MedEdPORTAL®
The Journal of Teaching and Learning Resources

Original Publication

OPEN ACCESS

Dehydration: A Multidisciplinary Case-Based Discussion for First-Year Medical Students

Yerko Berrocal, MD*, Jonathan Fisher, PhD, Jenna Regan, PhD, Amy L. Christison, MD

*Corresponding author: berrocal@uic.edu

Citation: Berrocal Y, Fisher J, Regan J, Christison AL. Dehydration: a multidisciplinary case-based discussion for first-year medical students. *MedEdPORTAL*. 2018;14:10725. https://doi.org/10.15766/mep_2374-8265.10725

Abstract

Introduction: As many medical school curricula shift to integrated learning of multiple basic science topics as well as clinical concepts, there is an increasing need for instructional materials that incorporate multiple topics yet are targeted to the knowledge basis of first-year medical students. This interactive case-based session for first-year medical students centers on the clinical presentation and initial evaluation of a patient experiencing dehydration after running a marathon in a high-altitude city. **Methods:** After completion of assigned out-of-class preparation, students followed the patient from a healthy state to moderate dehydration over the course of two 2-hour class sessions. Throughout discussion of the case, students answered questions requiring them to integrate elements of cell biology, biochemistry, physiology, and clinical reasoning with minimal faculty involvement. The learning activity was administered at University of Illinois College of Medicine campuses in both a small-group setting (10 students, one faculty facilitator) and a large-group format (55-90 students, multiple faculty facilitators). Following the activity, we assessed student perceptions of the design and implementation of the materials as well as effectiveness at meeting the learning goals. **Results:** Of 198 students who participated in the case discussions on dehydration, the majority rated the case positively, indicated by a rating of good or excellent. **Discussion:** This multidisciplinary case on dehydration can be used early in medical education to introduce students to clinical scenarios while learning fundamental science content. An integrated approach to medical content and versatility with regard to class size make this case a valuable teaching tool.

Keywords

Hemoglobins, Adaptation, Dehydration, Osmolarity, Homeostasis, Body Fluids, Marathon, High Altitude, Osmolar Concentration

Educational Objectives

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

1. Define the different fluid compartments of the body (intracellular fluid, interstitial fluid, plasma).
2. Describe concepts of passive diffusion, facilitated diffusion, channel proteins, and primary/secondary active transport.
3. Describe homeostasis and define osmolarity, osmolality, osmotic pressure, and tonicity.
4. List the primary determinants of extracellular fluid volume and osmolarity.
5. Describe the structure of a hemoglobin tetramer and its compositional changes through life.
6. Describe the sigmoidal O2 binding curve of hemoglobin.
7. Interpret the effects of changes in pH, 2,3-BPG concentration, and CO2 on the O2 binding curve.
8. Identify four signs and symptoms that are suggestive of fluid imbalance (patient complaints, skin color, vital signs, mental status, etc.) in an adult presenting with dehydration.
9. Calculate the percentage of body weight loss secondary to fluid imbalance.
10. Use Darrow-Yannet diagrams to explain the effects of a solution on the body's osmolarity and compartment volumes.
11. Predict fluid shifts after administration of different intravenous fluids.
12. Apply the principles of the Health Insurance Portability and Accountability Act of 1996 as related to patient confidentiality.

Appendices

A. Dehydration Case Facilitator Guide Part 1.docx
B. Dehydration Case Facilitator Guide Part 2 .docx
C. Dehydration Case Presentation Part 1.pptx
D. Dehydration Case Presentation Part 2.pptx
E. Dehydration Case Part 1 Handouts.docx
F. Dehydration Case Part 2 Handouts.docx
G. Dehydration Postcase Evaluation Questions.docx

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

Introduction

There has been a large push in recent years to increase the amount of integrated coursework in medical school curricula. The traditional model of basic sciences in years 1 and 2 and clinical sciences in years 3 and 4 is being replaced with a model that combines aspects of both across all 4 years.[1] This shift in educational dogma has coincided with an increased reliance on active-learning methodologies such as flipped classrooms, case discussions, and team-based learning (TBL).[2-4] This resource provides medical educators with an integrated active-learning module for dehydration that combines biochemistry, cell biology, and physiology into a clinical case scenario.

