Comparison of an e-learning package with lecture-based teaching in the management of supraventricular tachycardia (SVT): a randomised controlled study

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Abstract
Introduction To compare the impact of an e-learning package with theoretical teaching on the ability of both graduate and undergraduate medical students to learn the management of supraventricular tachycardia.

Methods We conducted a randomised, controlled, study at two Welsh medical schools. Participants were graduate-entry and undergraduate medical students, who were randomised (in a 1:1 ratio) to either 1 hour of training using an e-learning package or an hour of lecture-based teaching. The outcome was a comparison, within each group and between groups, of median scores achieved in assessments of knowledge through completion of preintervention, immediate post intervention and 2 weeks postintervention questionnaires.

Results Of the 97 participants available for randomisation, 47 underwent teaching using the e-learning package and 50 were taught in the lecture group. Median scores were higher in the e-learning package group than the lecture group, though this difference was not statistically significant (4.00 vs 3.00; p=0.08) immediately after intervention. At 2 weeks post intervention, median scores in the e-learning package group were significantly higher than the median scores in the lecture group (4.00 vs 3.00; p=0.002). This was despite a subanalysis of the results demonstrating that subjects in the lecture group reported having seen more cases compared with those in the e-learning group (32 vs 13; p=0.002). Further, there was a significant fall in score over 2 weeks in the group receiving lecture-based teaching, but no such decrease in those using the e-learning package.

Conclusion E-learning seems to be the preferred method of learning and the method that confers longer retention time for both postgraduate and undergraduate medical students.

Introduction

Carotid sinus massage (CSM) and the Valsalva manoeuvre (VM) are safe and internationally-recommended first-line approaches to terminate haemodynamically stable supraventricular tachycardia (SVT), before resorting to pharmacological interventions.1–3

Education in CSM and VM techniques has historically been rather informal, relying heavily on cultural practice and self-directed learning,4 often lacking the systematic rigour of teaching about the pharmacological management of SVT.

Given the ubiquitous nature of the internet and its capacity to provide a platform for delivering high-quality web-based teaching packages, incorporating multimedia, at a time, location and pace convenient to the learner, we designed and tested an e-learning package that proved to be a successful intervention to increase relevant factual knowledge.5 6 This e-learning module was approved by the Royal College of Physicians of London for one category 1 (external) CPD credit.7

Subsequently, we distributed a short questionnaire among doctors and medical students exploring their experiences of managing cases of SVT, and their knowledge of CSM/VM techniques, including method, duration and appropriate positioning of patients. A short video was made to demonstrate those techniques that have been shown to be most effective in the randomised controlled REVERT study.8 Our survey revealed a substantial variation in extent and depth of knowledge regarding CSM and VM, with limited experience of treating SVT among 'junior' doctors.

We hypothesised that medical students using an e-learning package would demonstrate better knowledge of CSM and VM, and better retention of that knowledge, than those who received traditional lecture-based teaching.

Aim

We carried out a randomised controlled trial comparing the effectiveness of this e-learning package with traditional lecture-based teaching in medical students.

Methods

Study population and recruitment of participants

Participants in the study were final-year medical students from two medical schools in Wales. A structured medical education weekend course has been run by one of the coauthors (HNH) in Swansea University since 2012. Although the course makes use of University facilities it is extracurricular and optional. This course, which includes dedicated sessions on cardiology, was used as the venue both to recruit participants and to provide the educational interventions. Candidates were given relevant information and then asked to consent to participate in the study, receiving teaching by one of the two methods, as described below. This course was replicated in Cardiff University under similar conditions. Importantly, neither medical school's curriculum included practical skills teaching sessions that were dedicated to learning vagal manoeuvres in the setting of SVT during the academic year of the study—2017/2018.

Inclusion criteria
Medical students in their final year of study—year 4 for graduate-entry students, year 5 for undergraduate students—and who provided informed consent were enrolled in the study.

Study design
The study was a two-arm randomised controlled study of the e-learning package compared with lecture-based learning based on the Consolidated Standards of Reporting Trials 2010 reporting criteria.

Participants meeting the inclusion criteria and consenting to participate were allocated to either group using block randomisation to ensure equal numbers within each teaching intervention group as previously detailed.9 Those allocated to e-learning used personal smartphones or were provided with tablet devices, and, for the convenience of the researchers, were asked to access the learning package during a particular 1-hour period. At the same time, the other group received a lecture-based teaching session in a lecture theatre.

All subjects received both a precourse and a postcourse questionnaire (scored out of 5) to evaluate change in knowledge post intervention. A further questionnaire was used at 2 weeks to assess retention of knowledge. The researcher responsible for data analysis (HNH) was blinded to the allocation of the participants.

