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Original Article

Effectiveness of case-based teaching of cardiovascular physiology in clinical pharmacy students

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الملخص

أهداف البحث: هدفت هذه الدراسة إلى صياغة وتنفيذ وحدة وظائف الجهاز القلبي الوعائي بنظام التدريس القائم على دراسة الحالة وذلك لطلبة السنة الثانية للصيدلة الإكلينيكية. كما قمنا بتقويم مرئيات الطلبة وتمت مقارنة الأداء الأكاديمي لمجموعة الطلبة الذين تم تدريسهم بنظام التدريس القائم على الحالة مع مجموعة الطلبة الذين تلقوا المحاضرات التعليمية التقليدية.

طرق البحث: أجريت هذه الدراسة الوصفية الكمية على ١٨١ طالبا الذين تم تقسيمهم إلى مجموعتين. وخضعت المجموعة ١ (٧٧ طالبا) إلى المحاضرات التعليمية التقليدية وتلقت المجموعة ٢ (٩٤ طالبا) نفس الموضوعات بنظام التدريس القائم على دراسة الحالة. تم إجراء امتحان كتابي في نهاية كلا الوحدتين. وتم استخدام استبانة موثقة للحصول على المرئيات حيال نظام التدريس القائم على دراسة الحالة ودرجات التقييم من جميع المجموعات وكانت نسبة الاستجابة ٩٣.٦٪.

النتائج: كانت ردود الطلاب حول نظام التدريس القائم على دراسة الحالة إيجابية، وذكر معظم الطلاب ٦٣ (٧٢٪) أنهم يفضلون نظام التدريس القائم على دراسة الحالة الذي جعل التعلم والفهم تجربة ممتعة. كما ذكر المشاركون أن التدريس القائم على دراسة الحالة حفز التفكير النقدي (٦٧; ٧٦٪) وساهم في ربط النظرية بالممارسة (٦٩؛ ٧٨٪). وعلاوة على ذلك، فضل ٧٠ (٨٠٪) منهم هذا النوع من التدريس والتقييم في المستقبل، واتفق ٧٠ (٨٠٪) على تضمين نظام التدريس القائم على دراسة الحالة في جميع المواد ما قبل السريرية. كما جاءت نتائج الاختبارات متوافقة مع مرئيات الطلبة، حيث كان متوسط النسبة المئوية لدرجات الاختبار في مجموعة التدريس القائم على دراسة الحالة أعلى بكثير مقارنة بالمجموعة التي تلقت المحاضرات التعليمية التقليدية. كشفت مقارنة أخرى داخل مجموعة التدريس القائم على دراسة الحالة عن تحسن في أداء الطلاب في الأسئلة "المستندة إلى حالة" مقارنة بالأسئلة التقليدية.

الاستنتاجات: في هذه الدراسة، يحظى نظام التدريس القائم على دراسة الحالة على تقدير كبير من قبل الطلاب لأنه يحفز التفكير المنطقي والمشاركة النشطة في الفصل، مما يؤدي إلى تحسين الأداء في الاختبارات.

الكلمات المفتاحية: محاضرة تعليمية تقليدية؛ التدريس القائم على دراسة الحالة؛ وظائف الجهاز القلبي الوعائي؛ الصيدلة الإكلينيكية؛ المحاضرات التقليدية

Abstract

Objective: This study aimed to formulate and implement a case-based cardiovascular physiology module for second year clinical pharmacy (CP) students. We also evaluated the students' feedback and compared the academic performance between a case-based teaching (CBT) group and a traditional didactic lectures (TDL) group.

Methods: This descriptive quantitative study was conducted on 181 students who were divided into two groups. Group 1 (77 students) underwent TDL and the same topics were delivered to Group 2 (94 students) through CBT. A written examination was conducted at the end of both modules. A validated questionnaire was used to obtain feedback from the CBT group regarding CBT and their assessment grades (response rate - 93.6%).