The University of Illinois College of Medicine updated the medical school curriculum to an integrated model for the 2017 academic year. The model we created arranges the weekly content around a summative core case comprising a medical scenario that merges clinical applications with multiple foundational science disciplines and health care system themes. The core case format uses an active-learning methodology such as TBL or medical case discussion to increase student engagement. The learning session described here is a product of the updated curriculum that we piloted for the first time this year. The design of the case allows for flexibility of use within a large-class or small-group discussion format.

This summative core case was used in our curriculum during a week in which other classes covered key concepts that included hemostasis, components of blood, fluid balance and osmosis, membrane transport, and action potentials. We chose to design a case centered around a dehydrated marathon runner because it presented an ideal clinical backdrop for applying topics from biochemistry, cell biology, and physiology and also gave us the opportunity to include the health care system topic of patient privacy under Health Insurance Portability and Accountability Act (HIPAA) practices. Given that the case was designed for first-year medical students with very little previous knowledge, dehydration also gave students a chance to explore the etiology of a common, broadly applicable condition. We administered the session during the second week of medical school, but it could be used at any point in the first-year curriculum. The case is broken into two separate sessions with the same patient who is preparing for and running a marathon. Students follow him from a healthy state to one of dehydration and learn the basics of intravenous hydration therapy.

The case discussion described here is a novel approach to teaching concepts of dehydration. While we have found *MedEdPORTAL* examples of case discussions centered on pediatric dehydration,[5] these are primarily intended to be used as learning exercises for clerkships or residencies. Another *MedEdPORTAL* publication addresses fundamentals of fluid dynamics but does not apply that knowledge in a clinical setting.[6] To our knowledge, our case is the first published resource to use a clinical scenario of adult dehydration to illustrate and reinforce basic science concepts early in the medical school curriculum.

Methods

Session Design

The case consisted of two class sessions of 2 hours each for a total of 4 hours. We designed these case-based learning sessions for preclinical medical students early in the first year of an integrated curriculum on the three campuses (Chicago, Peoria, and Rockford) of the University of Illinois College of Medicine. The case was flexible enough for delivery with a large-group discussion using one to three facilitators or with a small-group discussion (eight to 10 students per group) using one facilitator per group. We successfully implemented this case at multiple campuses within the University of Illinois College of Medicine system using both delivery methods.

Student Preparation

Several class sessions gave students foundational knowledge prior to the core case. These presession learning activities included basic blood biology, cell membrane structure, hemoglobin protein

biochemistry, and complete blood count markers; self-administered HIPAA training modules during school orientation; and introduction to vital signs and general appearance of the physical exam. For the core case itself, students received prereading assignments approximately a week before the class sessions. Prior to part 1 of the case, the students were responsible for reading excerpts of textbook chapters on fluid homeostasis and membrane transport,[7] hemoglobin and oxygen binding,[8] and fluid intake recommendations for long-distance runners.[9] Additional preparation materials for the second case session included a textbook chapter excerpt covering intracellular and extracellular fluid shifts.[7]

Facilitator Preparation

Facilitator requirements included familiarity with the basic science concepts discussed within the case, but expert-level training was not essential. We do recommend that facilitators receive training in case-based learning prior to facilitating the case discussions. Preparatory facilitator materials included copies of the case (Appendices A & B), the session PowerPoint slides (Appendices C & D), and the presession reading to be reviewed 2 weeks prior to the session. Approximately a week prior to the class sessions, we held a facilitator preparatory meeting to review the case, identify important discussion points, and discuss potential obstacles.

Session Delivery

To facilitate discussion and avoid unnecessary use of paper, we presented the unfolding case details using PowerPoint presentations on projector screens. The PowerPoint files revealed case details and related questions sequentially as the case unfolded. There were also relevant teaching slides included to illustrate important or difficult concepts. Optionally, facilitators could have chosen to provide students with paper copies of the patient data or application problems (suggested handouts are included in Appendices E & F) as these can be difficult to read from a screen.

