Hands-on activity for nephron physiology education: one example of active learning

Atividades práticas para o ensino de fisiologia do trato urinário: um exemplo de aprendizado ativo

Actividades prácticas para la enseñanza de la fisiología de la nefrona: un ejemplo de aprendizaje activo

Helena Carvalho,* Zane C. Giffen

Abstract

Physiology has traditionally been a difficult subject to teach because student success relies on conceptual understanding more than memorization of facts. The use of engaging instructional methods, such as manipulative models, dramatizations, and interactive computer programs not only helps to maintain students' attention but also to enhance learning and understanding. Here we present an active learning activity for use in renal physiology education. The activity utilizes a manipulative model of the nephron that is inexpensive and simple to construct. Working in small groups, students were asked to apply their knowledge by identifying the correct placement of various transporters and ion channels along the various segments of the nephron. The activity provides students with the opportunity to model and understand the relative changes in concentrations of various filtered solutes as they move through the nephron. The hands-on portion of the activity is paired with didactic explanations of key concepts and intermittent large-group debriefs the keep all students focused and address questions. Overall, the manipulative serves as a unique teaching tool that may be adapted for use in a wide variety of classroom settings. In our experience, the manipulative helped students identify gaps in knowledge and enhance their understanding of nephron physiology while having fun learning alongside their classmates.

Keywords: Active learning; Urinary tract physiology; Manipulative.

Resumo

Fisiologia é tradicionalmente considerado um assunto difícil de ensinar, porque o sucesso do aluno depende do entendimento conceitual mais do que da memorização de fatos. O uso de métodos instrucionais envolventes (ou ativos), tais como os modelos de manipulação, as dramatizações e os programas de computador interativos não apenas auxiliam a manter a atenção dos alunos, mas também melhoram sua aprendizagem e compreensão. Este artigo apresenta uma atividade de aprendizagem ativa para uso no ensino da fisiologia renal. Este método utiliza um modelo de manipulação do nefron que é econômico e simples de construir. Trabalhando em pequenos grupos, os alunos são convidados a aplicar os conhecimentos, identificando o correto posicionamento de vários transportadores e canais iônicos ao longo dos vários segmentos do néfron. A atividade proporciona aos alunos a oportunidade de manipular e assim entender as mudanças relativas nas concentrações de vários solutos filtrados pelo rins ao atravessar o néfron. A parte prática da atividade é pareada com explicações didáticas de conceitos-chave e intercalada com discussões que auxiliam na manutenção do foco e responder questões dos estudantes. Em geral, o manipulativo serve como uma ferramenta de ensino único que pode ser adaptada para uso em uma grande variedade de configurações de salas de aula. Em nossa experiência, o manipulativo ajudou os alunos a identificar lacunas no conhecimento e melhorar a sua compreensão da fisiologia do néfron enquanto promove um aprendizado divertido junto aos colegas de classe.

Descritores: Aprendizado ativo; Fisiologia do trato urinário; Manipulativo.

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*Corresponding address:
Centro de Doença Trofoblástica, Maternidade Escola, UFRJ.
Rua das Laranjeiras, 180,
Rio de Janeiro, RJ, Brasil. CEP: 22240-003.
E-mail: bragamed@yahoo.com.br

Resumen

La fisiología ha sido tradicionalmente un tema difícil de enseñar porque el éxito del estudiante depende de la comprensión conceptual más que de la memorización de hechos. El uso de métodos de enseñanza interesantes, como modelos manipulativos, dramatizaciones y programas informáticos interactivos no solo ayuda a mantener la atención de los estudiantes, sino también a mejorar el aprendizaje y la comprensión. Aquí presentamos una actividad de aprendizaje activo aplicable en la enseñanza de la fisiología renal. La actividad utiliza un modelo manipulativo de la nefrona que es barato, simple y fácil de construir. Trabajando con pequeños grupos, se pidió a los estudiantes aplicar sus conocimientos mediante la identificación de la colocación correcta de diferentes transportadores y canales iónicos a lo largo de varios segmentos de la nefrona. La actividad ofrece a los estudiantes la oportunidad de modelar y comprender los cambios relativos en concentraciones de diferentes solutos filtrados a medida que avanzan a través de las nefronas. La parte práctica de la actividad está emparejada con las explicaciones didácticas de conceptos clave y las preguntas de un grupo grande intermitente, esto mantiene a todos los estudiantes concentrados y formulando preguntas. En general los manipulativos sirven como la única herramienta de enseñanza que puede ser adaptada para el uso en una amplia variedad de salas de clase. En nuestra experiencia, los manipulativos ayudan a los estudiantes a identificar vacíos de conocimiento y mejorar su comprensión de la fisiología de la nefrona mientras se divierten aprendiendo junto a sus compañeros de clase.

