Urinary and Respiratory Systems: A Team-Based Learning Module for Histology
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Abstract

Introduction: Team-based learning (TBL) is an instructional strategy that promotes greater student engagement in the classroom. In TBL, scheduled class time is not used for lecturing. Rather, students are expected to master the basic facts and concepts of the subject matter before coming to class; in-class time is devoted to applying this knowledge to solve challenging problems with their teams. Methods: The purpose of this module is to become familiarized with the urinary and respiratory systems. The module enables students to recognize regions of the kidney and urinary tract based on histological images, explain functional differences among these regions, and describe select physiology and pathophysiology associated with different regions. Moreover, students will be able to describe the structural divisions, branching patterns, and histological features of the bronchial tree, explain how specific cell types are functionally significant in select diseases, and relate these structural features and cell types to select disease treatments. Results: When we implemented this module with a class of 30 graduate students, the mean scores for the Individual Readiness Assurance Test (77.9%), the Group Readiness Assurance Test (100%), and the clinically oriented Group Application Exercise (75.4%) reflected solid student understanding of the structure and function of the urinary and respiratory systems. Discussion: These results show that TBL methodology is an effective strategy to teach histology and that students do not require formal lectures to learn the material. Based on our experience, we believe that TBL offers learning outcomes comparable to lecture-based instruction but with greater clinical relevance.

Keywords
Histology, Urinary Tract, Respiratory System

Educational Objectives

By the end of this team-based learning module, the learner will be able to:

1. Distinguish between different regions of the kidney and urinary tract based on histological images.
2. Describe many of the endocrine and enzymatic functions of the kidney.
3. Describe the osmotic gradient of the kidney.
4. Pair histological images of the kidney with their corresponding locations in a gross specimen.
5. Explain how the structure and function of the various components of the respiratory tract are affected by cystic fibrosis.
6. Describe asthma in terms of diagnosis, pathophysiology, triggers, and treatment.
7. Recognize the structural divisions, branching patterns, and histological features of the bronchial tree.
8. Describe respiratory distress syndrome and the functional significance of surfactant and type II pneumocytes.
9. Interpret select clinical data related to disorders of the urinary and respiratory systems.
Introduction

Team-based learning (TBL) has been shown to be an effective teaching strategy for the basic sciences. One of the chief advantages of TBL is that it fosters greater student engagement in the learning process. In TBL, traditional lectures, generally regarded as passive learning, are replaced with in-class activities designed to enhance students' problem-solving and critical-thinking skills. In 2006, we converted our lecture-based histology course to the TBL format to both promote active learning and instill in students an appreciation of how relevant histology is to clinical practice.

The urinary and respiratory systems TBL module is one of 10 modules in the four-credit-hour course entitled Basic Histology, which is intended primarily for graduate students seeking entry into medical school. As such, it is taught with the same depth and rigor as the first-year medical histology course at our institution and in many ways is the equivalent course. Other than an initial lecture on microscopy and tissue preparation, our course is entirely lecture-free. Each TBL session encompasses the content typically covered in two or three traditional 1-hour lectures. Through the assigned text readings and other resources, the students are expected to master the basic facts and concepts of the subject matter before coming to class; in-class time is devoted to applying this knowledge to solve challenging problems with their teams.

In designing the 10 TBL modules comprising our course, we decided not to employ a singular clinical case as the entire basis of the Group Application Exercise, as is often the practice in TBL methodology. We felt this approach would not provide sufficient coverage of the relevant histology that the students needed to understand and apply. Instead, our Group Application Exercises consist of eight unrelated questions that collectively encompass the key concepts of the TBL topic at hand, in this case, the urinary and respiratory systems. In a typical Group Application Exercise, approximately half the questions involve histological identification, and the other half involve somewhat more difficult clinical or experimental vignettes. Due to the particular organization of our course, this module happens to combine the urinary and respiratory systems for presentation. But the questions related to these two topics are clearly distinct from one another and can be easily separated to accommodate other course organizations. The 10 TBL modules comprising our course encompass cell biology, epithelia and connective tissue, muscle and nerve, blood and lymphoid tissue, cartilage-bone and cardiovascular system, digestive system, urinary and respiratory systems, endocrine and integumentary systems, male and female reproductive systems, and eyes/ears.

We have previously reported that TBL modules and traditional lectures produce comparable learning outcomes in histology, as measured by our end-of-unit multiple-choice exams. The students take the TBL process seriously. They study the relevant advanced preparation materials (textbook reading assignments and class notes) prior to coming to class, and they demonstrate a good understanding of the subject matter. The students demonstrate effective teamwork, and they rarely miss a TBL session. They appear to feel an obligation to their teammates. To date, we have published seven of our TBL modules in MedEdPORTAL Publications.

