



Implementation and Evaluation of Case-Based Learning Approach in Microbiology and Immunology

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ABSTRACT

Background: Medical education in the last two decades has shifted from teacher-centered methods to student-centered methods, where students are learning through active participation. Clinical case-based learning (CBL) was found to be one of the excellent approaches to promote students learning. It enhances their critical thinking, problem-solving ability, knowledge retention, and exam preparation. The objective of the current study was to assess students' perception on the usefulness of CBL approach in Microbiology and Immunology course. **Methodology:** This study was conducted at College of Medicine and Health Sciences among 5th-year medical students of 2017-2018 batch. The study design included pretest, CBL discussion on selected topics, and the posttest after the CBL session. The data were collected, tabulated, and statistically analyzed using Microsoft Excel and SPSS version 22. The student's "t" test was used to compare pretest and posttest results and the $p < 0.05$ was considered as statistically significant. **Results:** A total of 114 fifth year medical students participated in the study. Majority of the students were in favor of CBL activity. More than 85% of the students stated that they enjoyed the activity and about 80% indicated CBL activity improved their critical thinking, problem-solving skills, and clinical reasoning. Majority of the students (90.35%) said it improved their knowledge retention and about 64.04% stated that it improved their exam grades. The difference between pretest and posttest scores was statistically significant with $p < 0.05$. **Conclusion:** CBL is an excellent educational tool to motivate and promote students learning. It enhances students' analytical thinking, clinical reasoning, conceptualization, and knowledge retention. It also benefits students in terms of their better examination preparation and performance.

Keywords: Active learning, CBL, Conceptualization, Critical thinking, Microbiology

Abbreviations: CBL: Case-Based Learning; PBL: Problem Based Learning; PMNs: Polymorph Nuclear Cells; CRP: C Reactive Protein; RR: Respiratory Rate; HR: Heart Rate; BP: Blood Pressure; CMHS: College of Medicine and Health Sciences

INTRODUCTION

Medicine is a multidisciplinary course, where students are trained in many integrated subjects; basic sciences and clinical sciences. In medical sciences critical thinking, clinical reasoning, and clinical correlations are important attributes for proper diagnosis and management of a clinical condition [1-3]. It is essential for all medical students to acquire these essential qualities for better diagnosis and patient management. The first two years in the medical course is devoted to pre-clinical subjects (basic sciences) where students study various basic science subjects with less or no emphasis on how knowledge or skills will be applicable or useful in understanding, diagnosing, and managing real-life clinical cases, later when they progress to clinical years [4]. Many students of clinical years have opined that basic science (preclinical years) curricula are theoretically overloaded with less applicability to clinical practice [5]. In such an environment, students are more concentrated in achieving a good score in the examination rather than focusing on how the basic science knowledge can be applied for better understanding, diagnosis, and management of clinical cases [4]. It has been observed that conventional teaching methods such as didactic lectures, where students are passive learners are less effective in promoting students' learning. They often fail to stimulate students' analytical and reasoning skills and their problem-solving ability. As a result of these students achieve less knowledge retention

and long-term memory [6-8]. Over the past two decades, medical educators have introduced many student-centered learning methods such as role-playing, problem-based learning (PBL), and case-based learning (CBL) that have facilitated students' learning. These active and interactive learning exercises evoke students' interest, promote their learning, and engage them in active discussion in solving a clinical problem. This, in turn, enriches their knowledge and memory, critical and analytical thinking, and their ability to utilize the appropriate knowledge in better understanding and diagnosis of real-life clinical cases during their clinical years [6,9-11].

Medical microbiology is one of the basic sciences course and involves the study of pathogens, their pathogenic mechanisms, clinical features, and laboratory diagnosis of infectious and immunological diseases. Students must acquire and retain sound knowledge of microbiology during their microbiology course training and apply this theoretical knowledge for correlation of clinical findings in a case/patient for a better understanding of the disease pathogenesis, diagnosis, and its management [12]. Therefore it is important to train the students in microbiology and immunology course by using teaching methods that promote their interest in learning, enhances their critical and analytical thinking, conceptualization, problem-solving ability, and improves their knowledge and long-term memory.

