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Abstract

Objective: iBook on Antiphospholipid Syndrome (APS) did not exist before our work, and hence the utility of an Apple iBook as a teaching method in APS for medical students has never been assessed. Our objective was to evaluate medical students' improvement of knowledge and satisfaction with an interactive APS iBook, in comparison with conventional teaching methods.

Methods: An iBook designer with the guidance of a medical team developed the APS iBook in both French and English. Second-year medical students, naive of APS knowledge, were enrolled from two institutions. For the "teaching intervention", participants were randomly assigned to three groups: a) APS iBook with interactive capability; b) printed copy of the APS iBook material; and c) classroom lecture presentation of the APS iBook material by a physician-scientist experienced in APS. The participants filled a standardized medical questionnaire about APS before and after teaching interventions to determine the relative change of knowledge. Participants were asked to fill out a standardized satisfaction survey. After 20 weeks of the intervention, recall capability of students was tested.

Results: A total of 233 second-year medical students were enrolled (iBook group: 73; print group: 79, and lecture group: 81). Relative change of knowledge was not different between the iBook group and the printed material group; additionally, it was significantly higher in the lecture group than the two other methods. Satisfaction was significantly higher in both the lecture and the iBook groups than the print group, on several dimensions including overall quantitative satisfaction, subjective enhanced knowledge, interactivity, quality of content, comprehensibility, and pleasure of learning. Recall capability of students (n=109, 47%) was not significantly different among groups.

Conclusion: The APS iBook is as effective as printed material in improving medical student's knowledge, although a classroom lecture was the most effective method when compared to self-learning methods. Among self-learning methods, medical students are more satisfied with the APS iBook, whereas the recall capability was not different among groups. These results suggest that the APS iBook will help medical students in their curriculum and increase the awareness of APS among the community.

Keywords: Antiphospholipid syndrome, medical education, educational innovation and knowledge, improvement of knowledge, lectures, iBook

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Introduction

Antiphospholipid syndrome (APS) is an autoimmune disorder that is characterized by thrombosis and/or obstetric complications in association with persistent antiphospholipid antibodies (aPL), that is, lupus anticoagulant test, anticardiolipin antibodies (aCL), and anti- β_2 glycoprotein-I antibodies (a β_2 GPI) (1). Deep vein thrombosis (DVT) is the most common venous thrombosis, and stroke is the most common arterial thrombosis; fetal death, growth restriction, pre-eclampsia, and recurrent early miscarriages constitute APS-associated pregnancy morbidity (2). Livedo reticularis, heart valve disease, thrombocytopenia, hemolytic anemia, cognitive dysfunction, and nephropathy can also develop in patients with high titer aPL (3). Clinical heterogeneity exists among aPL-positive patients. Different medical specialties, such as rheumatology, internal medicine, cardiovascular medicine, neurology, obstetricians, or nephrology, manage aPL-positive patients.

A recent literature review demonstrated that the public health impact of APS is significant: in a general population without autoimmune disease, aPL is present in 9% of patients with pregnancy losses, 14% with stroke, 11% with myocardial infarction (MI), and 10% with DVT. In the USA, aPL could be associated with approximately annual 50,000, 110,000, 100,000, and 30,000 pregnancy losses, strokes, MIs, and DVTs, respectively (4). Thus, it is important for medical students to understand the spectrum of aPL-related clinical problems, and receive proper training in the diagnosis and management of APS.

An "electronic book (eBook)" is the digital version of a published book, which can be read on an electronic device. eBooks are more interactive and portable than traditional textbooks, and they give us the opportunity to add images as visual learning materials enhance clinical education (5). Our society is in the midst of a digital textbook revolution (6), and eBooks developed for higher education are likely to

Main Points

- The objective of the study was to assess medical students' improvement of knowledge and satisfaction with an interactive antiphospholipid syndrome (APS) eBook, while comparing with conventional teaching methods.
- Second-year medical students were randomized into three groups: eBook Group (APS eBook with interactive capability); Print Group (printed copy of the material contained in the APS eBook), and Lecture Group (classroom lecture of the material contained in the APS eBook by a physician-scientist experienced in APS). Standardized questionnaires were used in each group for quantitative assessment.
- Improvement of knowledge showed no difference between the eBook group and the print group; however, it was significantly higher in the lecture group. Satisfaction was significantly higher in both the lecture and the eBook groups, compared to the print group.
- This study supports the use of an eBook as a powerful teaching method, which is as effective as printed material in improving medical students' knowledge while providing better satisfaction.
- Additionally, APS eBook is a useful free-of-charge tool that can be used in combination with traditional teaching interventions to teach medical students and other health care professionals about APS.

soon dominate printed books (7). Many eBook publishing options exist, including *iBooks*, a free eBook application by Apple Inc. To date, Apple's *iBooks Author*® is considered the best software in the publishing of text containing illustrations and graphics (8), and hence better suited to the image-rich field of medicine (9).

eBook/iBook on APS did not exist before this work. Therefore, we decided to develop an interactive APS eBook (using *iBooks Author* Application, Apple Inc) for medical students. This study aimed to assess medical students' improvement of knowledge and satisfaction in comparison with conventional teaching methods (print material or conventional lectures).