Results: Students' feedback about CBT was positive. The majority of students, 63 (72%), preferred learning and understanding through CBT, finding it an enjoyable experience. Participants stated that CBT stimulated critical thinking (67; 76%) and linked theory to practice (69, 78%). Furthermore, 70 (80%) preferred this type of teaching and assessment in the future and 70 (80%) agreed to include CBT in all preclinical subjects. Students feedback was supported by exam results: the mean percentage of exam scores in the CBT group was significantly higher in comparison to the TDL group (81.2% vs. 79%, p value <0.05). Further comparison within the CBT

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group revealed improved student performance in "case-based" as compared to "conventional" questions (82.75% vs. 80%, p value <0.05).

Conclusion: Students greatly appreciated CBT, as it stimulated logical thinking and active participation in the class, resulting in improved performance in exams.

Keywords: Cardiovascular physiology; Case-based teaching; Clinical pharmacy; Traditional didactic lecture

Introduction

There is currently a worldwide trend of shifting health education from the traditional system (didactic lectures) to case-based and interactive teaching.[1] The traditional system involves a teacher-centred approach and minimal student participation. This teaching methodology focuses on teaching students to give correct answers. The teacher usually asks the students to define, describe, or list the facts, rather than stimulating critical thinking, analysis, and application of knowledge.[2] Still some students like traditional lectures, because they get the information quickly from the teacher while listening.[3] Some authors believe that traditional lectures are the best teaching method for many students in many circumstances; especially for transferring conceptual knowledge, and where there is a significant knowledge gap between lecturer and students.[4]

Traditionally, students in health care are exposed to non-case-based lectures during the preclinical years. Interaction in clinical conditions occurs later when students start their clinical rotations.[5] However, medical educators from all over the world have realised that students should comprehend the relevance of preclinical learning to clinical work. This can be achieved by introducing case-based teaching (CBT) during the preclinical years.[6] 'The goal of CBT is to prepare students for clinical practice, through the use of authentic clinical cases in various settings. It links theory to practice, through the application of knowledge to the cases, using inquiry-based learning methods'. Moreover, Abraham et al. and Mc Lean et al. observed that "Case-based teaching can also aid in the development and implementation of major curricular reforms by facilitating the identification and removal of unnecessary components of lectures".[7,8] There are various modes of delivery of CBT. Case-based teaching in lectures is a novel teaching methodology that is a classical combination of traditional lectures and modified problem-based learning.[9,10]

Student feedback and exam results are the major indicators used by various authors to compare traditional didactic lectures (TDL) and CBT. Most authors have found that CBT enhances logical thinking and long-term memorization, which improve student performance on exams.[11,12] Moreover, CBT enhances the application of knowledge and therefore creates better health care professionals.[11–14] However, in some studies, CBT showed no advantages over TDL.[15–17] In fact, some authors reported better exam results with traditional teaching compared with CBT. One randomised-controlled trial conducted to compare CBT with TDL concluded that CBT was not appreciated by the students, and that the method was ineffective at imparting knowledge.[18] Kassebaum et al. also found the traditional lecture format to be superior in preparing for a written exam compared with a CBT format.[19] Various factors may be responsible for these findings, including faculty resistance for CBT, poorly trained faculty, poorly designed curricula, unnecessary lecture content, inadequate lecture objectives, poorly formulated case scenarios, poorly delivered information, lack of interaction between students and faculty, and poorly designed and conducted assessments.[11,12,15,17]

Data regarding the effectiveness of CBT and student feedback about this teaching method for undergraduate clinical pharmacy (CP) students is very limited and inconclusive.[20] In our teaching system, a unified physiology curriculum is being delivered for all the health colleges, including dental, clinical pharmacy, nursing, physiotherapy, respiratory therapy. Therefore, we felt a strong need to update the existing physiology curriculum for CP students. The new curriculum will focus on delivering the most relevant and required information. The primary aim was to formulate and implement case-based teaching of cardiovascular physiology for second-year clinical pharmacy students and to evaluate student feedback and satisfaction about this updated teaching method. The secondary aim was to compare the effectiveness of CBT and TDL by student performance on exams. The study results can be helpful in determining future strategies for curricular reforms.