Case-based learning (CBL) sessions have become more popular in medical education as an interactive student-centered learning approach. It was first introduced by the Department of Anatomy of a Medical school in Newfoundland, Canada [6,9]. In CBL clinical case scenarios that mimic real-life instances which the students encounter in future in their clinical years were used to promote their learning [13]. Cases designed in CBL are real-life situations that provide students the details of the patients such as the history of present illness, past history, clinical signs and symptoms, laboratory investigations and other related data. Students are actively involved in the discussion; interact with each other in a group and work together to solve the case and case related learning issues. The instructor will act as a facilitator. Studies have shown that the incorporation of clinical case-based learning (CBL) approach in the curriculum motivates students in learning. The major benefits include strengthening of students' critical thinking, clinical reasoning, and ability to connect the concepts for a better understanding of the disease and its management [14]. Also, it improves their knowledge, academic performance, and learning outcomes [15-19]. A literature search did not show any studies on CBL activity done in microbiology and immunology course in this region and hence the current research was undertaken to implement case-based learning exercise in microbiology and immunology curricula and assess its effectiveness in students' learning.

MATERIALS AND METHODS

It is a cross-sectional study and was conducted at Department of Microbiology, College of Medicine and Health Sciences (CMHS) during the academic session 2017-2018. The study group included 117 students enrolled in microbiology and immunology course for the academic year 2017-2018. The study was approved by the Institutional Research and Ethical committee and the study was conducted after taking necessary informed consent from the students.

Clinical case scenarios on 5 selected topics that are previously covered in regular didactic lectures were prepared by the faculty members for CBL sessions. The topics selected for the activity were anaphylaxis, staphylococcal wound infection, Hepatitis B, bacterial meningitis, and pneumococcal pneumonia (an example of a case scenario is given in Appendix 1).

Students were informed about the topic for the activity a week earlier. On the day of activity, pretest questions on the topic were distributed to students to determine how much knowledge they had acquired from the regular lecture. Students were then divided into groups of 20 for clinical case discussion. Each student of the group was provided with a handout containing clinical case scenario and various learning issues related to a clinical case such as clinical features, terminologies, clinical diagnosis, pathophysiological mechanisms, laboratory investigations, and case management. All students in the group were asked to actively participate in the discussion to solve the case and related learning issues. At the end of the activity, facilitator summarizes the case. Posttest consisting of questions related to case topic was distributed to all the participants to evaluate the knowledge acquired by them through the activity.

At the end of the academic session, after completing all the clinical cases, students were distributed a self-administered questionnaire to assess the students' perception about the effectiveness of the activity in their learning. The evaluation was performed on a 5 point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). A sample of the questionnaire along with the responses asked for is given in Table 1. The data were collected, tabulated, and statistically analyzed.

