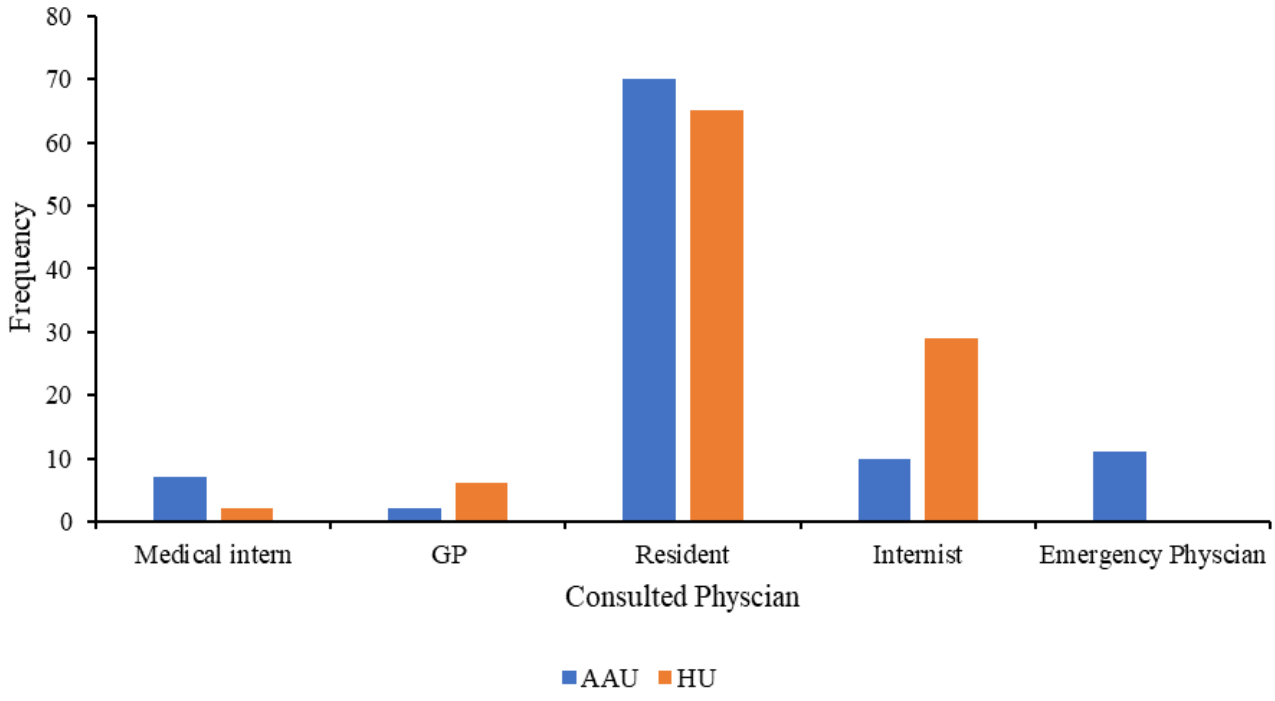

Figure 2: Consulted physician for ECG abnormalities

One hundred nineteen (58.9 %) of the group had tried to teach themselves ECG interpretation. Off these, 33.6 % use internet, 30.3 % use textbooks and 21% of GMS use video as self-teaching methods as it is shown in figure 3.

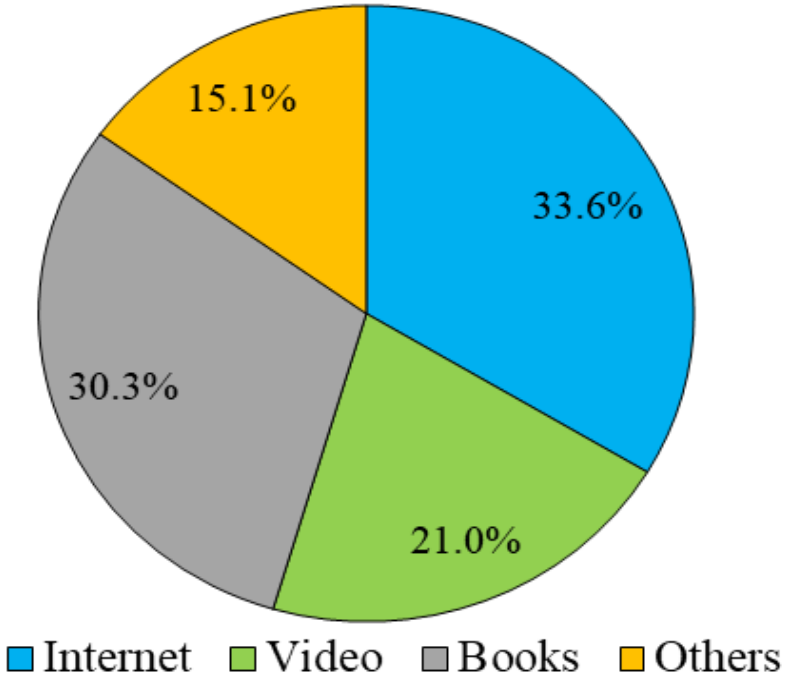

Figure 3: Types of self-teaching methods

5.2. Competency in ECG Interpretation

The percentage of accurate answers given for each of the 17 ECGs for both AAU and HU GMS are presented in Table 2. AAU GMS obtained a significantly higher mean score of answer 8.97 (SE= 0.41) when compared to HU GMS 3.33 (SE= 0.352) on the 17 ECGs. There were no individual ECG tracings where HU GMS performed better interpretation score than AAU GMS. In this study, the overall average of ECG interpretation was 35.9% [95% CI, 32.06–39.8%]. The AAU group gained an overall average of 52.65% (95% CI 47.88–57.41%), while HU group had 19.41% (95% CI 15.47–23.71%) with $P < 0.001$. Overall In this study, the competency in ECG interpretation was 20.8% (score ≥80%). The competency in ECG interpretations of GMS of AAU and HU; who score ≥80% of were 36.0% and 5.9% respectively. There was an improvement in ECG interpretation between HU and AAU groups, who had an Emergency medicine rotation in an undergraduate class in this study ($P <0.001$).

