Pharmacotherapy of Type 2 Diabetes: Team-Based Learning

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Abstract

Introduction: This activity was designed to help students learn the basic pharmacology of antihyperglycemic agents and treatment strategies used in type 2 diabetes, practice applying this knowledge to clinical decision-making, and consider general issues that influence the choice of medication for an individual patient. Methods: The activity follows standard procedures for team-based learning, including an advanced preparation reading assigned in advance, a Readiness Assurance Test taken both individually and then in teams, and a more complex application exercise where students apply their knowledge to a realistic clinical scenario, working together in teams and then discussing their reasoning with others. Results: The session has been offered for 3 consecutive years, twice exclusively to first-year medical students and once in an interprofessional format where teams included a mix of first-year medical and second-year pharmacy students. Knowledge outcomes assessed by end-of-course exams were similar to those obtained previously with lectures while affording greater learning opportunities beyond simple recall through student engagement with the materials and application exercise. The interprofessional version was particularly well received by learners of both professions, and we are continuing to offer the session in this format as well as pursuing opportunities to provide other interprofessional experiences. Discussion: The activity provides a useful model for adapting team-based learning to teach complex topics in pharmacology and demonstrates the feasibility and benefits of incorporating interprofessional experiences into the early years of undergraduate medical education.

Keywords
Team-Based Learning, Diabetes Mellitus, Type 2, Interprofessional Communication, Pharmacology, Type 2 Diabetes Mellitus

Educational Objectives

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

1. Describe the indications, mechanisms of action, distinctive pharmacokinetics, and adverse effects of medications used to treat type 2 diabetes.
2. Identify appropriate initial and add-on therapy for a patient with type 2 diabetes.
3. Identify clinically important interactions involving antihyperglycemic medications.
4. Discuss the place of insulin in treatment of type 2 diabetes.
5. Discuss general issues to consider when choosing a specific medication.

Introduction

This activity was designed to help students learn the basic pharmacology of antihyperglycemic agents and treatment strategies used in type 2 diabetes and to practice applying this knowledge to make clinical decisions. It also provides opportunities for students to consider general issues such as safety, tolerability, and efficacy that affect the choice of medication for an individual patient and to both think about and practice decision making in challenging clinical situations where current evidence does not provide an unambiguous single best answer. We adopted team-based learning on the basis of its growing evidence...
of effectiveness in medical education and its emphasis on application in addition to the basic acquisition of knowledge.\textsuperscript{1,2}

Students come to the session having already learned about pathophysiology and complications of both type 1 and type 2 diabetes and about insulin preparations and their use in type 1 diabetes. The in-class activities of the module serve to reinforce and link to these topics as well as emphasizing the learning objectives specific to the session. As of this writing, the session has been offered for 3 consecutive years to first-year medical students. In the first iteration, a preliminary version of the activity was implemented in addition to traditional lectures on pharmacotherapy of type 2 diabetes, while in the subsequent 2 years, the session in its current form was used alone, without lectures, as the primary method of instruction for this topic.

The most recent iteration of the session also included second-year pharmacy students in an interprofessional format. Medical and pharmacy students worked together in teams to pool their knowledge and learn more about what each profession brings to patient care. This called for some adaptations of our procedures, which are noted in the subsequent sections of this document. In contrast, session content including the advance preparation reading, readiness test, and application questions was largely unchanged, having been considered appropriate for both student groups by their respective faculty.

**Methods**

We follow procedures of team-based learning described in the literature.\textsuperscript{3} Individual sessions include advance preparation materials (e.g., reading materials and learning objectives outlined below) that students become familiar with, individual and group Readiness Assurance Tests (RATs) taken at the beginning of the session, and a brief review of any challenging concepts from the readiness test. After a short break, students then spend the bulk of the 110-minute session working in teams on a group application exercise consisting of a number of questions. Each application question is followed by simultaneous reporting of answers and faculty-facilitated whole-class discussion.

**Timing and Materials**

The approximate schedule of the session is as follows:

- Seating and introduction (5 minutes).
- Individual RAT (IRAT; 10 minutes).
- Group RAT (GRAT; 10 minutes).
- Brief, focused review (15 minutes or less).
- Break (10 minutes).
- Group application exercise (55 minutes).
- Wrap-up and closure (5 minutes).

Our students are familiar with this schedule and with team-based learning in general, which is used in combination with other modalities throughout our curriculum beginning in the first week of medical school. With students who do not have similar experiences, a clear description of the process and rationale delivered at the outset prior to the session may be especially helpful. Video introductions to team-based learning are available online\textsuperscript{4} and can be useful for orienting students and faculty new to the method.

The following appendices are included in this module:

- **A. Diabetes Learning Objectives**: contains a list of module learning objectives, to be distributed to learners before starting the session.
- **B. Diabetes Readiness Test**: learner version of the IRAT and GRAT.
- **C. Diabetes Readiness Test-Instructor Packet**: RAT key for instructor reference, with correct answers highlighted and a brief description of the testing process.
- **D. Diabetes In-Class Presentation**: includes learning objectives and questions slides for use when administering the RATs and group application exercise, as well as explanations of these questions.
E. Diabetes Group Application Exercise Handout: case scenarios to provide electronically or in hard copy during the session, so that students can more easily read and refer back while working on the group application exercise. When using hard copies, we provide one copy per two to three team members.

