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Expertise in interpretation of 12-lead electrocardiograms of staff and residents physician: current knowledge and comparison between two different teaching methods

Abstract

Background and objectives: Electrocardiogram is a commonly used procedure for diagnosis of heart disease. It is not known doctor skills nowadays and utility of intensive course electrocardiogram teaching. The objective is to evaluate the accuracy in the interpretation of electrocardiograms among residents and staff doctor and evaluate the usefulness of an intensive training course in ECG (one week, 20 hours long) with a standard rotation in cardiology unit.

Methods: Participants were included prospectively and divided into two groups for analysis: Hospital Group (82 residents during their Cardiology rotation) and Course Group (71 residents and 41 staff physicians from the audience to a specific electrocardiogram course). They fill in 2 different questionnaires of 10 basic electrocardiograms: "Initial Test" at the beginning and "Final Test" at the end. We assign one point for each correct answer and zero for incorrect one (score range was 0 to 10 points).

Results: The score achieved in the "Initial Test" (standard deviation) was 5.09(1.81). Residents obtained 5.28(1.8), and Seniors 4.4(1.6), p=0.006. In the "Final Test" score achieved was 5.91(1.9), Residents obtained 6.03(1.98) and staffs 5.48(1.7), p=0.104. We found no differences in the "Final Test" score between both ECG teaching methods after adjusting.

Conclusion: Real ECG knowledge between doctors is poor. Residents obtained better results than staff at the beginning but at the end there were not statistic differences. Intensive course were similar to classical teaching method.

Keywords: electrocardiography, electrocardiography skills, improving techniques, teaching methods

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Javier Higueras,[1] Sandra Gómez-Talavera,[2] Victoria Cañadas,[1] Ramón Bover,[1] Martínez-Losas P,[1] Juan Carlos Gómez-Polo,[1] Carmen Olmos,[1] Cristina Fernandez,[3] Julian Villacastín,[1] Carlos Macaya[1]

[1]Department of Cardiology, Hospital Clinico Universitario San Carlos, Spain
[2]Department of Cardiology, Hospital de Fuenlabrada, Spain
[3]Department of Preventive Medicine, Hospital Cl

Correspondence: Javier Higueras, Department of Cardiology, Hospital Clínico Universitario San Carlos, Profesor Martín Lagos SN, 28040 Madrid, Spain, Tel 00-34-913303001, Email javierhnb@yahoo.es

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Abbreviations: ECG, electrocardiogram; AMI, acute myocardial infarction; VT, ventricular tachycardia; LVH, left ventricular hypertrophy; WPW, wolff-parkinson-white pattern; IT, initial test; FT, final test; SD, standard deviation

Introduction

In 21st century, Electrocardiography is the most commonly used procedure for diagnosis of heart disease. It is frequently performed by many kinds of doctors. This procedure is simple, safe, reproducible, and relatively economical.[1]

The 12-lead electrocardiogram (ECG) has numerous potential clinical uses. It serves as the first diagnostic step, and usually the main tool and sometimes the one and only in order to initiate treatment in arrhythmias, myocardial infarction, conduction abnormality, and in general, suspecting the presence of heart disease.[2–7]

It is important for physicians of any specialty to whom interpretation of ECGs contributes to clinical decision-making to have sufficient knowledge to make an accurate diagnosis. However, many doctors are unaware of their limitations and believe that they can interpret ECGs well.[1] Adequate knowledge should include the ability to define, recognize, and understand the basic pathophysiology of certain electrocardiographic abnormalities or patterns.[2]

Very little is known about ECG interpretative skills of medical residents [8,9]. Accordingly, this study was designed to analyse the accuracy in the interpretation of a variety of basic ECGs among residents of several specialities and family staff doctors. We also wanted to test two different ways of teaching electrocardiography: a general rotation at the cardiology unit (not electrocardiography specific) and an electrocardiography one-week 20 hours long intensive course. A secondary goal was to identify particular weaknesses in ECG interpretation.

Materials and methods

We collected data from June 2010 to January 2014.

Participants

Participants were included prospectively and divided into two groups for analysis:

a. Hospital Group consisted on consecutive eighty-two residents from different specialities that were recruited during their fellow at the Cardiology unit in a cardiovascular reference hospital. Only one resident declined participation.

b. Course Group included seventy-one residents from different specialities and forty-two staff physicians (n=113) from several hospital and healt care facilities recluted from the audience to a

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specific ECG course (one week, 20 hours long) that take place in the same hospital. All participants in this course consented to participate in this study.

