COMPETENCY IN ELECTROCARDIOGRAM INTERPRETATION AND PLACEMENT OF ECG LEADS AMONG FINAL YEAR MEDICAL STUDENTS OF A NIGERIAN UNIVERSITY.

Alikor C.A., Onuwaje P.
Cardiology Division, Department of Medicine, University of Port Harcourt Teaching Hospital, Nigeria

Correspondence:
E-mail: alikorchizindu@yahoo.com

ABSTRACT

Background:

Electrocardiogram (ECG) is a very common and easily assessable tool used in the assessment of cardiovascular diseases. Accurate interpretation of ECG abnormalities remains vital in the adequate management of some cardiac emergencies. It is therefore expected that final year medical students (FYMS) who will soon become house officers should have good knowledge of ECG procedures and interpretation. Hence this study is aimed at determining the competency level of final year medical students of the University of Port Harcourt in placement of ECG electrodes (leads) and interpretation of abnormal ECGs.

Material/Methods:

It was a prospective study involving FYMS who were recruited by convenience. A structured questionnaire was administered to one hundred and sixteen (116) graduating medical students. The questions were on basic ECG training including frequency of training and mode of training; placement of ECG leads. A list of 20 ECG tracings was also developed for the students to interpret.

Results:

One hundred and fourteen FYMS fully participated in the study with a questionnaire response rate of 98.27%. The male to female ratio was 1.9 : 1. Most (61.4%) of the study participants were unable to correctly place any of the ECG precordial leads while only 7.8% of study participants correctly placed all the precordial leads V1 –V6 correctly. Of the 20 ECG slides in this study, 12 (60%) could not be interpreted by any of the study participants. Of the remaining 8(40%) ECGs, only 0.9% of the total study participants were able to interpret them correctly. Only 24.6% of the participants were able to correctly identify the normal ECG and none able to recognize important ECG emergency slides of ST segment elevation and ventricular tachycardia. Competency in ECG interpretation was higher in students who reported training during classroom lectures against other training modalities such as self training, ward-rounds or others (P -0.0001) .

Conclusions:

The basic knowledge of ECG interpretation and placement of ECG leads amongst final year medical students in this study was poor. Improvement in knowledge and interpretation could be achieved through revision of the medical school curriculum to include ECG as a course and incorporation of frequent tutorials both in the classrooms and during clinical rotations.

Key words: *Competency, Electrocardiogram, Interpretation, Placement of ECG, Final Year Medical Students.*

INTRODUCTION

Electrocardiography (ECG) is an important diagnostic and easily assessable tool in the diagnosis of certain heart diseases. [1] ECG as a diagnostic tool is useful in the diagnosis of ischemic heart disease, acute myocardial infarction (MI), arrhythmias. [2] Some electrolyte imbalances like hypokalemia and hyperkalemia may also be detected using ECG. [2] Final year Medical Students who will shortly become House Doctors and may have to work in the emergency rooms probably as the first to make contact with patients on arrival, should be knowledgeable with the placement and interpretation of these core emergency ECGs. This is very important because early and appropriate treatment is key for good emergency room outcome in the setting of acute coronary syndrome. [3] The Advanced Cardiac Life Support (ACLS) training

teaches and encourages early ECG performance and interpretation in the emergency room in patients presenting with chest pain. It states that ECG should be performed within the first the 10 minutes of a patient's admission to the emergency department [3,4]

This is achieved via placement of external electrode of either a 12-lead ECG or an 18-lead ECG at the appropriate position in order to measure the electrical conduction signals of the heart. [5,6] Interpretation of common emergency ECG abnormalities is a useful skill and may help save lives. [7] Studies have shown that the skill of ECG interpretation among medical students and even some resident doctors is grossly inadequate. [8,9,10,11] Basic ECG interpretation is taught in some training centers as part of the undergraduate medical curriculum during ward rounds or in classrooms.[5,6] In spite of this, some studies have reported ECG interpretation as challenging for both medical students as well as some doctors. [10,11,12]

Therefore, this study was aimed at assessing the competency level of final year medical students of the University of Port Harcourt in placement of ECG electrodes and interpretation of basic ECG abnormalities.