F. Diabetes Group Application Exercise-Instructor Packet: faculty guide to the application exercise, including full text of the case and questions, commentary, and advice for facilitating discussion of each question.

G. Diabetes Concept Slides: contains the information slides (as opposed to question slides) used in Appendix C and is designed to explain concepts from the RATs and group application exercise; can be released to students after the session as a study aid.

Additional materials required for the session include lettered cards for each team to hold up to simultaneously report their answers to application questions. These may be created by the facilitators. It is also helpful to have stands that allow these choices to remain visible during the subsequent discussion. While not strictly required, we use Immediate Feedback-Assessment Technique (IF-AT) scratch-off cards (available from www.epsteineducation.com) for the GRAT, in order to provide students with immediate feedback and allow multiple attempts if their first choice is incorrect. The IF-AT form number compatible with this module is located in Appendix C.

Setting and Team Formation
We have conducted the session with a single facilitator and classes of approximately 110 medical students in both a traditional auditorium-style lecture hall with assigned seating, so that members of the same team are grouped together as closely as practical, and a flat-floored classroom designed specifically for team-based learning with each team seated at a separate table. In the interprofessional version, where the total class size of approximately 150 exceeded the capacity of either room alone, we conducted separate sessions in two rooms simultaneously, each including two faculty members (one each from medicine and pharmacy) and half of the combined class.

We use teams of five to seven members that are assigned in advance to maximize within-team diversity, taking into account gender, age, and premedical background. The activity has been used successfully with teams that are stable across the first-year medical curriculum as well as with ones assigned only for this session. In the most recent version including pharmacy as well as medical students, teams are assigned specifically for the session and include consistent proportions of students from each profession.

Advance Preparation Resources
Assigned reading for this session covers basic pharmacology of noninsulin medications used to treat type 2 diabetes as well as the basics of treatment strategy. We used the reference cited below, but these topics are covered in many pharmacology texts and online resources. Students are provided with the session learning objectives (Appendix A) along with the reading to help guide study and self-assessment. Both are made available online 1 week prior to the session.

- Pages 733-742 of *Basic & Clinical Pharmacology*, 13th ed.

Readiness Assurance Process
The RAT is intended to confirm understanding of major concepts related to the objectives and to help clarify any points of confusion. The IRAT and GRAT are both taken without access to notes, books, or other reference materials. We administer the IRAT electronically, with instructors able to view the results in real time. Prior to receiving any feedback on the IRAT, students then take the GRAT in their teams using IF-AT scratch cards that provide immediate feedback and allow multiple attempts if an initial choice is incorrect.

The RAT is provided in ready-to-use form in Appendix B. The answer choices of the GRAT are arranged for use with IF-AT cards. The correct answer for each question is placed to correspond to the location marked as correct on the scratch-off card, while the remaining options are arranged randomly. If an IF-AT form with a different answer key is used, the correct answer to each question should be repositioned accordingly.
An instructor version with notes on the RAT process, highlighted correct answers, and the corresponding IF-AT form number is also provided (Appendix C).

While students take the GRAT, we review the IRAT results and flag for review any questions missed by at least 20% of the class. To prepare for the in-class presentation, questions that are not flagged for review are removed from the in-class presentation (Appendix D). Following the GRAT, faculty clarify the concepts addressed by these questions using this customized presentation. The review is kept brief and focuses on concepts, rather than the other details of specific test items.

For concerns about clarity or correctness of a test question, we allow teams to submit written appeals in the usual team-based learning fashion in which they can make a brief case for why they feel their chosen answer is correct or how the question could be written more clearly. These are reviewed by faculty after class but are not discussed or debated during the session itself.

Of special note regarding the RAT, question 9 involves an explicit comparison of efficiency between insulin and oral medication. The current edition of the advance preparation reading does not include background on this. We still wished to include it as a point to highlight in the session, and so we retained the question but marked it as a bonus question in the readiness test and announced to students that this question would not contribute to a grade for the activity. Instructors who use different advance preparation reading that includes the comparison of efficacy may wish to remove the bonus designation and treat this question identically to the rest.

Group Application Exercise
During the application exercise, students work in their teams on more complex problems where they apply the basic concepts to a realistic clinical scenario. Questions are shown one at a time on presentation slides contained in Appendix D, with time allowed for students to arrive at an answer in their teams before announcing their choices simultaneously by holding up lettered cards. Students may refer to notes, references (including advanced preparation reading), and online resources during this exercise. The case on which the applications are based is shown on-screen as part of the in-class presentation and also provided in a separate document (Appendix E), which can be distributed in hard copy or electronically for learner reference during the exercise. If providing the case in printed form, multiple copies per team are recommended so that it can be viewed readily by all team members.