The basal characteristics are summarised in Table 1. Participants' flow chart is showed in Figure 1.

Table 1 Basal characteristics of total population and different groups

	Total Study Sample	All Residents	Staff Course Group	P value	Residents Course Group	Hospital Group	P –value for Residents Course vs Hospital Group	Course Group	P –value
	N=195	N=153	N=42	(all Residents vs Staff)	N=71	N=82		N=113	(Course vs Hospital Group)
Age, y (SD)	31	28.23	44.22	<0.001	29.36	27.3	0.017	35	<0.001
	-8.82	-4.91	-8.47		-6.37	-2.99		-10.2	
Days on call (SD)	5.21	5.12	5.84	0.052	4.63	5.45 (0.91)	<0.001	4.95	0.041
	-1.5	-0.9	-3.4		-0.77			-1.92	
Lab exp days	419 (252.00-693.00)	397 (252.00-637.00)	2452	0.27	252	402 (293.25-610.00)	0.794	637.00 (252.00-1002.00)	0.603
Median (IR)			(0-6661.25)		-385				
Teaching method:	42	53.6	0	NA	0	100	NA	0	NA
% HR									
Speciality %	Cardio 6	Cardio 7,2	Cardio 2.4	<0.001*	Cardio 4.2	Cardio 9.8		Cardio 3.5	
	Ger 6	Ger 7.8	FM 66.7		Ger 4.2	Ger 11		Ger 2.7	
	IN 25	IM 32	Other 31		IM 29.6	IM 34	<0.001 †	IM 18.6	<0.001 ‡
	Neuro 5	Neuro 6.5			Neuro 0	Neuro 12		Neuro 0	
	FM 28	FM 17.6			FM 35.2	Fm 2.4		Fm 46	
	OMS 13.8	OMS 17.6			OMS 8.5	OMS 25.6		OMS 5.3	
	Others 15.4	Others 11.1			Others 18.3	Others 4.9		Others 23	
Residents %	78.5	100	0	NA	100	100	NA	62.83	NA

Cardio: Cardiology; FM: Family; Ger: Geriatry; HR: Hospital Rotation; IM: Internal Medicine; IR: Interquartile Range; ISD: Standard Deviation; LA: Latin America; Lab Exp: Lab Experience; NA: Not Applicable; Neuro: Neurology; OMS: Other Medical Speciality (anaesthesia, endocrinology, intensive care, nephrology, pulmonology); y: years

Statistic significances with Family doctors and Others. †Statistic significances with Family doctors and Others and Other Medical Speciality ‡Statistic significances with Family doctors and Others and Other Medical Speciality

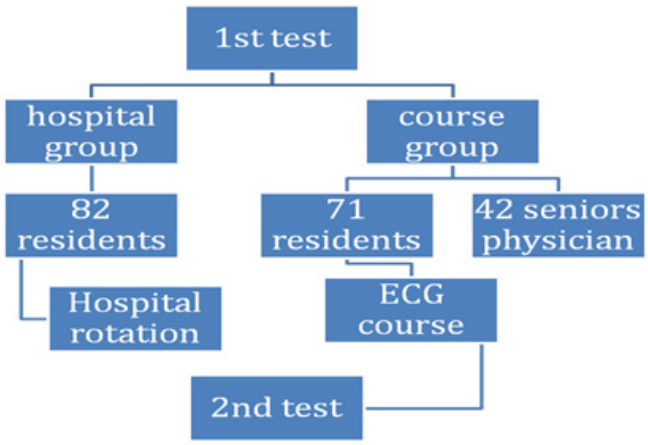

Figure 1 Population Study Flow chart.

Study design

This study is a questionnaire-based assessment of physician´s ability to interpret ECGs. Twenty 12-lead ECGs were selected from a cardiology database. The chosen ECGs were straightforward examples. Two senior cardiologists reviewed all ECGs independently and were asked to give a single diagnosis for each trace. They remained blinded to any clinical information or previous ECGs from the patient. There was 100% agreement on the diagnoses by the 2 experts.