Table 1 Questionnaire on effectiveness of CBL activity and students responses

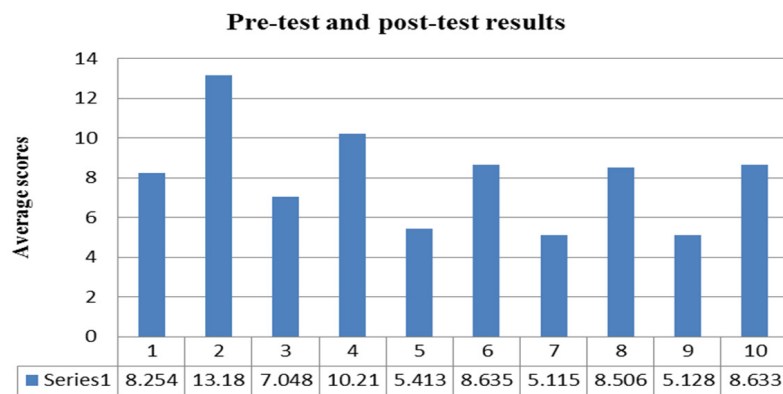
S. No.	Question	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	Mean (SD)
1	I enjoyed CBL sessions	4	3	9	58	40	4.11 (0.92)
2	CBL sessions held my interest	3	5	4	59	43	4.18 (0.90)
3	CBL sessions motivated me to learn	4	2	2	55	51	4.29 (0.88)
4	CBL sessions improved my critical thinking and problem-solving ability	9	8	6	48	43	3.95 (1.20)
5	CBL helped to focus on key areas and a better understanding of concepts	6	6	5	51	46	4.10 (1.06)
6	CBL helped to make clinical correlation for diagnosis in real clinical practice	5	6	5	55	43	4.10 (1.01)
7	CBL provides benefits in terms of knowledge and long-lasting memory	4	4	3	63	40	4.15 (0.91)
8	CBL sessions were useful to prepare for the exam	7	15	18	49	24	3.57 (0.00)

Data Analysis

The completed response sheets were collected and statistically analyzed to compute the results using Microsoft Excel and SPSS version 22. Qualitative data were expressed in the form of percentages and the quantitative data were expressed in the form of mean ± standard deviation. Student’s “t” test was used to compare pretest and posttest scores and expressed in terms of “p” value. The value of p<0.05 was considered statistically significant.

RESULTS

A total of 114 fifth year medical students participated in the study. In the study, the posttest scores after CBL sessions were significantly better than pretest scores of all the sessions (Figure 1). The ‘t’ test between pretest and posttest scores were statistically significant with a value of p<0.05. This suggests that CBL is effective in students’ learning.



- 1, 2- pretest and posttest scores of anaphylaxis respectively
- 3, 4- pretest and post test scores of Staphylococcal wound infection respectively
- 5, 6- pretest and posttest scores of Hepatitis B respectively
- 7, 8- pretest and posttest scores of Bacterial meningitis respectively
- 9, 10- pretest and posttest scores of Pneumococcal pneumonia respectively

Figure 1 Pretest and posttest scores of CBL sessions

Students’ perception of usefulness and effectiveness of case-based learning (CBL) was evaluated on a 5 point Likert scale questionnaire. The vast majority of the students reported satisfaction with CBL sessions and highly appreciated this method of teaching in microbiology and immunology. More than 85% of the students opined that they enjoyed CBL sessions and it held their interest and motivated them to learn better. A large number of students (79.82%) felt cases taught in CBL sessions presented many challenging questions that helped them to improve their analytical thinking and problem-solving ability. Students also opined that CBL improved their ability to correlate theoretical knowledge with clinical findings of a case and to rule-out and rule-in the possible diseases and etiologies in establishing the diagnosis. About 85% of the students agreed that CBL helped them to focus on key areas and a

better understanding of various concepts related to the topic. Majority of the students (90.35%) were in favor of CBL sessions in terms of benefits towards knowledge retention and long-lasting memory. However, only 64.04% stated that it helped them for better exam preparation.

DISCUSSION

Medical students were required to recall a lot of knowledge and skills learned during their medical training course and also keep up themselves updated to new knowledge and latest diagnostic and research methodologies in medical science. Rapid advances in medical technology have enabled medical teachers to adapt various interactive teaching methodologies and techniques to enhance students' learning process in terms of their self-directed learning skills, analytical thinking, clinical correlation, and knowledge retention. On a similar theme, the present study was conducted at CMHS to evaluate the fifth year medical students' perception of the effectiveness of the CBL approach in learning microbiology and immunology.