Table 2: Correct answer for each ECG abnormalities

ECG Finding	Place		Total	Pearson Chi-square test
	AAU	HU		
Heart rate	85(85.0%)	48 (47.1%)	133(65.8%)	< 0.001
Rhythm	91(91.0%)	64(62.7%)	155 (76.7%)	< 0.001
Axis	46(46.0%)	39(38.2%)	85(42.1%)	0.165
Asystole	73(73.0%)	20(19.6%)	87(43.1%)	< 0.001
Ventricular tachycardia	72 (72.0%)	11(10.8%)	83(41.1%)	< 0.001
Ventricular fibrillation	70(70.0%)	13(12.7%)	83(41.1%)	<0.001
PEA	5(5.0%)	--	5 (2.5%)	0.028
Atrial fibrillation	56(56.0%)	23(22.5%)	79(39.1%)	< 0.001
STEMI (Anteroseptal)	71(71.0%)	15(14.7%)	86(42.6%)	< 0.001
STEMI (inferior)	41(41.0%)	13(12.7%)	54(26.7%)	< 0.001
Hyperkalemia	45(45.0%)	22(21.6%)	67(33.2%)	< 0.001
First degree AV Block	56(56.0%)	19(18.6%)	75(37.1%)	<0.001
Second degree AV Block	45(45.0%)	6(5.9%)	51 (25.2%)	< 0.001
Third degree AV Block	38(38.0%)	11(10.8%)	49(24.3%)	< 0.001
LBBB	42(42.0%)	12(8.8%)	54(26.7%)	< 0.001
LVH	21(21.0%)	13(12.7%)	34(16.8%)	0.044
Pericarditis	50(50.0%)	17(16.7%)	67(33.2%)	< 0.001

PEA- pulseless electrical activity; STEMI- ST Segment elevation myocardial infraction; AV- Atrioventricular; LBBB- Left bundle branch block; LVH- Left ventricular hypertrophy

5.2.1. Basic ECG findings

In this study 61.3% (95% CI 56.3 – 66.3%) of GMS were able to correctly interpret the primary ECG parameters, such as heart rate, heart rhythm and an electrical axis of the heart. Overall Only 33.7% of GMS was competent (> 80%) for basic ECG interpretation. AAU GMS was more competent than HU GMS (37.0% v^s 30.4% respectively; P < 0.001).

One hundred thirty-three (65.8%) GMS identified heart rates accurately. Only 85(42.1%) of GMS identified axis of ECG correctly. On thus three basic ECG interpretation mean score for correct answer was 1.84; SE = 0.079. AAU GMS had higher mean correct answer than and HU GMS (2.23; *SE* = 0.079 vs. 1.46; *SE* = 0.122), See table 2. The difference was statistically significant with Mann-Whitney U test (U = 1.84, P < 0.001).

5.2.2. Arrest rhythm ECG abnormalities

The competency (≥80%) of ECG interpretation was assed for arrest rhythms, like asystole, PEA, Vtac, and Vfib; and only 3 (1.5%) of GMS were competent and is presented in figure 5. There was no GMS from HU was answered more than 80%. In this study, the average score of arrest rhythm was 32.75% (95% CI 28.25-37.25). AAU GMS had higher mean correct answer than and HU GMS (2.21; *SE* = 0.016 vs. 0.43; *SE* = 0.081). The difference was statistically significant with Mann-Whitney U test (U = 1.31, P < 0.001).

