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Type 1 Diabetes Mellitus: Pediatric Team-Based Learning Module

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Abstract

Introduction: Type 1 diabetes mellitus (T1DM) is an autoimmune disease that impacts roughly 200,000 youths in the United States. Many patients have limited access to specialist care. Therefore, general pediatricians are expected to be skilled in the management of diabetes. Recent studies suggest that an educational gap exists for general practitioners regarding diabetes care. Team-based learning (TBL), an active, learner-centered method of teaching, has been shown to be an effective tool in adult learning and teaching. Here, we outline a TBL activity focused on the education of pediatric residents in the comprehensive management of T1DM. **Methods:** Learners prepare in advance by reading through a review article on T1DM. They are formed into groups and work through the readiness assurance process first, followed by application exercises. The application exercises focus on choosing and applying an insulin regimen to a patient with a new diagnosis of T1DM, including modification of this regimen based on blood sugar trends, management of diabetes ketoacidosis, and recognition and management of hypoglycemia. **Results:** Learners showed improvement in their readiness assurance testing, from 81.4% individually to 91% as a group. Eighty percent of learners agreed or strongly agreed this was an effective method for improving diabetes skills and knowledge, and the learning process engaged them. **Discussion:** TBL may be a valuable educational strategy to enhance knowledge of T1DM care for general pediatricians. Future studies focusing on longitudinal educational outcomes would be beneficial.

Keywords

Team-Based Learning, Type 1 Diabetes Mellitus, Pediatric Endocrinology, Juvenile Diabetes, Insulin-Dependent Diabetes

Appendices

- A. IRAT & GRAT Questions.docx
- B. Application Exercises.docx
- C. Deidentified Blood Glucose Log (Case 2).pdf
- D. Deidentified Blood Glucose Log (Case 3).pdf
- E. Carbohydrate Counting Worksheet.ppt
- F. Insulin Onset of Action Worksheet.pptx
- G. 1-Minute Paper Evaluation.pdf

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

Educational Objectives

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

1. Recognize presenting symptoms of type 1 diabetes mellitus (T1DM).
2. Choose the initial and confirmatory tests in the diagnosis of T1DM.
3. Compare types of insulin therapy, including onset, peak, and duration of action.
4. Formulate a practical management plan for a patient newly diagnosed with T1DM.
5. Recognize symptoms of hypoglycemia.
6. Apply the Rule of 15s during an acute episode of hypoglycemia.
7. Identify short- and long-term complications of T1DM.
8. Analyze the diagnostic evaluation for diabetic ketoacidosis.

Introduction

Type 1 diabetes mellitus (T1DM) is an autoimmune condition leading to destruction of beta cells in the pancreas resulting in an inability to produce insulin. It is one of the most common as well as financially burdensome chronic diseases in the pediatric population. In the United States, the number of youths 20 years of age and younger diagnosed with T1DM annually has been estimated at 18,436 patients, and the incidence appears to be increasing.^{1,2} Furthermore, the current number of pediatric-trained

endocrinologists is insufficient to provide dedicated care to these patients, especially in rural areas.³ As a result, management of T1DM—in particular, inpatient management—often falls to general pediatricians or hospitalists.

The American Board of Pediatrics mandates that all board-certified pediatricians be able to diagnose new-onset T1DM. Additionally, it requires pediatricians to be able to develop a management plan for all aspects of diabetes care, including maintenance therapy, hypoglycemia, and diabetic ketoacidosis (DKA).⁴ However, although pediatric resident knowledge of diabetes management has not been specifically studied, past studies of internal medicine and family practice faculty/trainees have shown that significant knowledge gaps still exist that could result in medical errors and inappropriate patient care.⁵⁻⁷ Insulin therapy, the backbone of T1DM management, remains one of the most common medications associated with preventable medical errors.⁸ This highlights the importance of quality and comprehensive education for pediatric physicians in the management of T1DM in children.

However, there is a paucity of literature regarding best practices in the education of pediatric residents in T1DM management. Past interventions such as web-based curricula and diabetes simulation scenarios have shown variable short-term success.^{9,10} Therefore, it is crucial to engage residents in effective but feasible educational techniques to develop the practical skills necessary to care for pediatric patients with T1DM prior to independent practice.

Team-based learning (TBL) is a learner-centered teaching method that uses small groups to actively improve knowledge, application, and team-building skills.¹¹ It has been shown in numerous settings to be equivalent, if not superior, to traditional lecture-based learning in the enhancement of knowledge.¹¹ TBL is now being widely applied in numerous medical education settings, including residency training, with improvement in learner engagement, satisfaction, and, most importantly, knowledge gains.¹² Given this, TBL may be an effective teaching method to improve resident education regarding T1DM in children.

