HIV/AIDS: A Case-Based Learning Module for First-Year Medical Students

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In medical and healthcare-related education, case-based learning (CBL) is a teaching strategy that uses clinical cases to engage students in active learning using course concepts to solve important problems. Here we describe the design and implementation of a CBL module to teach first year medical students about the human immunodeficiency virus (HIV), acute retroviral syndrome, clinical progression to acquired immunodeficiency syndrome, HIV diagnostics, assays used to assess stage of disease and response to antiretroviral treatment, and highly active antiretroviral therapy. A team of basic science and clinical faculty in the disciplines of microbiology, immunology, infection prevention and control, clinical medicine, pharmacology, and medical ethics collaboratively designed the CBL module. The results of a questionnaire indicated that the students found the CBL case interesting, engaging, and a useful educational strategy for linking basic science concepts to important clinical problems. In our experience, the CBL promoted student synthesis of basic science concepts across disciplines and engaged learners in the application of basic science knowledge to address significant real-world clinical problems.

INTRODUCTION

The Western Michigan University Homer Stryker M.D. School of Medicine is a new medical school that has developed and implemented an educator-led curriculum designed to maximize integration of basic science and clinical sciences. Case-based learning (CBL) is one of several strategies we use in our preclinical curriculum to facilitate active learning and the application of basic science knowledge and clinical reasoning skills to solve important clinical problems. In medical education, CBL is a widely-used teaching strategy to engage learners in team-based active learning and practice using biomedical knowledge and clinical reasoning skills to solve important clinical problems in a manner that mirrors the way experienced clinicians revisit the underlying basic biomedical knowledge to solve complex, nuanced, or unfamiliar cases (1–4). Case-based learning is perhaps best described by Thistlewaite, as “a learning and teaching approach that aims to prepare students for clinical practice, through the use of authentic clinical cases. These cases link theory to practice, through the application of knowledge to the cases, and encourage the use of inquiry-based learning methods” (5). A similar definition of CBL has been put forth by Anderson, who describes CBL as an instructional method that uses patient cases to stimulate discussion, questioning, problem solving, and reasoning on issues pertaining to the basic sciences and clinical disciplines (6).

The HIV/AIDS CBL described here is one of six CBLs in the five-week Foundations of Immunology and Infectious Disease course developed for first-year medical students. The CBL occurs at the end of the fourth week of the course and serves to tie together several core immunologic concepts that students learn in their first exposure to the field of immunology. For example, one aspect of this CBL highlights the evolution of HIV diagnostic tests from first- to fourth-generation, and now fifth-generation, diagnostics. An understanding of the limitations of the early tests and strengths of the current tests serves as an illustration of basic immunology concepts, such as the concept that the adaptive immune response takes time to develop, and that antibodies are used as diagnostic tools (e.g., ELISA, Western blot, and flow cytometry). The CBL also strengthens the students’ understanding of the role of CD4 T-cells and adaptive immunity in general by revealing the susceptibility of patients with defects in CD4 T-cell function to reactivation of latent viruses such as the herpes viruses, and susceptibility to opportunistic diseases such as Pneumocystis pneumonia.

While several case-based resources are available to facilitate HIV/AIDS education (7, 8), we opted to create a CBL module to more precisely address our course-specific learning objectives, as well as to integrate aspects of foundational microbiology and immunology concepts, clinical reasoning, pharmacologic treatment, and medical
ethics. Thus, the CBL was collaboratively designed by basic and clinical faculty with expertise in the disciplines of microbiology, immunology, infection prevention and control, clinical medicine, pharmacology, and medical ethics. This module, originally developed for our inaugural class of 54 students, was revised for the 60 students in the class of 2019 and revised again for the 72 students in the class of 2020. During the CBL, faculty record student team responses to the CBL questions and use these data to revise problematic questions and, when necessary, to make questions more challenging.

**Intended audience**

This CBL activity was designed for first-year medical students in our Foundations of Immunology and Infectious Disease course (9). It is also suitable for masters or doctoral students in the healthcare professions.

**Learning time**

This CBL requires two-hours of in-class time to implement.

