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Embryology, Anatomy, and Radiology of Cervical Cysts and Cleft Lip/Palate: A Team-Based Learning Module for Medical Students

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Abstract

Introduction: Current medical education promotes enhanced integration of various disciplines and early exposure to clinically relevant topics. Against this background, we have developed a team-based learning (TBL) module for medical students in the preclerkship period that integrates embryology, anatomy, and radiology of the head and neck region. **Methods:** The module, which includes prereading assignments, readiness assurance tests, and an application exercise, focuses on the development of the head and neck region. Students were asked to consolidate their knowledge of the topic—acquired as part of their regular curriculum—and to apply this knowledge to cases of cervical cysts and cleft lip/palate. **Results:** The TBL module was developed for a class of 234 students. The students performed well in the TBL module. Although many students perceived the session as time-consuming, the majority of students evaluated it as relevant for their understanding of the course material and a valuable adjunct to their course. **Discussion:** To our knowledge, as of this writing, no TBL modules have been published that focus on the integration of complex embryological topics with anatomy and radiology and that are suitable for medical students at the beginning of their education. Therefore, the presented TBL module fills a gap in material available to educators in the field.

Keywords

Development, Anatomy, Team-Based Learning, Head and Neck, Radiology, Embryology, Cleft Lip, Cleft Palate, Cervical Cyst

Educational Objectives

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

1. Distinguish normal and abnormal neck anatomy on radiographic images.
2. Explain in what way the derivatives of the pharyngeal apparatus are important for the normal anatomic development of the head and neck region.
3. Explain how deviations from the normal development of the head and neck can result in congenital anomalies in these regions.

Introduction

This session was developed as part of the Human Structure (HS) course, which is a component of the preclerkship curriculum at the University of Texas Southwestern (UTSW) Medical School and is taught during the first semester. The HS course integrates human anatomy, embryology, and basic radiology. It consists of traditional lectures, video lectures, cadaver-based dissections, osteology exercises, online learning modules, and two team-based learning (TBL) sessions. A portion of this curriculum includes a head and neck block that contains lectures on head and neck anatomy, dissections of the neck and head region in the cadaver laboratory, and an online module on head and neck development delivered through the online learning management system MoodleRooms. In addition, an introductory lecture on radiographic images is given at the beginning of the HS course. In this lecture, the general concepts of radiographs, CTs, and MRIs are explained to students.

Appendices

- A. Advanced Prep Lecture Introduction to Radiology .pdf
- B. Advanced Prep Radiographic Imaging of Head.pdf
- C. RAT Questions Group A Student.docx
- D. RAT Questions Group B Student.docx
- E. RAT Questions Group A Instructor.docx
- F. RAT Questions Group B Instructor.docx
- G. TBL Application Student .docx
- H. TBL Application Instructor .docx
- I. Student Survey Results.pdf

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

Recent curriculum reform at UTSW Medical School aims to integrate preclinical course content, provide early access to clinically relevant material, and stimulate collaboration amongst students. With these goals in mind, two TBL sessions were developed for the HS course, one of which is presented here. This TBL covers the development of the head and neck region, its anatomy, and its presentation in radiographic images. We decided to focus on an embryological topic because, in our experience, students often find these topics difficult to understand and fail to see their applicability and clinical relevance. In the literature, several educational resources on head and neck are available. These resources either cover development,¹ anatomy,² or radiology^{3,4} of the head and neck region or are clinical scenarios.⁵ However, these available resources neither integrate embryology, anatomy, and radiology of the head and neck region nor are designed as TBL activities. To our knowledge, this is the first published TBL activity designed for preclinical medical students that integrates the embryology, anatomy, and radiology of the head and neck region.

This TBL module was first implemented in October 2015 with a class of 234 medical students during their first semester. In this TBL, three cases of malformation in the head and neck region were presented, and the students were asked to integrate and apply the information they had previously acquired in other course activities such as lectures, online modules, and so on. The cases were chosen to solidify the students' knowledge of the development and anatomy of the head and neck region. The applications are based mostly on radiographic images, which the students had to interpret in order to answer the questions in the applications.

Methods

TBL Classroom Logistics

Although TBL is intended to be performed in large classes,^{6,7} managing a large number of teams causes some logistic challenges. Several resources available at UTSW Medical School were used to overcome these challenges.

