Title

The effectiveness of a nationwide interactive ECG teaching workshop for UK medical students

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Abstract

Purpose

Interpreting a twelve-lead electrocardiogram (ECG) is a basic, albeit essential skill for most healthcare professionals to attain. Despite its importance, evidence suggests that the competency of healthcare professionals to interpret ECGs can be improved. We evaluated the effectiveness of a national interactive workshop designed to improve ECG interpretation in the UK medical student cohort.

Methods

UK medical students who attended a national workshop were asked to complete a pre- and post- workshop test which comprised of 20 ECGs which showed a variety of pathologies relating to conduction disturbances, tachycardia and acute coronary syndromes. The workshop was interactive and consisted of six hours of ECG tutorials, divided into hourly sessions which covered all key topics such as ‘basic electrophysiology’ and ‘electro-conduction problems’. Pre- and post-workshop test scores were compared by difference in means using the paired two-tailed t-test.

Results

A total of 145 participants completed the pre-test and of those 44 completed both the pre and post-test. The mean pre-test and post-test scores were 9.7/20 questions (48.9%) and 11.2/20 questions (56.2%) respectively, with a mean improvement of 1.5/20 (7.3%) from pre- to post-test (+7.3%, 95% CI:+1.8 to +12.8%, p=0.01).

Conclusion

A national ECG workshop which emphasizes activity-based learning may be effective in improving the competency of medical students to interpret ECGs. Further exploration with multi-center controlled studies involving a diverse cohort of students and analyses to determine their cost-effectiveness is warranted.

Keywords:

Electrocardiogram teaching

Workshop-based learning

Medical education

Background

The twelve-lead electrocardiogram (ECG) is an essential diagnostic investigation to screen and detect life-threatening cardiovascular disorders [1,2]. Interpreting a twelve-lead ECG is a basic, albeit essential skill for healthcare professionals to attain. The British Foundation Curriculum lists ECG interpretation as a "core investigative skill" for physicians and expects doctors to "seek, interpret, record and act on results of ECG" [3]. Despite its importance, recent evidence suggests that the competency of healthcare professionals to interpret ECGs must improve [4–6]. The lack of expertise is not solely observed in practicing healthcare professionals such as general practitioners, hospital doctors and nurses [7–9], but also in medical students [10–12].

Medical schools have used a number of different teaching methods which all aim to improve medical students' ECG interpretation skills. Although many universities rely exclusively on lectures or seminary teaching to deliver their curriculum [13], others have introduced alternative contemporary techniques such as self-directed learning (SDL) and electronic learning (e-learning) [14], online simulations [15] or tutorials [16]. In addition, most medical schools have student-led cardiology societies [17] which help to support students by organising university-specific ECG teaching events. Several one-day courses are offered by a range of cardiology institutions and societies [18,19], which claim to be organised with an aim to develop medical students' interpretation skills further. The effectiveness of such courses at improving ECG interpretations skills in medical students is unknown. Therefore, their effectiveness must be determined, which to date, has not been formally conducted.

This study aimed to examine the effectiveness of a national interactive workshop at improving the ECG interpretative skills of a UK medical student cohort using a formative assessment measure.

Methods

Participants recruitment

The study's participants were all students who attended the British Undergraduate Cardiovascular Association (BUCA) ECG workshop day. To enrol, the students had to be attending a medical school in the United Kingdom (UK) at the time of the event. All participants were recruited between December 2017 and February 2018.

UK medical students were informed of the ECG workshop through a variety of avenues which included social media (Facebook and Twitter), marketing platforms (MailChimp), and via email which was delivered to university administrative offices who then distributed the information to the students at their medical school.

The participants were given the opportunity to attend the workshop, even if they did not wish to take part in the study. Ethical approval was obtained by the Faculty of Medicine and Health Sciences Research Ethics Committee, University of East Anglia and written consent was obtained from all the participants.

Baseline data

Before registering for the event, participants were asked to complete an online questionnaire administered using JotForm (San Francisco, USA) [20].

Baseline demographic characteristics were collected, including age, sex, year of study, university name, and potential motives for their interest in cardiology as a future career, experience of ECG interpretation before the event, and the ECG teaching methods they had previously received. Upon submission of the form, each participant was independently allocated a unique identifying number (UIN) which was used throughout the study to ensure that the researchers were blinded, and the data remained confidential.

The participants undertook an online ECG assessment (pre-test) which was available a month before the workshop, using an online link via JotForm. It aimed to determine if the participants were competent to accurately identify important pathologies such as atrial fibrillation, ventricular tachycardia, ventricular fibrillation, atrial flutter and other pathologies (Supplementary material A) listed as essential knowledge for first year post-graduate UK doctors in the foundation curriculum 2010 [12]. The test comprised of 20 ECG Multiple Choice Questions (MCQs), each worth 1 point, which needed to be completed within 30 minutes. The ECGs covered all of the cardiac areas and showed examples of acute coronary syndromes, heart rhythm abnormalities and cardiomyopathy (Figure 1). No questions appeared more than once, and the participants were not notified of their scores after the pre-test.