Methods

Antiphospholipid syndrome eBook development

An award-winner eBook designer (10) under the supervision of experts in APS developed the APS eBook in both English and French. The content of the APS eBook was established by the leading publications, book chapters, review articles, and online image libraries (images were either re-created or used by permission), allowing students to use various interactive functions such as picture clicking, video extensions, information boxes, text input, or page jumping (Video 1) (11).

Teaching intervention

Second-year medical students from New York, USA, and Nancy, France, were enrolled. At the end of the second-year, medical students in both USA and France are supposed to know the basis of immunology but are naïve of knowledge on APS. Physician-instructors responsible for the medical student education in both institutions were contacted in advance for their guidance in setting up the "teaching intervention". Following institutional review board approvals (Approval date: 9/22/2016; Project number: 1603017059) in both centers, the content of the study was presented to all the students. Those interested in participating were randomly assigned to three groups by drawing names from a hat (ratio 1:1:1): APS eBook with interactive capability (Group A); printed copy of the material contained in the interactive APS eBook (Group B); and classroom lecture of the material contained in the APS eBook by a physician-scientist experienced in APS (SZ or DE) (Group C). The participants filled a standardized medical questionnaire about APS (10 multiple-choice questions; total score: 10 points) before and after all three teaching interventions. Students were unaware that the pre- and post-test questionnaires were identical. At the end of the teaching sessions

(60 min), participants were asked to fill out a standardized satisfaction survey. Satisfaction was measured using either categorical values for quantitative assessment (10 points scale: 2–3, 4–5, 6–7, and above 8) or qualitative assessment based on five dimensions (subjective enhanced knowledge, interactivity, quality of content, comprehensibility, and pleasure of learning). All steps of the initial teaching intervention are summarized in Video 2 (12). Recall capability of students was tested at 20 weeks after the intervention (10 multiple-choice questions; total score: 10 points). During this waiting period, students did not have access to either the APS eBook or the material contained in the eBook. Following the recall capability assessment, the APS eBook was published for free on iTunes Store (13, 14).

Statistical analysis

Relative change of knowledge (RCK), which was the primary outcome measure, was assessed by the difference in the number of correct answers between post-test (PosT) and pre-test (PreT) divided by the number of correct answers obtained during the pre-test (PreT), that is, $RCK = (PosT - PreT) / PreT$. We decided to compute the RCK instead of the improvement of knowledge (PosT-PreT) because RCK is less influenced by PreT answers. Indeed, even after a randomization, PreT answers among groups were different. Relative percentage change of knowledge corresponded to $RCK \times 100$. Additionally, we computed the percentage of students in each group who increased the number of correct answers between PosT and PreT significantly (above 2 standards of the mean of the PreT values). Satisfaction and recall capability were assessed by comparing

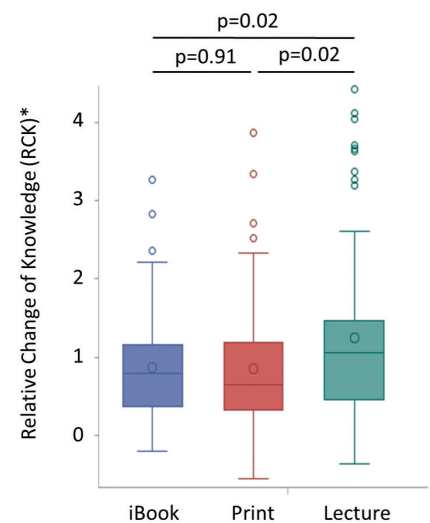


Figure 1. The difference in the number of correct answers between post-test (PosT) and pre-test (PreT) divided by the number of correct answers obtained during the pre-test (PreT), i.e., $RCK = (PosT - PreT) / PreT$.

the results among three groups. Characteristics of sample were described by percentage for categorical variables and mean, standard deviation, median, quartiles, and min/max values for continued variables. To identify superiority between groups, Student t tests for quantitative variables were used with two by two comparisons. To identify RCK equivalence between groups, equivalence analysis using the two one-sided t-test was performed (margin of 0.28). Global comparison of quantitative variables (satisfaction or recall capability) between the three groups

(iBook, print, lecture) was done using an analysis of variance. Furthermore, Chi-square or Fisher's exact tests were used for qualitative variables. Alpha risk was 5% for all analysis. These statistical analyses were performed using the SAS 9.4 software (SAS Institute Inc.; Cary, NC, USA).