METHODS AND MATERIALS

Study design and population

It was a prospective study involving FYMS who were recruited by convenience. A structured questionnaire was developed and administered to one hundred and sixteen (116) FYMS. The questions were on basic ECG training including frequency of training and mode of training; placement of ECG electrodes. A list of 20 ECG tracings was also developed for the students to interpret having been verified by a cardiologist.

Table1. ECG abnormalities presented to the students.

ECG SLIDE NUMBER	ECG SLIDE DIAGNOSIS
1	Normal
2	Sinus bradycardia
3	Sinus tachycardia
4	P-mitrale
5	Right atrial enlargement
6	Left ventricular hypertrophy
7	Right ventricular hypertrophy
8	First degree Atrio-ventricular block
9	Mobitz I
10	Mobitz II
11	Prolonged QRS
12	ST segment elevation
13	ST segment depression
14	T wave inversion
15	Atrial fibrillation
16	Atrial flutter
17	Ventricualar Tachycardia
18	Ventricular Tachycardia
19	Prolonged QT
20	Shortened QT

ECG MEASUREMENT

Method/equipment: Twelve lead surface electrocardiograms should be recorded on patients after resting for 10 minutes using a portable ECG machine. The device should be equipped with ECG analysis software that automatically measures amplitudes (to the nearest 5 mV) and the duration of ECG waves (P, Q, R, S, R9, QRS, T, and U) in each of the 12 leads. Standard intervals (RR, PQ, and QT) were also automatically computed

Subject preparation : Patients for routine ECG should not have taken alcohol, cigarette, tobacco and cold water 2 hours before the procedure and also did not exercise prior to procedure.[13] Subjects should be asked to remove all jewelry from neck, arms, and wrists. The nature of the procedure should be explained to the patient with subsequent reassurance.

Procedure/placement of electrodes : Patients should be asked to lie supine on a bed (lying uniformly flat), arms by the side in a comfortable ambient temperature. Areas on subject's arms, legs, and chest where small metal discs (electrodes) were placed were cleaned. Conducting gel, embedded in the middle of a self-adhesive pad onto which cables clip were applied. P[13]atients should be asked to lie very still and breathe normally during the test. Chest electrodes were placed in their correct positions, limb electrodes on wrist and

ankles. These[13,14] electrodes should be hooked to the ECG machine. After the procedure, the ECG paste should be wiped off and the investigator cleans the 12 leads.

Recordings: Recordings should be made at 25 mm/sec, calibrated at 10 mm/mV and printed onto a graph paper with time represented on the x-axis and voltage represented on the y-axis and a background pattern of 1mm squares, with bold divisions every 5mm in both vertical and horizontal direction. Each mV should be represented on the y axis as 1 cm and each second as 25mm on the x-axis (that is a paper speed of 25mm/s). At a paper speed of 25 mm/s, one small block of ECG paper translated into 40 ms. Five small blocks should make up one large block, which translated into 200 ms. Hence, there were five large blocks per second.

Statistical analysis : All data was analysed using the statistical package for social sciences (SPSS) version 21.0 analytic software. Categorical variables were expressed as proportions or percentages. Proportions or categorical parameters were compared with the chi-square test where appropriate. All test with a p-value of <0.05 were considered statistically significant.

RESULTS

One hundred and fourteen FYMS fully participated in the study with a questionnaire response rate of 98.27%. The male to female ratio was 1.9: 1. Most (61.4%) of the study participants were unable to correctly place any of the ECG precordial leads while only 7.8% of study participants correctly placed all the precordial leads V1 –V6 correctly. There were 20 ECG slides in this study, 12 (60%) of which could not be interpreted by any of the study participants with only 0.9% of the total study participants able to interpret 40% of the ECGs correctly. Only 24.6% of the participants were able to correctly identify the normal ECG and none able to recognize important ECG emergency slides of ST segment elevation and ventricular tachycardia. Competency in ECG interpretation was higher in students who reported training during classroom lectures against other training modalities such as self training, ward-rounds or others (48.3% vs 6% *vs.* 6.9% vs 36.2%; p<0.0001) . There was no statistically significant difference between the male and female study participants with respect to the skill of lead placement and ECG interpretation (p=0.197) and (p=0.100) respectively.