In the present study, a significant improvement in the students' learning following CBL sessions has been observed. The posttest scores of all the CBL sessions were significantly higher than pretest scores ($p < 0.05$). These findings are in line with many other similar studies conducted across the globe [4,18,19]. In general, the majority of the students had a positive response to CBL sessions. The median and mode for each statement on 5 points Likert scale feedback were 4 indicating the positive impact of CBL sessions in students' learning. In the present study, the vast majority of the students opined that CBL was an effective learning method and it strengthened their learning, enhanced their critical and analytical thinking skills, and motivated them for self-directed learning. Many previous studies on CBL in different medical specialties conducted across the world have reported similar findings [5,11,20-23]. In the present study, students perceived CBL as an excellent tool in correlating the basic science knowledge and concepts learned in lectures to analyze the clinical and laboratory findings provided in the clinical case scenarios to arrive at a correct diagnosis. It also enhances their ability to rule-out and rule-in the possible diagnosis and etiologies. This further helps the student to focus on key areas of the topic, reinforce important concepts and thereby strengthens information retention and long-term memory. These findings were consistent with a study conducted by Chamberlain, NR et al., [19]. Several studies have shown that student-centered activities such as case-based learning (CBL) and problem based learning (PBL) benefit students in terms of improvement in exam grades [19,24]. This could be due to the fact that CBL enhances students' knowledge retention and long-term memory as they are actively involved in a group discussion in solving the clinical problem by recalling and applying the knowledge and concepts learnt in lectures in addition to utilization of other resource material. It allows the students to quickly review the lecture material focusing on key areas and concepts before the examination. In the present study, around 64% of the students opined that CBL improved their exam grades. However, out of the remaining 36%, 18 students remained neutral and 22 students disagreed with the statement. According to their opinion, a number of CBL sessions conducted are too less to comment on its usefulness in the improvement of exam grades.

CONCLUSION

From the findings of our study, it can be reasoned that the case based learning (CBL) approach is a good learner-centered educational tool to motivate and promote students' learning. It provides an excellent opportunity to learn better through active participation, critical thinking, and clinical reasoning. Also, it enhances their conceptualization, knowledge retention, and better examination preparation.

DECLARATIONS

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

- [1] West, Daniel C., et al. "Critical thinking in graduate medical education: a role for concept mapping assessment?." *Jama*, Vol. 284, No. 9, 2000, pp. 1105-10.
- [2] Herreid, Clyde Freeman. "Case studies in a science-a novel method of science education." *Journal of College Science Teaching*, Vol. 23, No. 4, 1994, pp. 221-29.

