Basics of Hemodialysis and Continuous Renal Replacement Therapy

Michael Berkoben, MD, John Roberts, MD*  
*Corresponding author: john.roberts@duke.edu

Abstract

Introduction: Because there are now roughly 500,000 patients undergoing chronic HD in the United States, medical residents will certainly care for chronic hemodialysis (HD) patients no matter what field of medicine they enter. However, many residents report a lack of understanding of the dialysis procedure. The purpose of this resource is to help the learner understand the scientific underpinnings of dialysis, the differences between conventional HD and continuous renal replacement therapy (CRRT), and the limitations of renal replacement therapy. Method: This resource served as a supplement to a lecture, Hemodialysis Basics, for nephrology fellows, and as a supplement to a whiteboard and magic marker talk during an elective course, Fluids and Electrolytes, for third- and fourth-year medical students at our institution. The resource includes an electronic blackboard-style video for instruction and a quiz to assess medical knowledge related to concepts discussed in the video. Results: All nephrology fellows found it to be helpful. One fellow remarked, “I thought the video was excellent. I give it a 10 [out of 10].” Similarly, from the evaluations of our third- and fourth-year medical student course, 100% of the respondents (11 of 26 students) ranked the video as high quality. Discussion: We believe that this a succinct but excellent educational resource for not only renal fellows but all medical students and physicians who care for chronic HD patients or those with acute renal failure undergoing conventional HD or CRRT.

Keywords

Hemodialysis, Renal Dialysis, Continuous Renal Replacement Therapy, Dialysis, Clearance, Diffusion, Convection

Educational Objectives

By the end of this tutorial, the learner will be able to:

1. Understand the scientific underpinnings of dialysis, the differences between conventional hemodialysis (HD) and continuous renal replacement therapy (CRRT), and the limitations of renal replacement therapy.
2. Define dialysis.
3. Describe the configuration of the modern dialyzer.
4. List the variables that affect solute removal during renal replacement therapy.
5. Describe the difference between diffusion and convection.
6. Describe the differences between conventional HD and CRRT.
7. Describe how the differences between conventional HD and CRRT affect hemodynamic stability.
8. Determine the best renal replacement modality in the following circumstances: acute kidney injury in a hemodynamically unstable patient, acute kidney injury in hemodynamically stable intensive care unit patient with voluminous fluid intake, and poisonings.

Introduction

This resource was designed for nephrology fellows and for Fluids and Electrolytes, an elective course for third- and fourth-year medical students at our institution, to help them understand the scientific
underpinnings of dialysis, the differences between conventional hemodialysis (HD) and continuous renal replacement therapy (CRRT), and the limitations of renal replacement therapy. For the nephrology fellows, the video served as a supplement to a lecture, Hemodialysis Basics, given in the first week of fellowship. For Fluids and Electrolytes, the video serves as a supplement to a whiteboard and magic marker talk. Videos enhance student learning. The ubiquity of Internet access makes videos convenient for the current generation of learners. Studies analyzing the best practices for instructor-led videos have been performed. The electronic blackboard tutorial has been associated with high levels of student engagement.¹

We believe that this video may also serve as an important resource for medical and surgical residents. Because there are now roughly 500,000 patients undergoing chronic HD in the United States, medical residents will certainly care for chronic HD patients during their training. After completion of training, they will certainly care for chronic HD patients no matter what field of medicine they enter. In addition, medical and surgical residents are more likely than ever to care for intensive care unit patients who need renal replacement therapy, either conventional HD or CRRT. A recent study reported that the incidence of dialysis-requiring acute kidney injury (AKI) increased at an average annual rate of 10% from 2000 to 2009.² In spite of their frequent encounters with chronic HD patients and with patients with dialysis-requiring AKI, many residents lack a basic understanding of the scientific underpinnings, technical considerations, and limitations of renal replacement therapy. It is our impression that, for many residents, the dialysis procedure remains a black box.

Methods

This resource consists of a single video (Appendix A), a quiz (Appendix B), and an answer key (Appendix C) that will facilitate learning in many settings. The video can be viewed on any computer or electronic device with Internet access and a media player. The target audience for this resource includes medical students, residents, and nephrology and critical care fellows.