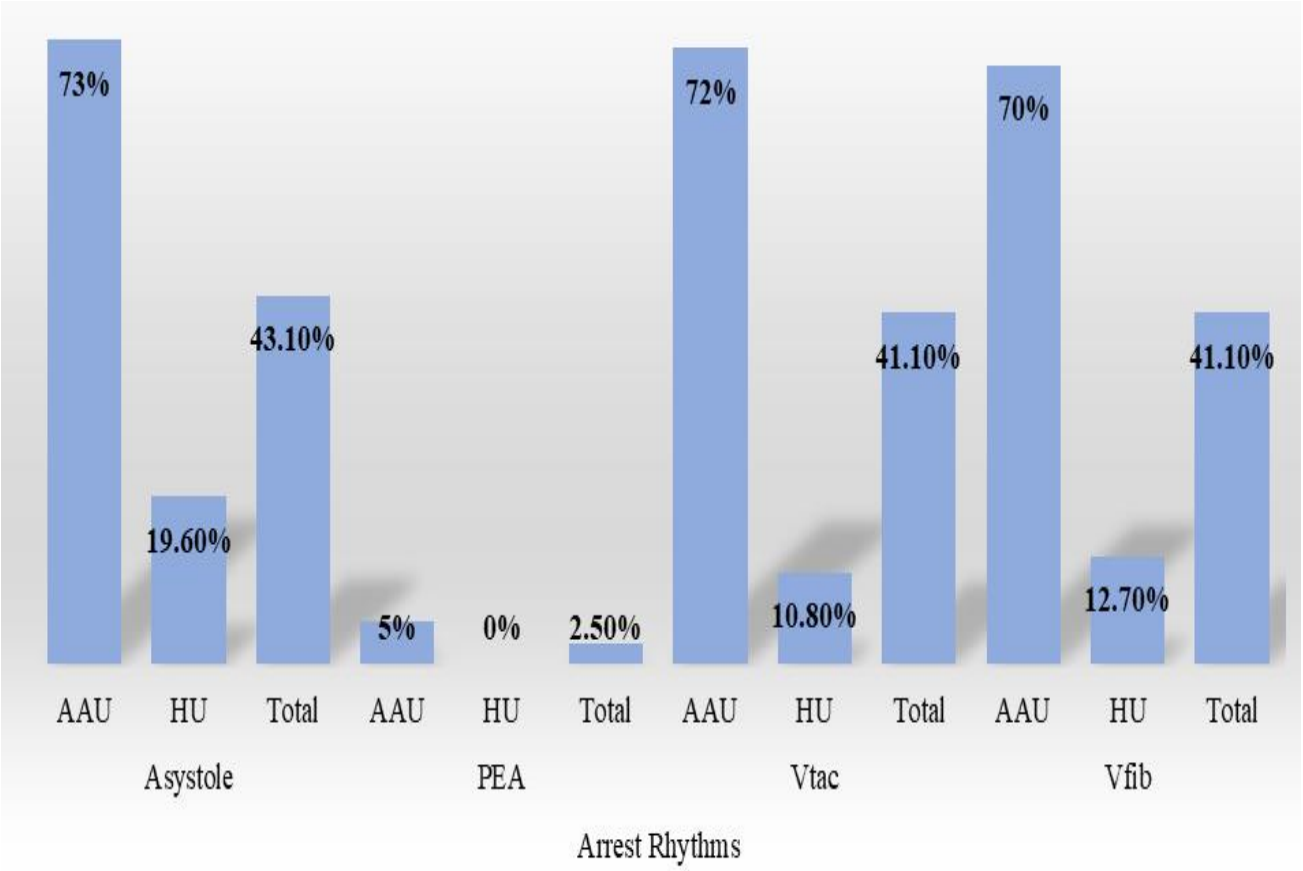

Figure 4: Arrest rhythms

5.2.3. Common life-threatening emergency ECG abnormalities

Competency of ECG abnormalities for the list 10 ECG were assessed, i.e. atrial fibrillation, Anterio septal and inferior ST segment elevation myocardial infraction (STEMI), Hyperkalemia, First degree AV block, second degree AV block, third-degree AV block, LBBB, LVH and pericarditis.

In this study 30.4% (95% CI 26.0 – 34.9%) of GMS were able to correctly interpret common life-threatening ECG abnormalities. The mean score of accurate answer for 10 common emergency ECG abnormalities was 3.04 (SE = 0.225). On thus 10 usual emergency ECG abnormalities AAU GMS had higher correct answer than HU GMS (4.69; *SE* = 0.331 vs. 1.43; *SE* = 0.232). The difference was statistically significant with Mann-Whitney U test (U = 3.04, P < 0.001).

Overall only 19.3% of GMS were competent for interpretation of common life-threatening ECG abnormalities. AAU GMS were more competent than HU GMS (33.0% v_s 5.9% respectively; P-value < 0.001).

The ability to detect from common ECG abnormalities was Anterio septal STEMI, Afib and first-degree AV block were 42.6%, 39.1%, and 32.1% respectively. The inferior myocardial infarct was recognized by 54 (26.7 %) of the group. The least identified ECGs by the group was third-degree AV block and LVH (24.3% & 16.8% respectively) (Table 2).

5.3. Factors Affecting Competency in ECG Interpretation.

In this study, the overall accuracy of ECG interpretation of GMS in their ECG interpretations was similar in the male and female (COR = 1.232 (0.614-2.474)).

In the uni-variable analysis, ECG class; undergraduate emergency medicine rotations; ECG interpretation as part of the exam; university of undergraduate study; confidence level; and frequency of ECG interpretation per month were associated with the competency of ECG interpretation (Table 3). GMS, who received ECG class and who had emergency medicine rotation were 9.000 times more competent in ECG interpretation than who did not have (COR=9.000 (3.586 - 22.591)). GMS, who were from Addis Ababa University 9.000 times more competent in ECG interpretation than who were not (COR=9.000*(3.586-22.591)). GMS who received ECG interpretation as part of the exam was 5.273 times more competent than who did not have (COR=5.273 (2.543-10.935)). GMS, who was confident and neutral in ECG interpretation were 3.875 and 5.471 times more competent in ECG interpretation than GMS who were not confident and neutral (COR = 3.875 (1.213-12.376), 5.471 (2.39-12.522), respectively). GMS, who had 5-10 ECG interpretation per month were 3.950 times more competent than who did not interpret at all (COR = 3.950(0.834-18.701)).

In multivariable analysis, place of the university; ECG class; undergraduate emergency medicine rotations; and confidence level were found to have an association with competence in ECG interpretation (Table 3). Since GMS from Addis Ababa University have had ECG class and emergency medicine rotation, and they were 9.078 times higher in ECG interpretation than Haramaya University GMS, (AOR = 9.078 (2.556-32.249)). GMS, who were confident and neutral in ECG interpretation were 3.983 and 5.471 times more competent

in ECG interpretation than GMS who was not confident (AOR = 3.983 (1.053-15.064, 6.057 (2.362-15.533)), respectively.