Materials and Methods

This descriptive quantitative study was conducted on 171 second-year CP students of the College of Clinical Pharmacy, Imam Abdulrahman Bin Faisal University Dammam (IAU), from September 2017 to September 2018.

Grouping of the students

The study population was divided into two groups. Group one (G1) received the Cardiovascular (CVS) Physiology module via traditional didactic lectures (TDL). Group two (G2) was taught CVS physiology via CBT.

Description of the module and lecture details for the TDL and CBT groups

The CVS Physiology module for both the TDL and CBT groups included eight lectures (1-h each), one laboratory session (2 h) and two tutorial sessions (2 h each). Before the beginning of both modules, all the related materials, including PowerPoint slides, tutorials, and other reading material, were made available to the students. Despite the difference in teaching methods for the two groups, the following measures helped to minimise the effects of

confounding factors on the exam results: same number of credit and contact hours, same lecture objectives, same lecture content, same facilitator delivering the lectures and tutorials for both groups, same grade point averages in preparatory year (indicating comparable mental capabilities and learning abilities), same exam formats (multiple choice questions [MCQs]). Both exams were found to be highly reliable and had almost equal difficulty indexes (CBT: 0.72 and TDL: 0.74) and Cronbach's alpha/Kuder-Richardson 21 values (CBT: 0.85 and TDL: 0.81).

TDL (G1)

This module was delivered using a traditional non case-based method without any vertical integration. Eight face-to-face lectures were delivered to the students.

CBT (G2)

A cardiovascular team was formed for efficient formulation and delivery of this module. The team included two physiologists, one clinician specialised in CVS diseases, one clinical pharmacist, and two final-year CP students. The learning objectives, clinical scenarios, tutorials, vertically integrated questions (to be used in lectures and tutorial sessions), timetables, and assessment tools were finalised after meetings and discussions amongst the team members. After several meetings, eight case scenarios were designed and finally approved. These cases were relevant, well-structured, and focused. Special care was taken to provide a balance of physiology and pharmacology, as providing unnecessary information could ruin the goal of integration.

Large group interactive sessions (LGISs)

Case-based teaching was incorporated into LGISs and tutorials. At the beginning of the LGIS, the facilitator introduced a case scenario and lead a 10-min brainstorming and discussion session among the students. Then the LGIS was continued for the next 35 min. An interactive teaching approach was adopted by pausing the LGIS at key points. Various predesigned questions were also incorporated into the lecture. The students were invited to integrate elements of the case with the lecture objectives at various steps. Finally, the key content of the lecture was summarised by the facilitator in the last 10 min. At the end of the session, the facilitator made sure that all the gaps in knowledge were filled, all the queries were clarified, and all the learning objectives were achieved.

Tutorial sessions

Further discussion on the case scenarios and related objectives took place in the tutorial sessions (two 2-h sessions). Tutorial #1 covered the topics from lectures 1–4, and tutorial #2 focused on the topics from lectures 5–8. (Two sample case scenarios and trigger questions are provided in Appendix A).

Formulation of integrated questions

Finally, the integrated MCQs were designed by the team. This process was one of the biggest challenges faced by the committee. Efforts were made to design the questions to assess knowledge, application, and analysis (Blooms Taxonomy). A blueprint was developed, which provided a reasonable distribution of the lecture objectives based on Miller's pyramid.[21]

The questions included were all multiplechoice questions (MCQs). The cognitive level of the questions was classified using *Buckwalter's Modification* (Buckwalter, 1981) of *Bloom's Taxonomy* (Bloom, 1956). Level CI included knowledge recall and simple understanding questions, whereas Level C2+C3 included higher cognition testing questions (application, analysis and evaluation questions).[22]

Exam questions were also designed as either case-based questions or conventional questions on the basis of the presence or absence of a case scenario. Highly focused case scenarios were used in the stems of the case-based questions. All these questions belonged to the C2+C3 level. There were no case scenarios featured in the stem of conventional questions, but they included both C1 and C2 questions.