The 20 ECGs represented examples of conditions that any non-cardiologist physician should be able to diagnose. They included cases of acute myocardial infarction (AMI), atrial flutter with and without AV block, atrial fibrillation, ventricular tachycardia (VT), acute pericarditis, left ventricular hypertrophy (LVH), Wolff-Parkinson-White pattern (WPW), type 2:1 second-degree AV block, complete heart block and cardiac tamponade. Some ECGs were obtained at the emergency department and specifically chosen because they

illustrated urgent conditions that require immediate and accurate interpretation (i.e. AMI, VT, cardiac tamponade and complete heart block). The selected ECGs were divided into two sets to design two different questionnaires. One of them was called "Initial Test" (IT) and was administered to the participants before any teaching period (either rotation or course). After completion of the teaching period, a second one called "Final Test" (FT) was given to all participants. Table 2 lists the diagnoses of the 20 ECGs used in the study in the order they appeared in the questionnaires.

Table 2 Diagnosis of the two ECG questionnaires used in this study

ECG Diagnosis	
IT1: Common Atrial Flutter with AV block	FT1: Common Atrial Flutter
IT2:Ventricular Tachycardia	FT2:Ventricular Tachycardia
IT3:Atrial Fibrillation	FT3:Atrial Fibrillation
IT4:WPW pattern	FT4:WPW Pattern
IT5: 2:1 2nd degree AV Block	FT5: Complete AV Block
IT6: Normally functioning pacemaker ECG	FT6: Cardiac Tamponade ECG
IT7: Inferior Myocardial infarction	FT7: Pacemarker dysfunction ECG (capture and sensing)
IT8: Cardiac Tamponade ECG	FT8: Normal pace marker ECG
IT 9: Left Ventricular hypertrophy	FT9: Pericarditis
IT10:Ventricular extrasystoles	FT10:Anterior Acute Myocardial Infarction

AV, atrial-ventricular; ECG, electrocardiogram; FT, final test; IT, initial test; WPW, wolf Parkinson white

The questionnaires had a fill-in-the-blank format, and the participants were asked to interpret each ECG and describe their answer on a blank line on a separate answer sheet. None of the ECGs offered multiple-choice answers. All subjects were asked to complete both questionnaires without any prior knowledge of the study. No clinical history was provided and automatic interpretation of ECG machine was removed to avoid influencing the participant's interpretation of the ECG.

A score ranging from 0 (incorrect) to 1 (correct) was assigned to each ECG. If the primary diagnosis was given, the ECG was scored as correct and was granted 1 point. If the participant was unable to give the primary diagnosis, the ECG was scored incorrect and given a zero. All questions left unanswered were scored also zero. Thus, the maximum total score achievable for 10 correctly answered ECGs was 10 each test (Initial and Final Test).

We also collected the following information from each participant: age, days since the beginning of professional activity, speciality, birthplace, and the number of days on call on a normal month.

Written informed consent was waived.

Statistical analysis

Two blinded, independent graders (J.H. and S.G.) revised and scored each participant's test. The analyses included both an investigation of physician interpretation of each individual ECG and the combination of the results of the 10 ECGs for an overall maximum achievable score of 10 in the Initial and Final Test.

Quantitative data are presented as mean±standard deviation (SD) or median and interquartile range (p25-p75) in asymmetric ones. Qualitative variables are displayed with frequencies distribution and percentages.

A $\chi 2$ test or Fisher exact test (if 25% of expected were lower than 5 in independences samples) was used for qualitative variables. In paired data Mc Nemar's test was used. For the analysis of the ECG diagnosis accuracy and the differences between staffs and residents odds ratio and its confidence interval 95% (CI 95%) was obtained. We analysed quantitative variables for each of the independent variables categorized by the T test Student (in comparisons of a variable with two categories) and/or analysis of variance (ANOVA). If asymmetry differences with non-parametric test, the Mann-Whitney test or the median test assessed where appropriate. In pair comparisons data corresponding test were used.

To set the final scores based on baseline scores and those potentially confounding factors multivariable linear regressions were modelled and the parameters are presented along with their CI 95%.

In all hypothesis tests the null hypothesis with a type I error less than 0.05 or α error was rejected. The software package used for analysis was SPSS for Windows versión 15.0.

