RESEARCH ARTICLE

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Utilization of case presentations in medical microbiology to enhance relevance of basic science for medical students

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Background: Small-group case presentation exercises (CPs) were created to increase course relevance for medical students taking Medical Microbiology (MM) and Infectious Diseases (ID).
Methods: Each student received a unique paper case and had 10 minutes to review patient history, physical exam data, and laboratory data. Students then had three minutes to orally present their case and defend why they ruled in or out each of the answer choices provided, followed by an additional three minutes to answer questions.
Results: Exam scores differed significantly between students who received the traditional lecture-laboratory curriculum (Group I) and students who participated in the CPs (Group II). In MM, median unit exam and final exam scores for Group I students were 84.4% and 77.8%, compared to 86.0% and 82.2% for Group II students ($P < 0.018$; $P < 0.001$; Mann-Whitney Rank Sum Test). Median unit and final ID exam scores for Group I students were 84.0% and 80.0%, compared to 88.0% and 86.7% for Group II students ($P < 0.001$; $P < 0.001$).
Conclusion: Students felt that the CPs improved their critical thinking and presentation skills and helped to prepare them as future physicians.

Keywords: *microbiology*; *case presentations*; *critical thinking*; *basic science*

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Medical students can be overwhelmed and frustrated by the traditional means of teaching medical microbiology (MM) (1). Students are required to learn the 'bug parade' with an emphasis on the microorganisms and the factors they produce that leads to human pathology. Our MM course, delivered during the spring of the first year of medical school, is organized according to microorganism characteristics. Diseases caused by the microorganisms are briefly discussed during MM. In the past, we heard students state that the MM course requires a lot of memorization of random microbial facts that lack obvious clinical relevance. This student-held impression conflicts with the 2010 Infectious Diseases Society of America guidelines, which encourage the integration of facts related to microbiology and their application to patients for improving the teaching of MM (1).

Our physician colleagues have pointed out that patients don't describe the etiologic agent causing their condition; rather, they present with various signs and symptoms that are usually the result of pathology caused by the infectious agent or by the host's response to that infectious agent. In situations where students have been required to evaluate a patient, e.g., standardized patient encounters, we believe our students have experienced recall delays as they mentally sorted through potential etiological agents organism by organism. To help students re–organize their microbiology knowledge toward a more clinical way of thinking, we provide an Infectious Diseases (ID) course that discusses infectious diseases by organ system and disease. In ID, we encourage students to learn the most common causes of the infectious diseases routinely encountered in the U.S., and to compare and contrast the signs, symptoms,

and laboratory findings that will help them differentiate the most likely cause from other etiologic agents that may cause the same disease. ID starts three months after MM ends. Before the introduction of case presentation exercises (CPs), during the interim period between the two courses many students tended to forget the important microbiological concepts needed to fully understand disease processes. We were concerned about this lack of concept retention, since diagnostic accuracy is higher in experts that have some understanding of basic science knowledge (2, 3).

We believe that MM lacked the relevance that is important for inducing long-term memory (4–6) and for enhancing diagnostic abilities (7). When we taught MM more like an ID course and less like the traditional MM, students reported feeling adrift and uncertain of their microbiology knowledge. Usually, over half of our students have not taken an undergraduate microbiology course, and these individuals felt that a traditional introduction to MM should precede ID.

To increase the relevance of MM, clinical vignettes were incorporated into written examinations in 2001. By 2004, clinical vignettes accounted for 70–80% of exam questions. Several students in subsequent classes performed poorly. Upon questioning, these students revealed that if they didn't know the correct answer on the multiple choice vignettes, they would choose an answer at random. Apparently, they had not developed the ability to rule-out some of the closely matching distractors and struggled when picking the correct answer. Noting that this ability to rule-in and rule-out potential agents and diagnoses is essential in clinical practice, we began to consider changes in our teaching practices to enhance these critical thinking skills.

