

Original Publication

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Team-Based Learning Is Effective in Teaching Appropriate Utilization of Hemostasis Laboratory Tests Using Storyline Case-Authoring Software

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Abstract

Introduction: Team-based learning (TBL) is an effective way to teach medical students a challenging topic: coagulation. This TBL requires students to discuss a differential diagnosis, order and analyze laboratory tests, and decide upon appropriate treatment. **Methods:** The coagulation TBL was utilized in a hematology/oncology system-based medical course. The TBL began with Individual and Group Readiness Assurance Tests (IRAT and GRAT, respectively) consisting of the same 10 multiple-choice questions. Next came a team application activity with the goal of evaluating a bleeding patient. Each team was given the clinical case and a whiteboard. Each team recorded a differential diagnosis and chose relevant laboratory tests from 20 hematology/coagulation assays placed in case-authoring software. Next, teams recorded the laboratory results, final diagnosis, and treatment on the whiteboards. Teams then voted for the best whiteboard. After discussing the highly voted whiteboard, instructors provided case discussion and elaboration about all 20 laboratory tests and their interpretation. **Results:** The IRAT average score was 77.0% compared to the GRAT group average of 99.5% for the year 2016-2017. Instructors noted great enthusiasm and teamwork. Institutional module evaluation feedback results showed that students were pleased and felt competent analyzing laboratory tests in a bleeding patient. **Discussion:** TBL provides a powerful way of teaching students the clinical reasoning approach to a bleeding patient and the appropriate use of laboratory test ordering and analysis. It is enjoyable and interactive and teaches students how to narrow their differential diagnosis by effective laboratory utilization.

Keywords

Team-Based Learning, Coagulation, Hemostasis

Appendices

- A. TBL IRAT & GRAT.docx
- B. Articulate Storyline Project folder
- C. TBL Coagulation Case.docx
- D. Storyline folder
- E. aPTT Diagram.docx
- F. Normal Laboratory Values .docx

All appendices are peer reviewed as integral parts of the Original Publication.

Educational Objectives

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

1. Outline their clinical reasoning approach for a bleeding patient.
2. Order and interpret hematological laboratory tests relevant to the case.
3. Describe and identify patients with acquired factor VIII deficiency.

Introduction

Team-based learning (TBL) is used in undergraduate medical education to facilitate higher-order content learning, promote learner engagement and collaboration, and foster positive learner attitudes.¹ Compared to a traditional lecture, TBL's simulated clinical scenario provides students with an opportunity to work as a team to apply their knowledge, discuss a wide differential diagnosis, and familiarize themselves with the available data, while being provided with immediate feedback from faculty.

The Hematology and Oncology course is the first of six system-based courses in the preclinical curriculum and is intended for first- or second-year medical students. Our course is given at the end of first year. Coagulation is a challenging topic, and the purpose of this TBL was to determine whether a TBL involving a complicated bleeding diathesis case would positively impact student learning. TBL was chosen for this topic versus another format to allow students to be engaged interactively in the processes of applying

knowledge, articulating their thinking, reasoning, and problem solving when confronted with varied opinions from other team members. Additionally, the course had limited faculty (three to four individuals), thus making TBL an attractive small-group learning modality.

Prior to the TBL, students had reading assignments and optional lectures. The TBL case required students to discuss a differential diagnosis, describe rationally the logical order of ordering lab tests, analyze the results from a set of laboratory tests, and propose basic treatment. By the conclusion of this module, students had become familiar with common uses for a variety of coagulation and hemostasis test methods, potentially strengthening their competencies in laboratory medicine, and had learned to approach a bleeding patient in a systematic fashion.

This TBL has some similarities to the *MedEdPORTAL* publication “Biochemistry and Pathology of Bleeding: An Integrative Approach to Team-Based Learning,”² which provides an understanding of the coagulation cascade and clinical laboratory testing. However, our TBL focuses on giving students the opportunity to choose laboratory tests from a list simulating an actual clinical setting, rather than providing them with the pertinent lab results in the case. The laboratory tests are presented through an innovative Storyline module, which gives students immediate lab results and limits the number of lab orders to 10 to encourage a systematic and cost-conscious approach.

Methods

The teams were instructor formed in the beginning of the first year and used in all TBLs during that year. There were 20 teams, each composed of six to seven students with varying levels of biomedical expertise and training. The exercise met the 4S criteria, as the case represented a significant problem, every team worked on the same problem with simultaneous reporting, and the answers represented specific choices (diagnoses and lab tests). The specific choices, which were open ended, were presented as a gallery walk.

Teams were divided equally based on the following criteria:

- Work in the medical field (e.g., physician assistant, registered nurse, emergency medical technician, paramedic, etc.—not shadowing).
- PhD in the basic sciences.
- Other graduate degree in the basic sciences.
- Nonscience major.