Results

Total population

The study sample consisted on 195 physicians (153 residents and 42 staff). They were 31 (SD 8.82) years old, with a lab experience of 419 days (RI: 252-693). The overall mean (SD) score achieved in the Initial Test was 5.09 (1.81) out of a maximum of 10. The 50th percentile was 5 points and 90th percentile was 8 points. Residents obtained 5.28 [CI 95% 4.98-5.57], and Seniors 4.4 [CI 95% 3.90-4.91, p=0.006].

In the FT the overall mean (SD) score achieved was 5.91(1.9), representing an improvement in score of 0.8 points [CI 95% 0.55-1.12; P<0.001]. The 50th percentile was 6 points and 90th percentile was 8 points. Residents obtained 6.03 (1.98) and staffs 5.48 (1.7), p=0.104. Almost 56% of residents improved their score (FT – IT >0), whereas 57% of staffs improved their score. The mean improvement in score was 0.75 points [CI 95%, 0.44-1.10, p<0.001] for residents and1.07 [CI 95% 0.47-1.67, p=0.001] for staffs.

There were no differences in the FT score between residents and staffs, after adjusting by IT score, age and specialty. Differences between residents and staff are summarised in Table 3.

Table 3 Total residents score vs Staffs score

	Residents Score (CI 95%)	Staffs Score	P- Value
	N:153	(CI 95%)	
		N:42	
ITS	5.28 (4.98-5.57)	4.40 (3.90-4.91)	0.006
FTS	6,03 (5.71-6.34)	5.48 (4.94-6.01)	0.104
Improvement (FTS-ITS)	0.75 (0.44-1.10)	1.07 (0.47-1.67)	0.344
FTS Adjusted by ITS	5.97 (5.68-6.25)	5.77 (5.22-6.32)	0.538
FTS Adjusted by ITS and speciality	6.13 (5.82-6.43)	5.82 (4.68-6.95)	0.603
FTS Adjusted by ITS, speciality and age	5.95 (5.61-6.30)	6.19 (5.02-7.36)	0.718

CI, confidence interval; FTS, final test score; ITS, initial test score

Comparison between hospital rotation and ECG course

To compare the two different ECG teaching methods, we analysed only residents' results in order to achieve population homogeneity. The basal characteristics are summarised in Table 1.

In the IT, the mean score (SD) was 5.9 (1.80) for Hospital Group and 4.54 (1.57) for the residents in the Course Group (p<0.001). In the FT, Hospital Group achieved a mean score of 6.52 (2.01), whereas residents in Course Group obtained a mean score of 5.45 (1.80), (p=0.001). Fifty six percent of residents in Hospital Group and 55.7% of residents in Course Group improved their score (p=0.962). After their rotation, residents of Hospital Group improved 0.62points [CI 95% 0.14-1.1; p=0.011), while residents of Course Group improved 0.91 [CI 95% (0.48-1.41) p<0.001]. We found no differences in the FT score between both methods after adjusting by IT score, speciality and age. There was statistically significant interaction between teaching method and speciality (p=0.003) Figure 2.

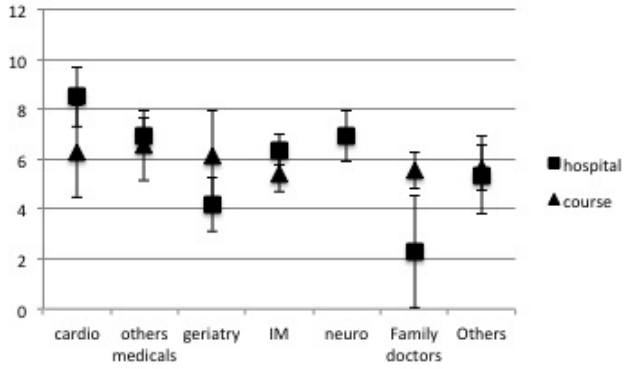

Figure 2 Error bar showing mean value of FT score and 95% Confianceinterval. There was an statistically significant interaction between teaching method and speciality. Familiy doctors improve FT score better with course method than hospital one. (p=0.003).

Cardio: Cardiology; IM: Internal Medicine; Neuro: Neurology.

ECG interpretation scores

Table 4 lists the percentages of correct diagnoses obtained for each individual ECG. We show staff and residents results of total sample.