**Prerequisite student knowledge**

Prior to matriculating into the Foundations of Immunology and Infectious Disease course, our students complete four foundational courses: molecular, cellular, genetic, and metabolic foundations of health and disease. Before attending the CBL, students are expected to complete a preparatory assignment consisting of two independent learning assignments developed by faculty. The time required to complete the preparatory assignment is about two hours, approximated by faculty as the amount of time required to study and learn the content. Depending on the individual background knowledge of each student, this time may vary. The assignment is designed to provide the students with the requisite foundational knowledge of HIV virology and antiretroviral therapy to prepare them to engage in the CBL. Below, we provide the learning objectives associated with our independent learning assignments. A variety of resources are available to address these learning objectives, and two reading assignments that can be used in lieu of our independent learning assignments, which are copyrighted by our institution, are recommended below.

**HIV virology learning objectives:**

1. Describe the HIV replication cycle.
2. Describe the natural history of HIV infection.
3. Describe some of the early manifestations of primary symptomatic HIV infection.
4. Describe the diseases associated with chronic HIV infection.
5. Explain how HIV infects T-cells and list the other immune cells that can be infected by HIV.
6. Compare and contrast the mechanisms of HIV latency and persistence.
7. Explain the mechanisms by which HIV causes severe T-cell immunodeficiency.
8. Explain how CD4 T-cell counts are used as a relative prognostic marker.
9. Describe the consequences when CD4 T-cell numbers decline over time.
10. Explain why AIDS is considered a secondary or acquired immunodeficiency and contrast this with the definition of a primary or congenital immunodeficiency.

**Suggested reading assignment:** Schaechter’s Mechanisms of Microbial Disease, 5th edition (10), Chapter 38: The Human Retroviruses: AIDS and Other Diseases

**Antiretroviral therapy learning objectives:**

1. Describe the mechanism of action of: nucleoside/nucleotide reverse transcriptase (RT) inhibitors, non-nucleoside RT inhibitors, protease inhibitors, fusion inhibitors and integrase inhibitors.
2. List the toxicities associated with each individual antiretroviral agent.
3. Design a treatment plan for initiating antiretroviral therapy in a treatment-naive HIV infected patient.

**Suggested reading assignment:** Basic and Clinical Pharmacology, 13rd Edition (11), Chapter 49: Antiviral Agents.

**CBL learning objectives**

By the end of this CBL, learners will be able to:

1. Describe the clinical course of AIDS.
   a. Differentiate between: primary infection, acute HIV syndrome, clinical latency, constitutional symptoms, opportunistic diseases, and symptoms of AIDS.
   b. List the major pathogens and the opportunistic diseases associated with AIDS.
2. Describe the limitations of early HIV diagnostic tests and compare and contrast these tests with the current fourth/fifth generation tests.
   a. Indicate what the early HIV diagnostic tests (first/second generation) measured.
3. Explain the use, interpretation, and advantages of fourth/fifth generation HIV diagnostic tests and assays to assess disease progression, response to therapy, and immune status.
   a. Indicate the current HIV test used to track patient response to antiretroviral treatment.
4. Explain how HIV genotyping guides the selection of therapy.
   a. List the HIV genes that are routinely genotyped.
   b. Indicate the purpose of HIV genotyping.
5. Describe the pharmacologic approach to treating a treatment-naive HIV-positive patient.
   a. List the antiretrovirals used to treat a patient newly diagnosed with HIV.
6. Describe the mechanism of action of HIV antiretroviral drugs.
   a. Indicate the mechanism of action of: saquinavir, emtricitabine, lamivudine, efavirenz, tenofovir, and raltegravir.
7. Explain the role of the physician in preventing HIV-positive patients from infecting others within the constraints of existing state laws using the American Medical Association Code of Medical Ethics guidelines.

Overlap between several of the learning objectives associated with the preparatory assignments and the learning objectives of the CBL indicate the intent to provide students practice applying prerequisite knowledge to an authentic clinical vignette.

PROCEDURE

Materials

The learning materials for this CBL activity (Appendix 1) are accessed by students via a PowerPoint presentation that is projected on classroom screens in a sequential reveal format. The CBL activity is implemented in the same manner as the group application exercises described for team-based learning as defined by Michaelsen (12). Specifically, the case is based on a significant problem (i.e., a complex real-world clinical scenario), teams work on the same problem at the same time, each multiple-choice question has a specific choice (i.e., a single best-fit answer), and student groups reveal their answers simultaneously using color-coded placards.

