Impact of case-based lectures on students’ performance in vascular physiology module

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Lecture-based teaching (LBT) remains the predominant form of teaching in healthcare profession education (6, 14). It is excellent in providing an overview of a particular topic to a large number of students. However, the concern, which has been highlighted time and again, is the monotony and passive nature of this form of information transmission, which may alienate students away from the learning process (11, 18). It has also been blamed for causing stress and information overload and producing doctors with poor critical thinking and problem-solving skills (8).

Case-based teaching (CBT) is a teaching technique that exhibits a teacher-dependent approach to large groups of students (23). In contrast to LBT, CBT is interactive, provides increased motivation for learning by using clinical scenarios, and develops an effective clinical reasoning process (10).

We have been fortunate enough at the Department of Physiology, College of Medicine, University of Dammam, a budding institution of the Kingdom of Saudi Arabia (KSA), to introduce a number of innovative teaching techniques emphasizing the interactive form of learning to understand physiological aspects in a better and interesting manner. This is possible only because faculty members have a commitment to development, are willing to step out of their conventional roles and try new approaches, and take risks. One of the techniques was to replace LBT with CBT while retaining large groups of students. The rationale for the use of cases in the lecture was fourfold: 1) to act as a tool to achieve the required knowledge of basic physiological concepts, 2) to provide a scaffold for the organization of facts, 3) to provide exposure to methods of clinical reasoning, and 4) to promote communication skills by fostering active discussion and participation.

The majority of studies documenting students’ better performance in CBT (12, 20, 22) have been done in the United States, Europe, and Australia, whose entry level to a medical education program is graduation, in contrast to the KSA, where entry is at the undergraduate level. Hence, their results cannot be applied to the KSA (as students’ maturity may be a factor in the effectiveness of CBT), and it would be a major leap of faith to assume that most medical school entrants in KSA universities will be as mature as medical school entrants in the above-mentioned countries. In the KSA, a recent study (12a) has compared traditional lecturing with problem-based learning (PBL) and shown significant improvement in results. However, due to differences in the PBL technique used in that study (student-centered self-directed learning in small groups facilitated by facilitators with no lectures at all) with those of CBT (teacher-centered lecturing in larger groups with incorporation of clinical cases among the lectures), these results cannot be applied to CBT.

Therefore, we designed the present study to compare the performance of students in two curriculums, i.e., “old” (traditional) versus “new” (CBT). It is the need of the hour. Multiplicity in the medical teaching approach is to be embraced, but only if it will produce better doctors than do traditional curriculums by comparing the doctors produced by new and traditional curriculums. However, by that time, any damage caused by a patchy knowledge base, if at all, would have already occurred (3). This compelled us to conclude that the comparison should begin without delay and should follow doctors as they progress through their career.

METHODS

Objectives

The purpose of this study was to compare the effectiveness of the two different teaching approaches, CBT and LBT, in terms of students’ exam performance.

Methodology

The present study was designed as quantitative study that used two groups of cohorts after permission from the university ethical board to collect quantitative data to assess the effectiveness of CBT was obtained.

Course Format/Module Description

The vascular physiology module, which was taught as seven lectures (1-h duration), one case-based tutorial (35 students/group, 2-h duration), one laboratory (35 students/group, 2 h-duration), was selected. Regardless of the delivery mode, both teaching alternatives consisted of the same number of contact hours, covered considerably similar material, and required similar assignments.

Lecture Format

There were seven face-to-face lectures/sessions with the same instructor covering the same academic contents. The same PowerPoint slides were used for both groups except that the CBT group had additional slides describing the case at the beginning/middle of each topic.

LBT (academic year 2011–2012). The module was offered in a lecture format with teacher-centered approach. All class materials were distributed in class for student convenience. CBT (academic year 2012–2013). Each lecture was interactive and started with a clinical case scenario. A vascular physiology module team consisting of five members (one clinician specialized in cardiovascular diseases and four physiologists with areas of specialization in cardiovascular physiology) jointly prepared the cases keeping in mind that cases served two basic requirements: 1) they must serve as a stimulus to provoke the type of cognitive thinking that is needed and 2) they must cover the fundamental areas of content. All team
members agreed that the cases were interesting, relevant, properly structured, open ended, and required students to use previous knowledge. When a case was first introduced to them, students were given 5–10 min to discuss its physiological basis with their immediate neighbors. An interactive approach to stimulate thinking was introduced by pausing the lecture at key points to direct questions at pairs (or groups) of students to foster active processing of their understanding (examples of cases along with the questions asked have been provided in the Appendix).