The most commonly reported incorrect response was 2:1 second degree AV block in staff group (only 4.8% of correct diagnoses) and LVH in residents group (11.8% of correct diagnoses).Others ECGs with poor results (<50% of correct diagnoses) in staff group were LVH (16.7%), Cardiac Tamponade (21.4% in Initial Test), WPW pattern (28.6% in IT and 16.7% in FT), pericarditis (16,7%), normally functioning pacemaker ECG (28.6% in IT and 45.2% in FT), common Atrial Flutter (31%) and VT (47.6%). In residents group poor results were found in cardiac tamponade (23.5% in IT), WPW syndrome (29.4% in IT and 24,2% in FT) and pericarditis (37.3%).

Table 4 Residents Hospital Group score vs Residents Course Group score

	Residents Hospital Group	Residents Course Group	P-Value
	(CI 95%)	(CI 95%)	
	N:82	N:71	
ITS	5.90 [5.51-6.30]	4.54 [4.17-4.92]	<0.001
FTS	6.52 [6.08-6.97]	5.45 [5.02-5.88]	0.001
Improvement (FTS-ITS)	0.62 (0.14-1.10]	0.91 (0.48-1.41)	0.494
Adjusted by ITS	6.28 (5.87-6.69)	5.77 (5.33-6.22)	0.112
Adjusted by ITS and speciality	5.82 (5.31-6.32)	5,97 (5.43-6.50)	0.697
Adjusted by ITS, speciality and age	5.80 (5.29-6.31)	5.93 (5.38-6.48)	0.733

CI, confidence interval; FTS, final test score; ITS, initial test score

When analysing the ECGs with the most critical diagnoses, results were slightly better. On one hand, staff group did not achieve 50% of correct diagnoses in VT (47.6%, in IT), type 2:1 2nd degree AV Block (4.8%) and cardiac tamponade (21.4% in IT). On the other hand, resident group did not achieve 50% of correct diagnoses in type 2:1 2nd degree AV Block (36.6%). In FT, both staff and residents achieved almost 50% of correct diagnostic in critical diseases (Table 5).

Table 5 ECG interpretation scores

ECG	Staffs % (N:42)	Residents % (N:153)	P-value	Odds Ratio	ECG	Seniors % (N:42)	Residents % (N:153)	P-value	Odds Ratio
				Resident/Staff					Resident/ Staff
IT1: CAF with AVB	90.5 (38)	88.95 (136)	>0.999	0.84 [0.27-2.65]	FT1: CAF	31.0 (13)	52.9 (81)	0.012	2.51 [1.21-5.19]
IT2:VT	47.6 (20)	61.4 (94)	0.091	1.80 [0.91-3.58]	FT2:VT	66.7 (28)	58.2 (89)	0.319	0.69 [0.34-1.42]
IT3:AF	69.0 (29)	72.0 (110)	0,655	1.18 [0.56-2.49]	FT3:AF	81	92.8	0.036	3.04 [1.13-8.13]
IT4:WPW Pattern	28.6 (12)	29.4 (45)	0.916	1.04 [0.490-2.21]	FT4:WPW Pattern	16.7 (7)	24.2 ((37)	0.302	1.59 [0.65-3.89]
IT5: type 2:1 2nd degree AVB	4.8 (2)	36.6 (56)	<0.001	11.545[2.69-49.60]	FT5: Complete AVB	92.9 (39)	82.4 (126)	0.095	0.36 [0.10-1.25]

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Table Continued...

ECG	Staffs % (N:42)	Residents % (N:153)	P-value	Odds Ratio	ECG	Seniors % (N:42)	Residents % (N:153)	P-value	Odds Ratio
				Resident/Staff					Resident/ Staff
IT6: Normal PM	28.6	56.9 (87)	0.001	3.29 [1.57-6.92]	FT6: Cardiac Tamponade ECG	83.3 (35)	71.2 (109)	0.114	0.49 [0.20-1.20]
IT7: Inferior wall AMI	90.5	87.6 (134)	0.789	0.74 [0.24-2.31]	FT7: PM dysfunction (capture and sensitivity)	50 (21)	55.6 (85)	0.601	0.74 [0.24-2.31]
IT8: Cardiac Tamponade ECG	21.4 (9)	23.5 (36)	0.775	1.129 [0.49-2.58]	FT8: Normal PM	45.2 (19)	60.8 (93)	0.08	1.13 [0.50-2.58]
IT 9: LVH	16.7 (7)	11.8 (18)	0.43	0.67 [0.26-1.72]	FT9: Pericarditis	16.7 (7)	37.3 (57)	0.015	2.97 [1.24-7.12]
IT10:VE	42.9 (18)	54.9 (84)	0.22	1.623 [0.81-3.23]	FT10: Anterior wall AMI	64.3 (27)	70.6 (108)	0.433	1.33 [0.65-2.74]