A sample of two vertically integrated (case-based) MCQs is provided in Appendix A.

Student feedback

At the end of the module, student feedback on case-based teaching and assessment was requested from all cohorts of the CBT group (94 CP students). No feedback was taken from the TDL group, as this group was not exposed to CBT. The measurement tool was a questionnaire (made up of 10 questions) developed by the authors, which had been based on previous studies.[14,20] The questionnaire was validated by two experts in medical education. This was followed by pilot testing and a test-retest reliability analysis carried out on 20 students. The reliability was found to be 0.807. The objective of the study and all the terminologies used in the questionnaire were explained to the students. The questionnaire was distributed to all 94 CP students, and they were given 15 min to fill it out. The questionnaire and its detailed analysis are provided in the results section (Table 1).

Comparison of exam results

Exam results were also included in the analysis. At the end of the module, both the CBT and TDL groups were administered a written exam. Each exam consisted of 25 MCQs. The exam results of the two groups were compared. The types of questions on each exam (CBT and TDL) are shown in Table 2. The CBT group was exposed to a greater number of higher cognition testing questions compared with the TDL group. Both exams were found to be highly reliable as indicated by their Cronbach's alpha/Kuder-Richardson 21 value (CBT: 0.85 and TDL: 0.81).

Statistical analysis

All statistical analyses were conducted using SPSS version 20 (IBM Corp., Armonk, NY, USA). Descriptive statistics for exam results, including mean score, standard error of the mean (SE), and standard deviation (SD), were compared between the CBT and TDL groups. An unpaired t-test was used for this comparison, and a p value ≤ 0.05 was

considered to be statistically significant. The 10 items of the feedback questionnaire were measured using a 5-point Likert scale, from 1 (strongly disagree) to 5 (strongly agree). The 5-point Likert scale responses were grouped as follows: *strongly agree* and *agree* as *agree*, and *strongly disagree* and *disagree* as *disagree* (Table 1).

Results

A total of 88 out of 94 students completed and returned the questionnaire, for a response rate of 93.6%. Results of the analysis of the 5-point Likert scale responses (agree [combination of *strongly agree* and *agree* responses], *disagree* [combination of *strongly disagree* and *disagree* responses], and *uncertain*) are presented in Table 1. Seventy-two percent of the students felt that CBT made learning enjoyable, compared with 22% who did not. Most stated that CBT stimulated their critical thinking (76%) and helped them to link theory to practice (78%). The majority of students agreed that CBT improved their attendance in class (75% vs 14%), and helped them to grow more confident in their ability to perform future clinical work (81% vs 11%). Furthermore, 83% felt that the use of case-based questions was a better method of assessment compared with conventional questions. Seventy-nine percent indicated that they would prefer this type of teaching and assessment in the future. Eighty percent agreed that the CBT approach should be used in all preclinical lectures.

Table 3 presents a comparison of overall student performance on the exams between the CBT and TDL groups. All the questions, including knowledge recall and higher cognition testing, were included in this comparison. The mean percentage of exam scores in the CBT group was significantly higher compared with that of the TDL group (81.2% vs. 79% and p value <0.05), indicating that CBT enhances learning and understanding.

Table 1: Feedback of eighty-eight students from the case-based teaching group.