- [3] Nair, Sandhya Pillai, et al. "Case-based learning: a method for better understanding of biochemistry in medical students." *Journal of Clinical and Diagnostic Research*, Vol. 7, No. 8, 2013, p. 1576.
- [4] Singhal, Anita. "Case-based learning in microbiology: Observations from a North West Indian Medical College." *International Journal of Applied and Basic Medical Research*, Vol. 7, 2017, p. 47.
- [5] Hashim, Rizwan, et al. "Perceptions of undergraduate medical students regarding case-based learning and tutorial format." *JPMA*, Vol. 65, No. 1050, 2015.
- [6] Tayem, Yasin I. "The impact of small group case-based learning on traditional pharmacology teaching." *Sultan Qaboos University Medical Journal*, Vol. 13, No. 1, 2013, p. 115.
- [7] Kumar, Vandana, and Cynthia C. Gadbury-Amyot. "A case-based and team-based learning model in oral and maxillofacial radiology." *Journal of Dental Education*, Vol. 76, No. 3, 2012, pp. 330-37.
- [8] Miller, Cynthia J., and Michael J. Metz. "A comparison of professional-level faculty and student perceptions of active learning: its current use, effectiveness, and barriers." *Advances in Physiology Education*, Vol. 38, No. 3, 2014, pp. 246-52.
- [9] Shigli, Kamal, et al. "Case-based learning: A study to ascertain the effectiveness in enhancing the knowledge among interns of an Indian dental institute." *Journal of Indian Prosthodontic Society*, Vol. 17, No. 1, 2017, pp. 29-34.
- [10] Zhang, Zhiren, et al. "A trial of patient-oriented problem-solving system for immunology teaching in China: a comparison with dialectic lectures." *BMC Medical Education*, Vol. 13, No. 1, 2013, p. 11.
- [11] Ciraj, A. M., P. Vinod, and K. Ramnarayan. "Enhancing active learning in microbiology through case-based learning: Experiences from an Indian medical school." *Indian Journal of Pathology and Microbiology*, Vol. 53, No. 4, 2010, p. 729.
- [12] Chavan, Shazia, et al. "Learning and teaching in Microbiology: Students' perception." *Virology*, Vol. 28, 2016, pp. 17-2.
- [13] Nadershahi, Nader A., et al. "An overview of case-based and problem-based learning methodologies for dental education." *Journal of Dental Education*, Vol. 77, No. 10, 2013, pp. 1300-05.
- [14] Shah, Samit, Launa MJ Lynch, and Lilia Z. Macias-Moriarity. "Crossword puzzles as a tool to enhance learning about anti-ulcer agents." *American Journal of Pharmaceutical Education*, Vol. 74, No. 7, 2010, p. 117.
- [15] Meyers, C, Jones, TB. "Case studies. In: promoting active learning: Strategies for the college classroom." San Francisco, CA: Jossey Bass, 1993. pp. 103-19.
- [16] Newble, D. I., and R. M. Clarke. "The approaches to learning of students in a traditional and in an innovative problem-based medical school." *Medical Education*, Vol. 20, No. 4, 1986, pp. 267-73.
- [17] Yoder, Janice D., and Catherine M. Hochevar. "Encouraging active learning can improve students' performance on examinations." *Teaching of Psychology*, Vol. 32, No. 2, 2005, pp. 91-95.
- [18] Blewett, Earl L., and Jennifer L. Kisamore. "Evaluation of an interactive, case-based review session in teaching medical microbiology." *BMC Medical Education*, Vol. 9, No. 1, 2009, p. 56.
- [19] Chamberlain, Neal R., et al. "Utilization of case presentations in medical microbiology to enhance relevance of basic science for medical students." *Medical Education Online*, Vol. 17, No. 1, 2012, p. 15943.
- [20] Tathe, Suvarna Sande, and A. L. Singh. "Case-based lectures versus conventional lectures for teaching medical microbiology to undergraduate students." *International Journal of Current Research and Review*, Vol. 6, No. 4, 2014, pp. 35-41.
- [21] Sharma, Nitin, and R. Choudhary. "Evaluation of acceptance for case-based learning in the undergraduate medical curriculum." *Scholars Journal of Applied Medical Sciences*, Vol. 3, 2015, pp. 2365-68.
- [22] Nair, Sandhya Pillai, et al. "Case-based learning: a method for better understanding of biochemistry in medical students." *Journal of Clinical and Diagnostic Research*, Vol. 7, No. 8, 2013, p. 1576.
- [23] Gade, Shubhada, and Suresh Chari. "Case-based learning in endocrine physiology: an approach toward self-directed learning and the development of soft skills in medical students." *Advances in Physiology Education*, Vol. 37, No. 4, 2013, pp. 356-60.
- [24] Dulloo, Puja, and Nirmal A. Pathare. "Case-based methodology: a method to enhance the learning of physiological basis of a cardiovascular and respiratory system to undergraduate medical students." *American Journal of Educational Research*, Vol. 19, No. 10, 2013, pp. 425-29.