Interactive approaches to learning that involve questioning of students about their understanding have been shown to improve student exam performance (1, 24), irrespective of whether case-based learning is used or not. Therefore, both groups were asked the same questions. The only difference was that in the CBT group, questions were specifically linked to the cases themselves, whereas in the LBT group, questions were linked to the topic of the lecture as there were no cases in LBT. This was done to clearly show that the case study analysis itself, and not merely the questioning of students, was associated with any significant change in exam performance.

Subjects/samples. The subjects were women in the second year of the Medicine degree of academic years 2011–2012 and 2012–2013. The number of female students enrolled in 2011–2012 and 2012–2013 was 108 and 96, respectively. As per our university rules, the number of students in a class should not be more than 50. Therefore, each class was divided into two equal groups, and their classes were held in separate lecture halls. There were 54 students in the LBT group and 48 students in the CBT group.

Instrument/format of the exam. Evaluation included performance in a written exam immediately at the end of the course and 2 mo after the course. Each exam was of 1-h duration based on multiple-choice questions (MCQs) and short-essay questions (SEQs) assessing three levels of Bloom’s taxonomy (knowledge, comprehension, and application) in the knowledge structure. Some of the exam questions were case based, and some were conventional. In both delivery alternatives, a few test questions were drawn from the department test bank, and the remaining questions were prepared by the department team of faculty experts. The exam questions given to both groups (CBT and LBT) at two different times (at the end of the course and 2 mo after the course) were different and contained a different mix of MCQ and SEQs from each other. Nevertheless, since the classes covered the same topics, the exam was quite similar in both years. The number of questions allocated in each section was also similar. We examined the same concept and followed the same peer review process for both years; therefore, a direct comparison of the average of the exam scores was possible.

Statistical Analysis

SPSS (version 13) software was used for statistical analysis. Descriptive statistics (such as means and SE) were compared between traditional and case-based student exam data. An unpaired t-test was used to analyze the exam data for the two delivery modes to find out whether there was any statistical significance in exam performance between the two groups. Statistical significance was set at the 95% confidence level ($P < 0.05$).

RESULTS

Student performance was evaluated by comparing exam scores between the two classes. The goal was to determine if there were significant differences in student performance between classes. Although two different groups of students were compared, use of the same text, same instructor, similar assignments, evaluation of the same concept in exams, and similar format allowed for direct comparison.

As shown in Tables 1 and 2, there were significant differences between average exam scores immediately and 2 mo after course completion.

DISCUSSION

Although exam results are but one of an array of criteria normally used in evaluating student performance, in our case they served as a readily available measure. From the data collected, there were significant differences in student performance based on the teaching layout. This is an encouraging result and bodes well for the future of case-based education in large groups of students.

Our findings clearly show that basic science information, especially physiology, can be learned and applied more effectively when didactic lectures are supplemented with clinical cases and there is active participation of the students. The same questions were asked during the lectures from both groups. In the LBT group, students did not show much willingness in answering the questions, whereas in the CBT group, students answered all questions actively. This clearly shows that the case study analysis itself, and not merely the questioning of students, was associated with gains in exam performance. The same instructor taught both groups, and, according to her, when she asked questions from the CBT group, they all showed their willingness to answer by raising their hands. They also questioned her during the lecture. However, in the LBT group, students never asked any questions, and most of them were not even willing to participate when the instructor asked them questions.

Since student in the CBT group performed better in another exam 2 mo after course completion, this indicated that CBT improved not only the short-term memory of our students but long-term memory as well.

Our results agree with multiple studies available in the literature documenting improved knowledge with the use of CBT in surgical clerkship students (4), obstetrics/gynecology residents (7), final-year medical students (9a), and veterinary students (15).

The reasons behind the improved knowledge with CBT may be twofold, as discussed below.