This formula ensured diversity in background/expertise and undergraduate training.

Description of Advance Preparation Resources

The advance preparation assignment included session objectives and reading materials that were given out 5 days in advance.

- Read *Robbins Basic Pathology*,³ pages 101-112 and 485-491.
- Read *Hoffbrand’s Essential Haematology*,⁴ chapter 27 (Thrombosis 1: Pathogenesis and Diagnosis).
- Read *Basic and Clinical Pharmacology*,⁵ chapter 34 (sections on basic pharmacology of the anticoagulant drugs, fibrinolytic drugs, and antiplatelet agents).

General Logistics for the TBL Activity

The TBL was administered in a large lecture hall with a maximum occupancy of 160. Student groups were asked to sit in two neighboring rows, around their team-number sign, thus allowing the students in the front row to turn and interact with those in the second row. Students began the session by completing the Individual Readiness Assurance Test (IRAT; 15 minutes), then worked with their teams to complete the Group Readiness Assurance Test (GRAT; 45 minutes). Upon completing the tests, each team was given the team application activity folder (see the Description of Team Application Activities section, below).

Outside of the curricular materials, each group was given a small whiteboard (1×2 feet), dry-erase marker (including four colors), dry eraser, and sticky notes for the gallery walk.

Description of Readiness Assurance Process

The TBL began with the sequential IRAT and GRAT, with the same 10 multiple-choice questions for each (Appendix A, with pertinent normal lab values reported in Appendix F). The questions were application questions from the reading assignments. Students took the IRAT first online and were not provided feedback. The GRAT required students to agree on the best answer as a team without the use of outside resources. The IRAT was allotted 15 minutes, while the GRAT with discussion took up to 45 minutes.

Students were given GRAT feedback immediately as to whether their choice was incorrect; they could choose another answer but had points deducted. Each question in a GRAT was worth 4 points. Each wrong scratch removed 1 point. For a normal 10-question GRAT, the maximum possible score was 40 points. Students' percent score was multiplied by the maximum score for the GRAT based on the weights the class had voted for. These were usually 30% for the IRAT and 70% for the GRAT. For a 2-point IRAT/GRAT, the IRAT was therefore worth 0.6 and the GRAT 1.4. Students were able to appeal their grade. The IRAT/GRAT counted as 2% of the final module grade.

Immediate Feedback

Students received immediate feedback at the end of the GRAT through the scratch cards, which revealed the correct answers. On the whiteboard, students wrote the questions to be discussed by the faculty. Faculty discussed these and answered other questions from students.

Description of Team Application Activities

The TBL group exercise allowed students to explore and build the scaffolding required to integrate knowledge acquired from the advance preparation resources. The goal was to determine the best, most effective, and most efficient way to work up and diagnose a patient with acquired factor VIII deficiency who presented with a bleeding disorder. Students demonstrated accountability with this challenging case since they were required to show their whiteboard answers simultaneously.

Faculty first created the case with the laboratory tests and results in a Word document. Later, our institution's educational technology (EdTech) department transferred the laboratory tests with their results to a modifiable Articulate Storyline project (Appendix B). Our EdTech department pays an annual subscription fee for Articulate 360. Other programs such as Adobe Captivate or PowerPoint could be used instead. However, we did not use PowerPoint because students would have had access to all the results at one time and we would not have been able to limit the number of tests ordered. The Storyline project was published for Web, and the file package was uploaded to our webserver. The hyperlink to the story.html was placed on a page in our learning management system, Canvas, and a link was provided in the course calendar for students to access at a specified time. We restricted access to the page until 15 minutes into the TBL case. We have provided the Articulate Storyline project file for users to modify (viewable if you have access to Articulate Storyline 360; Appendix B).

At the beginning of the team application activity, each team was given a folder with the clinical case scenario with an image of a hematoma (Appendix C) and a whiteboard with dry-erase markers. Students were required to use one team member's laptop (PC or Mac) with internet access. We instructed both students and faculty on how to access the published hyperlink in the course calendar in Canvas before the start of the TBL case. We discussed how to navigate through it and informed them that they were restricted to ordering no more than 10 tests but were permitted to explore outside resources and to choose labs with limitations. Each team had 15 minutes to record a differential diagnosis based on the clinical history alone. After 15 minutes, the Canvas page with the hyperlink opened, and students were able to choose/click the best five initial laboratory assays/panels from a list of 20 hematology and coagulation assays available via the Articulate Storyline hyperlink (Appendix D has instructions how to

unzip and deploy the D_storylinerevised.zip file, place the files on a webserver, and hyperlink to the story.html). Next, students recorded their differential diagnosis, sequence of next laboratory tests ordered, analysis of results, rationale for final diagnosis, and treatment on their whiteboards. After 45 minutes, student teams placed their individual team whiteboards in front of the room so they were visible to everyone.