AF, atrial fibrillation; AMI, acute myocardial infarction; AVB, atrial-ventricular block; CAF, common atrial flutter; ECG, electrocardiogram; FT, final test; IT, initial test; LVH, left ventricular hypertrophy; PM, pacemaker; VE, ventricular extrasystoles; VT, ventricular tachycardia; WPW, wolf-parkinson-white

Discussion

ECG interpretation skills

In this study the overall accuracy of ECG interpretation was low for both resident and staff physicians. This finding is of particular interest given the fact that the ECGs were chosen as examples of diseases or conditions that any physician should have been able to recognize and properly diagnose.

In the present work residents score was 5.28 in IT and 6.03 in FT. A systematic review published in 2003 that included 12 articles, demonstrated that resident physicians detected 36% to 80% of ECG diagnoses as determined by experts.[10] Our results are consistent with these findings. Few studies have investigated ECG interpretation skills of resident physicians. Commonest errors reported in the literature are failure to recognize AV block, acute posterior MI, and supra ventricular dysrhythmia.[11] In the present study, AMI was missed by 13.4%, VT was missed by 44.1%, and 2nd degree AV block was missed by 64.6% of the residents in the IT. In a study by Gillespie et al.[12] more than 50% of residents failed to recognize AV block and posterior MI when interpreting ECGs. It is notable that although residents improved their results, the score of FT remained poor. We expected residents to have achieved higher scores after the teaching period.

The study also revealed that staffs´ competency was even poorer. This group was composed of 66% family doctors and 33% general practitioners and out-hospital emergency physicians. They obtained 4.4 points in IT and 5.4 points in FT, improving on average 1 point at the end of the ECG course. There are few available data of ECG interpretation skills of staff physicians. In a recent Swiss study, the mean proportion of correct answers was only 31%.[13] Other studies show similar findings. Accurate ECG diagnoses were observed in only 36% of senior house officers and in 17% to 67% of family doctors.[14] More important, there were a significant proportion of potentially fatal diseases that were missed: less than 50% of doctors were able to correctly detect VT, 2nd degree AV block or cardiac tamponade.

It is remarkable that Residents Group obtained better score in IT than Staffs, but in FT there were not differences, perhaps indicating a better utilization of teaching method by the staffs.

Many causes could be responsible of these poor results. No clinical information or automatic interpretation of ECG machine was provided to avoid influencing the participant's interpretation of the ECG. Previous research has demonstrated a strong and consistent effect of clinical scenario on the accuracy of ECG interpretation and identification of ECG features by physicians at all levels of training, but especially for providers with less experience.[9,15–17] Moreover, non-cardiologists seem to be more affected by the clinical context of the patient when interpreting an ECG.[15] Otherwise pattern recognition, which is an essential component of ECG interpretation, is learned only through repeated exposure. Such repeated exposure is especially important because of the need to visually recognize the many diagnostic variations. It is known that completion of a residency or fellowship does not guarantee adequate training in electrocardiography.[18] Although there is no scientific study to rely on, it is estimated that most physicians can obtain competence only after reading at least 500 tracings under the supervision of an expert electro-cardiographer.[2] Perhaps, in the era of a highly technological medicine, physicians are more prone to base their judgement on imaging techniques such as echocardiography, scanner and cardiac resonance than in classic diagnostic tools like ECG, chest radiograph or even physical examination. As a consequence, they may not recognize the value of acquiring and maintaining competency in ECG interpretation. In the worst side, this is the real ECG knowledge of physician in our days.[14,15,19,20]

Assessment of the teaching methodologies

Both ECG teaching methods seem to have helped residents to improve their ability to accurately interpret ECGs. Residents in Hospital group completed a cardiology rotation with a median duration of 77.5 days (IR 33). They improved on average 0.62 points, whereas residents in the course group improved 0.91 points. When comparing

the FT score, we found no statistically significant differences between these two teaching methods, neither in the univariate nor in the multivariate analysis. Analysing FT score, univariate analysis and after adjusted by Initial Test score, age and speciality there were not significant differences between both learning methods.