Methods

This TBL module consists of four documents, including the Educational Summary Report, the Individual Readiness Assurance Test (iRAT; Appendix A), the Group Readiness Assurance Test (gRAT; Appendix B), and the Group Application Exercise (Appendix C). Explanations of correct answers are provided with the iRAT and Group Application Exercise documents. All images used in this module are originals owned by the first author, except where noted with Creative Commons License citations.

Prior to the TBL session, students are expected to complete the Advanced Preparation Assignment, which consists of textbook readings and laboratory work. An example of a suitable assignment would be:

- Read chapters 19 and 20 in Histology: A Text and Atlas.
- Complete the corresponding microscopy laboratory sessions on the urinary and respiratory systems.

We follow the TBL methodology described by Michaelsen et al. At the start of the course, the students are assigned to teams consisting of five to seven members. To assure a fairly uniform distribution of skills
across the teams, the students are first stratified according to undergraduate degree earned (science vs. nonscience) and the specific graduate program they are enrolled in, because some programs are more clinically oriented than others. The students are then asked to line up and count off by the number of teams being formed and are assigned accordingly (e.g., all 1s go to team 1, all 2s go to team 2, etc.). This process also prevents students from self-selecting into groups of friends or acquaintances. The teams remain in place for the course duration. Further information about the theory and practice of TBL, including team selection processes, can be found on the Team-Based Learning Collaborative website.15

Once groups are assigned, the TBL module begins.

At the start of the TBL session, all students take the 10-question iRAT (10 min.). The purpose of the iRAT is to assess each student’s knowledge of the basic material and preparation for group activity. The answer sheets are collected, scored, and recorded.

Each team then answers the same 10 questions again, but this time working as a group (10 min.). This is the gRAT. The team discusses the questions until a consensus is reached about the correct answers, which are marked on special scratch-off Immediate Feedback Assessment Technique (IF-AT) cards (available from Epstein Educational Enterprises; http://www.epsteineducation.com/home/). Teams receive full credit for a correct answer on the first try and half-credit for a correct answer on the second try. No credit is given for subsequent attempts. The IF-AT cards are collected, scored, and recorded.

The iRAT and gRAT are taken as closed-book activities. Because the IF-AT cards provide immediate feedback as to the correct answers, the Readiness Assurance Test (RAT) questions are not discussed further with the class unless there is some confusion that needs clarification from the instructor.

After completing the gRAT, each team works through the Group Application Exercise, which requires synthesis of information and higher-order reasoning (60 min.). Some of the questions are clinically oriented and are not answerable unless the team accesses external sources of information. For this reason, the Group Application Exercise is taken as an open-book activity. Students are allowed to use their textbook and class notes. We also provide the teams with copies of d'Fiori's Atlas of Histology, an unabridged medical dictionary, and The Merck Manual. These are our suggestions, but comparable resources will suffice. Each team marks its consensus answers on a worksheet that is collected, scored, and recorded.

After the teams’ answer sheets have been collected, the instructor sequentially reviews each question on the Group Application Exercise and asks the teams to simultaneously report their answers (30 min.). This is done by holding up a colored card that denotes the team’s answer to a given question. In this way, all of the teams can see each other’s answers at the same time. Teams with different answers are asked to explain/defend their choices. In the ensuing discussion, the instructor reveals the correct answer and clarifies misunderstandings.

If a team misses a question on the Group Application Exercise and believes that credit should be given, that team has 48 hours to submit its appeal in writing to the instructor. The reasons for the appeal should be documented. Appeals are considered only from teams, not individuals. If the appeal is granted, the team score is changed, as well as the score of each member. However, the scores of the other teams are not changed. Each team must be responsible for its own choices and not expect to benefit from the successful appeal of another team.

This TBL module requires approximately 2 hours to complete.

**Results**

Data collected during the 30-student pilot administration of this module demonstrated that on average, students scored 77.9% correct on the iRAT, 100% correct on the gRAT, and 75.4% correct on the Group Application Exercise. The Table shows the students’ responses to our end-of-course survey for the 10 years we have employed TBL. Note that the students' attitude towards TBL has improved in recent years. We speculate that this shift in attitude may be due, in part, to prior exposure, as either undergraduates or...
graduate students, to similar active learning strategies in other courses. Perhaps active learning strategies like TBL are becoming more common than they once were and our survey results simply reflect changing student expectations.

