An open-access transfusion medicine course for medical students

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**Abstract**

The senior author created a two-week online transfusion medicine course for fourth-year medical students to meet an unmet need at our institution. The course includes organized and concise online videos, reading assignments, and 100 quiz questions. Assessments include two oral quizzes via video call with 10 questions per quiz. The course was completed by 78 of 102 students (77%). Mean ratings ranged from 6.7 to 7.0 on a seven-point scale. We share our experience as well as our complete materials (including quiz questions and free videos) via open access for this two-week online course in transfusion medicine that may be used for medical students, pathology residents, and other learners.

**Keywords:** Clinical pathology, Curriculum, Education, Online course, Open-access course, Pedagogy, Teaching methods, Transfusion medicine

**Introduction**

Transfusion medicine training is important to many medical specialties, and blood transfusions are the most common procedure completed in American hospitals. However, despite its direct relevance to nearly all medical specialties, transfusion medicine training is often overlooked. One study completed in 2011 found that 17% of medical schools had no transfusion medicine didactic lectures in their curriculum, and other studies have found significant deficits in training and practicing physicians’ knowledge of transfusion medicine citing a lack of learning opportunities. In multiple studies done on internal medicine and hematology residents, scores were consistently below 60% on transfusion medicine-related quizzes and greater than 90% of the participants communicated an interest in increasing transfusion medicine education.

Experts in the field have created transfusion medicine curriculum for medical students to improve the safety and efficiency of patient care as well as lower the cost of healthcare for patients and healthcare systems alike by decreasing excessive ordering and misinterpretation of laboratory tests. The success of these curricula has been contingent on the presence of small group and case discussions with low student to faculty ratio focused on clinical correlations and practice problems. There are a variety of different approaches taken by medical schools to include laboratory medicine in their pre-clinical curriculum; some schools have a dedicated block course for the subject, some have laboratory-based teaching and case sessions interspersed throughout the curriculum, and some schools focus on problem-based learning (PBL) exercises.

During clinical clerkships, the greatest exposure to transfusion and laboratory medicine tends to occur during the internal medicine rotation. In a few rare programs, there is a required laboratory medicine clerkship as well with a greater focus on diagnostics and transfusion medicine. Many schools also offer elective courses on laboratory medicine. Beyond core and elective curriculum, there are many online resources to teach and test students’ understanding of laboratory and transfusion medicine. Laboratory medicine-related questions are included in the United States Medical Licensing Examination (USMLE) step 2 and step 3; however, subscores for these questions are not provided by the NBME, so it is difficult to gauge medical students’ knowledge level of this vital field.

As is the case with institutions worldwide, the University of Wisconsin Madison School of Medicine had to rapidly change and adapt its curriculum in response to the start of the COVID-19 pandemic and related restrictions. This abruptly created a dire need for effective and efficient online learning for students throughout our medical school’s three phases of curriculum: pre-clinical courses, clinical rotations, and advanced clinical experiences and selectives, which are specialty elective courses that all students are required to complete during the third and final phase of medical curriculum. Students are able to choose which selectives to take to fulfill a credit number requirement for graduation.

In response to this new goal and the emergency shift to online learning, the senior author adapted videos for an online transfusion medicine-focused pathology-based selective. The videos already existed before the course was created. The senior author made them for pathology residents’ rotation exam review, as each resident is required to do three transfusion medicine rotations and take a different rotation exam at the end of each rotation.

Some of these resident rotation exam videos were repurposed for use in the medical student course with some material omitted to increase...
relevance for medical students and keep it at their level of understanding. While the same videos were used, students in the medical school course had access to a question bank, later used for class quizzes, that focused on fewer, higher-yield topics. The course included two transfusion reaction assignments and two ten-question video oral quizzes completed via Zoom, an audiovisual conferencing platform, with a passing score for the course of 70%. Before participating in the course, students must already have all required basic sciences and clerkships completed to ensure comprehension of course material.

Materials and methods

This project is IRB exempt by our institution's standards. The general structure of the course included two written assignments about transfusion reactions and two oral quizzes. Student questions were addressed via Zoom, email, or through the online discussion forum, a unique online message board created for each class using our institution's online learning platform.

The course (and the supplemental materials) included a catalog of free videos adapted from the course creator's pathology residency program. Table 1 summarizes the topics of each video. The course syllabus also contained links to relevant information on websites for the Centers for Disease Control and Prevention (CDC), Association for the Advancement of Blood & Biotherapies (AABB), American Society for Apheresis (ASFA), etc. The course included institutional access to an online textbook. This could be replaced with the student's home institution's access to the same textbook or revised to reference a different book. If no electronic textbook is available through the home institution, the videos could stand alone as the main resource for the course.

Graded assessments for the course consisted of two written assignments and two synchronous video oral quizzes. For the two “transfusion reaction” assignments, students chose two reactions per assignment from a list of transfusion reactions and described the blood product transfused, signs and symptoms, workups, a summary of pertinent negatives, treatment course, and any other important information surrounding each reaction. Each case was worth five points for a total of ten points per assignment and twenty points for the duration of the course with a passing score of fourteen.