There are many teaching methodologies that have demonstrated their utility: traditional instruction and ECG puzzle methods[21] self-directed learning, specific workshops or lectures.[22] In these studies, diagnostic accuracy improved 10% to 15% with any of the teaching methods, which is consistent with our results. In our study, residents in the course group improved their score 9.1% those in the hospital group, 6.2%. So, specific one-week course seems to be as effective of those ECG learning methods.

Specific weaknesses in ECG interpretation

Staff group (66% family doctors, 33% others) obtained poor scores in some cardiac conditions or disease like, as WPW pattern, hypertrophic cardiomyopathy, pacemaker's ECG or cardiac tamponade. This finding is probably related to the fact these conditions are not frequently seen in their daily practice. Consequently, they got better results in those ECGs, like atrial fibrillation or atrial flutter that are frequent in a general practitioner's office.

Myocardial infarction was correctly identified by most of the staffs (90.5%), being one of the conditions with the best results. This is consistent with other studies and probably due to the high prevalence of ischemic heart disease in our days and the capital role of family doctors and out-hospital emergency doctors play in diagnostic and therapeutic chain of the ischemic process.[10]

Resident group (28.23 years, 397 days of lab experience on average) obtained poorest scores in the same specific diseases (WPW pattern, type 2:1 2nd degree AV Block, cardiac tamponade, myocardial hypertrophic disease). In this group, the results could be better explained by the lack of experience. They had also the best results in myocardial infarction, probably because they were familiar with such a frequent condition nowadays.

Both groups obtained poor results in some potentially fatal diseases. However residents obtained better scores than staff in type 2:1 2nd degree AV Block (4.8 vs 36.6, $p<0.001$), VT (47.6 vs 61.4% $p=0.091$), pericarditis (16.7 vs 37.3, $p=0.015$) and normally functioning pacemaker ECG (IT: 28.6% vs 56.9%, $p=0.001$, FT: 45.2% vs 60.8%, $p=0.08$).

The present study highlights that the current electrocardiography knowledge is undoubtedly poor. Many reasons can be argued: a lack of practical experience, the inadequacy of residency teaching programs to reach a proper competency, the failure of continuing medical education or the devaluation of this classic diagnostic tool in favour of the other techniques. Nevertheless, we found that both teaching methods can be useful in improving ECG interpretation skills in both residents and staffs.

In view of our results we consider that improving teaching methodology is of great importance, not only to give residents the opportunity of obtain proper ECG interpretation skills but also to guarantee that they, as staffs, are able to maintain a good level of competency in this field. Efforts should be intensified in those conditions that are usually missed by non-cardiologists. New technologies can help us to design new attractive and teaching tools such as online courses, online contest or specific periodic evaluation format.

Limitations

This study has many limitations that deserve consideration. First, it is not a randomised study and groups are not necessarily comparable. Although we have adjusted our results by the most frequent confounding factors, we cannot exclude the existence of biases. On the other hand, the 2 ECG questionnaires are not standardised. We have chosen 20 easy and frequent ECG and divided them into two homogeneous groups. But it is possible than one of them could be more difficult. Finally, this is a small single-center study, and therefore it is not representative of the nation as a whole.

Conclusion

Young residents of several specialities and general staff physician demonstrated overall low proficiency when interpreting daily practice ECGs. ECG specific course and cardiology rotation have demonstrated to be useful improving ECG knowledge. Nevertheless, we should find new methods in order to achieve better results. There was an statistically significant interaction between teaching method and speciality. Familiy doctors improve FT score better with course method than hospital one.

Authors contributor ship

Higueras J contributed in study design, patient inclusion, ECG analysis, data analysis and the process of article writing. He is the responsible for the overall content as guarantor.

Gómez-Talavera S contributed in patient inclusion and ECG analysis of every participant and data analysis.

Cañadas V contributed in data analysis and the process of article writing.

Martínez-Losas P, contributed in patient inclusion and the process of article writing.

Bover R contributed in patient inclusion and data analysis.

Gómez-Polo JC contributed in study design and patient inclusion.

Olmos C, contributed in study design and patient inclusion.

Fernandez C contributed in study design, data analysis and statistical analysis.

Villacastín J contributed in study design and patient inclusion.

Macaya C contribute in study design, data analysis.

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Conflicts of interest

The authors declare there is no conflict of interests.

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None.

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