On the days of the case sessions, facilitators arrived 10-15 minutes early to organize the classroom and ensure that the technology was working as expected. During the sessions, faculty shared case details and questions via the projected PowerPoint while students shared answers with the group. When necessary, question answers were then followed by brief discussions, with facilitators promoting student-to-student discussion and peer teaching. At the end of the final case session, students were asked to identify an additional question related to the case materials that they would be interested in exploring further. They were responsible for submitting their question, researching the answer to it, and submitting a brief summary of their findings to the course director within 24 hours of the end of case session 2. We incorporated this additional element to promote the critical thinking and self-directed learning skills that are a major focus of our integrated undergraduate medical curriculum. We told students not to exceed 300 words in order to keep the assignment brief for students and faculty.

Assessment

To assay the effectiveness of this learning activity, we used several methods that were exempted by the Institutional Review Board at the University of Illinois College of Medicine at Peoria. We evaluated assessment of student satisfaction with the presession preparation, content delivery, and relevance of material at the end of the second case session via an anonymous online polling system (Poll Everywhere). We sent the link to the Poll Everywhere survey to students on all campuses shortly after the case session. These postcase feedback questions are included in Appendix G. Student responses to these surveys were noncompulsory, but 30% (n = 95) of the students participated. We also assessed the success of meeting content goals and learning objectives at the conclusion of the week's curriculum. We randomly selected a portion of students for an anonymous electronic survey that was administered following the weekly quiz. This survey rated the case sessions on quality of content using a 4-point Likert-type scale of poor, fair, good, and excellent. We provided the same survey to students from each campus.

Results

The three-campus system of the University of Illinois College of Medicine created a unique opportunity to deliver the core case in different settings. In Peoria, we divided the 58 first-year medical students into small groups of eight to 10 members; a faculty facilitator led each group through the dehydration case. The Rockford campus used a large-group instruction format where three faculty facilitators led 55 medical students. Chicago used a similar large-group format with two groups of approximately 90 students, each group led by two facilitators. The PowerPoint presentation, facilitator guides, and student surveys were the same for all campuses.

The results for the electronic survey administered to a randomly selected group of students are shown in Tables 1 and 2. Students were asked to rate the quality of the session's contents using a 4-point scale of poor, fair, good, and excellent. Table 1 shows the number and percentage of students who completed the survey on each campus. The results from all three campuses are listed in Table 2. With the exception of session 1 in Chicago, the quality of all case sessions was rated as good or excellent by 50% or more of the students completing the survey. Students on all campuses rated session 2 more highly than session 1.

Table 1. Participation in Postsession Survey

Campus	Total Students	Survey Participation: *n* (%)
Chicago	182	72 (40%)
Peoria	58	20 (34%)
Rockford	55	13 (24%)

Table 2. Student Ratings of Quality of Case Content (Shown as Percentage of Survey Respondents)

	Grade			
Session	Poor	Fair	Good	Excellent
Chicago				
Session 1	23.6	31.9	29.2	15.3
Session 2	11.3	23.9	49.3	15.5
Peoria				
Session 1	15.0	35.0	40.0	10.0
Session 2	10.5	15.8	47.4	26.3
Rockford				
Session 1	0	30.8	53.8	15.4
Session 2	0	15.4	53.8	30.8

The postsession survey was administered via Poll Everywhere. Ninety-five students from all campuses (32% of the student body) participated in the survey. When asked to rate the amount of preparatory materials for the case, 76% of the students responded that the volume was just right. We asked the students to rate the overall quality of the case. Forty-one students (45%) gave the case a good rating, while 25 students (27%) rated it excellent. When asked to rate the difficulty of the case questions, 64 students (68%) chose the "Moderate: I could answer most questions because I prepared" option. There also was an open-text question for student comments on the dehydration case. While there were a few negative comments, most of the written responses were positive. One student remarked, "I enjoyed this case experience. I think it helped solidify the material we had learned." Another student commented, "I prefer this style of case session to the TBL style."