This resource can be used in multiple ways. In our nephrology fellowship curriculum, we used this video to supplement a small-group lecture on HD basics, which is part of the fellowship core curriculum. The video was available on our fellowship curriculum website so first-year fellows could revisit the content as needed to foster self-directed learning and mastery. We have also used this video in a flipped classroom elective course for third- and fourth-year medical students called Fluids and Electrolytes. In this course, the video was assigned viewing for medical students prior to a classroom session on HD basics. At the beginning of the classroom session, we had students complete the quiz to check learning and understanding of the material. Following the quiz, we would recommend devoting time to address the quiz questions and to answer student questions or clear up misunderstandings. The quiz key is available to the instructor so he or she can prepare for this question/answer session. We also envision that the video and quiz could be used to supplement experiences with inpatient rotations. For example, rounding internal medicine physicians could assign the video to their team of learners (students, interns, residents) and then check understanding later with the enclosed quiz. The quiz key is available to the teacher to prepare for the discussion and questions when it is time to review the correct answers in the quiz.

Results

This video was designed, in part, for Fluids and Electrolytes, an elective course for third- and fourth-year medical students. It is being incorporated into course materials in 2016. However, a whiteboard and magic marker talk with very similar content was very highly rated by the students in 2015. In addition, we have utilized other videos as supplements to lectures for Fluids and Electrolytes. The students in this course felt that the videos sufficiently conveyed basic concepts. As a result, they suggested that no additional lecturing was needed. Instead, classroom time could be devoted to discussion of clinical cases.

We have also utilized other video tutorials (similar in style to this video) as supplements to lectures in a physiology course for first-year medical students.³ Fifty-nine percent of the students said that these videos were more helpful than both lectures and course notes. When compared to a historical control year, the
addition of these videos resulted in an 11-point increase in the first-year class’s performance on the renal section of the examination.

From the evaluations of our third- and fourth-year medical student course, 100% of the respondents (11 of 26 students) ranked the video as high quality. Associated commentary from students noted high ratings for our pencast videos: “Pencasts were fantastic.” As mentioned, we also implemented this video in our nephrology fellowship training program, which is now a mandatory part of the curriculum for our nephrology fellows. All nephrology fellows found it to be helpful. One fellow remarked, “I thought the video was excellent. I give it a 10 [out of 10].”

Discussion
This tutorial video would work in a variety of learning scenarios. In our nephrology fellowship curriculum, it was used to supplement a small-group lecture on HD basics. We have also used it in a flipped classroom where the video was assigned viewing prior to classroom instruction. The quiz can be used at the beginning of class to check understanding and to motivate learners to prepare for the classroom session. Ideally, we envision this video also having a role within the day-to-day learning that occurs on hospital wards and intensive care units. For example, it would work well as a stand-alone supplement for students, residents, or fellows (especially critical care) on clinical rotations that involve direct care of patients treated with renal replacement therapy. Any health care providers (even experienced physicians) who may feel uncomfortable or inexperienced with dialysis therapies could assign this video to learners or choose to watch it together as a group. Patients with AKI or end-stage renal disease are highly prevalent in the inpatient setting, and we have found that inpatient teachers are frequently unprepared to teach learners about concepts related to dialysis. We anticipate this resource filling a need by addressing a common, but commonly misunderstood, process.

Regarding implementation of the video, we have learned a few lessons. First, when implementing the video in a flipped classroom, students prefer little to no overlap between content in the video and content that will be covered in class. To make best use of classroom time, try to create scenarios or cases that directly build on content covered in the video. Second, our video is close to 20 minutes long, and we now know that students seem to prefer videos that last less than 10 minutes. To ease downloading and viewing, we kept this video intact as a single file, but a student or teacher could easily watch it in two pieces. We think that a nice halfway point is at the 13:00 time stamp on the video.

We chose the video tutorial because it is a well-utilized format among the current generation of learners. The video can be viewed on a smartphone, tablet computer, or desktop computer, and the viewer can learn at a customized pace. These videos are versatile and could easily be inserted into many different learning environments. We have found that these types of video tutorials are highly regarded by medical students and residents, and we believe this video will give users a solid understanding of the dialysis procedure so that it will no longer be a black box.

Michael Berkoben, MD: Associate Professor of Medicine, Division of Nephrology, Duke University School of Medicine
John Roberts, MD: Medical Instructor, Department of Medicine, Duke University School of Medicine

Disclosures
None to report.

Funding/Support
None to report.

Ethical Approval
Reported as not applicable.
References


Received: November 29, 2015 | Accepted: April 5, 2016 | Published: May 20, 2016