Statement	Agree n (%)	Disagree n (%)	Uncertain n (%)
The CBT made learning enjoyable.	63 (72%)	20 (22%)	5 (6%)
The cases and trigger questions stimulated my critical thinking.	67 (76%)	9 (10%)	12 (14%)
The cases were challenging but interesting.	62 (71%)	14 (16%)	12 (13%)
The cases were focused and helped me to understand the link between physiology and pharmacology.	77 (87%)	7 (8%)	4 (5%)
The CBT helped me to link theory to practice.	69 (78%)	9 (10%)	10 (12%)
The CBT helped me to grow more confident in my ability to perform future clinical work.	71 (81%)	10 (11%)	7 (8%)
The CBT improved my attendance and motivated me to actively participate in the class.	66 (75%)	12 (14%)	10 (11%)
I would prefer this type of teaching and assessment in the future.	70 (79%)	11 (12%)	10 (11%)
The use of case-based questions is a better assessment method compared with conventional questions.	73 (83%)	7 (8%)	8 (9%)
I think the CBT approach should be used in all preclinical lectures.	70 (80%)	9 (10%)	9 (10%)

CBT=Case-based teaching.

Table 2: Exam question types for the CBT and TDL groups.

Groups	Case-based questions	Conventional questions	Knowledge and recall questions (C1)	Higher cognition testing questions (C2+C3)
TDL Group	0%	100%	44%	56%
CBT Group	41%	59%	32%	68%

CBT, Case-based teaching; TDL, Traditional didactic lectures.

Table 3: Comparison of overall student performance on exams between the TDL and CBT groups.

Groups	No. of students	Mean percentage	SD	SE	*P* Value
TDL Group	77	79%	3.90	0.43	<0.05
CBT Group	94	81.24%	4.81	0.55	

CBT, Case-based teaching; SD, standard deviation; SE, standard error; TDL, Traditional didactic lectures.

Table 4: Comparison of student performance on higher cognition testing questions between the TDL and CBT groups.

Groups	No. of students	Mean percentage	SD	SE	*P* Value
TDL Group	77	76.7%	2.15	0.31	<0.05
CBT Group	94	81.25%	3.70	0.42	

CBT, Case-based teaching; SD, standard deviation; SE, standard error; TDL, Traditional didactic lectures.

Table 5: Comparison of student performance between case based and conventional questions within the Case Based Teaching group.

CBT group	No. of students	Mean percentage	SD	SE	*P* Value
Case-based	94	82.75%	2.26	0.33	<0.05
Conventional	94	80%	3.31	0.39	

CBT, Case-based teaching; SD, standard deviation; SE, standard error.

We also compared the exam scores between CBT and TDL groups with regards to the higher cognition testing questions Table 4. Significantly higher percentages were noted for the CBT group compared with the TDL group (81.25% vs. 76.7% and p value <0.05), indicating that CBT improves cognitive and analytical thinking, which results in better performance on exams.

Further comparison of student performance on case-based and conventional questions was carried out within the CBT group. The results showed that students performed better on the questions with case scenarios, compared with the conventional questions (82.75% vs. 80% and p value <0.05) Table 5. In fact, adding a case to the question helps the students link theory to practice, which results in a better application of knowledge.

Discussion

The results of the present study indicated that most participants in the CBT group enjoyed case-based teaching and found it very useful. We also observed that supplementing the lectures and exam questions with case scenarios results in a marked improvement in both student participation in class and their performance on exams. This is consistent with the finding of prior reports.[12,23] Case-based teaching is actually a classical combination of traditional lecture and problem-based learning.[7] Although lectures are an excellent method of delivering information to a large group of students, conventional didactic lectures are usually monotonous in nature and do not stimulate interaction, problem-solving, or reasoning in the students.[2,3,19,24] Introducing relevant case scenarios and triggering questions in the lecture, with guidance from the facilitator increases critical thinking and active discussion, thereby converting passive lectures to a more interactive session, even in large groups.[25,26]

We observed that the success of CBT depends largely on the quality of the case scenarios. Jeggles et al. also demonstrated that the ideal case for CBT should be relevant, realistic, engaging, challenging, instructional, enjoyable, and based on a real-world professional context.[13] In the present study, 87% of the students responded that the cases were focused and helped them to understand the link between physiology and pharmacology. Seventy-one percent indicated that the case scenarios were challenging but interesting, and 72% reported that CBT made learning enjoyable.