TBL space: UTSW recently built a 17,600-ft² room dedicated to TBL sessions. The room is furnished with 40 tables, each sitting a complete TBL team (up to seven students), and is equipped with twelve 90-inch monitors. Additionally, a 42-inch monitor is mounted to each team table. The students can wirelessly connect their laptop computers to this monitor using a media sharing device such as Creston AirMedia or a similar apparatus. A central instructor station is equipped with a desktop computer, but an additional laptop computer can be connected if desired. All monitors in the room are connected to the instructor station, and the facilitator can transmit the content of any given monitor to all other monitors in the room. Additionally, each table has a push-to-talk microphone, which can be used for discussions among the teams. Several whiteboards are available as well. The room can be divided into three smaller rooms, which retain the same functionality.

ExamSoft: UTSW uses ExamSoft as a computer-based testing tool. ExamSoft allows for test taking using the students' own laptop computers in a secure environment. Under these testing conditions, ExamSoft controls the computers and prevents the students from accessing any data or software on their computers or the internet. We used ExamSoft to deliver the readiness assurance tests (RATs). The individual RAT (iRAT) was performed completely in ExamSoft, meaning each student answered the iRAT questions in ExamSoft, allowing the program to create an immediate item analysis of the iRAT. The group RAT (gRAT) questions were also delivered through ExamSoft. The teams' answers, however, were recorded using Immediate Feedback Assessment Technique (IF-AT) scratch cards, which provide immediate feedback to the students.⁸

MoodleRooms as a learning management system: UTSW Medical School uses MoodleRooms as an online learning management system. The entire HS course is presented as a self-contained course in MoodleRooms, and all course resources are accessible by the students through this source. Some of the tools available in MoodleRooms were used to deliver the TBL application (see below).

Team Formation

The class initially performing the TBL in 2015 had a total of 234 students. For all TBL sessions during the first semester, the students were assigned to one of 38 permanent teams, each consisting of six or seven students. The teams were formed prior to the start of the preclerkship period by the registrar's office. Team formation aimed for the highest possible diversity⁸ with respect to the following criteria: gender, ethnic background, assignment to the school's college groups, and personality profile as determined by the DiSC personal assessment tool.⁹

For this TBL module, the 38 teams were split into two groups; the first group (A) consisted of 120 students in 19 teams, and the second group (B) consisted of 114 students in 19 teams. The class was split into two groups mostly for organizational reasons: Dissection sessions and TBL sessions were run in parallel. The two identical TBL sessions were held over 2 afternoons to accommodate the entire class. Each group of 19 teams was further subdivided into three groups (A, B, & C): They were seated in different areas of the TBL space and reviewed each other's answers to some of the questions (Application II, Parts 2 and 3).

Advanced Preparation Resources Background

Prior to the TBL session, the students needed to master the following prereading learning objectives:

- Identify the anatomical structures forming the neck.
- Distinguish various densities (air, fluid, bone, soft tissue, etc.) on radiographic images.
- Describe the organization of the pharyngeal apparatus.
- Name the derivatives of the pharyngeal arches (arteries, skeletal elements, muscles, and cranial nerves) and pharyngeal pouches and clefts.
- Explain the development of the thyroid gland.
- Describe the five facial primordia and explain how they form the face and the palate.

In order to master these learning objectives, the students were asked to revisit material that was primarily from the regular curriculum and that had been delivered to them 2 to 8 weeks prior to the TBL (see below for details). One week before the TBL, a prereading requirement was presented to the students via MoodleRooms. This prereading requirement listed the prereading learning objectives (as given directly above), the prereading assignments, and the learning outcome for the TBL session (as listed in the Educational Objectives).

Advanced Preparation Resource List

Head and neck development: This prereading assignment covered the structure of the pharyngeal apparatus and its development into the definite structures of the head and neck, the development of the thyroid gland, the tongue and salivary glands, and the development of the face (including the palate) from the five facial primordia. The assignment was based on the textbook *The Developing Human*¹⁰ (pp. 155-164: Pharyngeal Arches, Pharyngeal Pouches, Pharyngeal Grooves, Pharyngeal Membranes; pp. 168-169: Development of Thyroid Gland; pp. 174-186: Development of Face, Development of Nasal Cavities, Development of Palate) and covered topics relevant to the United States Medical Licensing Examination Step 1.