Study day

The participants attended an ECG workshop in January 2018 in Peter Samuel Hall, London UK, free of charge. The workshop involved six hours of ECG teaching, divided into hourly sessions on topics such as ‘basic electrophysiology’, ‘rhythm

analysis' and 'electro-conduction problems'. Learning objectives were listed at the start of each session and abnormal ECGs were interpreted by the group together whilst referring back to a normal ECG. The workshop was interactive and focused on active student participation. The sessions were delivered by doctors mainly in specialist training and an acute cardiac syndrome specialist nurse registered with their relevant UK medical and nursing councils.

Within two weeks following the workshop, the participants were asked to complete a second online ECG test (post-test) via email and a response rate of 30% was received. This investigated their knowledge of the same disease states as in the pre-test. Although the same 20 ECGs were used in both tests, they were not discussed during the workshop tutorials and the options were presented at random.

Statistical Analysis

SPSS V25 (IBM Corp., Armonk, NY) and GraphPad Prism 7.0 (San Diego, USA) were used to perform statistical analyses and create all figures. The ECG tests were scored in binary format: correct = 1; incorrect = 2. Normality was determined using the Shapiro-wilk test of normality prior to analysis. Basic descriptive statistics defined baseline variables. Pre-test and post-test scores were compared by difference in means using the paired two-tailed t-test; p-values and 95% confidence intervals were reported. A p-value of <0.05 defined statistical significance.

Results

A total of 145 participants completed the pre-test and of those 44 completed both the pre and post-test. To determine that our inclusion criteria were not introducing

selection bias, we also compared the difference in means between the pre-test only group (n=101) in addition to those who completed both the pre-test and post-test (n=44). The 101 students that did not complete the post-test were excluded from final analyses comparing pre-test and post-test groups, therefore leaving the sample size of n=44 for statistical analysis.

Baseline characteristics for the final sample (n=44) are displayed in Supplementary material B. A total of 45.5% of students who attended the workshop were in their fourth year, i.e. senior medical students in the penultimate year of their studies. Earlier years of medical school were less well represented with years 1, 2 and 3 comprising 1.3%, 11.4% and 6.8% of attendees respectively. The mean age of participants was 22.6 years (range: 19-36 years) and attendees were predominantly female, which is in keeping with the current proportion of female medical students in the UK (female: 61.4%; male: 38.6%) [21]. 40.9% of participants attended the workshop because they wanted to revise their ECG skills having previously studied their cardiology module at university, even though most attendees (56.8%) remained unsure of whether they wanted to progress into cardiology specialty training in the future. 47.7% of attendees reported spending just 1-3 hours per year revising ECG interpretation and the most common revision method was reading ECG-dedicated literature (45.5%) followed by online ECG teaching resources (38.6%).

The pre- and post-test group (n=44) achieved a mean pre-test score of +1.06 (5.3%) compared with pre-test only group (n=101), however this was not statistically significant (95% CI -4.5% to +11.1%, p=0.07) (Figure 2).

The mean pre-test and post-test scores were 9.7/20 questions (48.9%) and 11.2/20 questions (56.2%) respectively, with a mean improvement of +1.5/20 marks (+7.3%, 95% CI:+1.8 to +12.8%, p=0.01) from pre- to post-test. The extent of improvement varied considerably as shown in the box plot comparison in figure 3. The spread of participant scores was lower in the post-test than the pre-test scores which is supported by a pre-test interquartile range (IQR) of 4 points, and an IQR of 3 points for post-test scores.

The percentage of correct answers in all students who performed the pre-test (n= 145) and the 44 students who performed the post-test (n=44) for each question is shown in Supplement material C. Figure 4 shows the percentage of correct answers in 44 students who completed both tests. The percentage difference between pre-test and post-test scores in these students is displayed in Figure 5.

Discussion

ECG is one of the most commonly used investigations in cardiology, and its interpretation is a skill that needs to be acquired by health care professionals to diagnose and manage patients with cardiovascular diseases [22]. Despite the common goal for all medical schools to produce students who excel in reading and interpreting an ECG, current methods used to teach ECG interpretation to medical students are varied. A literature review by Fent et al. [1] identified no single method as most effective in delivering these skills, but highlighted that self-directed learning (SDL) resulted in poorer outcomes, perhaps because it relies on the students' own motivation to engage in learning [1]. Mahler et al. [11] found SDL to be more successful in a format of computer-based tutorials compared with a written manual,

which is consistent with other studies that show e-learning is a promising teaching method [14,23]. However, reviews performed by Cook et al. [24] and Chumley-Jones et al [25] suggest that e-learning is not superior to traditional lecture-based teaching, but rather a valuable addition. Fent et al. [15] suggests that this may result from lacking flexibility to modify the teaching approach and also the inability for the teacher to respond directly to individual learners' questions in a timely manner. As such, the competence of medical students and junior doctors in interpreting an ECG has been inadequate [8,22,26].