Table 3: Factors associated with competency of ECG interpretation

Factors		**ECG Interpretation**		**COR (95% CI)**	**AOR (95% CI)**
		< 80%	**≥ 80%**		
Gender	Male	91(77.8%)	26(22.2%)	1.232 (0.614-2.474)	
	Female	69(81.2%)	16(18.8%)	1	
ECG class	Yes	64(64.0%)	36(36.0%)	9.000 (3.586-22.591) *	9.078 (2.556-32.249) *
	No	96(94.1%)	6(5.9%)	1	1
Place	AAU	64(64%)	36(36.0%)	9.000 (3.586-22.591) *	9.078 (2.556-32.249) *
	HU	96(94.1%)	6(5.9%)	1	1
Attending all class	Yes	51(60.0%)	34(40.0%)	3.923 (0.826-18.634)	
	No	13(86.7%)	2(13.3%)	1	
Undergraduate emergency medicine rotations	Yes	64(64.0%)	36(36.0%)	9.000 (3.586-22.591) *	9.078 (2.556-32.249) *
	No	96(94.1%)	6(5.9%)	1	1
ECG interpretation as part of exam	Yes	44(61.1%)	28(38.9%)	5.273 (2.543-10.935) *	1.031 (0.363-2.932)
	No	98(81.7%)	22(18.3%)	1	1
ECG training	Yes	87(77.0%)	26(23.0%)	1.437 (0.725-2.848)	
	No	73(82.0%)	16(18.0%)	1	
Confidence level	Confident	16(72.7%)	6(27.3%)	3.875 (1.213-12.376) *	3.983(1.053-15.064) *
	Neutral	51(65.4%)	27(34.6%)	5.471 (2.39-12.522) *	6.057 (2.362-15.533) *
	Not confident	93(91.2%)	9(8.8%)	1	1
Frequency of ECG machine use per month	< 5	54(81.8%)	12(18.2%)	1.065 (0.471 -2.411)	
	5-10	7(63.6%)	4(36.4%)	2.353 (0.635 -8.715)	
	>10	19(67.9%)	9(32.1%)	2.229 (0.862 -5.765)	
	Not at all	80(82.5%)	17(17.5%)	1	
Frequency of ECG interpretation per month	< 5	65(74.7%)	22(25.3%)	1.924 (0.870 - 4.256)	0.901 (0.349-2.326)
	5-10	5(62.5%)	3(37.5%)	3.950 (0.834-18.701)	1.217 (0.209- 7.084)
	>10	11(68.8%)	5(31.2%)	4.788 (1.602-14.306) *	1.075 (0.266-4.348)
	Not at all	79(86.8%)	12(13.2%)	1	
Ask for help for interpretation of ECG	Rarely	6(66.7%)	3(33.3%)	2.000(0.250-15.991)	
	Sometimes	53(82.8%)	11(17.2%)	0.830(0.155-4.455)	
	Always	93(78.2%)	26(21.8%)	1.118(0.224-5.559)	
	Not at all	8(80.0%)	2(20.0%)	1	
Self-learning methods	Yes	87(77.0%)	26(23.0%)	1.364(0.680-2.375)	
	No	73(83.0%)	16(18.0%)	1	

COR – reported Crude odds ratios; AOR- adjusted odds ratio p – p value of test statistic; CI – confidence interval; * statistically significant variable.

6. DISCUSSION

Interpretation of ECG abnormalities can be difficult. But, the ability to interpret ECG abnormalities remain a core clinical competency for GMS and as a physician. Junior doctor's confidence and competence have been demonstrated to be unsatisfactory, with potential poor diagnostic and management skills as a result. Undergraduates do not consistently receive teaching on ECG interpretation and this can impact confidence (4,5,12). This study also showed only GMS from AAU have taken, ECG class.

There is no specific guideline from the minister of health or minister of science and higher education in Ethiopia regarding ECG training and assessment for Undergraduate Medical Education. Studies Recommendations for Clinical Skills Curriculum for Undergraduate Medical Education simply stated that by the end of the pre-clerkship curriculum, a medical student should be able to correctly perform and interpret a normal electrocardiogram (4).

The overall average of ECG interpretation was 35.9% [95% confidence interval (CI) 32.06–39.8%]. The AAU group had an overall average of 52.65% (95% CI 47.88–57.41%), while HU group had 19.41% (95% CI 15.47–23.71%). Overall In this study, the competency in ECG interpretation was 20.8% (score ≥80%). The competency in ECG interpretations of GMS of AAU and HU; who score ≥80% of were 36.0% and 5.9% respectively. The mean score difference was statistically significant with Mann-Whitney U test ($U = 6.14$, $P < 0.001$). Likewise, Jablonover et al. found 37% accuracy in ECG interpretation among 231 GMS (11).

This study demonstrated 61.3% (95% CI 56.3 – 66.3%) of GMS was able to correctly interpret the primary ECG parameters. In contrast, Grzegorz Kopeć et al. most students of clinical years (86%) were able to correctly interpret the primary ECG parameters like heart rate, heart rhythm and an electrical axis of the heart. This difference could be explained by 50.1% of group participant didn't take ECG class. HU GMS get a lesser accurate answer on primary ECG analysis than AAU (74.3% Vs 48.7%, respectively).

This study revealed that the accuracy of ECG interpretation for arrest rhythm, like PEA, Asystole, Ventricular tachycardia and ventricular fibrillation, were lower than study done by Kopeć et al., which was 32.75% (95% CI 28.25-37.25) and 69% respectively (3). Only 3 (1.5%) of GMS were competent for arrest rhythms ECG interpretations. Off these there is no

GMS from HU was answered more than 80 %. It was statically significant between HU and AAU GMS with P < 0.001. This could be explained by there is no undergraduate formal ECG class and undergraduate emergency medicine rotation for HU GMS.

Self-learning method was not statistically significant for the competency of ECG interpretation (COR 95% CI: 1.364(0.680-2.375)). Likewise, the studies of Mahler *et al*. described the importance of formal ECG class achieved a higher score than self-directed study (14). Against to this study, A study by Kopeć *et al*. revealed that competency in ECG interpretation was higher in students who reported ECG self-learning methods. This difference could be explained by the number of GMS using self-learning methods were small.

There was a direct correlation between the confidence of GMS and their competency to accurately identify abnormal ECG tracings. GMS, who were confident and neutral in ECG interpretation were 3.983 and 5.471 times more competent in ECG interpretation than GMS who were not confident (AOR = 3.983 (1.053-15.064, 6.057 (2.362-15.533)), respectively. Equivalently, an FTP for Undergraduates demonstrated the greatest most considerable in confidence and competence in ECG interpretations (5). In this study, confident GMS were less competent than GMS who rate their confidence level as neutral. This showed overconfidence might lead misinterpretation of ECG.

In the present study, GMS who received ECG interpretations as part of the evaluation in the undergraduate had higher interpretations skill than who didn't take it, but it was not statistically significant (AOR of 95% CI: 1.031 (0.363-2.932)).