Introduction to Radiology lecture: This was a 1-hour lecture, which had been given to the students at the beginning of the course, about 8 weeks prior to the TBL. The lecture covered the principles of radiographic imaging (e.g., imaging planes, anatomical regional terms), different imaging techniques (i.e., X-ray, ultrasound, CT, MRI), and their application. Particularly relevant for this TBL, the students were taught how to discriminate between various tissue densities in radiographic images. The students were provided with detailed lecture notes, which were part of the prereading material (Appendix A).

Radiographic Imaging of the Head lecture: Five CT images were presented to the students via MoodleRooms, which showed the head and neck region in sagittal, coronal, and axial planes. Structures relevant to the TBL (e.g., hard and soft palate, mandible, epiglottis, hyoid bone, sternocleidomastoid

muscle, internal jugular vein, common carotid artery) were labeled. These images were not discussed during any other session of the curriculum; the students needed about 15 to 20 minutes to study this material on their own. This reading is located in Appendix B.

Readiness Assurance Process

The TBL module included RATs both at the individual (iRAT) and group levels (gRAT).⁸ Both tests consisted of the same multiple-choice questions and were closed-book tests, meaning that the students were not allowed to access any material, either printed or provided by the internet.

The iRAT, which consisted of 10 multiple-choice questions (allotted time: 10 minutes), was given at the beginning of the session through ExamSoft. Each correct answer was awarded 4 points. The test results were analyzed and graded in ExamSoft by staff of the Office of Medical Education (OME) as soon as the students had uploaded their answers. While the teams performed the gRATs, the item analysis was made available to the facilitators and was utilized for the iRAT/gRAT discussion after the gRAT phase was completed (see below).

The goal of the iRAT was to ensure that each student had mastered the preassigned material. Since the class was divided into two groups, two different iRATs (Groups A and B) had been developed to minimize security issues. For practical reasons, the two image-related questions were the same for both groups. Student RAT questions for both groups are contained in Appendices C and D. Instructor versions of the RATs are provided in Appendices E and F.

Immediately after the students had completed the iRAT, the teams performed their gRATs, using the same questions as in the iRAT. Again, the test was delivered through ExamSoft; the answers, however, were marked on IF-AT cards (scratch-off cards). A correct answer in the first attempt was awarded 4 points, in the second attempt 2 points, and in the third attempt 1 point. Twenty minutes were allotted for the gRAT. After the test, the IF-AT cards were collected and the results graded by staff of the OME. iRAT and gRAT grades counted 3.3% toward the total course grade, with iRAT and gRAT weighted equally.

The content of the RAT was discussed as needed. The facilitator had prepared one or two PowerPoint slides per RAT question to summarize the rationale for the correct answer and explanations why the other choices were incorrect, although this is an optional step for future facilitators. The actual discussion was kept brief (6-8 minutes) and focused on the three questions the students had scored lowest on as determined by the iRAT item analysis provided by ExamSoft.

Prior to the discussion, the appeal procedure was explained to the students: A team could appeal an RAT question in writing during or immediately after the TBL session if the team members felt that a different answer should be counted as correct. If the appeal was successful, only the team that appealed would receive additional points for the question. However, in our experience, no appeals were made.

Team Application Activities

During the application activity, which was not graded, the students worked in their teams to apply their knowledge of the development of the head and neck and the radiologic presentation of that area to clinical cases. All presented cases dealt with developmental anomalies, and the significance of the problems had been confirmed by two clinical faculty members, who reviewed the TBL content in advance.

Unlike the RAT phase, application activities were open book. Thus, the students were allowed to access their course material as well as the internet for clarification. The same application material was delivered to all teams at the same time by the Lesson Tool function in MoodleRooms. Each part of the application was presented in an individual, password-protected lesson. This setting allowed the teams to work through each part of the application at their own pace, and the passwords necessary to access each lesson allowed the facilitator to build in stopovers for the simultaneous report of results and subsequent interteam discussions.¹¹ The student version of the application activity is located in Appendix G, the instructor version in Appendix H.