Table. Percentage of Students Who Agreed or Strongly Agreed With Survey Statements

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<tr>
<td>I prefer TBL sessions rather than traditional lectures.</td>
<td>54.8</td>
<td>28.6</td>
<td>39.1</td>
<td>31.0</td>
<td>25.0</td>
<td>53.3</td>
<td>65.4</td>
<td>55.0</td>
<td>83.3</td>
<td>66.7</td>
<td>48.3*</td>
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<td>I was able to identify the important elements of the material without a traditional lecture.</td>
<td>64.5</td>
<td>60.0</td>
<td>87.0</td>
<td>65.5</td>
<td>59.4</td>
<td>73.3</td>
<td>76.9</td>
<td>70.0</td>
<td>87.5</td>
<td>71.4</td>
<td>70.5*</td>
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<tr>
<td>The Application Exercises enhanced my understanding of the material.</td>
<td>64.5</td>
<td>45.7</td>
<td>60.9</td>
<td>48.3</td>
<td>62.5</td>
<td>46.7</td>
<td>84.6</td>
<td>80.0</td>
<td>83.3</td>
<td>71.4</td>
<td>63.1*</td>
</tr>
<tr>
<td>The TBL sessions assisted my learning of the material better than a traditional lecture.</td>
<td>48.4</td>
<td>31.4</td>
<td>39.1</td>
<td>24.1</td>
<td>25.0</td>
<td>40.0</td>
<td>65.4</td>
<td>55.0</td>
<td>70.8</td>
<td>61.9</td>
<td>44.3*</td>
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<tr>
<td>Overall, I feel the TBL sessions helped my course grade. [Added to survey in 2008.]</td>
<td>NA</td>
<td>NA</td>
<td>26.1</td>
<td>51.7</td>
<td>53.1</td>
<td>60.0</td>
<td>61.5</td>
<td>45.0</td>
<td>70.8</td>
<td>47.6</td>
<td>52.7b</td>
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Abbreviations: NA, not applicable; TBL, team-based learning.

*Cumulative response rate: 271 out of 276 students responding (98.2%).

bCumulative response rate: 205 out of 208 students responding (98.6%).

Of the eight questions in the Group Application Exercise, our piloting of this module revealed that question seven was found to be both the most challenging and the most appealing. This question provides students with pairs of respiratory structures and asks students to determine a relationship that is shared by all pairs except one. Determining such relationships requires knowledge of not only the structure and function of all answer choices but also how the members of each pair relate to each other. Students spent considerable time struggling with the concept of a structural relationship and how it can be applied to these anatomical terms. Thus, this question has been revised to include an example to allow students to more quickly focus their attention on the specific structural pairs. The revised question is included in this submission.

Discussion

Our philosophy of teaching this module—and all the other modules in the course—is to provide students with a comprehensive introduction to the topic coupled with sufficient clinical material to illustrate the relevance of histology in practice. The RAT questions are designed to assess basic information and are not intended to be especially challenging. The Group Application Exercise is designed to be more challenging, of course, but even here we take a balanced approach of including some relatively easy questions (e.g., those focusing on histological identification) along with the more demanding questions (e.g., those requiring problem solving). We emphasize the clinical relevance of histology by including questions that require students to access The Merck Manual® or a similar resource. We believe this reinforces the linkage between the basic and clinical science and instills in students the habit of seeking information outside their textbooks.

The following recommendations are distilled from our direct experiences of what has worked (and not worked) during our 10 years using the TBL format, as well as suggestions provided by our students.6

- Schedule the microscopy lab sessions—or however histologic images are taught in your course—before the corresponding TBL sessions. Although seemingly counterintuitive, this was a frequent suggestion by students. Having prior exposure to relevant histologic images appears to enhance the students’ familiarity and comfort with material when it is presented again in the context of TBL application exercises.
- Do not allow Internet access during application exercises. The power of search engines is such that students can enter a few terms (e.g., patient symptoms) and quickly find the right answer to an application exercise but cannot explain why it is correct. However, we do make limited exceptions for online versions of the textbook, atlas, and The Merck Manual® (http://www.merckmanuals.com/professional/index.html).
• Assure that all team members participate in the class discussions and are prepared to explain and defend their team’s answers on application exercises. Relying on volunteers to answer questions limits class participation to a few bold individuals. However, systematically calling out names from team rosters requires everyone to participate.

• At the conclusion of the application exercise, provide a brief summary or take-home message of what the students are expected to understand about the topic. Students often need help seeing the relevance of the basic science material to the clinical problems presented in the application exercises. This practice also provides students with another opportunity to ask the facilitator clarifying questions. We have included a few Key Points slides in the Group Application Exercise PowerPoint that instructors may wish to use for this purpose.

• If possible, utilize computer-based delivery of the application exercises so that each team views the questions as a group. In this way, the questions are delivered sequentially, forcing the entire team to engage in answering each question before going on to the next, as opposed to team members dividing up and answering individual questions without having to pay attention to all of them, which we found was common when using paper handouts.

• Incorporate TBL scores into the final course grade; otherwise, the students fail to take the TBL sessions seriously. Calibrate the apportionment of points awarded the iRAT, gRAT, and Group Application Exercise to optimally reward both individual initiative and group effort. This may take some experimentation. We finally arrived at a point system whereby iRATs = 10 points, gRATs = 5 points, and Group Application Exercises = 15 points. These particular point values are not important other than to illustrate relative weights. Our course is based on 1,000 total points, with each TBL session worth 30 points. Because we have 10 TBL sessions, the TBL component constitutes 30% (300 points) of the course grade.

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