Power calculation
While no studies have previously been performed investigating improvements in knowledge of vagal manoeuvres, an estimate of power was undertaken. The minimum target sample size for this pilot study was found to be 80 students. Based on previous research which found a mean score of 26.7 (±9.1) in a similar population it was estimated that a sample size of 80 (40 in each group) would have 90% power to detect a 7.7 point difference between the groups (9). At baseline, participants completed questions about their age, gender, number of cases of SVT seen and number of cases of SVT treated.
Intervention

The e-learning package was designed to accommodate a number of learning styles, through a combination of text, videos, images and interactive learning tasks that enable effective and engaging learning.10 Interactive tasks also facilitate ‘deep learning’ rather than mere recollection of facts.11–13

Suitable learning outcomes (box 1) were agreed with consultants in emergency medicine and cardiology and with a university-based educational specialist. The maximum duration of the e-learning package was designed to be 1 hour, in keeping with the overall aim, to provide a general overview of the topic. Much of the textual content within the package was drawn from material in the REVERT study and from commonly used postgraduate textbooks on this topic.6 14–16

Control

Participants randomised to the control/comparator group received a lecture prepared by an expert cardiologist (CW) and provided by one of two clinicians, both of whom possessed postgraduate educational degrees.

Procedure and outcome measures

Medical students were voluntarily recruited via an email advertising the course and the planned study. The interactive responses of candidates were recorded using Hypertext Preprocessor and Hypertext Markup Language form handling commands and stored securely on a private online host.17 The data could then be converted into a spreadsheet showing date and time of submissions and IP addresses of each of the entries. In cases where candidates attempted more than one entry, only the first completed entry was taken into account.

The primary aim was to compare the performance of participants in a Royal College of Physicians validated module,7 based on their allocated learning method, immediately after their learning session and to judge short-term retention of knowledge. The secondary aim was to gauge the preferred learning methods of undergraduate and postgraduate learners. Another test which was voluntary was electronically distributed 2 weeks after teaching to the 97 participants for whom full contact details were available in order to assess long-term retention (figure 1).

The test questionnaire encompassed five multiple choice questions (online supplemental file 1) related to the management of SVT. They focused on vagal manoeuvres regarding position, timing and method used. One mark was given for each correct answer (maximal score of 5). The correct scores were based on the Royal College of Physicians module.7

The primary outcome of the study was performance in the immediate postintervention questionnaire and 2 weeks following teaching. A preintervention questionnaire was designed and consisted of seven items including: number of SVT cases seen, treated, position of patient when attempting CSM and VM, duration of CSM and VM and finally which method the participant will favour when attempting VM in an acute setting. A postintervention question was similar to the above although questions about the number of cases seen and treated were excluded. The similar 2 weeks post questionnaire was e-mailed twice to the whole cohort who attended the teaching sessions. Secondary outcome measures (ie, preference of teaching method) were assessed using a different questionnaire completed by study participants. All participants were asked to complete a post-teaching questionnaire asking five questions regarding the teaching they received. Participants rated the following five questions on a 1–5 Likert Scale where 1 was ‘definitely not’, 2 was ‘probably not’, 3 was ‘possibly’ 4 was ‘probably yes’ and 5 was ‘definitely yes’.

1. Were the learning objectives clearly defined?
2. Was the teaching pitched at the right level?
3. Was the content easy to understand?
4. Has this improved your understanding and confidence of vagal manoeuvres?
5. Any additional comments (free text)

Questionnaire (Supplementary)

Statistical analysis
Baseline differences between the two groups were explored through Mann-Whitney U tests, and $\chi 2$ tests. A Shapiro-Wilk's test ($p<0.05$) combined with visual inspection of histograms, box plots and Q–Q plots demonstrated that scores for both the lecture and e-learning arms were not normally distributed. Accordingly, non-parametric tests were used. This included a Mann-Whitney U test to compare average scores between two independent study groups (different universities or different learning intervention) or a Kruskal-Wallis one-way analysis of variance where more than two groups were analysed. Average test scores were presented as median and 95% CIs where quoted.
Analyses were carried out using the Statistical Package for the Social Sciences (SPSS V.23.0, IBM Corp.).

Results
One hundred forty-two students were eligible for inclusion in the study, by virtue of their attendance at the weekend revision sessions. Of these, 97 (42 graduate-entry medical students and 55 undergraduate medical students) (see table 1) gave consent to participate and were randomised. Forty-five participants declined participation in the study. A total of 47 participants underwent teaching using the e-learning package and 50 were taught in the lecture group.