Discussion

Following the publication of the Carnegie Report in 2010,[10] an increasing number of medical schools are now undertaking curricular reform. A common theme among many redesigned curricula is the integration of different subject areas that were previously taught separately. Additionally, schools are placing increased emphasis on the inclusion of clinical experience and clinically relevant applications of basic science concepts starting early in the undergraduate medical curriculum. We created this dehydration case study with these aims in mind by integrating multiple basic science concepts (membrane transport, fluid homeostasis, hemoglobin function and oxygen binding, and tonicity) and disciplines (cell biology, biochemistry, and physiology) within a clinically relevant scenario that would illustrate to students how

these concepts interrelate. Additionally, the integration of HIPAA privacy content added a dimension of health care systems application to the activity. Consequently, this dehydration case scenario succeeded in meeting our goals of an integrated curriculum by connecting many ideas that had been previously taught separately into a single learning activity. Combining them in this way emphasized their connections with each other, highlighted their clinical relevance, increased medical student engagement, and reduced the amount of time spent with traditional didactics in class.

The dehydration case activity displayed its educational versatility during our first trial at the University of Illinois College of Medicine. The College of Medicine consists of three separate campuses in the state of Illinois: Chicago, Peoria, and Rockford. The number of students and faculty varies greatly between the three campuses. Chicago, for example, admits over 150 medical students each year, while Rockford has only 60. However, we were able to use the same dehydration case successfully on all three campuses. Peoria used a small-group discussion format where one faculty member discussed the case with about 10 students. The Chicago and Rockford campuses presented the case in a large-class format with 50 or more students. Feedback for the case was very positive from both students and faculty regardless of the campus or style of delivery. These results suggest the case is a valuable resource for a medical school of any size.

Using a multidisciplinary, clinically relevant case to teach first-year students in their second week of medical school did present some challenges. We needed to be very careful about the order in which material was presented to ensure that we did not make inaccurate assumptions about the students' level of knowledge. For example, while all students had been introduced to vital signs and the basics of physical examination during their clinical skills course, some students were not yet familiar with the concept of a differential diagnosis. Additionally, students at one campus did not discuss membrane transport in class before participating in the first session of the case discussion due to scheduling variations. Because this case integrates elements of cell biology, biochemistry, and physiology, other educators who use it should check to ensure the learning goals are appropriate for their students. Conversely, more complex content regarding electrolyte imbalance, the causes of altered mental status, or the role of the renal system during dehydration could be layered onto the existing case framework for use with advanced students.

Students' ability to fully engage in this learning activity relied on them completing the out-of-class preparation assignment. Rather than directly assessing student preparation at the start of the case sessions, we chose to target the case discussion to the level of the well-prepared student. Students were well aware of the expectation of completing assigned preparation as part of the standard of professionalism they were asked to maintain. However, lofty ideals do not always translate into practice, and doubtless some students failed to complete the assigned preparatory work. Educators who adapt this resource for their own use may want to consider adding a short readiness assurance quiz at the beginning of each session if adequate student preparation is likely to be a concern. When facilitating the case in an open-discussion format, asking for answers or comments from specific students or groups (rather than waiting for a volunteered answer) may also encourage better preparation from all.

Although there was general satisfaction with this case study, we have identified some opportunities for improvement. Conducting the case discussion in small groups has many advantages, but it also requires a greater number of facilitators and opens more possibility for interfacilitator discrepancies. Unique perspectives from different facilitators can be valuable, but students are sensitive to perceived variations in the quality of facilitation between groups, whether related to the experience level or simply to the personalities of the faculty facilitators. The facilitator guide is designed to allow anyone to deliver the dehydration case regardless of his or her expertise. However, performing a complete trial run of the case facilitation with inexperienced small-group facilitators would further increase the uniformity of quality.

For future use of this case, we will also consider changing the logistics of the "exploring further questions" exercise at the end of session 2. Students were given an entire day following the final case session to submit their responses, but many groups simply handed in a quick note immediately after class. The questions they identified were frequently very rudimentary, and their sources were the quickest ones available (Google or Wikipedia). Unfortunately, some students seemed to view this exercise as busywork rather than self-directed learning. Providing additional guidance on appropriate sources and making out-of-class collaboration easier might improve the quality of student participation. Additionally, if time allows, having the students work through the exercise in person before leaving the core case session may be beneficial. This approach would allow faculty to circulate and give guidance on appropriate questions and sources.

Finally, there were some student suggestions to improve the case. Most of the students asked for more practice with Darrow-Yannet diagrams. Other students wanted more information on electrolyte panels and intravenous fluids. We delivered this case early in the medical curriculum, and we purposely limited the discussion on these complex ideas to prevent cognitive overload while planning to discuss fluid homeostasis, electrolyte disorders, and intravenous therapy in further detail during the renal system later in the year. However, we may need to include more practice problems with this content to increase student contact with the material in the future.