Table 1. Baseline demographics of the study participants.

Participants	Frequency(n)	Percentage %
SEX		
Male	74	64.9
Female	40	35.1
TOTAL	114	100
AGE GROUP		
20-25 years	57	50
26-30 years	51	44.7
31-35 years	4	3.5
>35 years	2	1.8
TOTAL	114	100

n = number of cases, % = percentage.

Competency in ECG Lead Placement

61.4% of the study participants were unable to correctly place any of the ECG precordial leads while only 7.8% of study participants correctly placed all the precordial leads V1 –V6 correctly.

Table 2. ECG Precordial Lead placement by study participants

Precordial lead placement	Frequency	Percent
One lead	13	11.2
Two leads	5	4.3
Three leads	9	7.8
Four leads	4	3.4
Five leads	4	3.4
Six leads	9	7.8
Total	44	38.6
No lead placement	70	61.4

Competency in ECG interpretation

There were 20 ECG slides in this study, 12 of which could not be interpreted by any of the study participants. Of the 8 slides interpreted, only 28 (24.6%) of the participants were able to correctly identify the normal ECG (SLIDE 1) , while 49 (43%) were able to identify sinus bradycardia(SLIDE 2) , 16 (14%) were able to identify sinus tachycardia (SLIDE 3), 11 (9.7%) identified P-mitrale (SLIDE 4), only 1 (0.9%) was able to interpret right atrial enlargement (SLIDE 5), while 2 (1.8%) interpreted SLIDES 6 and 7 (LVH and RVH respectively) correctly. Only 1 (0.9%) participant got the diagnosis of first degree AV block (SLIDE 8) . None of the final year medical students were able to recognize important ECG emergency slides of ST segment elevation and ventricular tachycardias

TABLE 3.COMPETENCY IN ECG INTERPRETATION

ECG SLIDE NUMBER	ECG SLIDE DIAGNOSIS	FREQUENCY	PERCENTAGE
1	Normal	28	24.6
2	Sinus bradycardia	49	43.0
3	Sinus tachycardia	16	14.0
4	P-mitrale	11	9.7
5	Right atrial enlargement	1	0.9
6	Left ventricular hypertrophy	2	1.8
7	Right ventricular hypertrophy	2	1.8
8	First degree Atrio-ventricular block	1	0.9
9	Mobitz I	0	0
10	Mobitz II	0	0
11	Prolonged QRS	0	0
12	ST segment elevation	0	0
13	ST segment depression	0	0
14	T wave inversion	0	0
15	Atrial fibrillation	0	0
16	Atrial flutter	0	0
17	Ventricualar Tachycardia	0	0
18	Ventricular Tachycardia	0	0
19	Prolonged QT	0	0
20	Shortened QT	0	0

DISCUSSION

This study comprised of only final year medical students which could be attributed to the fact that they are expected to be more knowledgeable than the students in the lower classes. Final year medical students are soon to be house-officers who are usually the first in line during the call hours and are the medical personnel who may make first medical contact with the patient in times of emergencies, hence their ability to perform an ECG and identify basic ECG abnormalities remains very crucial.

Our results showed less than one –tenth of the participants were able to place all the ECG precordial leads correctly. Wrong ECG leads placement has been documented as a source of inaccurate reading as this has a great influence on the ECG signals. [10,11,12,13]. The analysis of ECG tracings from wrongly placed electrodes could result in diagnostic errors with a study by Bond et al [14] showing as much as 17-24% of patients having diagnostic error from misplaced leads further emphasizing the importance of adequate training.

In this study, the poor competency in ECG interpretation is a call for action as 60% of the study ECGs could not be interpreted by any of the study participants and only 0.9% of the total study participants were able to interpret the remaining 40% of the ECGs correctly. This is not comparable with the sub-optimal level of competence in the skill of emergency ECG interpretation among medical students demonstrated in a study by Jablonover et al, [15] where he reported only 37% of graduating students being able to interpret the ECGs correctly. Kopec and co-workers in a study involving Polish medical students [16] in their clinical years (4^{th}-6^{th}), reported a higher percentage of about 58% of study participants being able to recognize common ECG abnormalities.