Active Learning

Clinical problems convert passive didactic lecturing into active mental activity (13), which is a must for learning, as recommended by cognitive theory (5). Petress (16) showed that

### Table 1. Student performance immediately after course completion

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Students</th>
<th>Mean Scores</th>
<th>SD</th>
<th>SE</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBT group</td>
<td>106</td>
<td>21.58</td>
<td>4.49</td>
<td>0.44</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>CBT group</td>
<td>92</td>
<td>23.48</td>
<td>5.33</td>
<td>0.56</td>
<td></td>
</tr>
</tbody>
</table>

LBT, lecture-based teaching; CBT, case-based teaching.

### Table 2. Student performance 2 mo after course completion

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Students</th>
<th>Mean Scores</th>
<th>SD</th>
<th>SE</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBT group</td>
<td>58</td>
<td>7.98</td>
<td>2.36</td>
<td>0.31</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>CBT group</td>
<td>69</td>
<td>9.42</td>
<td>3.24</td>
<td>0.39</td>
<td></td>
</tr>
</tbody>
</table>
retention of knowledge is increased by active learning. Although only few students were randomly picked for answering questions, there was close to complete participation from the students in the CBT group as all of them raised their hands, showing their willingness to participate in the discussion.

Enjoyment

According to Richardson (17), the key student behavior that brings about active learning is engagement. The method was well accepted, appreciated, and enjoyed by the students (unpublished observations). Enjoyment might be the cause of more engagement and motivation for learning, more retention of knowledge, and better exam performance of students.

Medical students are, in fact, more enthusiastic about a topic and its relevance to their professional lives when it is taught using a problem format rather than a traditional lecture-based course (8). The cases incorporated into lectures provided the motivation to learn concepts and processes that might otherwise be of little interest or enticement when presented in lecture. It also allowed correlation of basic physiological principles to a clinical setting. Discussion of the cases among neighboring students provided an excellent chance to break the monotony of lecture, enhancing student communication skills and supporting team-building skills. The instructor teaching the two modules also endorsed the CBT format because it made the learning more enjoyable; students were more comfortable asking questions and making comments in the CBT group. CBT was more interactive, which encouraged students to discuss all their assumptions freely with the instructor. In contrast, the LBT format was teacher centered and none of the students discussed their assumptions with the instructor.

Unlike PBL, which is an open-ended exploration in small groups and blamed for being time inefficient, frustrating for time-pressed medical learners, and often leads to erroneous conclusions (19), our CBT format was a guided inquiry in large groups, which motivated learners to focus on the key points of a clinical case to learn about the relevant physiological concepts. Importantly, the lecturer corrected false assumptions of the learner there and then, which usually does not happen in PBL.

Future Recommendations

We believe that discrete, ostensibly objective outcomes, such as examination grades/scores, may not be reflective of the advantages of CBT. Instead, complex outcomes, including problem solving, critical thinking, ethics, and professionalism, may also be improved in the CBT model. This and other studies do not begin to address these important but difficult to measure parameters. The CBT model may confer advantages in developing lifelong learning skills that may only be apparent years later. While prospective research is needed as medical students step forward, after graduation during the first years of practice, to best assess the utility of CBT as an alternative to LBT, the preliminary data of the present study suggest there would be no harm in continuing and introducing more interactive case-based lectures in physiology courses in the future. The findings of this study can be applied to multiple disciplines; to mention a few, nursing, dentistry, pharmacy, physical therapy, physician assistant training, public health, respiratory therapy, and many other specialties may benefit from our study.

Conclusions

Today, more than ever, is the time to identify the most appropriate teaching system for medical students so that students demonstrate mastery of skills and knowledge before graduation from their respective medical school. Our study suggests that CBT might be an effective approach compared with a traditional lecture-based approach for educating medical students in preclinical years. This represents a meaningful, positive outcome for medical institutions seeking alternative educational approaches without demanding additional resources in terms of technology or manpower, which remain serious concerns when introducing new strategies into an academic environment.