This resource contains a TBL activity targeting pediatric and internal medicine—pediatric residents at all levels of knowledge. This TBL module was created as a replacement for an annual, lecture-based session built into the core general pediatrics curriculum for residents. By the end of this activity, pediatric resident learners will have a better understanding of comprehensive T1DM management, including etiology, diagnosis, daily management, insulin action, and sick-day management.

Methods

This TBL module follows the principles of TBL as described by Parmelee and colleagues in “Team-Based Learning: A Practical Guide.”¹¹

Preparation and Resources

One week prior to the module, learners are electronically provided with the preparatory article on pediatric T1DM written by Gregory, Moore, and Simmons in *Pediatrics in Review*,¹³ a journal published by the American Academy of Pediatrics focusing on the enrichment and maintenance of the clinical knowledge of pediatric practitioners. Additionally, learners are provided with the module’s objectives.

Group Assignment and Introduction

Upon entry to the classroom, residents are assigned to small teams of five to seven participants. Each team is composed of learners at all levels of training from postgraduate year-1 (PGY-1) through PGY-4. At our institution, medical students on pediatric clerkship join all core curriculum lectures. They are therefore incorporated into groups and invited to participate for learning purposes. Each team is given a folder that contains all materials needed to complete the activity. Learners are then introduced to the concept of TBL and an outline of the activity. Materials to be provided in this folder include the following:

- One readiness assurance test (RAT) for each team member.
- One individual readiness assurance answer card for each team member.
- One Individual Feedback-Assessment Technique (IF/AT) card per team.
- One RAT appeal worksheet per team.
- One group application exercise for each team member.

- A copy of both deidentified blood glucose logs for each team member.
- A copy of the carbohydrate counting worksheet for each team member.
- One insulin onset of action worksheet for each team member.
- One evaluation worksheet for each team member.

Individual and Group Readiness Assurance Process

Learners first complete an eight-question individual RAT (IRAT), which is designed to test each individual learner's baseline knowledge and mastery of required prereading (Appendix A). Subsequently, they retake the same test in groups/teams employing immediate feedback by way of an IF/AT form. Upon completion, this group RAT (GRAT) is reviewed as a large group, and learners are given the opportunity to ask clarifying questions or submit an appeal for unclear questions. Reference materials are not permitted throughout the readiness assurance process.

Group Application Exercise

The group application exercises are composed of three case vignettes. Following completion of the readiness assurance process, teams work stepwise through each case and answer all questions located in Appendix B. In cases 1 and 2, learners evaluate the same patient with a new diagnosis of T1DM. The goals of case 1 are to (1) diagnose DKA, (2) formulate a management plan for DKA, and (3) formulate a plan for transition following resolution of DKA. The goals of case 2 are to (1) identify and apply a practical insulin regimen in newly diagnosed T1DM, (2) review the Rule of 15s for hypoglycemia therapy, and (3) practice adjusting insulin in the setting of repeated hypoglycemia. Case 3 evaluates an established patient with T1DM managed on an insulin pump; this gives residents the opportunity to compare and contrast insulin pump therapy to subcutaneous insulin injections as well as apply sick-day rules. Appendix C is needed to complete case 2. Appendix D is needed to complete case 3. Appendices E and F can be used as supporting resource tools for learners to complete all cases.

Teams review each case in its entirety prior to moving to the subsequent case. The corresponding questions for each case are first discussed by the individual team; then, teams are asked to simultaneously report their answers to the larger group. During this time, teams are given the opportunity to debate, defend, and appraise their answers. Reference materials are permitted during the application exercises.

Summary and Evaluations

Upon completion of the group application exercises, the facilitator should provide a short summary of the activity and reinforce important learning points. Participants are given time to complete an evaluation in the form of a 1-minute paper (Appendix G) to outline one point that was learned and one that remained unclear, as well as provide an overall rating of the activity. Areas that remain unclear can be used to target future learning topics for residents.

Facilitation Schema

This T1DM module is 120 minutes in length. For this module, a suggested facilitation outline is as follows, using 5 of the 120 minutes for transitions between segments of the session.

- Formation of groups and introduction to TBL (10 minutes).
- IRAT (10 minutes).
- GRAT (20 minutes).
- Case 1 vignette and discussion (20 minutes).
- Case 2 vignette and discussion (20 minutes).
- Case 3 vignette and discussion (20 minutes).
- Summary and wrap-up (10 minutes).
- Evaluations (5 minutes).

Results

Pediatric and internal medicine—pediatric residents from PGY-1 to PGY-4 were invited to attend this session. Additionally, any third- and fourth-year medical students participating in their pediatric clerkship at

our institution were invited to attend. However, given that resident learning was the focus of this project, individual student data are not included in the analysis. Of the 35 residents, 12 were interns, and 23 were upper-level residents. Ten students were in attendance for the module. To help with facilitation, we had one pediatric endocrinology faculty member in attendance and three pediatric endocrinology fellows. We collected both qualitative and quantitative data throughout the session.