APPENDIX 1

A Sample of Clinical Case (Staphylococcal Surgical Wound Infection with Septicemia)

Case 1: A 26-year-old Hassan, a national football player of Oman underwent knee surgery. Two days, later, he noticed mild swelling, increasing pain, and redness at the site of surgical incision. He was prescribed paracetamol and intravenous cefotaxime injections. His condition did not improve and within the next week, his condition further deteriorated. He developed fever, vomiting, and diarrhea. On examination, a physician noticed sun burn like rash on lower extremities. His vitals RR: 28/minute; HR: 104 beats/minute, BP: 90/60 mm of Hg; Temperature: 102°F. Initial laboratory workup show leukocytosis with a predominance of polymorph nuclear cells (PMNs), reduced platelet count and raised ESR (Erythrocyte sedimentation rate) and CRP (C-reactive protein) (Figure 2).



Figure 2 Infected wound

1. What is your most likely clinical diagnosis?
2. Enumerate the possible etiological agents responsible for this condition?
3. Describe the pathophysiology involved in the development of the above clinical features.
4. How do you investigate this case?
 - Discuss the sample collection methods for investigation.
 - Discuss the laboratory investigations you would like to perform.
5. Wound swab was collected and sent to the laboratory for investigation (Figure 3).
 - Discuss the method of sample collection by using a sterile swab
 - How do these swabs are sterilized before using



Figure 3 Sterile swab

6. Following laboratory investigations were done by using wound swab specimen:
 - a. Microscopy of the gram stained specimen is as shown in the image (Figure 4).

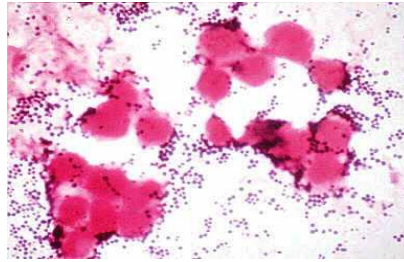


Figure 4 The microscopic picture

b. Culture on blood agar, nutrient agar, mannitol salt agar shows growth as shown in Figure 5.

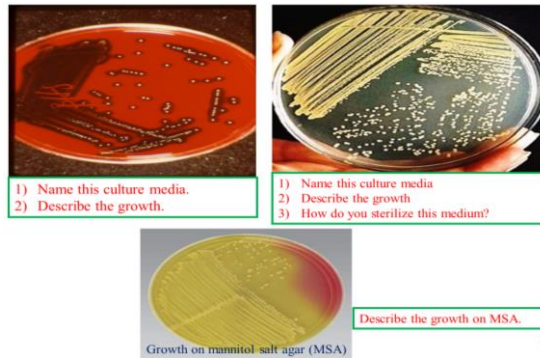


Figure 5 Growth Culture

c. Following biochemical tests were done on the culture growth (Figure 6).

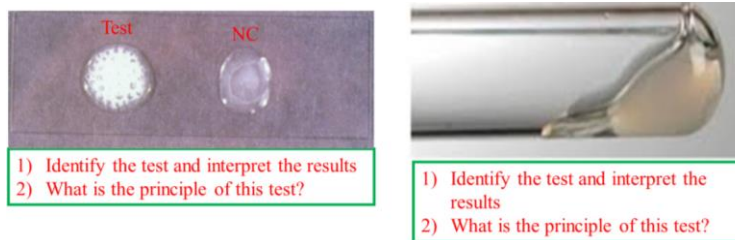


Figure 6 Biochemical test

d. Antibiogram of the culture growth is as given below in Figure 7.

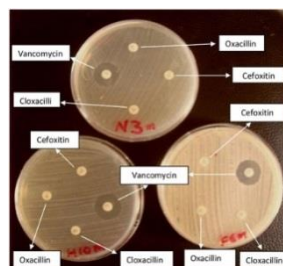


Figure 7 Antibiogram of the culture growth

- What is this method of antibiotic sensitivity testing is called as?
- Discuss and interpret the antibiotic sensitivity report

7. Based on clinical findings and laboratory findings:

a. What is your final diagnosis?

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b. What is the etiological agent?

c. How do you manage this case?

d. What precautions you would take to prevent the occurrence of such condition?