Limitations of the Study

As with any study, there were several situational and methodological limitations that need to be considered, as follows:

- Methodologically, the present study was limited to a single medical school in the KSA. Thus, any generalizations are left to the discretion of the reader.
- We cannot guarantee that a homogenous cross-section enrolled in each year. It is entirely possible that the demographics and mental capabilities of the two groups may have differed.
- We compared only two types of teaching formats: LBT and CBT. As there are a variety of programs being used in medical institutions, such as true PBL and hybrid PBL, the study findings might not be generalizable to all medical programs.
- Each section used a common text, MCQ bank, and similar schedule and assignments, with the same instructor placing equal emphasis on different topics. The intention was to minimize the differences in instructional approaches but did not completely abolish them. The instructor’s previous experience in CBT was less compared with her experience in LBT. Therefore, it is possible that this had some impact on the results of this study.
- The subject’s degree of effort when learning the material and taking the examinations was not taken into account.
- We compared overall exam performance only. There is a possibility that students taught in CBT might have performed better in case-based MCQs than in conventional MCQs and vice versa.
- The use of examination scores as markers for overall student performance is not universally accepted. Certainly, such scores are only a rough surrogate for actual clinical performance and represent another limitation in transferring study results to actual practice.

The aforementioned limitations might, in various ways, have impacted on the study outcomes. Regardless, this research may be considered a landmark study on CBT in preclinical education in the KSA, as it was the first of its nature. This is important due to the lack of literature focusing on CBT compared with LBT in the field of medical education in the KSA.
Finally, the beauty of this research was that since there was no communication across the groups, no contamination occurred, which probably made detecting differences in performance between groups easier.

APPENDIX

Case and Questions Added in the Lecture of Shock in CBT and LBT

A 25-yr-old man was brought to emergency room with multiple bodily injuries due to a car accident. The patient was bleeding extensively from these sites and was drowsy. Clinical examination revealed cold pale skin, a heart rate of 140 beats/min, and a blood pressure of 90/60 mmHg.

Question 1. Explain the physiological basis of low blood pressure in this patient/shock.

ANSWER TO QUESTION 1. In previous lectures, students had learned the factors affecting venous return and the Frank-Starling law, the determinants of blood pressure. Thus, they were able to recall and guess what caused hypotension in this patient/shock.

Question 2. What could be the possible reason of tachycardia in this patient/shock?

ANSWER TO QUESTION 2. Students were able to relate the baroreceptor reflex previously taught to them with tachycardia.

Question 3. Why is the skin pale in this patient/shock?

ANSWER TO QUESTION 3. The answer to this question required students to recall the various factors controlling the arteriolar radius.

Question 4. What treatment can a doctor give to bring blood pressure back to normal in this patient/during shock?

ANSWER TO QUESTION 4. Again, students needed to recall the determinants and factors affecting blood pressure.

Cases and Questions Added in the Lecture of Forces Affecting Bulk Flow and Edema in CBT and LBT

A girl presented with gradual swelling of the face and feet. Examination of her urine showed an increased presence of proteins (proteinuria).

Question 1. How can proteinuria lead to edema?

ANSWER TO QUESTION 1. The answer to this question required students to recall the Starling forces affecting bulk flow and justify edema.

Sakina, a 45-yr-old woman, comes to the hospital with complaints of progressive swelling of the left arm for the last 3 wk. The swelling is worsening with time. She can no longer use the affected arm in her daily house chores as it is easily fatigued. Six months ago, she was treated for breast cancer and underwent a left mastectomy (removal of the breast) along with axillary lymph node resection of the same side. Now, this change in how her arm looks is distressing to her and worsening her postoperative physical and emotional strain. The doctor diagnosed her as suffering from lymphedema.

Question 1. What is the role of lymphatic in edema?

ANSWER TO QUESTION 1. The answer to this question required students to recall the Starling forces affecting bulk flow and the lymphatic system.

Manal, a 56-yr-old woman suffering from liver damage caused by chronic hepatitis C virus infection, presented with gradual swelling of her feet and lower legs.

Question 1. How can liver damage lead to edema?

ANSWER TO QUESTION 1. The answer to this question required students to recall the Starling forces affecting bulk flow.

Case and Questions Added in the Lecture of Venous Return and Factors Affecting Venous Return in CBT and LBT

Faisal is a businessman who is going to the United States by air. His flight is continuous for 20 h. After some time, he starts to feel discomfort in his feet. He takes off his shoes and notices that his feet are slightly swollen.

Question 1. What is the cause of swelling of feet in this patient/after a prolonged flight?

ANSWER TO QUESTION 1. The answer to this question required students to relate the factors affecting venous return with this patient/swelling of feet.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: R.L. conception and design of research; R.L. performed experiments; R.L. analyzed data; R.L. interpreted results of experiments; R.L. prepared figures; R.L. drafted manuscript; R.L. edited and revised manuscript; R.L. approved final version of manuscript.

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