This study revealed that the frequency of ECG machine use per month and the frequency of ECG interpretation per month did not statistically affect the competency of ECG interpretation.

Only AAU GMS were having undergraduate emergency medicine rotation while they were on year four or clinical year two. Competency of ECG interpretation of GMS who took undergraduate emergency medicine rotation and undergraduate ECG class were nine times more competent than GMS who did not take emergency medicine rotation (AOR 95% CI: 9.078 (2.556-32.249)). But there was no association with attending all class, so assessment methods or teaching approaches should be assessed and changed. Similarly, A study

performed at Worcester Royal Hospital on the undergraduate and postgraduate clinical training have demonstrated ECGs are interpreted sub-optimal, and competency of GMS who attended formal teaching program was significantly higher than GMS who use self-learning methods (5).

There are several strengths to this study. The respondents were enrolled from both medical schools, who have undergraduate emergency medicine curriculum (AAU) and who didn't include (HU). The simple randomized method was used to avoid bias. This study specified the areas of life-threatening and common emergency ECG abnormalities interpretation skills that need to be improved. This study clearly revealed factors of competency of ECG interpretation. Finally, this study reported the impact of undergraduate emergency medicine rotation as a curriculum and current ECG education in medical schools on competency in ECG interpretation.

The limitation of this study is ECG interpretation skill of GMS was not assessed directly on ECG strips on the bedside. There was no nationalized curriculum in Ethiopia which asses competency in ECG interpretation for GMS.

7. CONCLUSIONS

This study showed GMS demonstrated low competency in ECG interpretations. Competency of ECG interpretations was significantly improved by undergraduate emergency medicine rotation and undergraduate ECG class. Unfortunately, attending all class did not associated with competency of ECG interpretation skill. Moreover, most students reported that the number of ECG classes during medical education was insufficient. This shows different teaching models should be applied for ECG interpretations.

8. RECOMMENDATION

Based on this study finding, undergraduate emergency medicine rotation and formal ECG class should be included in a curriculum to all medical schools in Ethiopia, as this improve accuracy of diagnosis and patient outcome. Amount of ECG class should be extended and teaching methods should be revised and changed.

Further large study should be done on assessment of competency of ECG interpretations among GMS.

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Annex I. Questionnaires

Part – I

Directions: Please place a mark on the given spaces, encircle choices, and write comments accordingly. You can skip any questions that you feel are not applicable to you. Thank you!

1. Age
2. Sex A. Male B. Female
3. Which medical students' program are you in?
   A. AAU B. HU
4. Did you have undergraduate emergency medicine rotations?
   a. Yes B. No
5. Did you have any ECG class in your under graduate study?
   A. YES B. NO
6. If your answer is **yes** for Q. No 5, when (write your year of study)
7. If your answer is **yes** in Q. No 5, did you attend all class?
   a. YES b) NO
8. Do you think the amount of ECG class was enough?
   a. Yes b) No
9. Did you take ECG interpretation as part of exam?
   a. YES b) NO
10. Have you received any ECG training?
    a. Yes b) No
11. How confident you are on interpretation of ECG?
    a. Confident
    b. Neutral
    c. Not confident
12. How frequently ECG machine do you use per month?
    a. <5 **b)** 5-10 **c)** > 10 times **d)** Not at all
13. How frequently do you interpret ECG per month?
    a. <5 **b)** 5-10 **c)** > 10 times **d)** Not at all

14. How frequently did you ask for help for interpretation of ECG?

    a. Rarely b**)** Sometimes **c)** Always **d)** Not at all

15. If you were asking help for ECG interpretations from whom did you find?

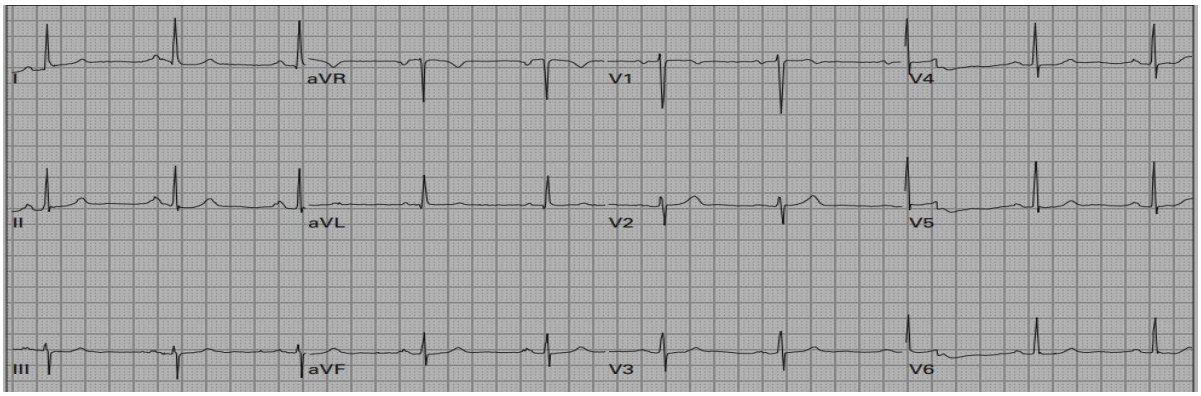
    a. Medical student (peer)
    b. General practitioner
    c. Resident
    d. Internist
    e. Emergency physician
    f. Cardiologist

16. Did you use any self-learning methods for ECG interpretations other than training and regular class?

    a. Yes **b)** No

17. If your answer is yes for Q.no 16 what was your methods

Part – II



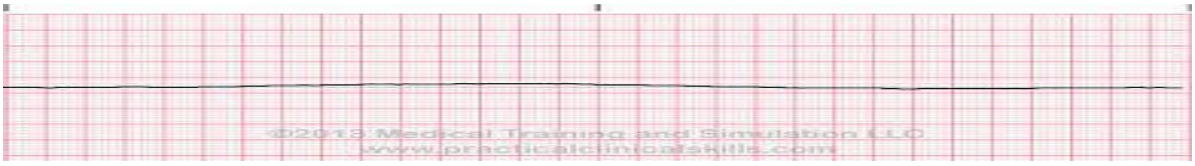
Based on the above ECG rhythm please fill your answer from question number 1 to 3.

