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An Online Module to Understand Body Fluid Status in Clinical Cases

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Abstract

Introduction: A thorough understanding of body fluid alterations is essential for the success of both practicing dentists and physicians. However, the time constraints of professional school curricula often limit the time available in physiology courses to address this material. **Methods:** The primary goal of this resource was to improve student comprehension of body fluid status by using three online videos that explain volume-osmolality diagrams. An additional goal was to improve students' ability to apply their physiological knowledge by showcasing real-life clinical situations in medicine and dentistry. The videos were created using custom-designed PowerPoint animations, video recordings, and Camtasia video-editing software. **Results:** On assessment of exam performance, students performed similarly in sections of the course that were taught using the online modules versus face-to-face lectures. Student performance was extremely high on the body fluid assessment-questions, with an average of 95%. This high level of student performance was notable, particularly given the complexity of the questions. **Discussion:** These results indicate that this online volume-osmolality module enabled students to improve their comprehension of body fluid concepts in physiology. Furthermore, the data indicates the feasibility of replacing lectures with online modules, freeing valuable class time for active learning or more advanced physiological concepts.

Keywords

Physiology, Dental Education, Osmolality, Online Learning, Body Fluids, Intravenous Solutions, Volume

Appendices

A. Volume-Osmolality Introductory Video.mp4
B. Volume-Osmolality Dental Cases.mp4
C. Volume-Osmolality Medical Cases.mp4
D. PowerPoint Slides and Transcript.pdf
E. Additional Learning Objectives.docx

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

Educational Objectives

At the conclusion of this online module, learners will be able to:

1. Interpret a volume-osmolality diagram, representing alterations in the body fluid status of a patient.
2. Evaluate the impact of five different clinical scenarios on the steady-state plasma volume and osmolality variables in a patient.
3. Apply their knowledge of body fluid concepts to new scenarios on summative assessments.

Introduction

For both physicians and dentists, an understanding of body fluid status is essential to the proper treatment of patients in many clinical situations, and this comprehension is crucial for discussions regarding fluid replacement through intravenous solutions. A study suggested that less than half of novice physicians are able to correctly report the amount of sodium found in the most common IV solution, normal saline.[1] This is of great significance, as postoperative fluid and electrolyte errors are believed to play in a role in approximately 9,000 deaths annually in the United States.[2-4]

Students often lack awareness that the human body is comprised of approximately 50-70% water by weight. Thorough knowledge of body fluid compartments, composition, and balance is an essential but often overlooked component in physiology classes. The authors of this module published data which showed that entering dental students had a very low comprehension of body fluid concepts.[5] When given a pretest at the beginning of the course, student performance on low-level assessment questions related to body fluids was only 43%.[5]

The primary goal of this resource was to improve professional-level student comprehension of body fluid status by using three videos that explain volume-osmolality diagrams. An additional goal was to improve students' ability to apply their physiological knowledge by showcasing real-life clinical situations in medicine and dentistry. Although this material could have been addressed via a lecture, many professors in professional programs are facing time constraints and an administrative push for alternative learning strategies. Thus, we desired to create educationally comparable materials in an online format. The resource consists of three videos that were used in both a first-year dental physiology course and in a summer prematriculation program for medical students. The modules were created using custom-designed PowerPoint animations, video recordings, and Camtasia video-editing software. The resource files also include transcripts and relevant PowerPoint slides for student notes.

The authors of this module previously investigated the impact of using online modules to improve student comprehension of material and qualitative class experiences.[5,6] In a dental physiology course, three review modules were created which produced a statistically significant increase in posttest scores (46% increase, $p < .05$, $n = 114$-115, one-way ANOVA and Tukey posthoc test).[5] Furthermore, previous studies also demonstrated that online clinical scenario modules produced a statistically significant increase in exam performance on clinical application questions (6% increase, $p < .05$, n = 119-120, one-way ANOVA and Tukey posthoc test).[6] This supports the hypothesis that the use of clinical video modules improves students' ability to answer high-level, clinically relevant exam questions. Likert-scale survey questions also indicated that students completing the clinical scenario modules had more positive perceptions of the physiology course.[7]

The clinical scenario videos used in the study mentioned above were published in *MedEdPORTAL* for use by other institutions.[8] The clinical scenario video publication page has currently been viewed 415 times and downloaded 70 times. This resource was similar in nature to a previous publication by our group on the autonomic nervous system, which has 546 views and 150 downloads.[9] The high number of downloads, as well as a high percentage of views that led to downloads, is similar to other online modules currently available in *MedEdPORTAL*.[7,10-12] These statistics suggest that many instructors are interested in high-quality online resources for use in their educational toolbox.