Another major contributor to successful CBT was the interactive mode of delivery.[11] This was achieved by starting the lecture with the case scenario for more student attention and engagement. Moreover, the lecture was paused at multiple key points, and predesigned relevant questions were asked. This approach helped to link the theory to the case. This interactive teaching method was also highly appreciated by the students. The students were satisfied with the CBT; they reported that the cases and triggering questions stimulated their critical thinking (76%) and motivated them to actively participate in the class (75%). Other authors have also found that teaching through cases enhances critical thinking skills and transforms the learning process from a passive to a more interactive one.[27] Regarding student satisfaction, most of the studies found that students prefer CBT over TDL.[23,24,28] However, Smits et al. were less satisfied with the CBT.[29]

The effectiveness of this teaching method was supported in the comparison of the exam results of the CBT and TDL groups. The overall exam scores for the CBT group were significantly higher than those for the TDL group. Moreover, the CBT group also showed better exam scores on higher cognitive testing questions. Other authors have also reported similar results, indicating that CBT promotes active participation, provokes cognitive and analytical thinking, and facilitates better understanding of the concepts. It has been demonstrated that CBT supports long-term memorization, which improves performance on exams.[27,30,31]

We also aimed to determine the impact of adding case scenarios to the questions. This was achieved by comparing performance on the case based questions with that of the conventional questions within the CBT group. The students performed better on the questions with the case scenarios compared with the conventional questions. Eighty-three percent of the students responded that 'use of case-based integrated MCQs was a better method of assessment compared with conventional questions'. In fact, adding a case to the question helps the students to link theory to practice, which results in a better application of knowledge.[8] These findings were in line with those of a previous study in which 85% of the participants responded that placing the students in real situations (case scenarios) and asking them to apply their knowledge, enhances their analytical and answering skills, and 89% of the participants agreed that CBT was helpful in improving their exam scores.[32]

In contrast to our findings, some studies showed no significant difference in the exam results between the CBT and TDL groups.[15,17] Some authors even found TDL to be superior to CBT, and most of their students reported that CBT was not effective in imparting knowledge or improving their exam results.[18,19] It is therefore very important to identify the reasons for the differences in findings. Multiple factors can be responsible for these results (i.e. faculty resistance for CBT, poorly trained faculty, poorly designed curricula, unnecessary lecture content, inadequate lecture objectives, poorly formulated case scenarios, poorly delivered information, lack of interaction between students and faculty, and poorly designed and conducted assessments).

The above-mentioned problems can be solved by improving the design and implementation of case-based curricula. We expect our study to be useful as a tool for this purpose.

This study had two major limitations. First, we could not conduct the comparison on the same cohort of students (although it was our secondary objective). The College of Clinical Pharmacy's administration did not allow us to split

the same cohort of students into two subgroups, and to use two different teaching and assessment modalities for them. Therefore, two different cohorts of students were used. Second, our results are based on the findings of a single module. We therefore recommend future studies implementing CBT in multiple modules, using the same cohort of students.

Conclusions and recommendations

Based on the feedback from students and exam results, we concluded that most of the students were satisfied with the CBT and assessment, and they wanted to continue taking CBT-based lectures in the future. Compared with TDL, CBT enhanced logical thinking, facilitated active participation in the classroom, and improved student performance on exams through better application of knowledge and long-term memorization.

This study can be used as a model for designing and implementing case-based modules, with minimal resources, manpower, and technology. Not only can the findings of this study be beneficial for clinical pharmacy students, but they can also be helpful in other health science disciplines, such as medicine, nursing, dentistry, public health, physiotherapy, and respiratory therapy.

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Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

This study was approved by the Deanship of Scientific Research College of Medicine, Imam AbdulRahman Bin Faisal University Dammam [IRB aproval number 2017-01-360, Approval date: August 2017].

Authors' contributions

AAA Compiled the data, analysed and interpreted the data, drafted the manuscript, and revised it critically for important intellectual content. NR Conceptualised and designed the study, conducted the research, and wrote the initial and final drafts of the article. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jtumed.2020.11.009.

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