1. Heart rate
2. Rhythm
3. Axis

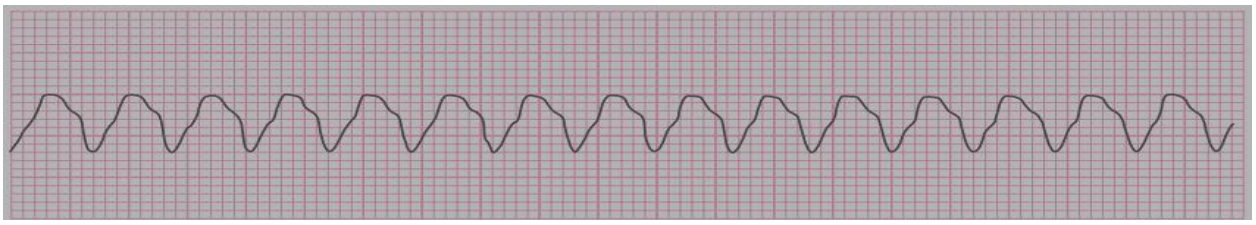
Part III

Write your diagnosis for each ECG strip.

4. A 40 years old female patient presented with loss of consciousness of 1 hour

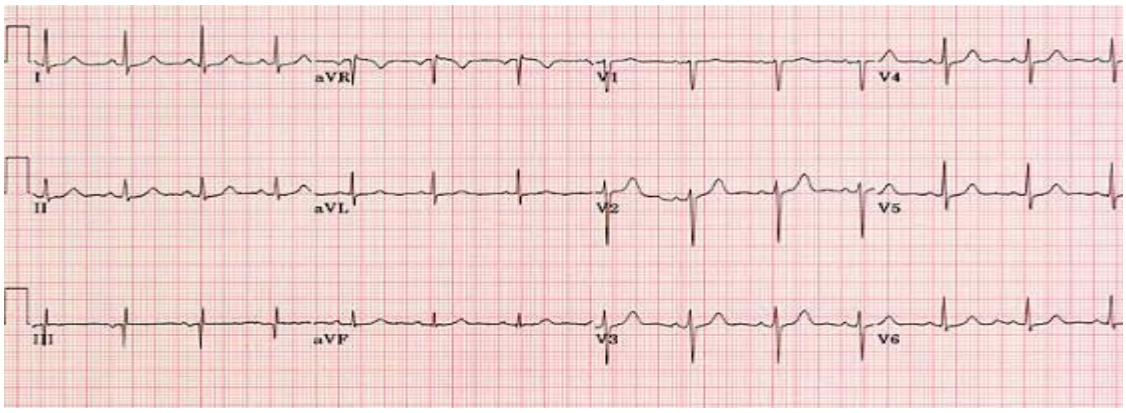


5. 54-year-old woman complains of midsternal chest pain and lightheadedness



6. 70 years old male presented to ED with compliant of chest pain, palpitation and shortness of breath

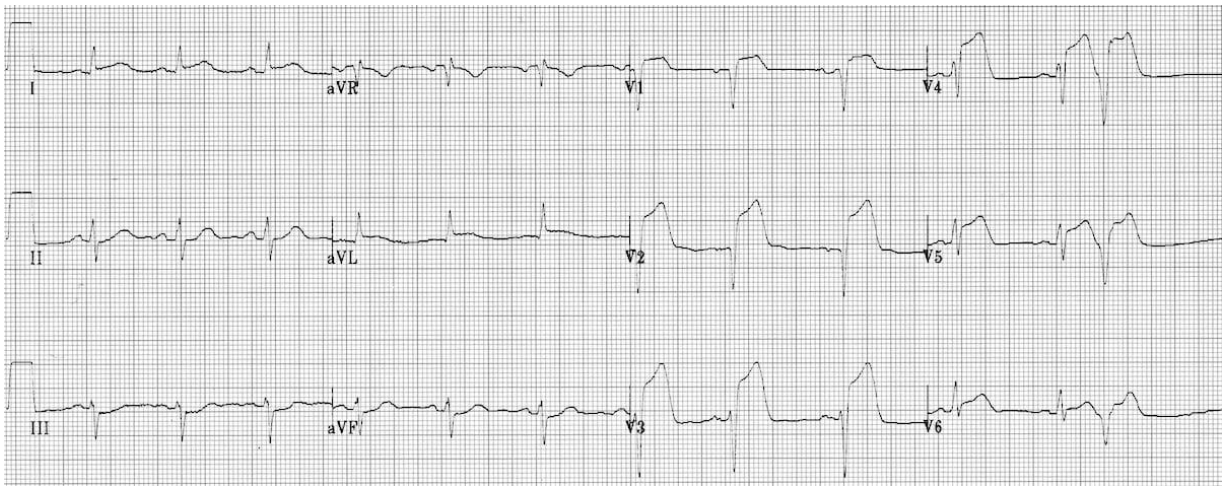
7. 55 years old man brought by his family after they found him on bed with loss of consciousness and upon arrival he was gasping and BP and pulse was not recordable