The mean score on the IRAT was 81.4%. There was no significant statistical difference in the IRAT scores based on level of training ($p = .4$). The mean score on the GRAT was 91.1%, showing a clear improvement in scores when learners worked in groups. The most commonly missed question during the IRAT process among learners at all training levels was question 4, which evaluated knowledge of nutrition management. The majority of learners answered that patients with T1DM should either limit all carbohydrates or avoid concentrated sweets (answer A or D, respectively).

Forty-three evaluations were collected from this session. Using a 5-point Likert-scale (1 = *strongly disagree*, 5 = *strongly agree*), 69.3% strongly agreed and another 10% agreed that TBL was an effective method for learning about T1DM. The remaining learners did not submit evaluations for review.

On qualitative review, several common themes arose. The majority of learners expressed that they gained knowledge in the areas of insulin onset of action, DKA management, choosing an insulin regimen, and understanding the difference between a sliding-scale insulin regimen and dosing based on an insulin-to-carbohydrate ratio with correction. One learner was surprised, stating, "There's a method! Picking an insulin regimen isn't random." Learners demonstrated appreciation for "practical practice" in modifying daily insulin dosing. Learners most commonly requested additional training in reading blood glucose logs and making appropriate insulin adjustments. Additionally, learners identified the need for more detailed education in management of DKA. In general, learners stated the session was "very helpful—much better than a blow-by noon, 45-minute lecture," "more memorable," "interactive," and "very engaging."

Discussion

This TBL curriculum improved pediatric resident knowledge in the practical management of T1DM in children. TBL is designed to incorporate learners at various stages of education and therefore was easily tailored to engage pediatric residents at all levels of training.¹¹ TBL also gave the upper-level residents an opportunity to share their knowledge and experience, thus indirectly solidifying knowledge and confidence in the given topic.

During this module, we observed that although residents had solid knowledge of the physiology and recognition of T1DM, they required higher-level discussion of the practicality of building an insulin and nutrition regimen, as found in questions 2 and 4 in the RAT as well as case 2 in the application exercises. Facilitators utilizing this module would benefit from allowing a longer time for this discussion. Additionally, although learners expressed improved knowledge of the recognition and management of DKA, many requested additional training in this area following the completion of the module. Of note, the residents at our institution do not participate in intensive care rotations until PGY-2. Learners who have not rotated through the pediatric intensive care unit may need more individualized education in management of ketoacidosis.

Residents appeared most engaged while interpreting blood sugar trends, as found in cases 2 and 3. This was supported in qualitative data collection, where residents expressed excitement about this experience and a desire for similar practice in the future. Future versions of this curriculum could benefit from increasing the amount of hands-on activities to further improve confidence in insulin dosing.

We acknowledge some important limitations to this project. This session was designed for 120 minutes of dedicated time to allow for thorough discussion throughout the GRAT and application exercises. Given this time allotment, we were able to closely mirror the facilitation schema suggested above. This allowance may be limiting to some programs that have only 60 to 90 minutes of teaching time built into their general pediatrics curriculum for diabetes management. Judging from our experience, the time allotted for the GRAT activity and application exercises could be limited to 12-15 minutes each without compromising the

discussion. In fact, six of the learners commented that the session would benefit from faster pacing during these activities. The amount of questions or number of cases employed during the application exercises can also be decreased to allow for tighter time constraints while still achieving the objectives of the module.

One of the primary goals of TBL is to facilitate team cohesion and foster successful problem solving through guided activities.¹¹ TBL typically relies on repeated encounters for learner groups to form into ideal, high-performance teams. Unfortunately, this amount of contact time is rarely available in residency curricula and was not available for the purpose of this module.¹⁴ We did, however, observe that team members were generally well engaged, with appropriate individual participation in discussion. We believe this time barrier was minimized because most learners had already had an opportunity to interact with each other in the clinical environment prior to the activity. Further studies directed at evaluating effectiveness of TBL in low-contact time settings would be helpful.

Lastly, due to the nature of the project, assessing long-term knowledge retention was outside the scope of this study. This module would benefit from future studies in knowledge retention compared to a traditional didactic education session. Additionally, given that the curriculum generates an increased awareness of preventable medical errors, long-term data could be collected to examine the impact of increased knowledge of safety and quality (e.g., decrease in insulin medical errors from resident prescriptions).

In summary, this TBL module was designed to provide instruction to pediatric residents in the management of T1DM. The module engaged learners in individual assessment followed by small-group application exercises, and residents expressed improved knowledge of diabetes care in children. We feel this is a valuable educational strategy to enhance knowledge of T1DM care for general pediatricians.

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Ethical Approval

This publication contains data obtained from human subjects and received ethical approval.

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