Palabras clave: Aprendizaje activo; Fisiología del tracto urinario; Manipulativos.

Introduction

Physiology at both the undergraduate and graduate level has been traditionally taught in a passive, lecture-based format. Didactic presentations, however, have been associated with poor long-term retention and understanding by students compared to more active methodologies.[1,2,3] A substantial amount of physiology knowledge is lost as early as the end of the first year of medical school.[4] In order to attenuate this knowledge loss and learn more effectively, students need to be actively engaged in the educational process.[1] Active learning utilizes interactive, multimodal teaching methodologies to emphasize understanding of complex physiology concepts over rote memorization of facts that will likely not be retained.

A number of undergraduate and graduate programs have implemented active learning into their curriculum with success and positive feedback from students.[5,6] Further, curriculums featuring more engaging lectures and active learning techniques have been shown to lead to improved student performance on test scores both at graduate[7] and undergraduate[8] levels. As our knowledge of the subject of physiology continues to grow and expand, so must the implementation of student-centered instruction that forces students to leverage their current knowledge and apply it to new topics.

Considering the proven success of active learning instruction, it is perhaps surprising that many institutions and instructors have yet to pursue such strategies. One major barrier may be resistance on the part of instructors. Didactic lectures permit the efficient presentation of large volumes of information in a relatively short amount of time. Further, teachers are generally very experienced with giving lectures but may be unfamiliar with active learning.[7] Resistance may also be felt from students. Because they have been attending didactic lectures for much of their academic careers, many students have become skilled at taking notes and organizing and memorizing lecture content.

Other significant barriers to the implementation of active learning include the time, effort, and cost of developing such activities. The adaptation of techniques previously described in the literature is one means of reducing the time and effort required to create and implement active learning techniques into the curriculum. Active learning methods have been published for several areas of physiology, including cardiovascular physiology[9] and neurophysiology.[10] Here we present an inexpensive manipulative model of the nephron for use in renal physiology education that may be easily incorporated into both undergraduate and graduate physiology classrooms.

Development

Diagrams of the major tubular epithelial cell types of the nephron were created and printed. The cell types included in the model were: early proximal tubule, late proximal tubule, thick ascending limb, early distal tubule, alpha-intercalated cell of the late distal tubule and collecting duct, and principal cell of the late distal tubule and collecting duct. Small pieces of color-coded cardstock were designed and printed to represent the major molecular transporters and ion channels present along the length of the nephron. While there are many possibilities for which transporters and proteins to include, we chose to use the ones traditionally emphasized in our curriculum and major medical physiology texts. Instructors may tailor the level of detail to the needs of their classroom. Strips of grid paper were used to represent the relative concentrations of various ions present within the tubular lumen, epithelial cells, and peritubular capillaries. Each strip of grid paper represents one ion and consists of ten boxes, with each box equating to ten percent of the filtered load of the respective ions. We believed that understanding the relative changes in solute concentrations that occur along the length of the nephron is more important to enhancing student learning than memorizing the absolute concentrations but, again, the units of the grid paper may be easily changed by instructors based on their classroom needs. The ions used for the purpose our demonstration included sodium, potassium, chloride, and bicarbonate.