Toward this goal, we introduced small group case presentations (CP) into MM and ID in 2008. Each CP is a one-hour exercise that occurs at the end of a block of lecture material and precedes a unit exam created from these lectures. There were three CPs in both MM and ID. Each student had 10 minutes to read a packet of case-related information, and then give a three-minute oral presentation covering the main issues in the case, explaining lab and procedure data, and ruling etiologies in or out from a provided list. The presentation was followed by a three-minute period for answering questions from student peers and the facilitator. Our goals were to ensure that the students were ready to succeed on the upcoming unit exam, and to provide the students with practice in analyzing patient history, physical exam data, and laboratory data. Additionally, students gained experience in defending a differential diagnosis limited to infectious disease, delivering an oral presentation, and practicing critical thinking skills. Here we describe how the CPs can be implemented with limited faculty, and we demonstrate that the CPs positively impacted exam scores and student perceptions in MM and ID.

Methods

Study participants

Medical students taught in years 2004, 2005, 2008, 2009, and 2010 were placed into two groups. Group I included 330 medical students taught in years 2004 and 2005. They participated in a total of 11 microbiology wet laboratories during MM and ID, but did not participate in CPs. Group II included 519 medical students taught in years 2008, 2009, and 2010. They participated in six CPs (three CPs each in MM and ID) and in three MM wet labs. Students taught in years 2006 and 2007 participated in standardized patient (SP) encounters (8) rather than CPs. We discontinued SP encounters and created CPs because of logistic and budgetary issues.

Clinical case creation

Clinical paper cases were created by the authors and were assessed for clinical relevance by a family practice physician. In MM, the CPs followed lecture blocks covering (i) general microbiology, virology, degenerate bacteria, and general aspects of bacteriology; (ii) bacteriology; and (iii) mycology and parasitology. For ID, the CPs followed lectures covering infections of the (i) skin, central nervous system, and ear; (ii) eye, bones and joints, respiratory tract, and genitourinary tract; and (iii) cardiovascular system and gastrointestinal tract, along with systemic infections and sepsis. Each case packet was no more than three pages long and followed the template in Table 1. All cases featured one or more photographs of the patient along with laboratory or medical procedure data that required interpretation by the student. Each case contained a question asking the student to identify the most likely etiologic agent or diagnosis from five choices.

Case presentations

For each of the six CPs, small groups comprising five students and one faculty facilitator met in rooms equipped with a computer and a 50 inch, wall-mounted screen. For most exercises, five faculties served as facilitators for seven consecutive 50 min CP sessions in a single day (35 total sessions; 175 students in a day; six times yearly). Facilitators used the same set of five cases for the morning sessions, and then switched to five new cases in the afternoon. Each block required approximately seven hours of facilitator time for each hour students spent in the CPs, and each block utilized 10 different cases (60 cases/year). CPs were scheduled 3–5 days before a unit examination so that students could identify weaknesses and focus their study efforts prior to the exam.

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Table 1. Case template

Case information		Patient's name:		Gender:	BP:
		Clinical setting:		Age:	T:
		Chief complaint:		Height:	HR:
				Weight:	RR:
CATEGORY: HPI					
1	Chief complaint	Description?			
2		Pain scale?			
3	Onset	When did it begin?			
4		How did it begin?			
5	Progression	Better, worse, same?			
6	Mitigating factors	What makes it better?			
7		What makes it worse?			
8	Associated symptoms?				
9	History of previous occurrence (details)?				
10	Pertinent other	Allergies to medications?			
		Current medications?			
12		Past medical history?			
13		Family history?			
14	Social history (smoking, alcohol, drugs)?				
15	Other				
CATEGORY: Physical exam					
16	Neurologic				
17	HEENT				
18	Chest, heart & lungs				
19	Abdominal				
20	Female breast & GU (& rectal)				
21	Male GU (& rectal)				
22	Musculoskeletal	General			
23		Upper extremities			
24		Lower extremities			
25	Lab findings				
26	Other diagnostics				
27	Radiographic procedures				
What is the best diagnosis/etiological agent for this patient's disease?					
Potential diagnoses Rule each In or Out	Answer A				
	Answer B				
	Answer C				
	Answer D				
	Answer E				