A workshop is an alternative teaching method that addresses the downfalls of e-learning and self-directed learning by enabling interactions to occur between the learner and the teacher and encouraging the students to learn actively [11]. Workshop-based teaching methods could effectively complement other proven methods of medical education such as obtaining first-hand clinical experience of interpreting ECGs in a range of health care settings during medical school clinical placements. A workshop empowers students to participate in activity-based learning, which allows them to integrate their theoretical knowledge of cardiovascular diseases with their ECG interpretation practice. It focusses on the student practicing ECG interpretation and then reflecting on their performance, which contrasts with lecture-based, passive teaching methods [27].

The effectiveness of ECG workshops has been trialled by Mahler et al. [11]. In this prospective randomised study with 223 participants, both workshop and lecture-based teaching formats showed a significant improvement in the test scores and were significantly higher than SDL format [11]. However, the results are difficult to

generalise to UK medical students as they were conducted in a single institution outside of the UK.

In this study, we have used an interactive workshop format to provide medical students with the knowledge to interpret ECGs and we examined the success of this educational approach. The workshop was unique. It delivered a curriculum based on the GMC's expectations of newly qualified doctors and provided a comprehensive cardiovascular education which was applicable for both clinical practice and medical school examinations. In addition, all workshops occurred on a single day event and was free of charge for all students to attend. This was important because of the limited time that medical students can dedicate to a single component of their curriculum and the financial difficulties that many medicals students face today must be considered. This is the first study to examine the specific effectiveness of an interactive workshop at improving the ECG interpretative skills of a nationwide UK medical student cohort using a formative assessment measure.

Our study demonstrated an improvement in the competency of medical students to interpret ECGs post ECG workshop. In addition to the overall test scores improving, the spread was lower in the post-test than the pre-test, suggesting increased homogeneity in the post-workshop scores, similar to previous findings in a published study [11]. How significant the 7.3% increase in scores relates to improved real-life clinical practice is uncertain but should be explored further in future studies. Mahler et al. [11] have suggested that an 8% change in ECG test scores is meaningful for real-life clinical practice. As a result, these findings support the implementation of workshop-based formats in the medical school curricula.

Study limitations

Our study was limited by the small number of participants, which predisposes to type 2 errors. We had a relatively low response rate (30%) for the post-test group. However, it is a recognized effect that post-event questionnaire-based surveys show low rates of participation [28]. This is likely attributable to lacking engagement from participants because the test was a formative assessment which has been previously described by Raupach et al. [10]. Although the cohort comprised of students from universities across the country, most students were from London-based universities, where the study day was held, which therefore restricts the external validity of our conclusions and limits its generalisability to the entire UK or internationally. To ensure its content was representative of all medical schools and the requirements for all doctors in the UK, the content for the workshops was specifically tailored towards the foundation curriculum [3] for UK junior doctors, published by GMC.

There was no retention test to examine the long-term effectiveness of the workshop, so findings are limited to medical students' short-term recall, rather than long-term memory. Although increasing familiarity with the ECGs could have contributed to improve post-test scores, our methodology limited this as much as possible because the test ECGs were not included during any study day sessions and the options in the post-test were provided in a random order. Only a small group of participants completed both tests, which could suggest that those who completed the post-test were either more motivated or had previously performed poorly in their interpretation of ECGs. However, the difference in pre-test scores between pre-test only group (n=

101) and pre-test and post-test group (n=44) was not statistically significant which suggests the n=44 cohort that defined our sample size is likely to be representative of students who completed the pre-test. Hence, selection bias is minimal.

In addition, our study involves two cross-sectional analyses of ECG test scores in participants, with the post-test occurring within 2 weeks following the study day. We did not restrict the participants' access to other resources during the 2 week period. There is a theoretical risk that participants could have accessed other resources during this time which could contribute to the observed improvement in test scores. Similarly, if the cohort in this study were on average poorer at interpreting ECGs than the typical medical student, the improved post-test scores could simply represent an improvement towards the average score expected from a medical student and may represent its value in improving the competency of underperforming medical students, rather than helping all medical students to excel.

There is no control group in this study which restricts our ability to attribute changes in the test scores solely to our intervention. No control group was used for practical reasons. It was challenging to recruit a nationally representative, unbiased cohort of participants motivated to perform both tests without attending the study day. Therefore, the results from this study should be considered exploratory. In the future, controlled studies should be performed to validate our findings.

The cost-effectiveness of teaching workshops is unknown. Despite various advantages of workshop-based education, they require a high teacher: student ratio which, with limited time available for practicing doctors to teach, and a growing

number of medical students at UK universities, these workshops may not always be feasible [1,29]. It is, therefore, important to consider its direct and indirect costs. Cost has been detailed in some published studies [12,30], however there has been limited exploration of the cost-benefit analysis of teaching methods, which is warranted in future analyses.

Conclusions

A national ECG workshop which emphasizes activity-based learning may be effective in improving the competency of medical students to interpret ECGs. Further exploration with multi-center controlled studies involving a diverse cohort of students and analyses to determine their cost-effectiveness is warranted.

Recommendations

In the future, a cost-effective combination teaching method may be the most effective way for medical students to learn and retain how to interpret ECGs because no single, most superior method has been proven [1]. A workshop-based teaching method with the addition of validated web-resources such as online learning (BMJ learning [31]) to reiterate key concepts may be an effective way for medical schools to integrate the two teaching formats in the future.

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