Current videos available in *MedEdPORTAL* have addressed the basic concepts of body fluids, such as the different fluid compartments and the physiological regulation of blood pressure and renal output.[13] There is also a substantial written tutorial available, which enables students to calculate alterations in compartment volume and osmolarity, and interpret the effects of various IV solutions.[14] Thus, our current module serves to expand upon these previous publications by enabling learners to apply their knowledge of basic body fluid concepts such as osmolarity and electrolytes, to clinical scenarios in a succinct and highly visual fashion. Additionally, rather than focusing on a single, involved case study, this resource exposes entry-level professional students to five different common clinical scenarios.

Methods

The video modules were created and implemented at the University of Louisville Schools of Dentistry and Medicine in Louisville, Kentucky. In the dental school, the module was implemented in a dental physiology course, a general science course for first-year DMD students with an enrollment of 120 students. The 6-credit-hour course is currently team-taught by five faculty members in the Department of Physiology & Biophysics. The design of the course is systems-based physiology and consists of a 2-hour didactic lecture, three times per week for 17 weeks.

In the medical school the module was implemented in summer prematriculation program created at the University of Louisville School of Medicine in 1989 to assist at-risk students in preparing for a demanding medical school didactic schedule. The program takes place over 4 weeks in the summer immediately prior to the beginning of the school year, and exposes 20-25 entering medical students to core content from the major first-year courses. Additionally, students are given tools to improve their stress management,

familiarity with the medical school, and exposure to tutoring resources. It was found that these at-risk medical students may have inappropriate study plans that can be improved through participation in a program that emphasizes study skills development.[15] Students participating in the program also exhibited high performance levels on assessments in the medical physiology course upon entering medical school.[15]

Students in both settings were first provided with a 2-hour lecture on the physiology of bodily fluids. Briefly, the topics that were covered in the lecture series included: water balance, body fluid compartments, transport processes, osmolarity and body fluid composition, electroneutrality, hypotonic/isotonic/hypertonic solutions, and the dilution principle. While the class slides and notes were created by the lecturer, a textbook containing this information, *Physiology* by Costanzo was recommended.[16] The body fluids lecture occurred in the first week of the semester, immediately after the introductory lectures on membrane physiology.

Following the body fluids lecture, students were instructed to watch two of three video modules. All students viewed an introductory video (Appendix A) which explained the basic makeup of a volume-osmolality diagram. Alterations to the diagram were explained using the example of a dehydrated patient. DMD students then watched the volume-osmolality dental cases video (Appendix B) which showcased five dental scenarios that led to altered body fluid status. The five dental scenarios included: postextraction hemorrhage, ingestion of a high-salt diet, overinfusion with a normal saline IV solution during an oral surgery, ingestion of a hypertonic salt solution following a dental procedure, and excessive intake of water due to xerostomia. Medical students, on the other hand, viewed the volume-osmolality medical cases video (Appendix C) which covered body fluid alterations more relevant to a medical situations. These scenarios included: overinfusion with a normal saline intravenous solution, excessive voluntary intake of water, traveler's diarrhea, severe dehydration, and ingestion of concentrated sea salts. Students were also provided with the video transcripts and slides to assist with note-taking (Appendix D).

In previous years of the course, these topics had been covered via lecture, but upon implementation of the videos this content was not addressed in the face-to-face class. The goal of the resources was to replace content that had previously been covered via lecture with online modules to save valuable class time, while also alleviating student confusion over the topics through clear and concise videos. An additional aim was to address portions of the following Medical Physiology Learning Objectives, as published by the American Physiological Society and the Association of Chairs of Department of Physiology (Appendix E). The resources also address standards for the Commission on Dental Accreditation and the Liaison Committee on Medical Education.

Assessment

The medical students enrolled in the prematriculation class do not take formal assessments, so no data was collected in that small student population. Therefore, to assess the effectiveness of the module, we focused on the DMD studetns in the dental physiology course. Dental student comprehension was analyzed via three multiple-choice questions embedded in exams. The first question was implemented immediately following exposure to the content (Unit Exam 1). The second question occurred approximately one month later on Unit Exam 2, and the third question occurred 3 months later during the final exam.

The exam questions follow:

Question 1: You are doing a rotation in the oral surgery clinic and accidentally overinfuse the patient with intravenous (IV) ½ normal saline (143 mOsm/L). This would be most likely to:

A. Increase the intracellular osmolarity
B. Decrease the extracellular volume
C. Decrease the intracellular volume
D. **Decrease the extracellular osmolarity**

Question 2: You instructed a patient to rinse with a hypertonic salt solution after oral surgery, but they misunderstood and drank the solution. This situation would be best represented by which of the figures below [Figure 1]:

A. Figure A
B. **Figure B**
C. Figure C
D. Figure D
E. Figure E

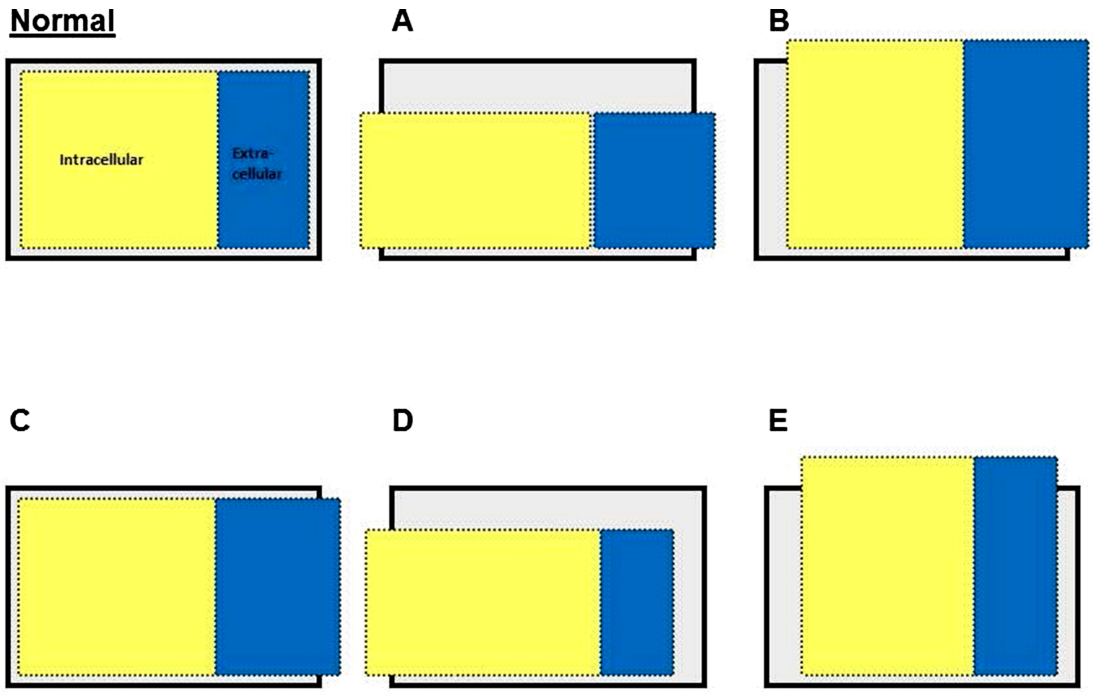

Figure 1. Volume-Osmolarity Diagrams.

Question 3: A patient with hemophilia, a bleeding disorder that affects blood clotting, has significant bleeding after a tooth extraction. This would be most likely to:

A. Increase intracellular volume
B. **Decrease extracellular volume**
C. Decrease intracellular osmolarity
D. Decrease extracellular osmolarity
E. Increase intracellular osmolarity

These same questions had been utilized to assess the effectiveness of similar lecture material in the 3 preceding years of the course. Exam security was protected through professor-conducted exam review sessions. Students were not given the opportunity to keep the exams or review the exams outside of these sessions.

Results

As shown in Figure 2, there was no significant difference between student performance on volume-osmolality assessment questions when the material was presented in lecture format versus an online

video module (p = .544, one-way ANOVA). When the video modules were utilized, students obtained a 95% average score, whereas lectures resulted in averages of 89% (Year 1), 92% (Year 2), and 90% (Year 3).