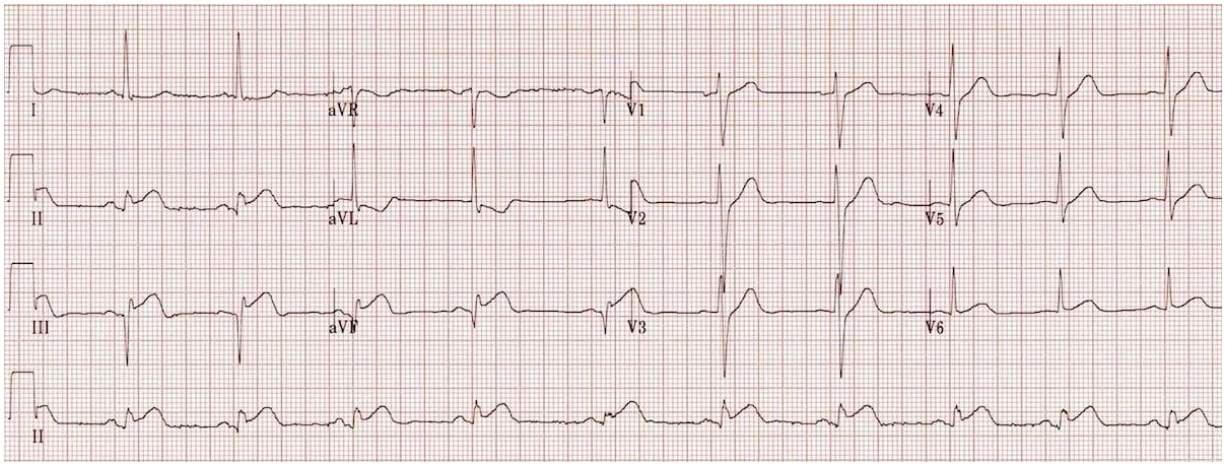
Part – III

8. 23 years old female known cardiac patient presented with palpitation

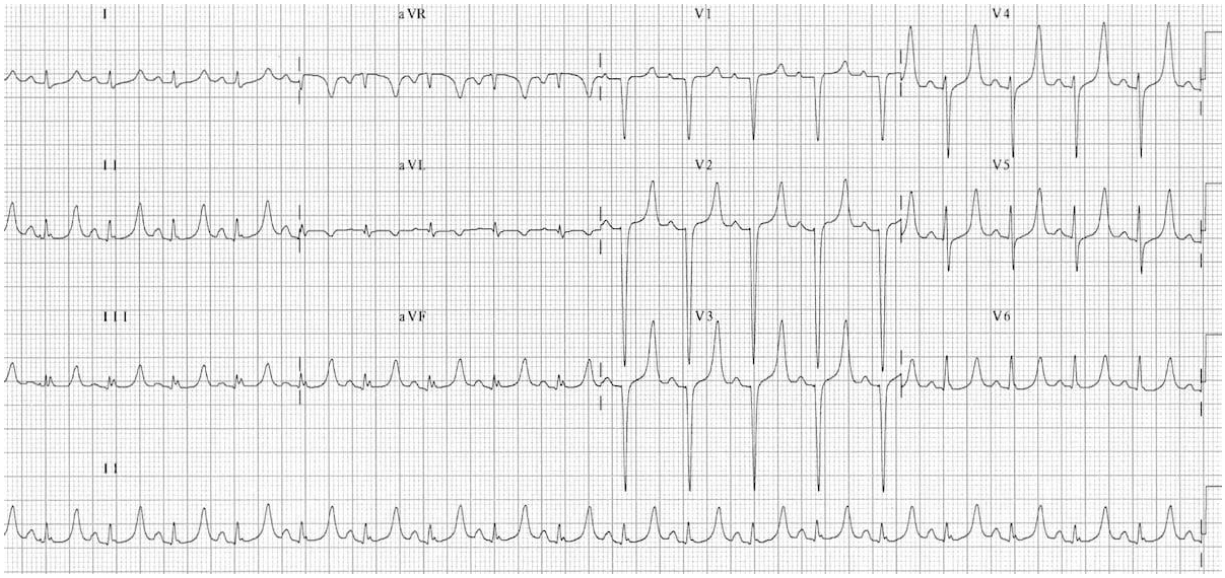
9. A 60 years old male patient presented with left side chest pain of 1 hour which radiates to right shoulder



10. 43-year-old obese woman with dyspnea, vomiting, and diaphoresis

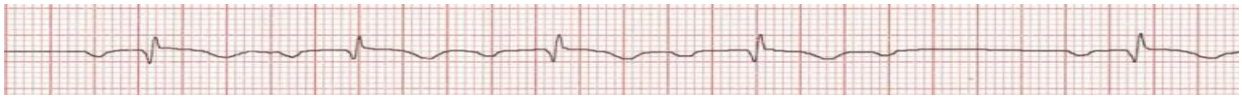


11. 26-year-old woman with history of renal failure reports generalized weakness and nausea



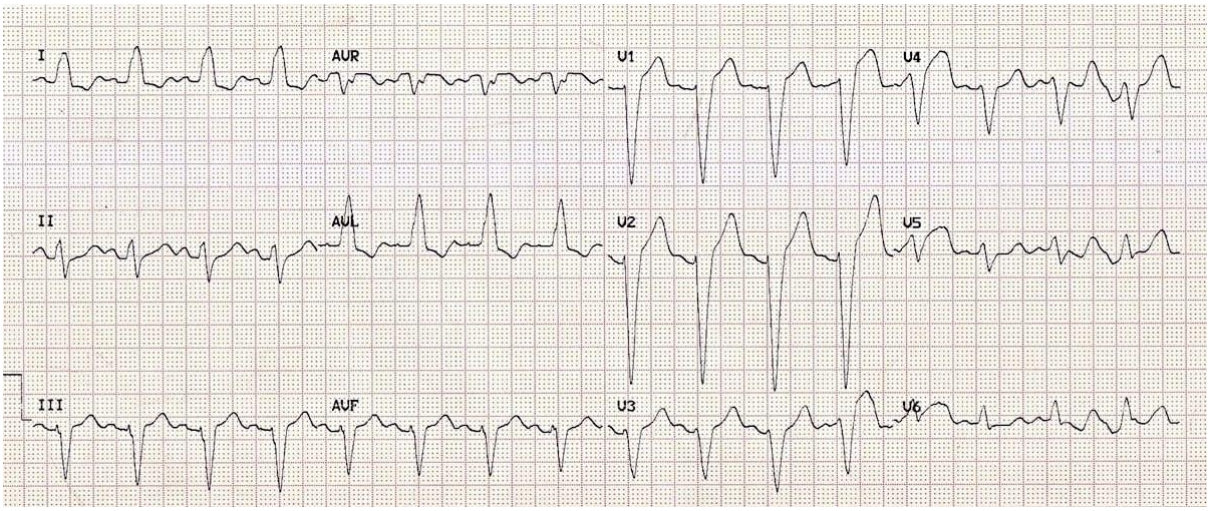
12. 25 years old male known cardiac patient on follow up