Median scores at baseline for the lecture group were 1 (95% CI 1.1 to 1.58) and for the e-learning group 1 (95% CI 0.96 to 1.51), p=0.39. There was no statistical difference in the scores achieved in the 5-point questionnaire between the lecture and e-learning groups prior to teaching and immediately after the teaching had been provided, post teaching score 3.00 (95% CI 2.39 to 3.87) versus 4.00 (95% CI 3.46 to 4.10); p=0.08, nor in the overall median scores of graduate entry medical students and of undergraduate medical students, 4.00 (95% CI 3.13 to 3.82) versus 4.00 (95% CI 3.25 to 3.76); p=0.95. Analysis of the median scores between medical students from Swansea University (graduate entry medical students) and those from Cardiff University (undergraduate entry medical students) preintervention was 1.00 (95% CI 1.04 to 1.58) versus 1.00 (95% CI 1.03 to 1.52), respectively, immediately after intervention; Swansea (graduate entry medicine group) were 4.00 (95% CI 3.13 to 3.82) versus Cardiff (undergraduate entry group) 4.00 (95% CI 3.25 to 3.76), respectively, and 2 weeks post intervention—3.00 (95% CI 1.72 to 3.55) versus 4.00 (95% CI 3.08 to 3.58), p=0.110, respectively. Students who reported having never seen a case of SVT had lower median test scores than those who reported witnessing 1–5 cases, or 10 or more cases, irrespective of teaching method, gender or university. This effect did not reach significance immediately after the intervention; no cases seen prior to teaching—median score 4.00 (95% CI 3.45 to 4.05) versus 1–5 cases seen 3.00 (95% CI 2.99 to 3.77) versus more than 10 cases seen—4.50 (95% CI 4 to 5) ; p=0.22, Kruskal-Wallis test. However, retention of information at 2 weeks following from educational episode was significantly higher in the groups who had more experience of SVT cases prior to the learning intervention; no cases seen 3.0 (95% CI 3.2 to 3.86) versus 1–5 cases seen 3.0 (95% CI 2.43 to 3.22) vs 3.5 (95% CI 3 to 4); p=0.011, Kruskal-Wallis test).

Of the original 97 participants, 64 completed the questionnaire at 2 weeks. Of these 64 participants, 35 were from the lecture group and 29 were from the e-learning package group, that is, a further 33 individuals were 'lost to follow-up'. The median scores of the e-

learning package group was significantly higher at 2 weeks than those of the lecture group (4.00 (95% CI 3.42 to 4.03) vs 3.00 (95% CI 2.42 to 3.11); p<0.001, Mann-Whitney U test). A comparison of each student's pairs of scores preintervention and immediately after the learning showed statistically significant improvements in knowledge in both groups: lecture group (median score 1.00 (95% CI 1.12 to 1.60) vs 3.00 (95% CI 3.04 to 3.60); p<0.001, Mann-Whitney U test), e-learning group (median score 1.00 (95% CI 0.94 to 1.49) vs 4.00 (95% CI 3.38 to 3.98); p<0.001, Mann-Whitney U test). For those students who completed the 2-week postintervention questionnaire, a comparison with their immediate postintervention scores showed a significant fall in the lecture-based group (median score 3.00 (95% CI 3.04 to 3.59) vs 2.5 (95% CI 2.42 to 3.11); p=0.019, Mann-Whitney U test) but no such fall in the scores achieved by students taught by e-learning (median score 4.00 (95% CI 3.38 to 3.98) vs 4.00 (95% CI 3.42 to 4.03); p=0.893, Mann-Whitney U test); see figure 2 and online supplemental table 1.

Finally, qualitative feedback given in the form of brief written comments after the teaching session demonstrated that both graduate and undergraduate medical students found the e-learning package a useful and acceptable method of teaching SVT management. Typical statements in favour of the lecture method included: "I think being taught in person is better than watching the videos as it can be confusing", "I would like to have been able to ask questions", "Not as good as face to face teaching as I won't remember this in a day's time". Statements in favour of e-learning included: "Very educative and informative session", "Concise, clear" "I was able to work at my own pace", "It was a good learning point for me as a medical student". Other statements included: "As it is so concise, so background physiology would have been great" and "Lecturer was good but I won't mind e-learning".

Discussion

This is the first study to investigate of the use of an online-delivered, self-directed teaching package on SVT management in comparison with a more traditional lecture-based approach. The aim of providing a mixed group of medical students was twofold; first validating the assessment method (as graduate medical students might be expected to perform better than undergraduate medical students) and second validate the e-learning package separately against a lecture format.

Although these results must be regarded as preliminary findings given the limited amount of teaching time in both groups, at this point, there is ample evidence at this stage that e-learning is equivalent to traditional teaching in the short term and offers longer retention of knowledge compared with teaching in a lecture format. This is confirmed by numerous previous computer-based teaching methods as well as multimedia learning tools.18–20
A comparison of the test scores immediately post intervention and at 2 weeks post intervention suggests that e-learning promotes better early retention of knowledge than lecture-based teaching. Our study also showed that subjects who report that they have seen more cases achieved higher scores both immediately after the intervention and at 2 weeks. This is most likely a function of their greater experience as being part of a team treating a case of SVT in the acute clinical setting, their prior learning, and their ability to use their clinical experience to contextualise subsequent learning.