Most of the applications required the teams to answer one or two multiple-choice questions with four or five distractors. At the beginning of each application part, a time frame was given to the teams for their discussion of the topic. However, when about half of the teams had finished their discussion (as indicated by moving on to a Ready for Discussion screen in the MoodleRooms lesson), the remaining teams received 2 additional minutes to finalize their discussion. In order to display their answer choice, each team had a set of five color-coded cards with the letters A-E printed on them. All teams displayed their answer cards simultaneously when prompted by the facilitator.¹¹

As stated previously, two parts of the application (Application II, Parts 2 and 3) required that the teams write their answers in a word processor and then display them on their tables' screens simultaneously. Since the class consisted of 19 teams, a traditional TBL gallery walk, during which each team reviews all other teams' answers,¹¹ was not feasible. Instead, the teams were organized into three groups of six to seven teams each and only reviewed the results within their group. Each team noted its top choice on a whiteboard, and the best answers were then displayed by the facilitator on all screens and used as the basis for the interteam discussion.

Each part of the application concluded with an interteam discussion during which the teams explained the rationale for their answer choice. After the discussion was completed, the facilitator showed one to three slides for each of the application parts and provided the reasoning for the correct answer. These slides were used to emphasize and illustrate arguments that had been brought up by the students and to summarize the results of the interteam discussion. These slides may be created by facilitators.

Facilitation Schema

The Figure illustrates all components of the TBL module and their time allotments.

Figure. Facilitation schema and time allotment of the team-based learning session. Rectangles represent the time needed for RATs, ovals the time for application activity by question. The time specification given in parentheses is the time that was actually used for each component; this number is the mean calculated from the two consecutively held team-based learning sessions. Appl., Application; gRAT, group readiness assurance test; iRAT, individual readiness assurance test; P., Part; RAT, readiness assurance test.

Results

Two hundred thirty-four students in two groups with 19 teams each attended the TBL sessions. All students were medical students in the first semester. The TBL was facilitated by Janine Prange-Kiel, the primary developer of the exercise; two other authors, Julie G. Champine and Alisa J. Winkler, assisted with facilitation. All faculty members were experienced educators and had taught the content of the TBL in lecture and seminar format before. Additionally, they had been trained in TBL to various degrees (attendance at the annual Team-Based Learning Collaborative meeting, TBL-focused workshops as part of the UTSW faculty development), but none of them had ever actively led a TBL session.

After the TBL, the students were surveyed on their TBL experience using REDCap software. A questionnaire was developed as a tool to survey all TBL sessions that were newly implemented in the course of the curriculum reform. For each statement, the students could choose the degree of agreement on a 5-point Likert scale. The detailed results of the survey can be found in Appendix I. Generally, more than 85% of the students thought that the goals and objectives for the TBL were clear, that the prereading

was tested in the iRAT/gRAT, and that these activities were relevant to both the application and the overall concepts intended to be learned during the TBL. Likewise, approximately 85% of the students agreed that the applications were relevant to their understanding of the course material, and almost 75% believed that the TBL activity added to their course learning. Many students (approximately 45%), however, disagreed or strongly disagreed with the statement that “The time to complete and present the applications was appropriate.” The students communicated after the TBL sessions that they thought that the session was too long and drawn out (see below).

Performance

The means for the iRAT were 85.3% and 87.2% for Group A and Group B, respectively. As expected, the teams performed even better on the gRATs, where the means were 99.2% and 99.7% for Group A and Group B, respectively.

Detailed information on test performance and item analysis for each RAT question is given in the RAT instructor documents (Appendices E & F). These documents also include the rationale for the correct answer to each RAT item.

Discussion

As mentioned in the Introduction, we aimed to develop a TBL session for first-semester medical students that covered important concepts of head and neck development, while integrating human embryology with anatomy and radiographic imaging at the same time. To accomplish this, a close collaboration between experts in various fields (embryology, anatomy, and radiographic imaging) was necessary to generate a meaningful learning experience by presenting significant problems to the students.⁸ While the basic sciences faculty identified the important concepts that students needed to understand in order to successfully proceed in the medical curriculum, the clinical faculty advised on the clinical relevance and applicability of those concepts and provided the radiographic images.