All of the previously described materials were prepared in advance and distributed during class to students working in groups of four or five. Groups of students moved to different areas of a large lecture hall to work on the activity. We first asked the students to place the six cell types in the correct order. Then, students were asked to place each of the transporters and ion channels in their appropriate locations. Slots were present on each of the paper cell types to represent where transporters should go (refer to Figure 1); the challenge for the students was distributing them correctly. Accurate placement of the pieces required students to understand not only which segment of the nephron various transporters were found in, but also whether the channel was present on the tubular lumen or basolateral side of the respective tubular epithelial segment. This portion of the activity was particularly valuable in producing group discussion and knowledge sharing (as well as some disagreements) that forced students to apply their previous knowledge and think critically about the subject matter.

After students had arranged the cells and transporters to their satisfaction, we paused to complete a large-group debrief of their correct placement. Students were encouraged to pose questions both to their peers and the instructors in order to understand the reasons behind their incorrect answers. Once students confirmed they had all of their transporters appropriately placed, they were asked to move a "plasma sample" consisting of ions (the aforementioned grid paper strips), glucose (represented by small pieces of cardstock), and plasma proteins (represented by small, wooden letter Ps) through the paper nephron they had constructed. The students' task was to demonstrate how the concentrations of various substances within the plasma changed as they moved through the segments of the nephron, relative to the total percentage of the filtered load of each molecule. When the students had moved through the entire nephron, they were said to have formed "urine."

At this point, students were debriefed on the correct percentages of substances filtered, reabsorbed, and secreted in various segments of the nephron using traditional PowerPoint slides. Additional questions that promoted student discussion and critical thinking were presented and discussed during this time (e.g., "Why are plasma proteins not filtered by the healthy glomerular membrane?").

The final portion of the activity involved assigning each small group a clinical scenario and asking them to explain the renal implications of the scenario using the model. Examples of scenarios include a person who had consumed a large salty meal, a patient with hemorrhagic shock, and a patient with syndrome of inappropriate ADH secretion (SIADH). Students were provided with additional materials and encouraged to create additional molecules or transporters (e.g., hormones, aquaporins) that would aid in their discussion and explanation. Each group then briefly presented their scenario to the rest of the class, with the instructor facilitating discussion and answering questions throughout.

Discussion

Overall, the instructors observed a great deal of discussion and peer teaching within the small groups. Feedback from students was largely positive, with many highlighting that the hands-on manipulative served as an assessment of their nephron physiology knowledge. Some students that had felt they already had a firm grasp on the subject matter realized they had gaps in the knowledge and understanding that still needed to be filled. The interactive nature of the activity was able to hold students attention. Students also reported that they appreciated that the small group activities broke up the large group discussions and didactic portions of the session. We are in agreement with Richardson in that we do not advocate getting rid of lectures entirely;[11] instead, we seek to improve didactic sessions by implementing more engaging components, which we were successfully able to do with this model.

Additionally, the group discussion of clinical scenarios applicable to real life helped to emphasize understanding over memorization. Having a firm grasp of the core concepts is undoubtedly more important that minute pieces of factual information in an age where information can be looked up quickly and easily using the internet.

The manipulative also gives instructors a great deal of flexibility with respect to its implementation. As mentioned, instructors can add or eliminate specific nephron segments, transporters, or ions based on the level of detail necessary for their institution's curriculum. Varying plasma samples may be used to emphasize different clinical scenarios and physiological concepts. Pharmacy students or medical pharmacology lectures may benefit from additional discussion of the sites of action and effects of various diuretic medications. Even the instructional technique may be easily tailored to different classroom settings. The activity can be completed in small groups as it was here or in a lecture hall using a large magnetic board to complete the activity with an entire class of students at one time.

In summary, we present an inexpensive manipulative model of the nephron for use in renal physiology education that may be of value to institutions seeking to implement more active learning into their curriculum. The model was well received by students and may be easily adapted to the needs of individual classrooms. We hope that the development of additional active learning techniques will continue to enhance students' experience with and understanding of physiology.

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Helena Carvalho

Basic Sciences Department. Virginia Tech Carilion School of Medicine. Roanoke, VA, United States.

Zane C. Giffen

Virginia Tech Carilion School of Medicine. Roanoke, VA, United States.