The two video oral quizzes were conducted one-on-one via Zoom and consisted of ten questions each that corresponded to the course videos and textbook chapters. The questions were chosen via a random number generator from the list of questions that were provided to the students on the course outline and syllabus. Some of the quiz questions overlapped with the previously published curriculum for anesthesiology residents. Table 2 shows the general topic areas and number of questions for each.

The quizzes were closed-note and closed-book, and the students were required to both be on camera for the duration of the quiz and share their desktop screen to minimize any chances for academic misconduct. Each question was worth one point for a total of ten points per quiz and twenty points total during the course with a passing score of fourteen. Both the assignments and the quizzes required a score of 14/20 in each category to pass the course. Some iterations of the course included group discussions Monday through Thursday in an office hour style that were ungraded and not required. These were discontinued due to poor attendance. However, one or more such sessions could be implemented if necessary.

A course evaluation report was compiled using data from a student survey including statements on a number scale from 1 to 7 with 1 being strongly disagreed and 7 being strongly agreed as well as open comments and suggestions section.

Results

The students who completed the course received a nine-question survey as described in Table 3. Statements were followed by choices 1–7 with 1 being strongly disagreed and 7 being strongly agreed. Not applicable was also an option but was not used by any participants. Seventy-eight students completed the survey. All statements had a mean between 6.7 and 6.9 on a seven-point scale.

In addition, all students passed the course, as they all achieved 70% in each category of assessments.

Discussion

Some online courses continue to be offered to fulfill requirements for certain non-clerkship courses, such as basic science electives. They have proven to be popular among medical students because they are compatible with concurrent residency interviews, scholarly projects, family and personal life activities, and travel anywhere there is a sufficient Internet reliability and bandwidth. Online course options have also become increasingly popular and useful during the COVID-19 pandemic.

Table 2

| Topic                             | Number of questions |
|-----------------------------------|---------------------|
| Transfusion Reactions             | 27                  |
| Therapeutic Apheresis             | 29                  |
| Products and Indications          | 6                   |
| Red Cell Antibodies               | 14                  |
| Autoimmune Hemolytic Anemia       | 13                  |
| Platelet Refractoriness/OB and Neonatal Transfusion | 11 |

Table 1

| Video title                        | Topic                                                                                                                                                                                                 | Length |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| Transfusion Reactions 1            | An introduction to transfusion medicine including scope, immunology, blood types, compatibility, and testing. A discussion of acute hemolytic, delayed hemolytic, febrile non-hemolytic, allergic, and anaphylactic transfusion reactions. | 44:27  |
| Transfusion Reactions 2            | Transfusion-related acute lung injury, transfusion-related circulatory overload, septic transfusion reactions, transfusion-associated graft-versus-host disease, and how to approach practice cases.                     | 39:37  |
| Therapeutic Apheresis 1            | Principles, considerations, and complications of therapeutic apheresis. A discussion of thrombotic thrombocytopenic purpura, Waldenstrom's, myasthenia gravis, and Guillain-Barre syndrome.                         | 25:56  |
| Therapeutic Apheresis 2            | Plasmapheresis as it relates to cryoglobulinemia, Wegener's, Goodpasture's, and FSGS. The principles, considerations, and complications of photopheresis and a discussion of cutaneous T-cell lymphoma, graft-versus-host disease, and lung transplant rejection with bronchiolitis obliterans. | 22:58  |
| Red Cell Antibodies 1              | Categories of antibodies, genes, antigens, antibodies, and compatibility of blood types, blood type testing, screening, and crossmatching, and the Lewis system of blood typing.                                   | 33:51  |
| Red Cell Antibodies 2              | Non-ABO blood typing systems, including Rh, Kell, Kidd, Duffy, and MNS.                                                                                                                                 | 19:56  |
| Autoimmune Hemolytic Anemia        | Warm autoantibodies, cold agglutinins, paroxysmal cold hemoglobinuria, and drug-induced immune hemolytic anemia.                                                                                      | 26:00  |
| Platelet Refractoriness 1          | Platelet refractoriness and its causes and treatments.                                                                                                                                               | 36:09  |
| Platelet Refractoriness 2          | Blood bank workup for platelet refractoriness.                                                                                                                                                      | 25:50  |
| Obstetric and Neonatal Transfusion | Neutrophil transfusions, hemolytic disease of the newborn, neonatal alloimmune thrombocytopenia, and posttransfusion purpura.                                                                      | 33:12  |
Table 3
Survey response averages from the 2019–2020 and 2020–2021 academic years with a total of 78 participants who were students that took the course and subsequently responded to nine statements regarding the course. Statements were followed by choices 1–7 with 1 being strongly disagreed and 7 being strongly agreed.