During the CP, students had 10 minutes to read their packet of case related information and take notes on a blank piece of paper. Students were not allowed to use text books, lecture notes, or any other reference materials during case review. After returning the case packets, each student was required to give a three minute oral presentation, during which they summarized the main issues in the case, explained lab and procedure data, and ruled etiologies/diseases in or out from a list of five choices. A PowerPoint® slide containing images of

the patient, key laboratory and procedure findings, as well as the five possible agents/diagnoses was projected on the screen to aid the student in summarizing the case during their presentation. Each student then had three minutes to field questions from their peers and facilitator. Students were graded with a rubric that assessed whether they included important aspects of the case in an organized manner, displayed critical thinking by ruling etiologies/diagnoses in or out well, answered questions well, were professional in appearance and behavior, and whether they added value to the discussion by asking thoughtful questions of their peers. Scores from the CP rubrics accounted for about 1% of students' grades. Students were required to write a self-reflection critiquing their own performance after each CP. Participation in CPs and self–reflections was required of each student to pass each course, so 100% of the students that took our courses participated in all CPs and wrote self-reflections despite their insignificant value to the calculation of final course grades.

Since clinical presentations are used at our clinical sites to assess student learning during their clinical rotation years, a physician was asked to evaluate the clinical cases used in the CPs for their relevance. A clinician also attended CPs to ensure the presentations were similar to what attending physicians require of medical students when they present cases.

MM and ID examinations

The unit and final examinations in MM and ID included 70-80% clinical vignettes. Unit exams covered material presented in the preceding 6–14 lectures. Final examinations were comprehensive and required students to recall information from the beginning to the end of each 10-week course. Students were expected to recall information presented in MM during the ID examinations. Although the students were allowed to review their graded exams and to ask questions under a proctor's supervision, students were not allowed to take written notes or to keep the examinations following the review period. Consequently, the exams that were used for all classes taught over the 2004 to 2010 study period were the same except for minor modifications such as updating nomenclature for microorganisms and re–mixing the order of questions.

Statistical analysis

To determine whether medical students in Groups I and II differed in academic abilities upon matriculation, Student's *t*-test was used to compare the mean MCAT scores, and cumulative and science undergraduate GPAs between the two groups. The scores on unit examinations and comprehensive final examinations in MM and ID were not normally distributed. The Mann–Whitney Rank Sum test was used to compare median examination scores earned by Groups I and II in these courses. In both analyses, significance was defined as $P < 0.05$.

Qualitative analysis of student reflections

After the final CP, all students taught in years 2008, 2009, and 2010 were asked to write a self-reflection on the following question, 'How have you progressed after six clinical case presentations compared to the first time you presented in Medical Microbiology?' Responses were analyzed by repeatedly reading the reflections to develop understanding and interpret meaning. The analysis involved data reduction or condensation, from which themes were identified. Author 1 read all 514 responses, while Author 3 read a sample comprising 100 responses, to reduce evaluator bias and to ensure that identified themes were similar between evaluators. An inductive and data-driven analysis process was used, in accordance with grounded theory (9, 10).

Results

Medical student academic characteristics

Student's *t*-test was used to compare MCAT scores, cumulative GPAs, and science GPAs for Groups I and II to ensure that students who earned higher exam scores in MM and ID did not do so simply because they were more academically gifted. There were no significant differences when these measures of pre-professional academic achievement were compared between the two groups (Table 2).

Comparison of examination scores

For MM and ID, median unit exam scores earned by students in Group I were pooled and compared to the pooled median unit exam scores earned by students in Group II using the Mann–Whitney Rank Sum test (Table 3). CP participants (Group II) earned significantly

Table 2. Undergraduate GPA and MCAT scores of study participants

Group number	N*	Mean science GPA** (SD)	Mean total GPA** (SD)	Mean total MCAT** (SD)
I	330	3.40 (0.64)	3.50 (0.51)	25.46 (5.96)
II	519	3.36 (0.63)	3.46 (0.53)	25.89 (6.22)