13. A 70 years old male presented with light headedness

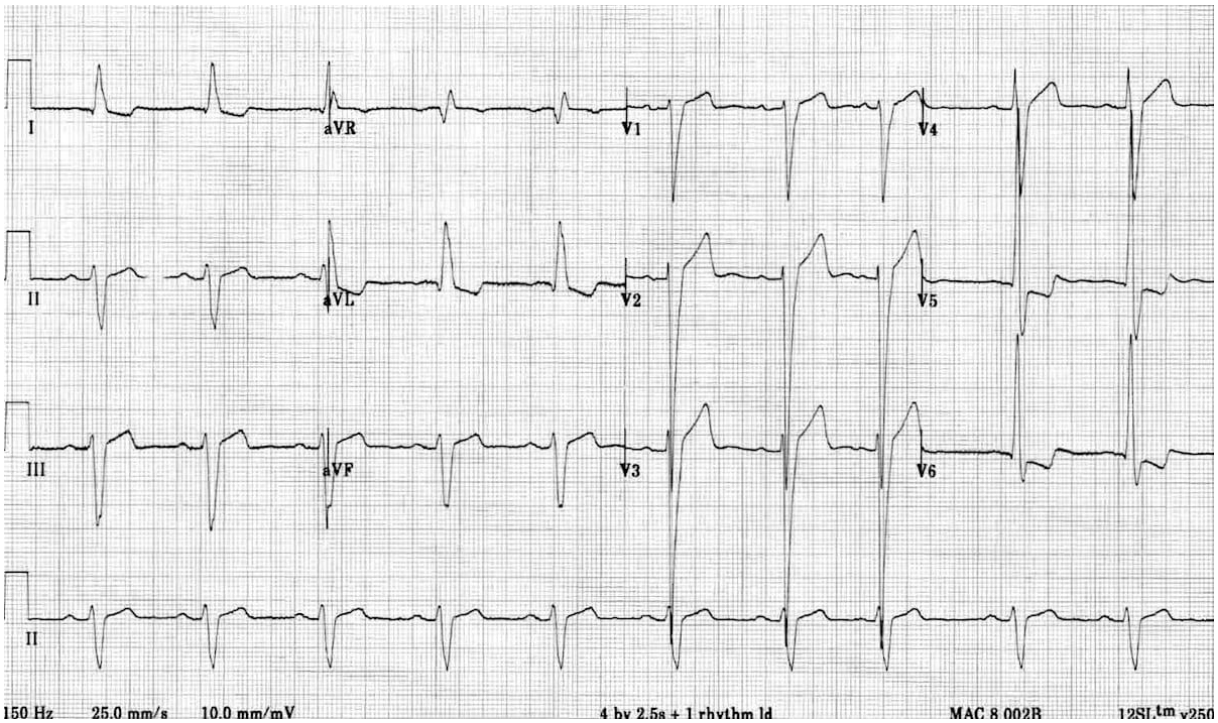


14. 64-year-old woman presents after a syncopal episode

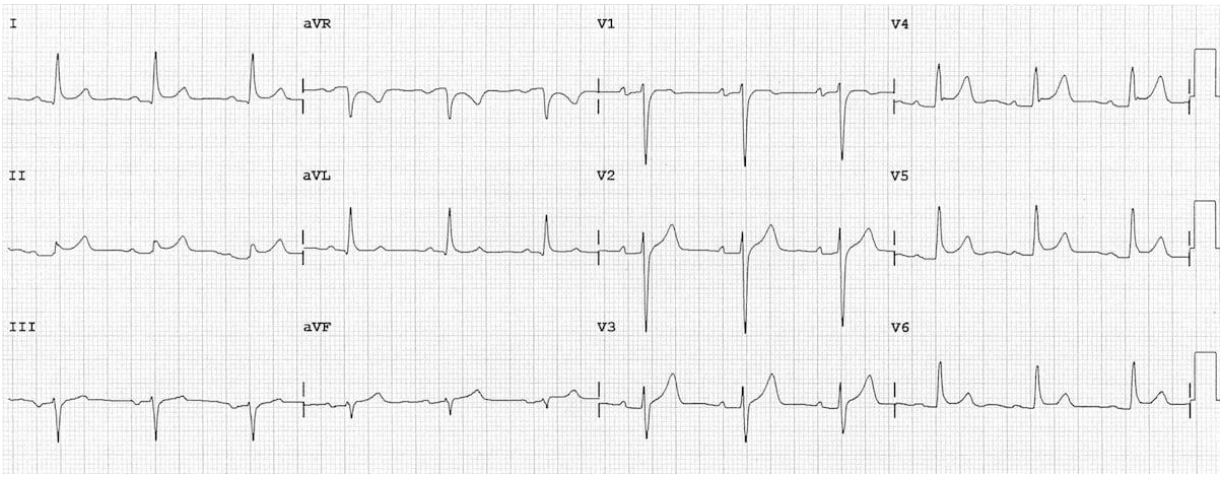
15. A 50 years old men presented with vomiting and chest pain



16. A 45 years old known hypertensive patient presented with easy fatigability and shortness of breath at exertion



17. 32-year-old man with pleurisy chest pain exacerbated by supine position and dyspnea


I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6