Student instructions

The CBL exercise consists of a single case divided into 14 sections. Each section includes between one and three multiple-choice questions. A timer is displayed on the classroom screens to keep discussions on track. Students are placed into teams of six to maximize engagement. There were nine groups for the class of 2018, 10 groups for the class of 2019, and 12 groups for the class of 2020. Teams are also provided with the United States Medical Licensing Exam normal lab values to help them analyze clinical data provided in the case. To facilitate discussion, each team is allowed access to only two computers to prevent the students from individually searching for material on the internet rather than using and sharing their knowledge and reasoning skills. Following each intra-team discussion, teams are asked to simultaneously reveal their answers by raising lettered, color-coded placards. Teams with different answers are asked to explain their reasoning for arriving at their answer choice. The CBL exercise is not graded; however, one or two questions related to the material in the group application exercise are included on the course summative exam.

Faculty instructions

Faculty actively circulate among the teams during the intra-team discussions in order to gain a sense of the level of discussion occurring, monitor team dynamics and individual student participation, and provide insight without leading students to the correct answers. The faculty involved in this portion of the CBL include the basic science course co-director and another basic science faculty member, both with expertise in immunology and microbiology, the clinical course co-director with expertise in infectious disease, and two clinical faculty members with expertise in clinical pharmacology and infection prevention and control. While the involvement of multiple faculty during the group application exercise enhanced the students’ experience, one basic science faculty and one clinician are sufficient to facilitate the CBL. In our experience, by the conclusion of inter-team discussions, the students arrive at the correct answers and understand the underlying reasoning. If needed, instructors use facilitation notes to guide the discussion to ensure that the intended content is covered and that the correct and incorrect answers are fully explained.

Suggestions for determining student learning

We assessed student learning by including examination items on the summative course examination (Appendix 2). Because the majority of the CBL content is exclusively taught in the CBL itself and is not presented in other course learning activities, student performance on summative examination items derived from the CBL activity reflects student learning during the CBL and during student preparation for the summative examination as they revisit the material presented in the CBL module. For each question, the item difficulty, point-biserial (PBS), and the number of students who answered the question are indicated. The item difficulty is calculated by dividing the number of students answering the question correctly by the total number of students who answered the question. The PBS is a correlation coefficient that measures the strength of correlation between a student’s score on a specific question and the student’s score on the examination as a whole. The PBS ranges from -1.0 to +1.0. The closer the PBS is to +1.0, the more reliable the question: 0.2 to 0.29 is considered fair; 0.3 to 0.39 is considered good, and 0.4 and above is considered very good (13).

Sample data

In the CBL exercise (Appendix 1), we have included facilitation notes that provide a sense of how the student groups perform on the more challenging questions.
Safety issues

None.

Internal review board approval

This study was reviewed by the internal review board of the Western Michigan University Homer Stryker M.D. School of Medicine and determined to be exempt under 45 CFR 46.101(b), 1 and 2.

DISCUSSION

Field testing

The HIV/AIDS CBL module described here was originally designed for the class of 2018 and sequentially modified for the classes of 2019 and 2020. The CBL was collaboratively designed by a team of basic science and clinical faculty with content expertise in microbiology, immunology, infection prevention and control, clinical medicine, pharmacology, and medical ethics.

Evidence of student learning

Student learning was assessed by including questions related to the CBL content on the course summative examination. The course summative examination includes at least one question from each of the approximately 70 learning events in the five-week course, each of which has between 4 and 10 learning objectives. Therefore, it is not possible to test every learning objective on the course summative examination (in our curriculum, a five-week course is evaluated with a maximum of 125 questions). For each class of students, we selected one or two questions to represent the CBL material on the summative examination. To date, we have tested questions that represent five of the seven learning objectives from this HIV CBL (Appendix 2 and Table). The average item difficulty for the five questions was 0.87 (range 0.83–0.92) and the average PBS was 0.34 (range 0.14–0.44). While the majority of the PBSs were 0.30 or greater, the PBS for question 2 was low (0.14), indicating that the item did not discriminate well among students who mastered the examination material and those who did not; based on this, the item could be revised.