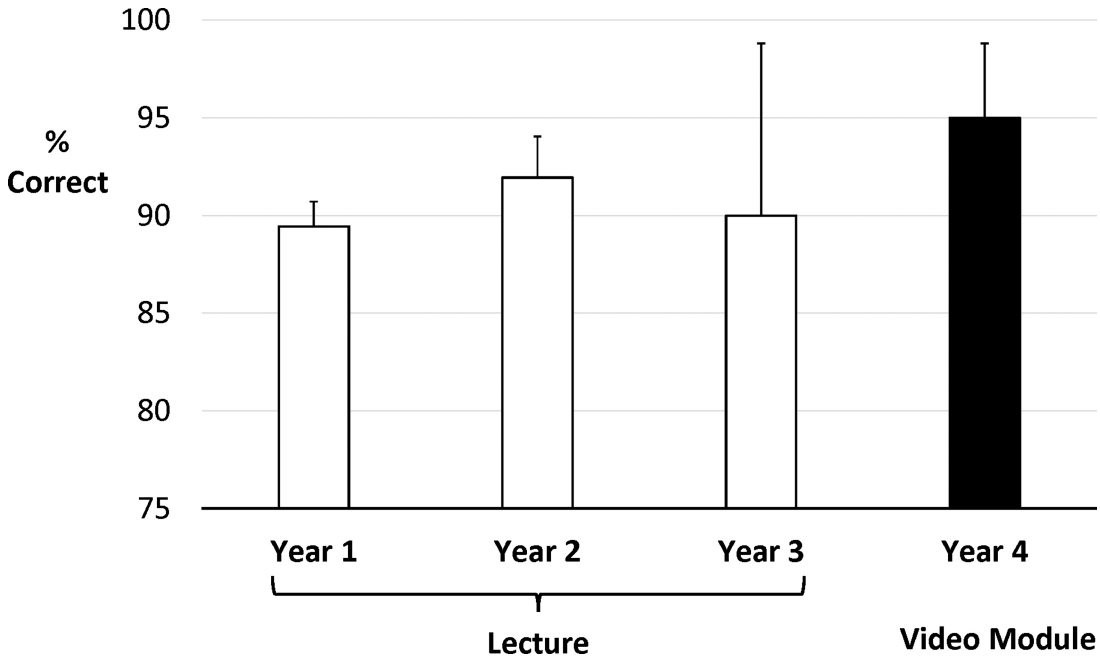

Figure 2. Dental student comprehension of volume-osmolality concepts on exam questions. Data presented as average number of correct responses on three assessment questions +/- SD (error bars). No significant differences were found between the groups (n = 120 students, one-way ANOVA).

Overall, student performance was extremely high on the body fluid assessment questions with use of the online module. While not statistically significant, this performance was slightly higher than the previous student performance when the material was presented during a traditional didactic lecture. This suggests that students successfully mastered the original objectives of the resources.

Discussion

These results previously described indicate that this online module can successfully replace a traditional didactic lecture for dental students. The succinct videos allowed the instructor to save approximately 30 minute of face-to-face class time, thus freeing time for active learning and more advanced physiological concepts. Specifically, a form of active learning referred to as “engaging lectures” was utilized in the physiology courses. In engaging lectures, students are given short periods of lecture followed by “breaks” that can consist of 1-minute papers, problem sets, brainstorming sessions, or open discussion. The use of engaging lectures led to a statistically significant higher average on unit exams compared with traditional didactic lectures (9% higher, $p < .05$). Furthermore, students demonstrated an improved long-term retention of information via higher scores on the comprehensive final exam (23% higher in engaging lecture sections, $p < .05$). Many qualitative improvements were also indicated via student surveys and evaluations, including an increased perceived effectiveness of lectures, decrease in distractions during lecture, and increased confidence with the material. Thus, the use of online modules, such as the body fluid videos presented here, can free valuable face-to-face class time for the use of active learning strategies.[17]

There are some limitations to the use of the body fluids module at other institutions. First of all, the content of the videos is limited, and may not work well as a self-contained unit. For optimal student comprehension, the module should be accompanied by a lecture on the basic physiology of body fluids. As many basic science courses are facing reduced contact hours, it may be difficult to allocate time to

these introductory topics. The resources are also limited in that they only describe body fluid disturbances with little discussion of clinical treatment options. This could necessitate additional in-class discussion, although the results do suggest that the body fluids module could successfully replace a 30-minute lecture on the topic. However, the assessments were very limited in their scope and further evaluation may be necessary to thoroughly determine the impact on student comprehension. This is an essential area of study, as thorough student comprehension of body fluid concepts is an important building block for their later understanding of both pathological conditions and fluid replacement strategies.

The biggest challenge encountered during the creation of this resource was that the three videos did require a significant amount of instructor time, from the development of custom PowerPoint files to the recording of video segments. While we have created and published many similar resources, the time expended for this project did at times seemed disproportionate to the amount of time that the faculty would typically spend preparing for a 30-minute lecture on the topic. It is estimated that the creation of the three videos required 6 hours of faculty effort to prepare, record, and edit the online material. Thus, it is of crucial importance that instructors be able to easily access high-quality, peer-reviewed online resources in journals such as *MedEdPORTAL*. By utilizing a consortium of effective online materials, professors could save significant amount of time while still insuring student mastery of essential concepts. Although there was a substantial amount of time invested in the creation of this specific resource, the module will continue to be used at our institution in both dental and medical school courses. The examples shown in the videos were selected for their continued relevance in the field of physiology for the foreseeable future.

When creating additional resources in the future, we would like to showcase simulated patients in the videos to improve the visual impact for learners. While this was an original aim of the project, it was found that many of the current examples that were provided (such as hemorrhage or diarrhea) would be difficult to portray in a succinct video. Thus, the current resource focused on establishing a basic level of understanding regarding physiological concepts. Future resources could then more effectively dive into a single-patient case with more advanced simulations and clinical-assessment skills. Alternatively, short, clinically relevant videos may be created that could be displayed within the lecture hall to help students immediately envision applications of the physiology content to their future careers as practicing dentists or physicians. Video modules could thus be an important bridge between basic science and clinical concepts in health sciences education.

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