In general, the qualitative comments regarding the e-learning package were positive, although it was obvious that having access to someone to answer questions would have aided acceptability. Overall these results indicate that using an e-learning package is both acceptable and well perceived by those who use it. The e-learning package itself was designed to be student-centred and this was demonstrated in the positive student feedback.

There are several advantages teaching using computer software compared with traditional techniques. At a time and place of the learners' choice, learning can take place at a pace which suits them and can be repeated as many times as is necessary.5 In addition, it is possible to independently review the contents of a simulator programme to validate its accuracy and quality. There is the potential to organise more flexible teaching schedules, and to modify the level of difficulty in a modular fashion. Students encounter the information first hand in an online setting, rather than receiving filtered information from a teacher whose style or background may differ from theirs.5 In a traditional lecture, instructors contextualise and personalise the information to meet their own needs, which may not be appropriate for all learners.5 20 Once learners access the online materials, there must be learner-content interaction to process the information. Learners navigate through the content to access the components of the lesson, which could take the form of prelearning, learning, and postlearning activities.11 13

The disadvantages of using computer software rather than a traditional teaching approach include the loss of flexibility to modify the teaching approach within a session, for instance to accommodate a predominantly visual learner.5 Furthermore, computer software does not currently have the ability to respond directly to individual learner questions although this may change with the advent of artificial intelligence algorithms.5 21
Only 64 participants completed the second test 2 weeks after recruitment. Since the test was neither mandatory nor taken under exam conditions, the results should be interpreted with some caution. The median scores in the e-learning package group were significantly higher than median scores in the lecture group, which was interesting given that there were more subjects who have observed more cases in the lecture group. Notwithstanding the low numbers of participants who took the test at 2 weeks, it is probable that both teaching methods are equivalent in terms of immediate retention of knowledge but the e-learning package due to it being more engaging confers a longer term retention of knowledge compared with lecture teaching.22

Students engaged in deep learning tend to prefer practical methods of assessment based more on ability and attitude, by means of using real or simulated patients, while those with a more superficial profile tends to favour multiple-choice tests, which are related to more cognitive and more immediate knowledge.23 This should encourage researchers and educators to explore other approaches to computer-based simulated learning such as virtual reality (VR) simulation training using a SVT programme simulator. The VR simulation programme would provide the participant with a close to 'real world' experience in the real world setting, whether that is the emergency department or hospital ward. It might also assist in assessing practical skills and team working rather than just factual knowledge in the management of SVT.

Limitations

There were a number of limitations to the study. The teaching intervention in both the lecture and e-learning groups was relatively short (1 hour), though unavoidable given the limited time available to recruit participants to the study. It should also be emphasised that the limitation of the e-learning package use within the session to an hour time slot was somewhat artificial; one of the main potential strengths of the software is allowing each learner to progress at their own pace and run through the packages as many times as required. Also, the 2 weeks post test may have been undertaken too close to the intervention and could possibly have been delayed in order to assess longer retention. It is uncertain whether the difference in retention of knowledge at 2 weeks would persist in the longer term. Future work should focus on allowing free access and evaluating the real usage patterns of the software by candidates and ending with a summative examination. Another limitation is that the efficacy of a hybrid approach involving the e-learning package combined with an experienced facilitator was not assessed. Such an approach would potentially offer the best of both worlds and would yield improved results over the isolated approaches that this study investigates. Finally, we acknowledge that with a significant drop-out rate (approximately 34%) there will be naturally some bias accrued. We note that this is often unavoidable for questionnaire/survey-based studies.

Conclusions

E-learning seems to be the method that confers longer retention time for both graduate and undergraduate medical students. These are preliminary findings which indicate that, at present, there is insufficient evidence to suggest that an e-learning package such as ours is superior to traditional teaching. Nevertheless, this technology may be a viable alternative method or at the very least may have a place as a supplementary means to augment knowledge gained from more traditional lecture-based learning, especially in this era of COVID-19. Such a teaching method may be helpful in the future of medical education and training as it enables enhanced retention of information while enabling social distancing.

Ethics approval

Ethical approval was deemed unnecessary by the Swansea Bay University Health Board Local Research Ethics Committee who reviewed the study protocol. That being said, participation was voluntary, and not a requirement for attendance at the weekend educational event. Participants were able to withdraw their consent at any time, on the understanding that they would not have to provide a reason for withdrawal, and that under such circumstances their data would be removed from the study. In the end, 45 of 142 attendees elected not to participate.

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