| Statement                                                                 | Mean | Median | Standard deviation |
|---------------------------------------------------------------------------|------|--------|--------------------|
| 1. The learning goals and expectations were clear.                         | 6.9  | 7      | 0.4                |
| 2. The learning environment was respectful.                                | 6.9  | 7      | 0.3                |
| 3. The course materials were useful and relevant.                         | 6.8  | 7      | 0.4                |
| 4. The instructor(s) were effective in guiding our learning and discussion.| 6.8  | 7      | 0.6                |
| 5. The structure and schedule provided sufficient time and opportunity to absorb the content and explore the topic in reasonable depth. | 6.9  | 7      | 0.3                |
| 6. Assignments and assessments enhanced my understanding of the topic.     | 6.9  | 7      | 0.4                |
| 7. There were adequate opportunities to understand the intersection between basic science and individual patient care. | 6.7  | 7      | 0.7                |
| 8. There was enough basic science content to justify its inclusion in a list of required science selectives. | 6.9  | 7      | 0.3                |
| 9. Overall, this was a good learning experience.                          | 6.9  | 7      | 0.5                |

as a necessity for improved safety. In an attempt to provide many avenues for instructor contact, optional office hours were included initially, but for most instances of the course, no students attended. Thus, they were discontinued. The main reason for the creation of this course was to provide a short elective course for medical students to gain knowledge of transfusion medicine topics that was in an online, flexible format to increase accessibility during the pandemic and beyond, using preexisting videos originally formatted for pathology residents.

There were many strategies used to ensure that medical students taking the course were able to focus on and understand high-yield concepts while still being exposed to the more complex information in the course material. Firstly, the course book used was a review book instead of a long-form textbook to minimize time spent reading information that was not relevant to course evaluations or on an appropriate level of understanding. Secondly, the course videos clearly identified the biggest learning priorities. Thirdly, students were provided a question bank with 100 questions pertaining to course material that would be selected randomly for the oral quizzes using a random number generator. So, as long as students were able to answer those specific questions successfully, they would have no problem passing the course. Many students commented that they appreciated having a structured course book with a concise review format to focus their learning on high-yield topics, which allowed them to optimize their time spent studying.

The questions were in short answer format instead of multiple choice to encourage recall and application rather than simple memorization or recognition, so that despite the students being provided the questions beforehand, they were still gaining an understanding of the concepts. These course study questions emphasized the high-yield points, and the students were informed that some topics in the videos or presentation slides would not be tested and were included for a broader understanding of the material.

Despite being in an online format, the course was still arranged to prevent any cheating or other academic misconduct that could affect the students’ understanding of the material and successful completion of the course. This goal was achieved by including both written assignments and oral quizzes, with the added security of the oral quizzes being completed on Zoom with the course professor, cameras, and microphones turned on, and the student's screen being shared for the duration of the quiz. The written assignments also minimize the risk of plagiarism because, unlike a short answer assignment, written assignments of prose are less amenable to copying.

Including a student presentation was considered for the course for an added element of depth but not breadth in chosen topics; however, presentations would require more faculty time and the current course arrangement allows for significant faculty involvement without imposing a lot of extra work or time commitments. For example, the randomly selected subset of quiz questions allowed students to learn all the high-yield topics while also allowing the proctor to minimize time spent administering and grading.

Additionally, minimal synchronous sessions, limited to the two 10-min oral quizzes, made the course compatible with other activities such as residency interviews and allowed the faculty to minimize repetitive delivery of the same lectures. This format also allowed the course schedule to be compatible with the instructor's schedule.

Furthermore, the reader may customize the course freely. For example, one could customize course logistics, assessments, or change the individuals that grade them. Instead of one faculty member that grades the assignments and administers the video quizzes, these tasks could be delegated to rotating or additional faculty, residents, or fellows as necessary. If the reader has different opinions of topics to include, their relative weights, or other characteristics, then those can be changed.

One major disadvantage of this course is that it is not an in-person patient care rotation in clinical medicine. We concede this point. We do not claim that this learning experience is the equivalent of a clinical rotation or that it can be used as a direct substitution. However, in-person rotations continue to exist, and the online course does not preclude the student from doing an in-person rotation as well. In fact, this course and in-person rotations in clinical and transfusion medicine complement each other well and may culminate in a broader and more in-depth understanding of clinical medicine as a whole. We also note that long-term retention of knowledge from the course has not been tested.

The general flexibility of the course and the generalizability of the material made it very simple to adapt it from material initially aimed at residents to a medical student course. The student prerequisites included the basic science courses and core clinical clerkships to ensure that the students had adequate background knowledge for this course.

Our data are from the medical student course, but the videos were originally created for pathology residents and repurposed for the medical student course. Thus, the videos and the curriculum's study questions could be useful learning tools for pathology residents as well as trainees in transfusion medicine, hematology/oncology, nephrology, nursing, clinical laboratory technology, and other specialties. All course materials, videos, and supplemental files are provided as Supplemental Material with this article to make the course as open access as possible to allow for future students, residents, and any other individuals interested in transfusion medicine.

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Declaration of competing interest
The authors declare no conflicts of interest.

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