Our study demonstrated that participants with some training were able to interpret more ECGs accurately than those without any form of training. More than half of the overall participants who were able to interpret more ECGs correctly reported classroom training compared to those who had no formal training and demonstrated less accuracy with lead placement and interpretation. Kopec et al [16] in their study involving undergraduates from all Polish medical schools found a higher competence in students who reported ECG self-learning but no difference was found between students who attended or did not attend regular ECG classes. Similarly, De Jager et *al.* [7] in their study involving 96 emergency medicine residents also reported self-learning to be the most frequently used technique . On the other hand, Mahler et *al.* [17] in a randomized prospective study over a 28 month period involving 223 medical students found self-learning to be less effective than formal teaching.

In this study, 43% of the participants were able to interpret ECG abnormality of sinus bradycardia with 14% being able to identify sinus tachycardia but the more complex and emergency ECG abnormalities like atrio-ventricular blocks and ventricular tachycardia and ST-segment elevation could not be identified by all of the participants with the overall rate of correct response being poor. However, Kopec et a*l* [16] reported a higher competence amongst their study participants with 69% of them being 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 in their study was 66% with competency in ECG

interpretation being higher in students in their clinical years than in preclinical students. There were no significant differences between 4th-, 5th-, and 6th-year students with respect to competency in interpreting primary ECG parameters (88%, 84%, and 88%, respectively). The researchers attributed the difference in their findings to the fact that most of the respondents recruited were interested in ECG interpretation ; therefore, the level of competency in ECG interpretation might have been overrated in their study.[16] Moreover, students also completed the survey without supervision; therefore, they could have used additional resources to answer the questions and they might have repeated the survey several times to get the best result.[16] Judging from these therefore, one can extrapolate that indeed the competency level from the work by Kopec et al may be less than what was reported which further buttresses the ECG knowledge gap among medical students.

CONCLUSIONS

The final year medical students in this study have demonstrated a poor knowledge with respect to ECG lead placement and interpretation of common ECG abnormalities. Participants with formal training from Classroom lectures performed better than those with other modalities of training while those without any formal training performed even worse.

RECOMMENDATION

This study recommends that;

· A formal education in ECG interpretation with introduction of compulsory ECG lectures and training as part of the medical school curriculum. This may be beneficial for medical students beginning from preclinical to clinical years.

· The use of a variety of ECG teaching methods including classroom lectures, ward rounds, workshops, group sessions and computer-based learning .

ACKNOWLEDGEMENT

We acknowledge Drs Ejituwu Jacqueline and Ugwu Nkiruka for their role in data collection.

REFERENCES

1. Moyer VA; Screening for coronary heart disease with electrocardiography: U.S. Preventive Services Task Force recommendation statement. *Annals of Internal Medicine 2012*; 157 (7):512-518.
2. *Fisch C. Evolution of the clinical electrocardiogram. J Am Coll Cardiol. 1989;14 (5):1127–38*
3. *Rajaganeshan R, Ludlam CL, Francis DP, Parasramka SV, Sutton R. Accuracy in ECG lead placement among technicians, nurses, general physicians and cardiologists. Int J Clin Pract. 2008;62 (1):65-70*
4. O'Brien KE, Cannarozzi ML, Torre DM, Mechaber AJ, Durning SJ. Training and assessment of ECG interpretation skills: results from the 2005 CDIM survey. *Teach Learn Med.* 2009;21 (2):111–5
5. Lever NA, Larsen PD, Dawes M, Wong A, Harding SA. Are our medical graduates in New Zealand safe and accurate in ECG interpretation? *N Z Med J.* 2009 ;122(1292):9–15.
6. Pudło J, Wierdak M, Macioł K, et al. The comparison of 4th, 5th and 6th year medical students knowledge of rules and practical skills in the interpretation of electrocardiograms at Jagiellonian University]. *Przegl Lek.*

2012;69(4):143–48.

7. de Jager J, Wallis L, Maritz D. ECG interpretation skills of South African Emergency Medicine residents. *Int J Emerg Med.* 2010;3(4):309–14.