Students were also asked to evaluate the CBL using a three-point Likert scale (1 = unsatisfactory, 2 = satisfactory, 3 = outstanding), and the student ratings from the class of 2018, 2019, and 2020 were: 2.29, 2.47, and 2.56, respectively, showing an improvement each year. In addition, anonymous student feedback is collected following the CBL through our learning management system. Examples of feedback from individual students in classes of 2018, 2019, and 2020 related to this CBL are provided below:

Class of 2018 – 5 comments

“Good case.”

“Great CBL.”

“Great.”

“CBL was a review of lecture/independent learnings rather than another paper which allowed for more time to review and learn this week’s materials.”

“It would help when having an imaginary patient to actually have a picture of him—it would better simulate the real-life scenario and help us engage with the more esoteric aspects of the material.”

Class of 2019 – 3 comments

“VERY well done. Enough time for questions, the questions weren’t too over-the-top, and we even got out on time!”

“This CBL was slower paced, which my group appreciated because we tend to spend a long time discussing answers before coming to a conclusion.”

“It is good to know the current treatment and legal issues about HIV and AIDS.”

Class of 2020 – 6 comments

“The CBL on Ted was very well run and I learned a lot.”

“Good CBL that required thought and group effort without requiring the internet more than three times.”

“I enjoyed this CBL and felt it was informative and progressive from basic science information to clinical applications.”

“The case was interesting and engaging.”

“Clinical perspective was helpful to a certain extent…but not at the expense of material we are going to be tested on.”

“Good CBL.”

Possible modifications

A possible modification of this CBL activity is to use it to create a team-based learning activity by drafting questions to assess student preparedness in the form of a traditional
readiness assessment test (12). In addition, while our students learn about the newer HIV diagnostic tests as well as pre- and post-HIV exposure prophylaxis treatment in separate learning events in our curriculum, these elements could be added to the CBL. Other possible modifications include addressing the socioeconomic aspects of HIV/AIDS, populations at most risk for HIV morbidity and mortality, and the psychological challenges associated with living with HIV/AIDS. Finally, faculty may also wish to record and grade student team responses.

SUPPLEMENTAL MATERIALS

Appendix 1: Case-based learning exercise with instructor facilitation notes
Appendix 2: Summative examination items with student performance data

ACKNOWLEDGEMENTS

The authors declare that there are no conflicts of interest.

REFERENCES


TABLE 1.
Summative examination data for the classes of 2018, 2019, and 2020.

<table>
<thead>
<tr>
<th>Question No.</th>
<th>Learning Objective</th>
<th>Item Difficulty</th>
<th>PBS</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Describe the clinical course of AIDS: List the major pathogens and the opportunistic diseases associated with AIDS.</td>
<td>0.83</td>
<td>0.42</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>Explain the use, interpretation, and advantages of fourth/fifth generation HIV diagnostic tests and assays to assess disease progression, response to therapy, and immune status: Indicate the current HIV test used to track patient response to antiretroviral treatment.</td>
<td>0.84</td>
<td>0.14</td>
<td>114</td>
</tr>
<tr>
<td>3</td>
<td>Addresses learning objective #4b: Explain how HIV genotyping guides the selection of therapy: Indicate the purpose of HIV genotyping.</td>
<td>0.84</td>
<td>0.30</td>
<td>185</td>
</tr>
<tr>
<td>4</td>
<td>Describe the pharmacologic approach to treating a treatment-naive HIV-positive patient: List the antiretrovirals used to treat a patient newly diagnosed with HIV.</td>
<td>0.90</td>
<td>0.40</td>
<td>114</td>
</tr>
<tr>
<td>5</td>
<td>Describe the mechanism of action of HIV antiretroviral drugs: Indicate the mechanism of action of: saquinavir, emtricitabine, lamivudine, efavirenz, tenofovir, and raltegravir.</td>
<td>0.92</td>
<td>0.44</td>
<td>125</td>
</tr>
</tbody>
</table>

The PBS measures the strength of correlation between a student’s score on a specific question and the student’s score on the examination as a whole. It ranges from -1.0 to +1.0: 0.2 to 0.29 is considered fair, 0.3 to 0.39 is considered good, and 0.4 and above is considered very good PBS = point-biserial score.