During the gallery walk (15 minutes), all students were asked to come to the front of the room to read the other teams' whiteboards. Each team had one group vote for the winning team submission and attached its team-number sticker (a post-it note) on its favorite whiteboard. Teams were not allowed to vote for their own whiteboards. The team with the most votes discussed its findings and clinical approach and answered questions raised by faculty members and peers. Finally, instructors provided additional case discussion, including explanation for selected laboratory tests with an emphasis on the number of labs ordered, relative costs, uses, and interpretation, while focusing on a cost-effective approach to laboratory testing. Faculty also addressed the best approach to diagnosis and treatment (Appendix E). This session was a modified TBL, so students did not do peer evaluations or receive a grade for the team application activity.

Facilitation Schema

The TBL required a total of 3 hours:

- IRAT: 15 minutes.
- GRAT: 15 minutes.
- GRAT discussion with faculty: 30 minutes.
- Reading the case for the team application component, reviewing the image, and writing initial differential diagnosis on each team's whiteboard: 15 minutes.
- Completing the whiteboards while using Storyline: 45 minutes.
- Voting for the best whiteboard: 15 minutes.
- Student discussion of the winning whiteboard: 20 minutes.
- Faculty discussion of the topic: 10 minutes.
- Faculty discussion of the laboratory tests, uses, and interpretation: 15 minutes.

Results

One-hundred twenty first-year medical students participated in the TBL. The IRAT average score was 77.0% compared to the GRAT group scores of 99.5% for the year 2016-2017. The IRAT average scores in 2014-2015 and 2015-2016 were 76.0% and 77.0%, respectively, while the GRAT average scores in corresponding years were 97.0% and 99.5%.

Instructors (two hematologists-oncologists and two pathologists) noticed great enthusiasm for the exercise, as well as effective teamwork and peer teaching. Institutional program evaluation forms indicated that participants were pleased with the TBL format. Example comments included the following:

- "I thought that the TBL in this course was engaging and relevant by giving us a case and having us decide what labs to get and then view the results."
- "This style of TBL should be used as a model for other classes."
- "I feel like I learned the coagulation disorders best because of the TBL."

Students stated they felt competent in their future approach to a bleeding patient and felt more familiarity with clinical laboratory hematology test orders and result analysis.

Students demonstrated mastery related to acquired factor VIII deficiency after this TBL, as well as to the differential diagnosis of the bleeding diathesis that they could possibly encounter in the future. They commented favorably that the lab results placed in Storyline simulated the electronic medical record

(EMR), requiring them to think before choosing a laboratory test and interpreting the result given; for example:

- “TBL was helpful (i.e., ordering labs, defending why, coming up with differential etc.)”
- “TBL was very effective in teaching the material.”

The students performed very well on the hemostasis-related questions on their final exam overall. One closely related coagulation laboratory question on average received a score of 95.5% as compared to the overall final exam average of 86.3%.

Discussion

TBL provides a powerful way of teaching students the clinical reasoning approach to a bleeding patient and the appropriate use of laboratory test ordering and analysis. Students have to synthesize information from the case to determine the differential diagnoses and then order appropriate laboratory tests to diagnose the patient. Through teamwork and discussion, groups are able to approach a challenging case. The use of Storyline to simulate the EMR, which prepares students for their future clerkships and familiarizes them with the potentially daunting list of hematology and coagulation assays available in practice, has been a tremendous success. This TBL accomplished the goal of teaching students how to narrow their differential diagnosis by effective laboratory utilization. Students found this TBL format enjoyable and interactive, and they performed well on the hemostasis section of the final examination. Student evaluations indicated that they preferred TBL to other small case formats and would like more TBL sessions in the course.

While this TBL may be useful in many medical school settings, one limitation is that only one case scenario is presented. We would like to add more TBL coagulation-related questions to the exam in order to provide more data on whether students can apply their knowledge to related hemostasis problems. One challenge is that some teams were done with the differential diagnosis before others and were forced to wait for the Storyline to be available after 15 minutes; we may work to make test ordering available earlier in the future. Another area that may be addressed in the future is the addition of any newer laboratory testing, including molecular assays. Students liked the test explanations provided in the TBL and by faculty, and take-home summary material may be added. Additionally, the college may purchase an EMR simulator, which could be used to improve the experience. Currently, based on our experience, Storyline is an excellent case-authoring tool for simulating an EMR.

In conclusion, Storyline can be used successfully in TBL and other cases to simulate test ordering in the EMR. Another TBL anemia case was modified to use Storyline, and TBLs on white blood cell disorders and other disorders involving laboratory medicine testing are under consideration for the future. Medical schools may wish to pursue similar TBL approaches and methods to teach students laboratory medicine and test-ordering concepts.

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Prior Presentations

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Ethical Approval

Reported as not applicable.

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