Results

Relative change of knowledge

The study included 233 second-year medical students (iBook Group [A]: 73; Print Group [B]:

79, and Lecture Group [C]: 81) and all students concluded both pre- and post-intervention medical questionnaires. Compared to iBook and print groups, the mean RCK was superior in the lecture group (Figure 1, Table 1); furthermore, it was equivalent between iBook and print groups ($p=0.02$). Relative percentage change of knowledge, that is, $RCK \times 100$ were $86.9\% \pm 70.4\%$, $85.5\% \pm 83.2\%$, and $123.3\% \pm 110.3\%$ for iBook, print, and lecture groups, respectively. Percentages of students who significantly increased the number of correct answers between pre- and post-test were 63%, 59%, and 71% in iBook, print, and lecture groups, respectively.

Satisfaction survey

Satisfaction was rated between 8 and 10 in 79% of iBook group, 36% of print group, and 77% of lecture group ($p_{ANOVA} < 0.0001$). Satisfaction was significantly higher in both iBook and lecture groups than the print group on several dimensions including subjective enhanced knowledge (diagnosis and pathogenesis), interactivity, quality of content, comprehensibility, and pleasure of learning (Figure 2, panels A to F) ($p_{ANOVA} < 0.05$).

Recall capability

After 20 weeks of the initial teaching intervention, recall capability was tested. Among 233 participants, 109 (46.8%) responded to the questionnaire. A total of 32 (29%) students belonged to the iBook group, 42 (39%) to the print group, and 35 (32%) to the lecture group. The mean PreT scores of these 109 students obtained during the initial teaching intervention were similar to those from students who did not responded (data not shown). Among 10 questions, the mean number of correct answers for recall capability was 7.9 ± 2.0 for the iBook group, 7.8 ± 2.1 for the print group, and 7.6 ± 2.0 for the lecture group. No significant difference was observed among the three groups ($p_{ANOVA} = 0.86$).

Discussion

Our international two-center randomized control study of medical students compared three APS teaching methods: iBook with interactive capability, a printed copy of the iBook material, and a classroom lecture presentation of the iBook material by a physician-scientist experienced in APS. We found that the mean RCK was similar between iBook and printed material group, and significantly higher in the lecture group. In addition, satisfaction was significantly higher in both the iBook and lecture groups than the print group, whereas the recall capability was not different among groups.

Table 1. Pre-test, post-test, and recall capability test results according to groups.

	iBook group	Print group	Lecture group
Pre-Test	5.9±2.5	5.0±1.8	5.2±2.4
Post-Test	11.6±3.4	11.3±3.4	12.4±3.5
Recall Capability Test	7.9±2.0	7.8±2.1	7.6±2.0

This APS learning experience:

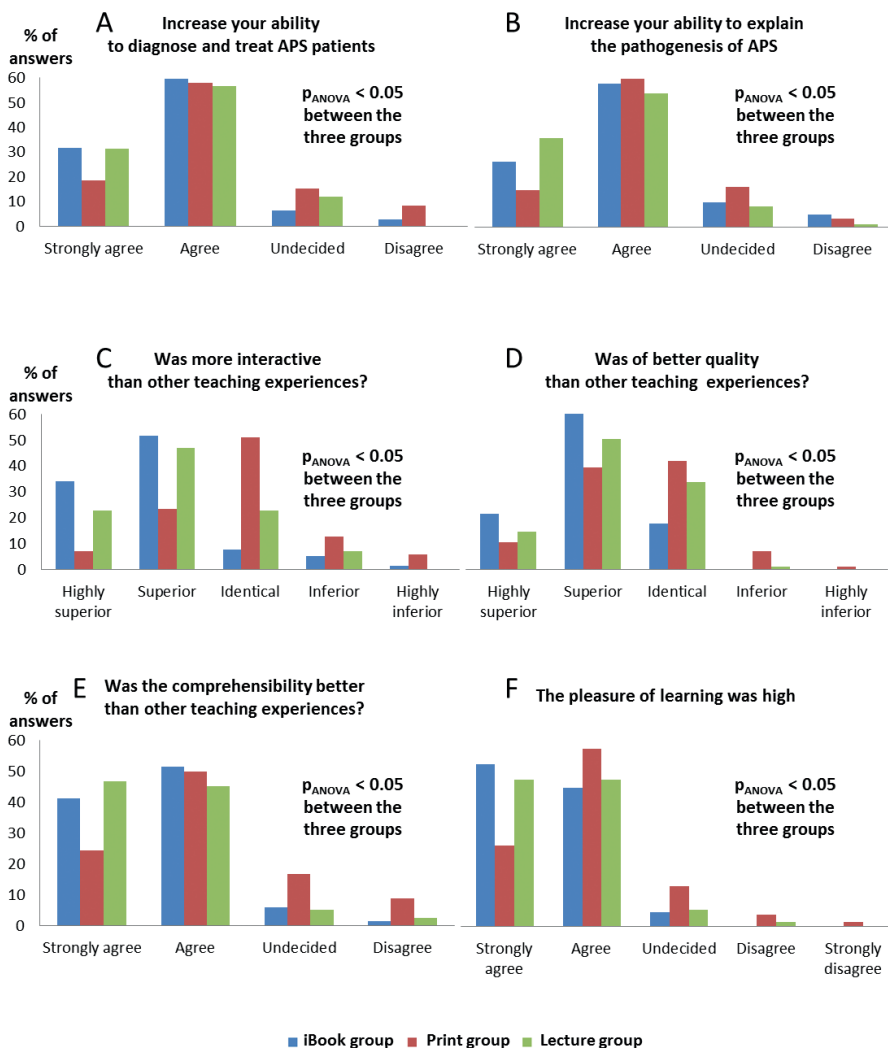


Figure 2. APS: antiphospholipid syndrome. Panels: A and B: subjective enhanced knowledge (diagnosis and pathogenesis), C: interactivity, D: quality of content, E: comprehensibility, and F: pleasure of learning.

Although an e-learning curriculum can improve students' information retrieval and patient management skills, and encourage the practice of evidence-based medicine (15). In our study, the classroom APS lecture was the most effective method in improving medical students' knowledge. This finding highlights the fact that a classroom lecture, presented by experts in field, remains the gold standard for improving medical knowledge; profound medical knowledge and clinical experience of the physician-instructors are considered as an important factor in clinical knowledge transformation (16). Furthermore, as demonstrated by others (17-19), attendance to lectures helps improve learning ability of the students. However, given that classroom lectures are not easily available for all students and the attendance has been decreasing due to increased use of self-learning methods, our study provides valuable information that an eBook is as effective as printed material in improving medical student's knowledge while providing better satisfaction.

Among the print and electronic versions of the same teaching material, many students prefer electronic versions (20). For instance, almost 90% of interns, residents, and fellows in the XXXXXX, Pittsburgh, PA, use eBooks to support their clinical care (21); medical students from the Royal College of Surgeons in Ireland, Dublin, prefer a self-developed interactive anatomy dissection software for their own use (22). Furthermore, eBooks are more affordable, portable, current, and interactive than traditional textbooks. Thus, we believe that the APS eBook developed by our team is a useful free-of-charge tool to teach medical students and other health-care professionals about APS.

A majority of residents today are familiar and proficient with digital technologies, and they shift toward digital learning (7). As millennial learners increasingly turn to digital resources, it is important to offer students more tailored opportunities to better support self-regulated learning (23). There is also a need to constantly assess the success of such learning modalities. Electronic books have a beneficial effect on the students' knowledge; they also improve students' attitudes toward learning experience (24, 25). Our data provided important information about the success of the eBook as a teaching tool. Our survey showed that students' satisfaction was significantly higher in both the lecture and the eBook groups than the print group. This finding also suggests that eBook has an impact on motivation for learning. Thus, we believe that when a classroom lecture is not available, the APS eBook should be the choice

of teaching method to facilitate the improvement of knowledge.

Retention of the information is one of the most important aspects of medical education. A recent study reported that although interactive teaching worked significantly better than textbook for complex knowledge, recall capability was similar among eBook, case-based learning, and classroom teaching (26). We also found no significant difference among groups with respect to recall capabilities of our students 20 weeks after the intervention. Although this finding is worrisome, in real-world experience, eBooks can be consulted at any time, which would probably increase student's retention of information.

Our study has limitations. Firstly, theoretical risk of teaching-to-the-test bias exists in the lecture group; however, the contents of the lecture and eBook groups were similar to decrease this bias. Secondly, we could have a higher number of questions to better evaluate the improvement of knowledge. Thirdly, we did not test the effect of combined lecture and eBook teaching methods. Lastly, 10 multiple-choice questions may not be sufficient to completely evaluate students' knowledge in APS. Despite these limitations, this is the first international, two-centered randomized study that investigates the effect of APS eBook, awarded the best book of the year in education category, in 2017 (10), as a teaching method in comparison with both a print material and a lecture by a physician-scientist.

In summary, our results support the use of an eBook as a highly effective teaching method for medical students (and possibly for other medical professionals), who were more satisfied with the eBook learning compared to print material. In addition, an eBook can be used in combination with traditional teaching interventions to provide medical students a more comprehensive learning environment especially in advanced subjects, such as APS.

Ethics Committee Approval: Ethics committee approval was received for this study from the institutional review board approvals (Approval Date: 9/22/2016; Project Number: 1603017059).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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Conflict of Interest: The authors have no conflict of interest to declare.

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