8. Crocetti M, Thompson R. Electrocardiogram interpretation skills in pediatric residents. *Ann Pediatr Cardiol.* 2010;3(1):3–7.

9. Berger JS, Eisen L, Nozad, et al. Competency in electrocardiogram interpretation among internal medicine and emergency medicine residents. *Am J Med.* 2005;118(8):873–80.

10. *Kligfield, P Gettes, Leonard S.; Bailey, James J.; Childers, Rory; Deal, Barbara J.; Hancock, E. William; van Herpen, Gerard; Kors, Jan A.; Macfarlane, Peter. "Recommendations for the standardization and interpretation of the electrocardiogram: part I: The electrocardiogram and its technology: a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society: endorsed by the International Society for Computerized Electrocardiology". Circulation.2007; 115 (10): 1306–1324.*

11. *Guijarro-Morales A., Gil-Extremera B., Maldonado-Martín A. "ECG diagnostic errors due to improper connection of the right arm and leg cables". International Journal of Cardiology 1991 30 (2): 233–235*

12. *Schijvenaars BJ, Kors JA, van Herpen G, Kornreich F, van Bemmel JH. Effect of electrode positioning on ECG interpretation by computer. J Electrocardiol. 1997 ;30 (3) :247-256*

13. Breen C, Bond R, Finlay D. A clinical decision support tool to assist with the interpretation of the 12-lead electrocardiogram. *Health informatics journal.* 2017 Jan 1:1460458216683534.

14. *Bond RR, Finlay DD,Nugent CD, Breen C, Guldenring D,Daly MJ. The effects of electrode misplacement on clinicians" interpretation of the standard 12-lead electrocardiogram. Eur J Intern Med. 2012;23(7):610-615*

15. *Jablonover RS, Lundberg E, Zhang Y, Stagnaro-Green A. Competency in electrocardiogram interpretation among graduating medical students. Teach Learn Med. 2014;26(3):279-284*

16. Kopec G, Magon W, Holda M, Podolec P. Competency in ECG interpretation among medical students. *Med Sci Monit.* 2015; 21: 3386–3394.

17. Mahler SA, Wolcott CJ, Swoboda TK, Wang H, Arnold TC. Techniques for teaching electrocardiogram interpretation: self-directed learning is less effective than a workshop or lecture. *Med Educ* 2011;45(4):347-353

QUESTIONNAIRE ON THE KNOWLEDGE OF ELECTROCARDIOGRAPHY AMONG FINAL YEAR STUDENTS OF THE UNIVERSITY OF PORT HARCOURT

1 GENDER
- Male
- Female

2. AGE GROUP (YEARS)
- **20 -25**
- **26 – 30**
- **31 – 35**
- **> 35**

3 **Year level**_____

4 Do you have any training on electrocardiography
- **Yes**
- **No**

5 If your answer is yes to the question above, how did you get the training?
- **Self – training**
- **During lectures**
- **During ward rounds**
- **Others (specify)** _____

6 If yes to No. 4, how many times have you been exposed to teaching on ECG
- **0 – time**
- **1 – 2 times**
- **3 – 5 times**
- **6 or more times**

7 What is the standard limb lead placement ? match the colour on a specific lead position written in column A by choosing an answer in column B. write the answer on the blank space provided

Column A	Column B
■ Right arm	a. black
■ Left arm	b. green
■ Right leg	c. yellow
■ Left leg	d. red

8 Placement of standard chest leads

9 What is the standard chest lead placement for the following?

V1.....
- **V2**.....
- **V3**.....
- **V4**.....

- **V5.....**
- **V6.....**

10.Please identify the diagnosis in the following electrocardiograms :
ECG 1.....
ECG 2.....
ECG 3.....
ECG 4.....
ECG 5.....
ECG 6.....
ECG 7.....
ECG 8.....
ECG 9.....
ECG 10.....
ECG 11.....
ECG 12.....
ECG 13.....
ECG 14 .....
ECG 15.....
ECG 16.....
ECG 17.....
ECG 18.....
ECG 19.....
ECG 20 .....