Other educators who adapt this material for their own use may wish to consider adding an element to the case discussion to allow assessment (either formative or summative) of student preparation and comprehension. Additionally, although using the case materials in both large- and small-group formats provided useful verification of its applicability in both settings, this document is not intended to be a study formally comparing the two methods of facilitation. Therefore, while student survey data from all three University of Illinois College of Medicine campuses are presented, they are insufficient to allow us to draw any conclusions about the relative effectiveness of small-group versus large-group settings for case-based discussion. We plan to investigate this question in the future through a specifically designed prospective study.

Overall, we feel that this case represents a successful step away from the traditional medical school teaching of basic science subjects in discrete, separated courses. Our hope is that these integrated cases will assist educators with guiding students into clinical and systems thinking at an earlier point in their career. We also hope we are adding to the publicly available pool of resources that promote best practices for medical education.

Yerko Berrocal, MD: Associate Professor, Health Sciences Education Department, University of Illinois College of Medicine

Jonathan Fisher, PhD: Assistant Professor, Health Sciences Education Department, University of Illinois College of Medicine

Jenna Regan, PhD: Assistant Professor, Health Sciences Education Department, University of Illinois College of Medicine

Amy L. Christison, MD: Assistant Professor, Pediatrics and Cancer Biology and Pharmacology Department, University of Illinois College of Medicine

Acknowledgments
The authors gratefully acknowledge Drs. Meenakshy Aiyer, Steve Ackerman, Hugh Clements-Jewery, Steve Leutkemeyer, Glenn Miller, Robert Wolford, and Connie Vitali for their contributions to the construction and editing of this teaching application.

Disclosures
None to report.

Funding/Support
None to report.

Ethical Approval
Reported as not applicable.

References

1. Muller JH, Jain S, Loeser H, Irby DM. Lessons learned about integrating a medical school curriculum: perceptions of students, faculty and curriculum leaders. *Med Educ.* 2008;42(8):778-785. https://doi.org/10.1111/j.1365-2923.2008.03110.x
2. Schwartzstein RM, Roberts DH. Saying goodbye to lectures in medical school—paradigm shift or passing fad? *N Engl J Med.* 2017;377(7):605-607. https://doi.org/10.1056/NEJMp1706474
3. Tune JD, Sturek M, Basile DP. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. *Adv Physiol Educ.* 2013;37(4):316-320. https://doi.org/10.1152/advan.00091.2013
4. Thistlethwaite JE, Davies D, Ekeocha S, et al. The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23. *Med Teach.* 2012;34(6):e421-e444. https://doi.org/10.3109/0142159X.2012.680939
5. Pronko K, Thompson R, Tjoeng YL, March G. Pediatric fluids and electrolytes: a flipped classroom. *MedEdPORTAL*. 2015;11:10153. https://doi.org/10.15766/mep_2374-8265.10153
6. Silverthorn D. Using IV fluid therapy to teach the principles of osmolarity & tonicity. *MedEdPORTAL*. 2010;6:8082. https://doi.org/10.15766/mep_2374-8265.8082
7. Hall JE. *Guyton and Hall Textbook of Medical Physiology*. 13th ed. Philadelphia, PA: Elsevier; 2016.
8. Lieberman M, Marks AD, Peet A. *Marks' Basic Medical Biochemistry: A Clinical Approach.* 4th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2013:97-101, 834-835.
9. Hew-Butler T, Verbalis JG, Noakes TD. Updated fluid recommendation: position statement from the International Marathon Medical Directors Association (IMMDA). *Clin J Sport Med.* 2006;16(4):283-292. https://doi.org/10.1097/00042752-200607000-00001
10. Irby DM, Cooke M, O'Brien BC. Calls for reform of medical education by the Carnegie Foundation for the Advancement of Teaching: 1910 and 2010. *Acad Med*. 2010;85(2):220-227. https://doi.org/10.1097/ACM.0b013e3181c88449

Received: January 24, 2018 | **Accepted:** May 23, 2018 | **Published:** June 26, 2018