We use a flexible timing system, where teams signal with a blank card (i.e., not the one showing their answer) when they have arrived at an answer. When 40% of teams have signaled, we announce 1 minute remaining and then call for all teams to report their answers simultaneously. Originally we waited for 50% of teams to finish before giving the warning; this was decreased in response to student feedback. Faculty then call on teams to explain their reasoning as a group and explain their choice. The application questions vary in difficulty, and discussion time can vary accordingly; when students arrive readily at a correct answer, it can still be worthwhile to briefly elicit their reasoning, providing reinforcement or correction as appropriate.

Appendix F includes the full text of the clinical case, application questions, and instructor notes detailing the rationale for the choice identified as correct as well as additional discussion points that can be raised as time allows. The applications are arranged to cover more fundamental concepts in the earlier questions. We include management of cardiovascular risk in the fifth application to highlight the importance of co-occurring medical concerns, but this can be omitted without compromising the rest of the activity in settings where students have not already learned about these topics if time is limited or if instructors prefer to focus more narrowly on the topic of the current session.

We do not count the application exercise toward a course grade, as greater leeway is taken in this exercise to go beyond the individual session objectives, link to related topics, and consider issues more challenging and sometimes ambiguous than would be included in a summative assessment for learners at this stage of training. We make explicit in Appendix F and to learners during the session when a given choice is not clear-cut and could lead to reasonable disagreement even among experts (e.g., application question 3). When discussing these questions, we emphasize the rationale for learner and faculty choices.
highlighting in particular how those choices are informed by information included in the session objectives even when that information does not lead to a single, clearly best answer.

Wrap-up and Closure
The final several minutes of the session are used to review major points, return to the learning objectives, and address any outstanding questions. After the module has concluded, the Diabetes Concept Slides (Appendix G), containing only the information slides, may be released to the students as a future study guide. Please note that the diagram at the end of the presentation, summarizing mechanisms of action and adverse effects of the medications, can be reviewed in a more or less interactive manner, as time allows, or simply provided to learners as a resource for independent study.

Results
As of this writing, the session has been offered for 3 consecutive years and has been well received in both medical student–only and interprofessional formats. The current iteration was rated as useful or very useful by 77% of medical students, and the chance to meet and interact with students from another allied profession was particularly appreciated by medical and pharmacy students alike. In an open-ended question where students were asked to identify strengths of the session, 64% of pharmacy students and 79% of medical students commented favorably on the opportunity to work with students of the other profession.

On course exams, student performance on questions related to this session’s content has been stable and consistent with previous years when the topic was taught via lecture. Each year’s exam has included six to eight questions related to pharmacotherapy of type 2 diabetes, with an average correct response rate of 78.5% in the last year when the topic was presented via lecture alone compared to 79.2% and 78.4% in the most recent 2 years using team-based learning exclusively.

Students have found the IRAT test challenging, with scores averaging 62% in both of the past 2 years, though when working together on the GRAT, they answer most questions correctly and teams typically score 90% or above. The particular questions that were most challenging have varied across the years, and the questions themselves have undergone some editing during this time. In general, medical students have performed most strongly on questions related to basic mechanisms of action (e.g., question 2), whereas questions related to clinical features and outcomes (e.g., questions 4 and 8) have been more challenging.

The session and supporting materials were revised several times during the past 3 years of use, mainly to keep pace with changing clinical practices and ongoing development of new medications to treat type 2 diabetes, as well as to tighten the alignment between learning objectives, assigned reading, and RATs. During the transition to an interprofessional format, the content, choice of correct answers, and accompanying rationale were reviewed by faculty of the medical and pharmacy schools to ensure consistency with both curricula. This led to inclusion of additional points and perspectives in the instructor notes in the Diabetes Readiness Test-Instructor Packet (Appendix C), whereas the content of the readiness test, case, and applications remained generally unchanged.

Discussion
This team-based learning activity has been implemented successfully both with first-year medical students and as an interprofessional activity with medical and pharmacy students working together. The greatest challenges we encountered were the initial investment of faculty time and effort to develop the session, whereas once designed, it required in- and out-of-class work comparable to a well-maintained lecture on this actively evolving topic.

We have been pleased with the degree of student involvement and greater opportunities for interaction and feedback provided by the team-based format. At the same time, the finding of similar knowledge outcomes, as assessed by course exams, is generally consistent with outcomes reported in other medical education literature. We hope that as part of a general shift toward more active and engaged methods of learning.
instruction, this method will contribute to student development of greater proficiency and confidence in both recalling and using information learned during the first years of medical school. Continuing to find ways to reliably capture these longer term outcomes of curriculum-wide change remains an area for future work.

The recent adaptation of the session to an interprofessional format was particularly well received by students and faculty. Students expressed appreciation for the opportunity to learn about and from their counterparts in another profession, and the addition of pharmacy faculty as cofacilitators helped to enrich whole-class discussion. The challenges involved were mainly logistical, in particular accommodating a combined class that exceeded the capacity of any single room at our facility, and this was managed successfully with use of an additional room. This was the first interprofessional activity in our first-year medical curriculum, and based on its success, we are continuing to offer the session in this format and pursuing opportunities to provide other early interprofessional experiences.

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References

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