The students' performance on both RATs was very good. The high grades in the iRAT indicated that the students prepared well for the TBL and took the assignment seriously. The fact that these high grades could be improved by the teams working together, resulting in even higher gRAT grades, speaks to the advantage of working in a team.^{8,12}

We believe that the teamwork experience was enhanced by the fact that the application activity was not graded, which is in accordance with a study by Deardorff, Moore, McCormick, Koles, and Borges.¹³ Their study showed that medical students perceived a reduction in stress, an improved learning environment, and higher quality group discussions when the applications were ungraded. At the same time, the students did not think that ungraded application activities would result in a reduction of knowledge acquisition or teamwork skills compared to graded applications.

Overall, the students evaluated the TBL positively, and they particularly appreciated the relevance of the material. The students' perception of spending too much time with the TBL was the only major concern. We think that the large class size at UTSW was the main cause for delays. Even with only half the class in one session, up to 120 students in 19 teams had to be managed. This high number of students caused more logistical delays, for example, in accessing the iRAT on ExamSoft and turning in the IF-AT cards, than one would expect for a smaller class. In our experience, thorough planning and organization can help to minimize transition times and delays. A particular challenge with a large number of teams was to determine when all teams were ready for the interteam discussion of a given application question. After we ran the first TBL with half of the class, it became apparent that it was almost impossible for the facilitator to easily observe which teams had finished their discussion. As a consequence, for the second session, a Ready for Discussion screen (see above) was implemented. Unfortunately, the student survey did not distinguish between the two groups, so the impact of the change could not be measured. However, students who participated in the second TBL conveyed that they considered the implementation of the Ready for Discussion screen as advantageous. In our TBL space, computer monitors were used for the display, but those could easily be replaced by any type of sign if necessary.

Regarding the application portion of the TBL, most teams had performed an internet search to find the answer for Application II, Part 2. This resulted in very similar replies among the teams. This problem had been anticipated to some extent as a pilot had been done with a small group of advanced students. In order to make the question more challenging and to engage the students, the teams had been asked to sort the potential clinical problems by severity. However, this did not seem very challenging to the students when given access to the internet and did not add enough variety to induce any fruitful discussion. Although preventing the students from using the internet for this part of the application may solve the described problem, it is more desirable to develop a more complex application that cannot be answered by a simple internet search. This change not only would result in a realistic learning experience, during which students have access to the same resources they would use in real-life situations, but would also foster more beneficial intra- and interteam discussions.

In addition, immediate student feedback revealed that the teams disliked the gallery walks for Parts 2 and 3 of Application II. Probably due to the displeasing experience with the first gallery walk of Part 2 and to the fact that the session was rather long, the students were not very engaged during Part 3 of Application II. Additionally, some students expressed the opinion that this question on physician-patient interaction was not appropriate for the HS course and would be a better fit for a more clinically oriented course. Note, however, that our school's preclerkship curriculum is currently fostering many clinically relevant and professionalism topics early in the curriculum and that we will continue to look for opportunities to address this topic in an integrative manner throughout various portions of the curriculum. In the future, we may proactively address these students' concerns by explaining to them prior to this part of the application that physician-patient interactions are complex and require skills that go beyond the knowledge acquired in a specific course. Pointing out to them that the ungraded TBL applications provide an excellent opportunity to train these work-life skills may increase their understanding and motivation.

Our students are exposed to radiographic images throughout the entire HS course. In addition to the radiographic material that is directly relevant to the TBL, radiographic images are integrated in many of the anatomy lectures and most chapters of our dissection guide. Accordingly, our students were not overwhelmed by the application material unbeknownst to them but perceived it as engaging and challenging. However, it may be necessary to adapt the material by providing more information when it is presented to students who are less familiar with radiographic images to maximize their performance in the TBL activity.

This module was delivered to medical students with very little to no clinical experience. Therefore, the clinical aspects of the presented cases did not play a major role in the application. However, it would be relatively easy to expand on these clinical aspects in order to make the TBL suitable for medical students in the clinical phase of their education.

To our knowledge, very little TBL material on embryology suitable for medical students has been published so far. This TBL exercise successfully facilitated the understanding of complex developmental processes, and therefore, the design of more modules with similar focus is desirable. In summary, we have developed a TBL module that allows for excellent integration of embryology, anatomy, and radiographic imaging. The module has been tested with a large class of medical students and can easily be adapted to smaller class sizes.

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Ethical Approval

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