*N = the number of students in the group

**Group I and II means were not significantly different from each other ($P > 0.05$).

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Table 3. Median examination scores for students in the medical microbiology and infectious diseases courses

	Group number	N	Medical microbiology	N	Infectious diseases
Pooled unit exam scores	I	990	84.4*	990	84.0**
	II	1226	86.0*	1526	88.0**
Comprehensive final exam scores	I	330	77.8**	328	80.0**
	II	519	82.2**	514	86.7**

*Median scores differed significantly between Groups I and II ($P < 0.018$); Mann–Whitney Rank Sum test
**Median scores differed significantly between Groups I and II ($P < 0.001$); Mann–Whitney Rank Sum test
N = the number of exam scores in the group

higher median unit exam scores than traditionally trained students who did not participate in CPs (Group I) in both MM ($P < 0.018$) and ID ($P < 0.001$). Similarly, CP participants earned higher median comprehensive final exam scores than Group I students in both MM ($P < 0.001$) and ID ($P < 0.001$).

Qualitative analysis of student self-reflections

CP participants were asked to reflect on their progress over the six CPs. Six distinct themes became evident from responses submitted by 514 students (Table 4). Nearly all the students felt that they had improved in their presentation abilities and were more effective at presenting their CP (99%). A large number felt that their ability to rule-in and rule-out the possible diseases or etiologies had improved (46.9%). Many felt that their ability to summarize and present pertinent patient information had improved (42.6%). Thirty-seven percent felt they were less nervous presenting their case during the sixth CP than when they gave their first CP. Thirty percent of the students felt the CPs would help them during clinical rotations, residency, or as a physician. More than 20% remarked that the CPs helped them prepare for examinations. Only a few students of the 514 felt the CPs did not help them or should be changed in some way.

Discussion

In this study, we demonstrated that CPs improved student performance on unit examinations and comprehensive final examinations when compared to students who did not experience CPs (Table 3). This study also revealed an improvement in student self-perceptions in regards to their abilities to analyze patient and laboratory data and to arrive at a correct diagnosis (Table 4). A qualitative analysis of the students' self-reflections following the last CP in the ID course demonstrated that a large number of students perceived improvements

Table 4. Themes identified from student self-reflections after the final CP exercise

Theme	Number that mentioned theme in reflections in years 2008; 2009; 2010 **Total**	Percent of students that mentioned this theme (N = 514)
Noted that they had made progress and were more effective at presenting their CP.	173; 166; 170 **509**	99
Noted that they were better at critical thinking to rule out the wrong answers and rule in the correct answer.	87; 91; 63 **241**	46.9
Noted that they were better at organizing information from the case and presenting important/relevant/pertinent findings from the case. Better organized to present case.	91; 52; 76 **219**	42.6
Noted they were less nervous than during the first CP.	39; 63; 88 **190**	37
Noted the CPs would help them during clinical rotations, residency, or as a physician.	53; 45; 55 **153**	30
Noted the CPs helped them study or prepare for course examinations.	46; 45; 18 **109**	21.2

in their ability to rule-in and rule-out answer choices and to present pertinent patient information (Table 4). Our findings suggest that the CP exercises increased our students' ability to recall microbial facts, strengthened the relevance of our MM and ID courses, and enhanced our students' clinical thinking skills.

Several factors likely contributed to the significant improvements seen in exam scores earned by students who participated in the CP exercises versus those who did not. First, active engagement with course material has been shown to enhance learning and content recall (11, 12). Students took responsibility for organizing their study materials and learning the information in a way that would help them arrive at a correct diagnosis without consulting external references during the CPs. Second, providing students with feedback that allowed them to gauge their learning (13) and strategically placing the CP exercises a few days before an examination allowed deficiencies to be identified and addressed proactively. Third, peer pressure undoubtedly provided motivation to perform well during the CPs. Although very few points were awarded for successfully completing the CPs, several students mentioned in their reflections that they wanted to avoid appearing deficient in their understanding and knowledge while in front of their peers and facilitator. Finally, others have demonstrated that learning is enhanced when the student becomes the teacher (14, 15). The students in the CPs served as teacher when they described their patients' history, physical examination data, laboratory findings, and discussed how they ruled in the correct diagnosis/disease and ruled out the other choices. They were also required to answer questions from their colleagues and a faculty member. Frequently, discussions occurred during the question and answer time as students realized deficiencies in their knowledge or wanted to know more about a particular subject. Lack of preparation for the CP exercises did adversely affect their ability to function as a teacher in these settings and may have motivated them to improve their preparation and performance during the next CP. The self-described improvement in organizing and presenting their patient cases may, in part, have resulted from their desire to do a better job of informing their colleagues and faculty about their patient (Table 4).

It is widely perceived that content without context has a negative impact on student learning because the content lacks relevance (4–6). In this case, the CPs appeared to provide students with the context they needed to improve their learning of MM and ID content. In fact, 30% of the students felt that CPs would be helpful to them during their third and fourth year clinical rotations, residency, or as a physician (Table 4).

Case presentations have been used extensively in outpatient and inpatient settings to communicate patient information between physicians (16). Case presentations have also been used by attending physicians to assess student physicians' medical knowledge and diagnostic abilities (17) and to assess the cognitive skills required of a physician while they care for their patients. Several of these skills require critical thinking. One critical thinking skill requires the physician to take patient data and use it to develop a differential diagnosis. This skill is demonstrated by the ability to organize the data in some fashion and to determine which data are pertinent in regards to the patient's chief complaint. The physician then needs to communicate the patient information in writing, and in some cases, orally. A large number of the students felt that the CPs helped them to be more organized, concise and pertinent when they presented information from their patient (42.6%; Table 4). The students were not required to develop a differential diagnosis list; however, they were required to present patient data that was organized, pertinent and timely in regards to the patient's chief complaint. It appears from the student self-reflection comments that the students felt their abilities to organize patient data had improved.

Another critical thinking skill physicians must develop is the ability to rule-out and rule-in the diagnoses they list after organizing the patient data. Over 46% of the students stated that the rule in/rule out portion of the CPs helped them to apply the material they were learning and required them to think critically (Table 4). Since multiple choice examinations test the ability to rule-out and rule-in the answer choices, improvement in this critical thinking skill may have also helped them on the multiple choice MM and ID examinations.

One limitation of this study is the use of required student self-reflections to determine improvements in student perceptions of the relevance of the MM and ID courses to their progress towards becoming physicians. While taking our courses, students may be inclined to give glowing remarks concerning their progress in a non-anonymous self-reflection essay. To test the validity of our conclusions from self-reflection data, we reviewed the results of an anonymous post-COMLEX-USA Level 1 questionnaire, which is offered by the College to all students to obtain their opinions regarding how well first and second year courses prepared them for the Comprehensive Osteopathic Medical Licensing Examination (COMLEX-USA); Level 1. The Level 1 exam, which is taken approximately seven months after the end of our ID course, is largely devoted to assessing basic science knowledge presented in a clinical vignette format. All students are required to pass this exam to graduate from our medical program, and passing it is the first of four required steps to eventually obtain their medical licenses. The class that took our courses in 2008 ranked both ID and MM second (94%) out of 21 courses (scoring range was 32–95%; data not shown). The class that took our courses in 2009 ranked

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MM first (98%) out of 22 courses (scoring range was 26–98%; data not shown). The ID course, for reasons unknown to the authors, was omitted from the questionnaire for the 2009 class. However, for the 2010 class, students scored ID and MM at 99 and 98%, respectively. With these scores, our courses ranked first and second out of 24 courses (scoring range was 25–99%; data not shown).

Although helpful to student learning, small group activities have been difficult to implement when student class sizes are large and the number of faculty is small. The exercises described here were implemented with a small faculty using relatively few physical resources. We have conducted CPs with as few as four facilitators and with as many as six students per small group. Even though the student-to-faculty ratio for our department was nearly 35:1, the CPs were completed in a well-coordinated and timely fashion, thanks in large part to skillful planning by staff and the cooperation between faculty, staff, and students.

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